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Fruits and vegetables at the supply center of Bahia, Brazil: why not just supply, but also loss?

Frutas e hortaliças na Central de Abastecimento da Bahia, Brasil: por que não apenas oferta, mas também perda?

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Highlights

Sellers reported a lack of training for working with food.
Conservation technologies were lacking (12.90% had refrigeration facilities).
An estimated 153.70 t of fruits and vegetables are lost weekly.
No policies were identified to prevent or reduce food loss.
Programs to prevent food loss are needed to promote environmental sustainability.

Abstract

Food loss is a global challenge with significant economic, environmental, and social implications. In Brazil, it is estimated that fruit and vegetable losses range between 30% and 35% from production to the final consumer. This study analyzed the extent of fruit and vegetable loss and its determinants at the Supply Center of the State of Bahia (CEASA-Bahia), Brazil, taking into account the diversity of sales establishments. A cross-sectional study with a quantitative approach was conducted using questionnaires administered to sellers at the Salvador Supply Center in Bahia, Brazil. The sample consisted of 132 sellers, representing three categories: *stalls, stones,* and *boxes.* Over 85% of the sellers had not received any training in food handling. Precarious facilities and insufficient conservation technologies were observed, with only 12.9% of sellers having refrigeration facilities. Although 56.1%

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of the sellers denied experiencing losses, a weekly loss of 26.30 t of vegetables and 127.4 t of fruit was estimated, representing 2.26% of the acquired amount. In absolute values, this corresponds to over 150 t of wasted food. There was no policy in place at the Center to prevent or reduce food loss, with only timid initiatives such as donations (28.8%) and discounts (6.8%). The findings highlight the potential for implementing programs aimed at preventing food losses.
Key words: Food and nutrition security. Food systems. Postharvest loss. Supply. Sustainability.

Resumo

A perda de alimentos é um desafio global, com implicações econômicas, ambientais e sociais. No Brasil, estima-se que as perdas de frutas e hortaliças atinjam entre 30% e 35% desde a produção até o consumidor final. Este estudo analisou a perda de frutas e hortaliças e seus determinantes na Central de Abastecimento do Estado da Bahia (CEASA-Bahia), Brasil, considerando a diversidade de estabelecimentos comerciais. Foi realizado um estudo transversal, com abordagem quantitativa, por meio da aplicação de questionários aos vendedores da Central de Abastecimento de Salvador, Bahia, Brasil. A amostra foi composta por 132 vendedores, representando três categorias - *bancas, pedras* e *boxes.* Mais de 85% não haviam sido treinados para trabalhar com alimentos. Foram observadas instalações precárias e tecnologias de conservação insuficientes - apenas 12,9% tinham instalações de refrigeração. Embora 56,1% dos vendedores neguem as perdas, foi estimada uma perda semanal de 26,30 toneladas de vegetais e 127,4 toneladas de frutas, representando 2,26% da quantidade adquirida. Em valores absolutos, isso corresponde a mais de 150 toneladas de alimentos desperdiçados. Não havia uma política no Centro para prevenir/reduzir o problema, com iniciativas tímidas, incluindo doações (28,8%) e descontos (6,8%). Os resultados indicam potencial a ser explorado na implementação de programas de prevenção de perdas de alimentos.
Palavras-chave: Fornecimento. Perda pós-colheita. Segurança alimentar e nutricional. Sistemas alimentares. Sustentabilidade.

Introduction

The global food system has been a subject of intense debate due to a crisis that intertwines issues of production, supply, access, human health, and climate change. While world food production has reached high levels sufficient to feed the population, challenges persist across three axes: social, human health, and environmental sustainability (High Level Panel of Experts on Food Security and Nutrition [HLPE], 2017; Food and Agriculture Organization of the United Nations [FAO], 2023).

On the social axis, inequalities have continued to deepen, and projections anticipate a world population growth to approximately 8.5 billion by 2030, 9.7 billion by 2050, and 10.4 billion by 2100, coupled with increasing urbanization (United Nations [UN], 2022; United Nations Department of Economic and Social Affairs [UN DESA], 2019). On the health axis, there is the global syndemic, which highlights the extremes of undernutrition and famine on one hand, and obesity and chronic non-communicable diseases on the other (Swinburn et al., 2019). On the environmental axis, productive

systems have exacerbated climate change by depleting land capacity and natural resources, with a considerable portion of produced food being lost or wasted. From a broader perspective, these realities represent setbacks and deviations from the goals defined in the Sustainable Development Goals (UN, 2015).

Regarding food loss and waste, these issues pose a challenge in both developed and developing countries, with wide-ranging implications (Dreyer et al., 2019; FAO, 2019). Food loss is defined as a decrease in the quantity (mass) or quality (attributes) of food resulting from decisions and actions by food suppliers in the chain, while food waste refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers, and consumers (FAO, 2019).

It is estimated that one-third of the food produced for human consumption worldwide is lost or wasted, amounting to about 1.3 billion metric tons per year (Gustavsson et al., 2011).

Among food commodities, fruits and vegetables (F&V) experience loss and waste throughout the entire food chain, from production to the final consumer (Gustavsson et al., 2011). It is estimated that 25 to 50% of the F&V produced is lost or wasted globally (Bancal & Ray, 2022). In developing countries, these losses are primarily due to inadequate infrastructure in production and distribution phases. The lack of specialized labor, insufficient mechanization of processes, logistics and distribution challenges, and the near absence of a cold chain are the principal barriers (Magalhães et al., 2021; Xue et al., 2017).

In Brazil, research on food loss and waste is still in its early stages and remains limited (B. V. L. Costa et al., 2023). The country experiences a paradox, as it is one of the largest exporters of food commodities in the world (Hungria & Siqueira, 2024) while having 33 million people living with hunger (Rede Brasileira de Pesquisa em Soberania e Segurança Alimentar e Nutricional [Rede PENSSAN], 2022). Approximately 26 million tons of food are wasted annually in the country, with 5.3 million tons from fruits and 5.6 million tons from vegetables (Centro de Estudos e Debates Estratégicos [CEDES], 2018). In this respect, food loss and waste not only exacerbates environmental stress but also diminishes the income of producers and suppliers, inflates food prices for consumers, and aggravates issues of access and food insecurity.

One of the principal mechanisms for the distribution of F&V in Brazil are the Supply Centers (CEASA), which are established across various municipalities (Companhia Nacional de Abastecimento [CONAB], 2018). Nationally, the Brazilian Association of Supply Centers (ABRACEN), which consists of 23 CEASAs, represents both the largest centers of distribution and significant points of food losses, particularly in the capitals of Brazilian states (Associação Brasileira das Centrais de Abastecimento [ABRACEN], 2023).

In the state of Bahia, the wholesale unit of CEASA (CEASA-Bahia) is one of the most important supply centers. It hosts about 1,265 selling points, along with an estimated 1,300 street vendors, and handles an average of 44 thousand tons of products sold per month (Correio 24 Horas, 2021). In 2017, a calculation based on the garbage collection

data indicated a daily average of more than 20 t of residues (Central de Abastecimento da Bahia [CEASA], 2018), with approximately 50% or 10 t per day being organic matter, likely consisting mainly of food losses (Lei No. 12.305 (2010); Nascimento et al., 2015) - representing a significant quantity of discarded food.

Given the magnitude of losses, the relevance of this issue, especially in developing countries, and the scarcity of related research in Brazil, this study aimed to analyze F&V loss and its determinants at the Supply Center of Bahia state (CEASA-Bahia), considering the diversity of sales establishments.

Materials and Methods

The wholesale unit is situated near a highway in the metropolitan area of the city (12°50'19.3" S 38°22'21.9" W) and spans a total area of 934,118 m², consisting of 500,000 m² of built area, 437,000 m² of uncovered area, and 53,000 m² of covered area. The covered area is organized into ten warehouses (known as *boxes*) for permanent permit holders and seven warehouses for non-permanent licensees. The latter is a marketplace structured into two sections known as *stones* and *stalls* (originally *pedras* and *bancas* in Portuguese).

Permanent permit holders, who occupy spaces within fixed and built structures belonging to the wholesale unit of CEASA Bahia, operate out of areas called *boxes.* Non-permanent permit holders are allocated spaces with simpler infrastructure, typically referred to as *stones* and *stalls.* The stones comprise 8-m^2 areas located in the Non-Permanent Sheds of CEASA-Bahia, designed for selling food items, including fruits and vegetables. These spaces are equipped with basic amenities such as electricity, shared bathrooms, and armed security services. The *stalls,* while similar to the *stones* in terms of amenities, differ in the size of the occupied area, with each module covering 2 m^2.

Data collection was conducted in three phases: a) a survey of records at the Central management; b) administration of semi-structured questionnaires to permit holders (sellers) for a quantitative analysis; and c) on-site observation.

The total population of F&V sellers consisted of 93 permanent permit holders located at boxes, and 377 non-permanent ones established at *stalls* and *stones.* The sample size was calculated using a simplified equation for finite populations in cross-sectional studies (Medronho et al., 2009). The final sample included 30 *box* permit holders, 11 *stall* operators, and 110 *stone* vendors, totaling 151 participants. Participants were selected via random draw generated using the statistical software R, version 3.3.3.

The questionnaire, pre-tested to ensure clarity of terminology for permit holders, contained 43 closed (single and multiple answers) and open questions divided into four blocks: (1) socioeconomic characterization of respondents; (2) characterization of sales points; (3) details on the acquisition, storage, and sale of fruits and/or vegetables; and (4) occurrences of F&V losses.

To quantify the losses, an estimate was made based on the sellers' reports, which detailed the quantities of fruits and

vegetables purchased per unit, bag, box, etc. These figures were then converted into kilograms. The data covered the quantities of F&V that were acquired, remained unsold, and were lost. The unsold products included both those that were still usable and those that were completely lost. The amounts of loss were specified by the interviewed sellers.

The quantitative data were compiled into a database and analyzed using descriptive statistical methods in R software, version 3.3.3. Association tests between variables were performed using Spearman's correlation in the SPSS statistical package, version 2.0, with a set probability level of α=0.05.

Field records also documented the organization of the establishments, including the setting and display of products, as well as the processes of receiving, transporting, storing, and trading operations. Additionally, photographic records were made with the permission of respondents.

The study received approval from the Ethics Committee of the School of Nutrition at the Federal University of Bahia – CEPNUT (CAAE: 15189219.1.0000.5023). Participation consent was obtained from the permit holders through the Free and Informed Consent Form.

Results and Discussion

A total of 132 questionnaires were administered: 28 to box permit holders, 10 to *stall* sellers, and 94 to *stone* sellers. Due to the COVID-19 pandemic and subsequent isolation measures implemented in Brazil in March 2020, it was not possible to reach the anticipated sample size of 151 respondents.

Sociodemographic profile of F&V permit holders

The sociodemographic analysis revealed that most sellers had access to primary and secondary education. However, the highest rates of incomplete elementary education were observed among *stone* (28.72%) and *stall* (30.00%) sellers. This low level of educational attainment is consistent with findings from studies on the F&V trade in supply centers and open markets in developing countries (Shahzad et al., 2013; S. F. D. Santos et al., 2020). In contrast, the educational outcomes for *box* sellers were more favorable, surpassing those reported by J. S. Lima et al. (2013) in Brazil, where only 3.67% had higher education. At this education level, box sellers stood out, as they own larger establishments, which implies a better financial condition.

Regarding monthly income, nearly 50% of *stone* sellers earned up to three minimum wages (MW). This percentage increased to 70% among *stall* sellers, many of whom reported living on a family income of up to one MW. Conversely, 57.14% of *box* sellers reported incomes exceeding six MW. For all categories, income derived from F&V sales constituted the primary source of family livelihood, echoing findings by Abadi et al. (2021) in the city of Kermanshah, Iran.

Significant differences in education level and income among the three categories of sales points reflect the broader social inequalities in the country. The Brazilian food system is described as mixed, combining well-structured (e.g., *boxes*) and poorly structured (e.g., *stones* and *stalls*) supply chains (Berchin et al., 2019).

Most permit holders (85%) lacked specific training in food handling. Even among those who had received some form of training, it was generally unrelated to food handling or preservation and focused instead on management skills. This lack of qualification is also cited as a factor contributing to F&V loss in the production chain (Lebersorger & Schneider, 2014; Rajabi et al., 2015).

Characterization of sales outlets

The physical infrastructure of the trading points (Figure 1) emerged as one of the most critical issues related to F&V losses both in Brazil and many regions of the world (Rajabi et al., 2015; S. F. D. Santos et al., 2020; Guarnieri et al., 2021; Moraes et al., 2022). The study identified structural inadequacies, such as limited water availability at *stones* and *stalls* (only 7% and 10% respectively) and visibly unclean areas. Over 50% of respondents were unable or unwilling to discuss their cleaning practices. The low frequency of cleaning at *stones* and *stalls* is likely tied to water scarcity. In contrast, *box* areas underwent more thorough cleaning, indicating greater care. Araújo et al. (2018) suggest that such infrastructural inadequacies and poor hygiene practices can expose F&V to pests and increase the risk of contamination and that the precarious hygiene conditions could be associated with a lack of training for the permit holders. The main consequences may include an increase in food wastage figures and possible F&V contamination.

Figure 2 highlights the reasons given for maintaining cleanliness in the establishments, showing a pronounced emphasis on hygiene. *Stone* and *stall* sellers reported that cleaner facilities attracted more customers, unlike the *box* sellers, who demonstrated greater awareness of food preservation, though overall percentages remained low. Permit holders acknowledged hygiene as an essential element for their operations and customer satisfaction, yet few recognized how such practices contribute to the good condition and conservation of vegetables, or their relationship with minimizing losses. It is worth noting that the responses "Avoid food contamination" and "Preserve food" received fewer mentions across the three sales point categories, indicating a lower awareness of the importance of environmental hygiene and food preservation.

When exposed to unfavorable environmental conditions, F&V are vulnerable to contamination and spoilage processes (Spagnol et al., 2018). Poor hygiene practices further increase the risk of contamination by foodborne pathogens (S. F. D. Santos et al., 2020). According to Goodman-Smith et al. (2020), the lack of training may be the most important barrier to reducing food waste. Thus, in this study, the apparent lack of awareness about the importance of hygiene at points of sale for preserving F&V could be addressed through educational initiatives for workers. Such training can transform good practices into routine habits, bringing both financial and non-financial benefits to the sector. Well-defined protocols, along with a trained team, are essential for the successful implementation of waste reduction initiatives (Goodman-Smith et al., 2020).

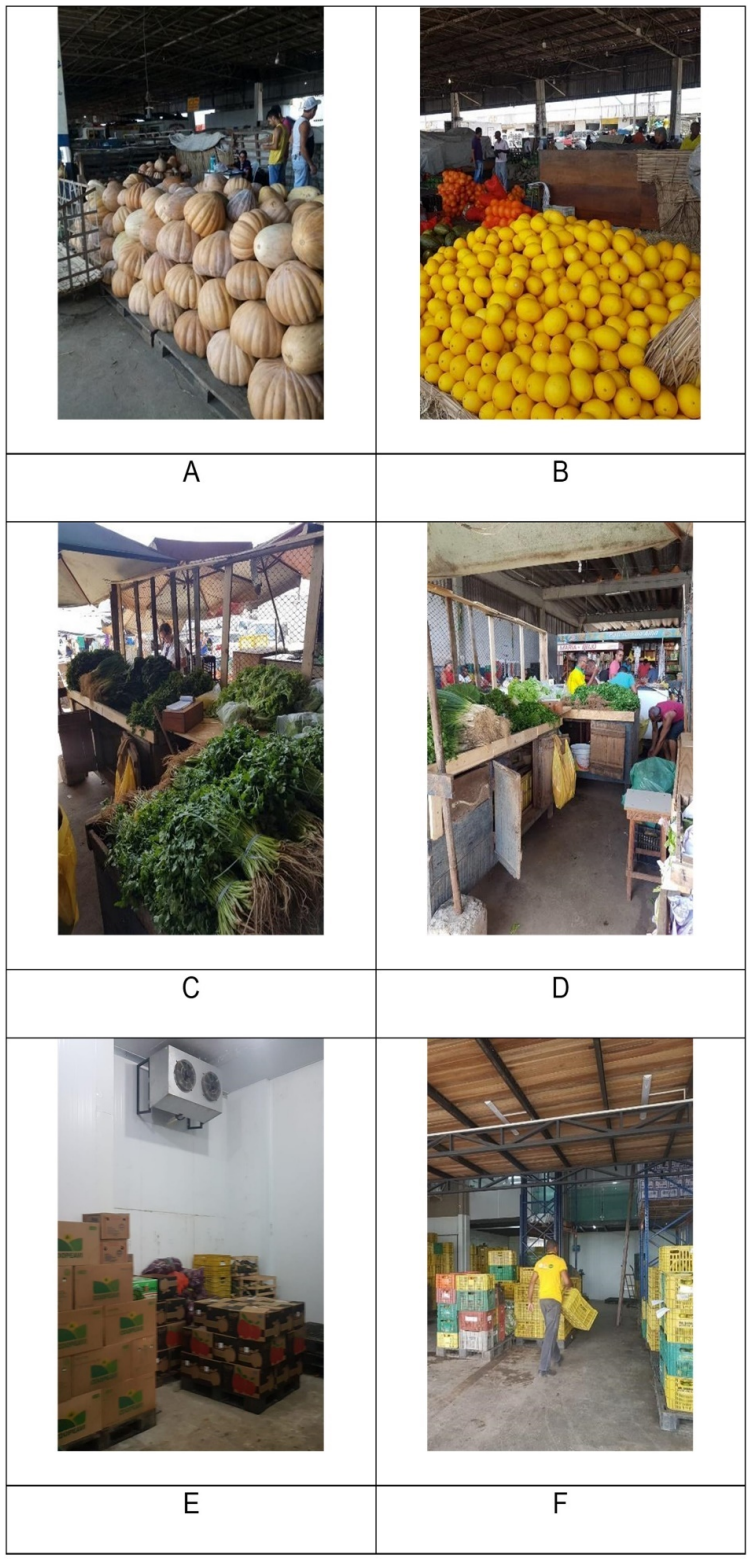

Figure 1. Characteristics of Fruit and Vegetable sales points at CEASA-Bahia: non-permanent permit holders: *stones* (A and B) and *stalls* (C and D); and their permanent counterparts: *boxes* (E and F). Salvador, Bahia, Brazil, 2019/2020.

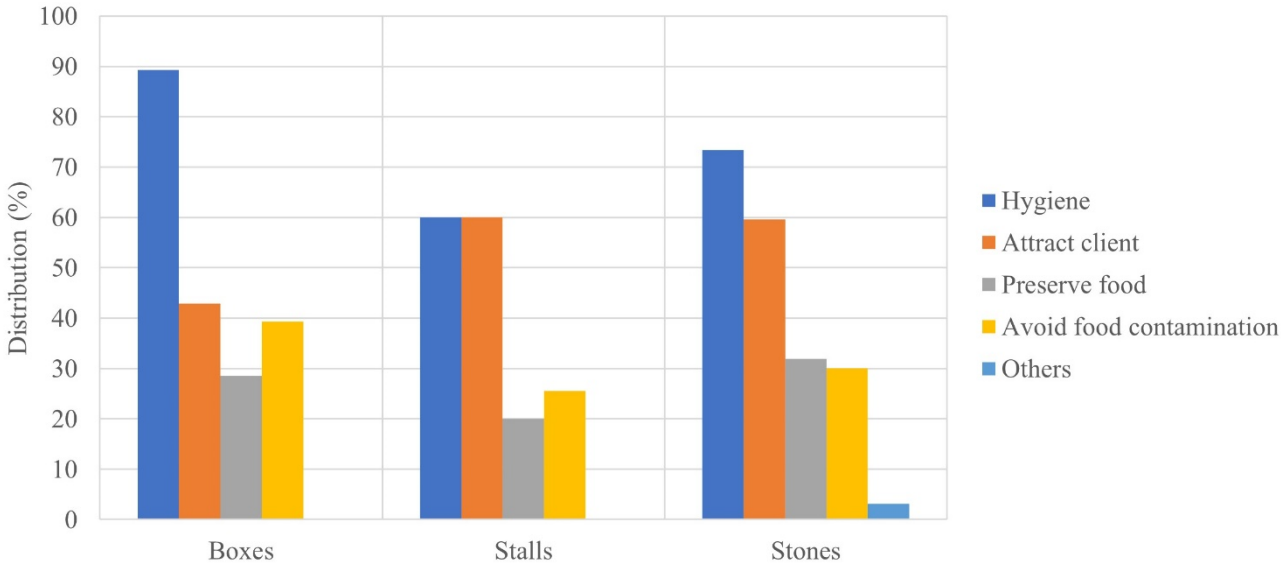

Figure 2. Distribution (%) of CEASA-Bahia permit holders according to the reason for keeping their establishments clean. Salvador, Bahia, Brazil, 2019/2020.

Acquisition, storage, and sale of F&V

In terms of acquisition planning, 35.11% of *stone* sellers and 20% of *stall* sellers claimed to always purchase the same quantity of products, disregarding previous losses. For 54.26% of stone permit holders, purchase planning depended on customer demand, a figure that dropped to 30% among *stall* sellers and rose to 89.3% for box sellers. In this regard, it is noteworthy that the purchase of goods without planning was indicated as one of the most detrimental to loss control (Shahzad et al., 2013; Guarnieri et al., 2021).

Weather conditions were also considered an important aspect in the acquisition and conservation of products. At CEASA-Bahia, rainy days were cited as the most critical for losses, leading to reduced customer flow and increased atmospheric humidity, which accelerates product deterioration. Rajapaksha et al. (2021) noted that exposing fresh F&V to environments with high relative humidity during the post-harvest period is a predisposing factor for spoilage. It is therefore recommended to adopt storage systems with humidity control to extend shelf life, although such systems require a high level of financial investment.

Data on the origin of the products, types of suppliers, transportation conditions, and packaging (Table 1) allowed a better understanding of the supply chain and its limitations. Most products originated from within the state of Bahia, primarily from nearby locations. This preference for local sourcing is partly attributed to the perishability of F&V, lower transportation costs, and support for regional trade (Guerra et al., 2018). J. S. Lima et al. (2012) observed a similar pattern at CEASA in Ceará, Brazil, where 51% of the products were sourced locally.

Regarding transport, the frequent use of non-refrigerated vehicles was notable. This situation highlights deficiencies and the negative impacts on the post-harvest transport system, not only in Bahia but across Brazil and other regions (da Costa et al., 2015; Loke & Leung, 2015). Anand and Barua (2022) argue that the absence of specialized vehicles for transporting fresh F&V is a major cause of post-harvest losses, a critical issue in countries with a tropical climate, such as Brazil.

Table 1
Distribution (%) of respondents regarding the origin, type of supplier, and transportation and packaging conditions of fruits and vegetables purchased at CEASA-Bahia. Salvador, Bahia, Brazil, 2019/2021

	Stones (n (%))	**Stalls** (n (%))	**Boxes** (n (%))
Origin			
Countryside	91 (96.81)	10 (100)	25 (89.29)
Other states	40 (42.56)	6 (60)	15 (53.57)
Type of suppliers			
Direct purchase from rural producers	85 (90.43)	9 (90)	24 (85.71)
Intermediaries / Middlemen	27 (18.09)	1 (10)	7 (25)
Own production	8 (8.51)	1 (10)	3(10.7)
Type of transport			
Truck body uncovered	13 (13.83)	1 (10)	2 (7.14)
Truck body covered with tarpaulin	73 (77.66)	3 (30)	17 (60.71)
Refrigerated truck body	6 (6.38)	4 (40)	7 (25)
Unrefrigerated truck body	18 (19.15)	2 (20)	7 (25)
Presence of packaging			
Products received with packaging	79 (84.04)	10 (100)	25 (89.29)
Products received without packaging	14 (14.89)	---	2 (7.14)
No reply	1 (1.10)	---	1 (3.57)
Type of packaging			
Plastic box	49 (52.13)	8 (80)	23 (82.14)
Cardboard box	5 (5.32)	---	9 (32.14)
Wooden box	6 (6.38)	1 (10)	8 (28.57)
Raffia bag	9 (9.57)	---	2 (7.14)
Other	41 (43.62)	2 (20)	8 (28.57)

Packaging for F&V was utilized in over 80% of cases, predominantly involving plastic boxes, which served both as packaging and as a display structure, especially at *stones.* Other packaging materials included straw, leaves from the plantation, nylon, and plastic bags. There were issues with the use of wooden boxes, which are not recommended due to difficulties in cleaning, as well as instances of vegetables being delivered unpackaged. In this respect, it is important for farmers and those in the distribution chain to recognize the ideal type of packaging for each product to maintain its safety and quality, thereby reducing losses and waste. Moreover, during the loading and unloading stages of F&V, it is essential for employees to know how to handle the products and their packaging to prevent physical damage (Anand & Barua, 2022).

Overall, the focus was on the condition of the F&V upon arrival at CEASA. The type of packaging is significant as it can influence the conservation of the product. Delicate fruits, such as grapes and strawberries, are susceptible to physical damage during transportation and require careful packaging (Zaro, 2018). These fruits are considered premium in the market, owing to their perishability and lower production in the tropical climate of Brazil.

During data collection at the visited sites, there was a noticeable lack of sufficient equipment for weighing, internal transport, and storage, particularly cold rooms. At *stones,* 98.94% of the establishments lacked refrigeration equipment for preserving F&V, and internal transport was facilitated using wooden handcarts, present in 78.80% of cases. Regarding weighing, 57.45% of the sites had a scale.

In the case of *stalls,* the absence of refrigeration equipment severely compromised the conservation of vegetables. Products were displayed on wooden desks at room temperature, which favored wilting and loss of turgor, especially in leafy vegetables. Only 40% of these points had handcarts for transport and 30% were equipped with scales. Similar to *stone* outlets, most products predominantly leafy vegetables were sold in units (packs or bunches).

At the *boxes,* for cold storage, 25% of the commercial units had refrigerators and 35.7% had cold rooms. Among respondents, 57.1% reported that their products were stored under refrigeration. Regarding equipment, most were equipped with handcarts and/or pallet trucks (89.3%), forklifts (35.7%), and scales (64.3%).

In storages without refrigeration, regarding product display, 28.72% of *stone* respondents indicated that their products were placed on boxes, most of them plastic (24.47%), and some wooden; in 3.19% of the cases, products were displayed on counters or stalls, 4.26% on nylon bags, and another 4.26% used other materials such as grass, mats, tarpaulin, and wood shavings.

In the case of *stalls,* according to 80% of the sellers, products were placed on wooden counters, with the use of pallets (10%) and plastic boxes (10%) also reported. For the *boxes,* in 57.1% of the cases, F&V were kept on pallets, 14.3% were placed directly on the floor, and 17.9% in plastic boxes. In addition to these, countertops, stands, and grass were also mentioned, totaling 10.71%.

The lack of sufficient equipment, especially regarding stones and stalls, can contribute to F&V loss, with the absence of refrigeration being among the primary determinants (Lana & Moita, 2019; S. F. D. Santos et al., 2020). Indeed, cold storage is the most effective and simple method to delay the deterioration of F&V (Spagnol et al., 2018). As an example, Shahzad et al. (2013) pointed out the inadequacy of cold temperatures in the plum production chain in Swat, Pakistan, as a state issue, necessitating investments in cold storage facilities from the early stages of production. This challenge is one of the main obstacles in preserving perishable products.

Regarding clientele, CEASA-Bahia establishments recorded considerable diversity (Figure 3). In the case of stones, supermarkets, smaller markets, restaurants, street vendors, and final consumers were prominent. At stalls, a similar demographic was noted, with the exception of street vendors, and a stronger emphasis on final consumers, the most mentioned. This trend continued at the boxes; however, supermarkets were notably prevalent, with over 70% of the indications. This framework emphasizes the importance of CEASA in Brazil, particularly in facilitating commerce from rural producers to the final consumer, playing an essential role in urban supply (Pechtoll, 2011).

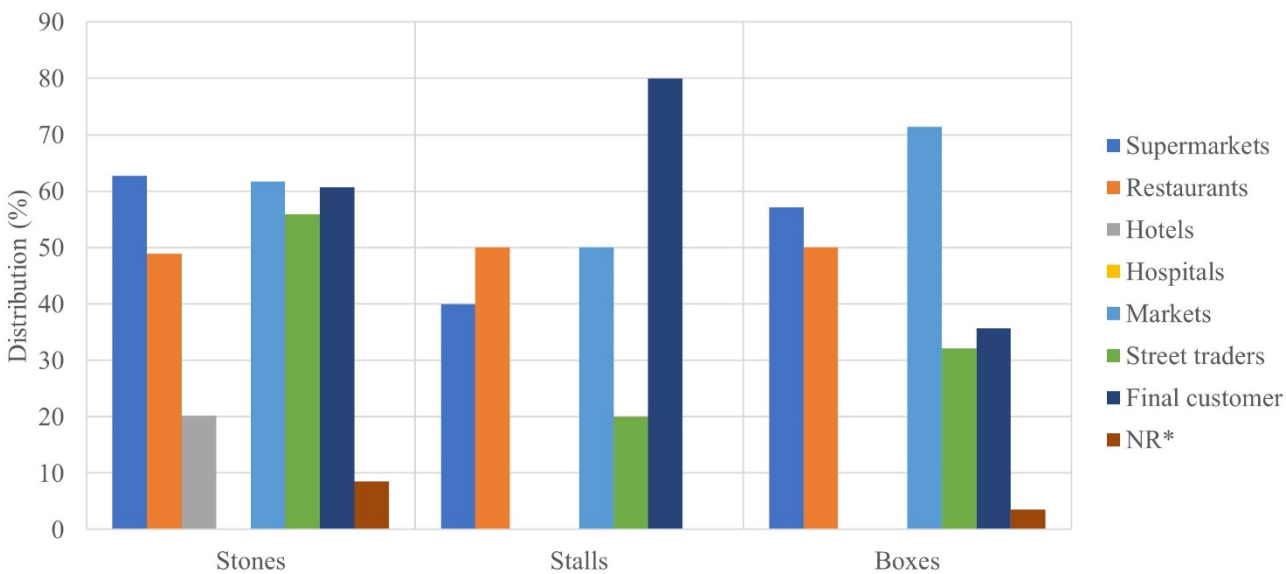

Figure 3. Distribution (%) of customer categories of CEASA-Bahia establishments, Salvador, Bahia, Brazil, 2019/2020. *NR – Did not respond or did not know how to respond. Multiple answers were possible.

When asked for an estimate on the weekly amount of unsold goods, 67.71% of those interviewed at the *stones,* 70% at the *stalls,* and 58.06% at the *boxes* reported occurrences. For the three categories, the main reason cited for unsold goods was delayed sales (*stones* – 44.68%; *stalls* – 50%; *boxes* – 53.57%), with the primary challenges being the difficult access and distance from CEASA-Bahia (located on the outskirts), mainly for end consumers; the precariousness of the facilities; and competition between companies. While facility conditions were often mentioned as a justification, they actually represent one of the main determinants of loss. Adequate infrastructure could potentially extend the shelf life of food.

It is also worth noting that some sellers purchased F&V without adjusting quantities to meet demand, leading to unsold and wasted food. It is important for F&V purchase orders to be aligned with demand to avoid both empty shelves and an excess of fresh products, which can cause more waste and losses. The organization of supply should be strategically planned and adapted according to the product type, supply capacity of the sales point, seasonality, among other factors (S. F. D. Santos et al., 2020; B. V. L. Costa et al., 2023). Additionally, implementing inventory management tools, establishing a routine for reverse logistics, and sourcing goods from local suppliers can also help reduce losses (Guarnieri et al., 2021).

Other common reasons for loss included product rotting (*stones* – 36.17%; *stalls* – 20%; *boxes* – 35.70%), unfavorable weather (*stones* – 32.99%; *stalls* – 20%; *boxes* – 17.86%), and poor quality of received products (*stones* – 21.21%; *stalls* – 10%; *boxes* – 28.57%). Additionally, improper or absent packaging and inadequate storage were cited as contributing factors.

Regarding the disposition of unsold products, 79.79% of the sellers either did not undertake any initiatives or were unable to provide information about any actions taken. Of the 20.21% who responded positively, at *stones,* 65.96% indicated donations and 20.20% mentioned other uses, e.g. extracting and freezing fruit pulp. Conversely, at *stalls,* 10% of participants reported using unsold goods for personal consumption and/or donation. Overall, 30% of the sellers indicated that the unsold products ended up in dumpsters. This loss was evident in the field, with observations of large amounts of leafy vegetables discarded on the ground near the displays and in waste containers.

At the *boxes,* 50% of sellers reported discarding unsold food, which is higher than the average for other sellers. Among those who did not discard, 14.29% used unsold vegetables for personal consumption, and 78.57% made donations. According to Moraes et al. (2022), it is essential to implement strategies for reusing unsold F&V, including donations and developing new products such as cakes and jellies. It is also important to raise consumer awareness about purchasing F&V that may have aesthetic imperfections but retain nutritional quality for consumption. B. V. L. Costa et al. (2023) also emphasize the need to allocate unsold products to food security programs, ensure their efficient use according to the Wasted Food Scale (formerly the Food Recovery Hierarchy) of the U.S. Environmental Protection Agency (Kenny et al., 2023), and for government actions to establish policies that minimize the issue.

Occurrence and assessment of F&V loss

Table 2 illustrates a higher volume of acquisition and loss of fruits compared to vegetables. *Boxes* were the largest purchasers and experienced the lowest loss rates. Among the types of establishments, the highest proportion of fruit losses occurred at *stones,* while for vegetables, the highest losses were at *stalls.*

Table 2
Acquisition estimates, unsold products, and weekly losses at CEASA-Bahia. Salvador, Bahia, Brazil, 2019/2021

	Stones (t (%))	Stalls (t (%))	Boxes (t (%))	Total (t (%))
Fruits				
Acquisition	1871.66 (100)	0.1 (100)	2228.49 (100)	4100.25 (100)
Unsold	126.86 (6.78)	0	56.66 (2.54)	183.51 (4.48)
Losses	120.79 (6.45)	0	6.57 (0.30)	127.36 (3.11)
Vegetables				
Acquisition	667.31 (100)	20.13 (100)	2020.55 (100)	2707.99 (100)
Unsold	82.35 (12.34)	6.96 (34.58)	93.00 (4.60)	182.31 (6.73)
Losses	9.10 (1.36)	1.98 (9.83)	15.21 (0.75)	26.30 (0.97)

* At the *stalls,* there was only one fruit seller who reported no losses.

Regarding fruits, it is important to note the large quantity unsold (183.51 t/week) and a correspondingly high loss (127.36 t/week). For vegetables, the high unsold volume (182.31 t/week) is proportionally greater than that of fruits, but the actual loss is significantly lower (26.30 t/week), which is inconsistent with the non-marketed quantity. This discrepancy suggests possible underestimation or data omission by respondents, as discomfort with their answers was evident. This gap may indicate either a lack of awareness or inadequate administrative control over the amount discarded. Possessing managerial skills and competencies is key to enhancing the efficiency of F&V distribution and controlling waste. In this context, effective management can identify critical waste points and propose organizational policies and strategies to reduce them (Özbük & Coskun, 2020).

Given that a higher incidence of unsold products can be associated with increased losses, statistical tests were applied, revealing some correlations. There was a moderate positive correlation between unsold vegetables at *stalls* and their losses (r=0.503; p=0.020). At the *stones,* there was a strong positive correlation between the unsold fruits and their losses (r= 0.965; p=0.000). At the boxes, there was also a moderate positive correlation between

unsold and lost F&V (fruits: r=0.568; p=0.001; vegetables: r=0.652; p=0.000). This finding demonstrates that the greater the number of unsold products, the greater their losses. Therefore, more effective purchase planning may play an important role in controlling food loss, as it can balance the relationship between acquisition and sales demand (S. F. D. Santos et al., 2020; Özbük & Coskun, 2020; B. V. L. Costa et al., 2023).

When comparing the quantities acquired and lost, in proportional terms, losses appear small around 3.11% for fruits and 0.97% for vegetables. However, in absolute terms, 0.97% corresponds to 26.3 t of vegetables discarded in one week, and 127.36 t for fruits. These figures draw attention, especially considering the effort to produce food and the number of people facing hunger in the country.

Simultaneously, it is essential to recognize that losses entail damages: economic, through invested resources and discarded goods; nutritional, by losing nutrients and health-promoting phytochemicals; and environmental, through resources consumed along the production chain and the volume of waste generated (FAO, 2019; UN, 2020; C. M. Santos et al., 2023).

Studies conducted in supply centers in different parts of Brazil have shown high quantities of F&V loss compared to the findings of this research. Silva et al. (2022) reported a total F&V loss of around 17.15 t per day at Maracanaú's CEASA, which is less than that reported in this study. On a smaller scale, S. F. D. Santos et al. (2020) found 1.58 t of F&V losses per day in retail CEASAs in Salvador, Brazil. The main reasons associated with these losses included failures in cold storage, truck unloading and handling, and inadequate local hygiene.

In the international scenario, there is a gap regarding F&V losses at the wholesale level most research focuses on supermarkets. A study conducted in six Swedish retail stores reported an annual F&V waste rate of 4.3%, similar in proportional terms to this study but comparable in absolute terms to S. F. D. Santos et al. (2020). In these markets, pre-store rejections were the primary cause of waste (3.01%), due to strict inspection routines and high standards for F&V received (Eriksson et al., 2012). In Austria, Lebersorger and Schneider (2014) evaluated food waste in 612 retail stores and found that F&V had the highest waste percentages (4.2%), with apparent flaws being the most common reason for discarding products (89%), followed by products reaching their best before/use-by/sell-by date (18%).

The study highlights several factors associated with the loss of F&V during transport and storage. A moderate positive correlation was observed between F&V loss and the use of vehicles covered with tarpaulin for transport, in the case of *stalls* (r=0.408; p=0.040). Conversely, the use of closed-body trucks, both with and without refrigeration, showed moderate negative correlations with F&V loss (r=-0.645; p=0.000 and r=-0.791; p=0.000, respectively), signaling protection against losses.

Furthermore, the analysis revealed that larger purchases (in absolute terms – tons) are associated with increased losses, regardless of the type of establishment. Positive correlations were found for F&V loss both at the *boxes* (r=0.560, p=0.000; r=0.367,

p=0.040) and *stones* (r=0.892, p=0.000; r=0.192, p=0.047). A moderate positive correlation was observed for vegetable loss at the *stalls* (r=0.500; p=0.004). S. F. D. Santos et al. (2020) also reported that losses increase with higher purchase volumes.

When respondents were asked if these losses could be avoided, 28.79% at the *stones,* 30% at the *stalls,* and 53.57% at the *boxes* responded affirmatively. This response was notably significant for the *boxes* but less so for the other two categories. Among the proposed actions to reduce losses, *stone* sellers mentioned increasing clientele (3.19%), using unsold products (1.06%), and boosting sales (1.06%). At the *stalls,* suggestions included donations (20%), selling products at cost price (10%), promoting sales (10%), and improving the infrastructure at CEASA - Bahia (10%). For the *boxes,* proposals included donations (3.57%), considering weather conditions during purchasing (7.14%), running promotions (10.71%), improving transport conditions (7.14%), better purchase planning (10.71%), and assessing and potentially returning low-quality products to suppliers (14.29%), among others.

As indicated, a number of measures should be established and institutionally supported by CEASA-Bahia, with a focus on reducing F&V losses, through a loss prevention and control program. In practice, it was noticed that the measures reported by the interviewees were adopted only individually. Nonetheless, these measures are currently being implemented individually rather than institutionally.

Participants were also asked if they were implementing any actions aimed at reducing losses. In response, 65.96% of *stone* sellers, 60% of *stall* sellers, and 53.57% of *box* sellers indicated they were not undertaking any such activities. Among those who were taking measures to prevent losses, the responses varied by sales point. For *stone* sellers, 10.64% made donations, 1.06% improved protection for fruits, 2.28% sought to enhance transport, 4.55% tried to attract more customers, and 1.06% promoted alternative uses for unsold products, among other initiatives. At the *stalls,* 20% made donations, 10% sold products at cost, and 10% offered special promotions. For *box* sellers, 10.71% reduced prices, 10.71% made donations, and 7.43% planned sales based on customer demand and/or supplier pricing.

Concerning the use of unsold products, a big gap was noticed, necessitating actions to prevent the disposal of food that could still be used, especially for feeding vulnerable populations. This situation contravenes both the principles of food security and the hierarchy of food loss and waste recovery (FAO, 2019; Guarnieri et al., 2021). When asked about awareness of loss prevention actions promoted by CEASA-Bahia, the majority of responses were negative 72.34% from *stone* sellers, 80% from *stall* sellers, and 64.29% from *box* sellers. Only 8.51% of *stone* sellers reported knowing about such actions, with 1.06% mentioning composting, 1.06% aware of permissions for food donations, 2.18% familiar with the *"Prato Amigo"* (lit. "friendly dish") program (which collects food donations coordinated with food marketing, storage, and processing networks to support social institutions and reduce food waste in urban and metropolitan areas), and 2.18% aware of the *"Sopão"* (soup kitchen) initiative.

Stall and *box* owners were unable to provide answers to this question.

To reduce food waste, especially of F&V, studies have suggested several measures, including improvements in infrastructure, promoting sales, donations to charity, training and educating employees, strategies for raising customer awareness and information, adjusting purchase planning to match demand, employing merchandising techniques, and monitoring waste (Mena et al., 2014; Rajabi et al., 2015; Scholz et al., 2015; Lebersorger & Schneider, 2014; Lana & Moita, 2019; S. F. D. Santos et al., 2020; Guarnieri et al., 2021; Moraes et al., 2022).

Limitations and prospects

The main limitation of this manuscript lies in the waste measurement methodology applied. Alternative methods, potentially more accurate in predicting waste based on determinants identified by traders in CEASA-BA, could have been utilized. The high number of units studied (151 permit holders), coupled with the complexity of the questionnaire, may have contributed to the relatively high variation in the findings. Future research could benefit from focusing on smaller, more controlled groups and variables, potentially yielding more precise results. Direct waste quantification, while likely the most accurate method, poses challenges when applied on a large scale, such as in CEASA units. This highlights the need for the development of new tools capable of providing more reliable F&V waste data (Lima & Oliveira, 2021).

Regarding the main prospects of the present study, it is inferred that F&V waste in the Wholesale unit of CEASA-BA is multifactorial. Many of the issues identified indicate a need for government intervention to improve infrastructure for F&V storage and sales, alongside a focus on educational interventions. The complexity of the F&V waste data provided by permit holders, and the potential underestimation of these values, could be a focus of future studies. Monitoring F&V waste in both developed and developing countries is crucial, first due to the scarcity of data in the scientific literature, and second for the opportunity to exchange experiences and evaluate F&V waste control measures based on the various existing practices worldwide. In countries such as Brazil, resilience in F&V distribution points, given the lack of adequate selling conditions, is a notable factor.

The ability to adapt to non-ideal conditions might be beneficial, but it could also promote the stagnation of permit holders to long-term precarious structures and habits (F. H. O. Costa et al., 2022). Therefore, F&V waste reduction strategies must be urgently implemented at CEASA-BA, considering its importance (D. M. Lima et al., 2022) as one of the main food suppliers in the region. The dissemination of knowledge by training permit holders and other workers (administration and food hygiene topics), as well as providing adequate storage and selling conditions, may be the most important points for future scientific and governmental/non-governmental interventions at the studied unit.

Conclusions

The scenario identified at CEASA-Bahia is that the estimated loss of F&V, in

absolute terms, was significant and alarming, considering national and international guidelines. However, when comparing the volume of goods purchased to the quantities unsold and lost, a considerable discrepancy was observed, with a positive correlation between them, suggesting underestimated loss results. In the practice of sellers, there appears to be a normalization of the losses, as if they were inevitable, or it is deemed simpler to discard nonstandard foods rather than introduce other uses for them. The identified losses highlight both a problem and a potential to be explored, with the support of the Central Administration of CEASA-Bahia and permit holders to establish programs aimed at loss prevention and reduction. In this sense, the adoption of technical measures, such as improving infrastructure, providing training for food handlers, and enhancing purchase planning and sales strategies, is of great importance. Moreover, it is important to develop activities that prioritize human needs, such as socio-educational actions for vulnerable communities, donations to charitable organizations, and the support of community restaurants, among others. In summary, actions that align with political guidelines and contribute to environmental sustainability and humanitarian care are of utmost importance.

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