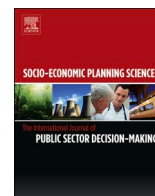




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How risk perception regarding the COVID-19 pandemic affected household food waste: Evidence from Brazil

Lucas Rodrigues Deliberador^a, Alexandre Borges Santos^a, Pâmella Rodrigues Silva Carrijo^a,
Mário Otávio Batalha^{a,*}, Aldara da Silva César^b, Luís Miguel D.F. Ferreira^c

^a Department of Industrial Engineering, Federal University of São Carlos, São Carlos, SP, 13565-905, Brazil

^b Agribusiness Engineering Department, Federal Fluminense University, Volta Redonda, RJ, 27255-125, Brazil

^c Univ Coimbra, CEMMPRE, Department of Mechanical Engineering, Portugal

ARTICLE INFO

Keywords:

Food surplus
Sustainable development goals
Consumer
Survey
Developing countries
Coronavirus

ABSTRACT

Food waste is a worldwide problem. One third of the food produced in the world is lost or wasted every year. Most of this waste takes place downstream of the supply chain due to consumer behavior. This issue is expected to increase in both developed and emerging economies. With the beginning of the COVID-19 pandemic, a range of challenges led to changes in consumer behavior. This study explores household food waste behavior during the COVID-19 pandemic through the lens of the Theory of Planned Behavior. The risk perception regarding the pandemic was integrated into a broader framework, which was analyzed by Structural Equation Modeling. The sample comprises the participation of 452 Brazilian individuals. The results show that all the predictors incorporated in the model were statistically significant. The intention of reducing household food waste during the pandemic was found to be the strongest predictor of food waste behavior. Additionally, the pandemic apparently influenced consumers' perceptions about the control they think they have over food waste. This research has theoretical and managerial implications. From a theoretical perspective, this study identifies key predictors of household food waste by considering a period of health crisis in an emerging country. From a managerial standpoint, this research may provide a learning experience for future similar scenarios. Results may also motivate consumers to look for ways to reduce, reuse and recycle food waste.

1. Introduction

COVID-19 (SARS-CoV-2) is a highly transmissible respiratory disease that has been a threat to the human population all over the world [1]. To date, over 555 million cases have been reported worldwide, causing more than 6 million deaths [2]. Some countries have been able to minimize the negative effects of the pandemic through the adoption of effective policies. Evidence has shown that there is not just one strategy to combat the spread of COVID-19 throughout countries [3]. It is known that the countries that have tackled the COVID-19 pandemic better are those that have been able to combine strong institutional policies with sound cultural orientation [4]. This implies, for instance, the availability of universal health coverage, a robust social protection system, and effective governance [5]. Because of lacking these pivotal resources, many undeveloped and developing nations have struggled to deal with the most severe health crisis of the last few decades.

In Brazil, the pandemic has caused the loss of lives and economic and

political damage since the first case was reported on February 25, 2020. More than two years later, the epidemic continues to spread across the country, with over 672,000 deaths and over 32 million cases [2]. The pandemic has impacted on people's lives and changed behaviors in several ways, such as: the need to work or study remotely [6]; general restrictions to avoid large gatherings [7]; changes in most people's social lives [8]; and changes in eating habits [9]. Eating habits refers to how people use a certain type of food, which may include the stages of food selection, production, preparation, and consumption [10].

When considering changes in eating habits during the pandemic, it is important to highlight that the main changes in behavior may be observed due to a series of facts. These include the following: increased online shopping to avoid frequent trips to the shops [11]; increased consumption of ready-to-eat products through delivery services; increased consumption of convenience food; stockpiling at home due to monetary or supply insecurity [12–14]; decreased visits to restaurants [15]; the search for healthier food as a way to strengthen the immune

* Corresponding author.

E-mail address: dmob@ufscar.br (M.O. Batalha).

<https://doi.org/10.1016/j.seps.2023.101511>

Received 11 September 2021; Received in revised form 5 December 2022; Accepted 11 January 2023

Available online 14 January 2023

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system and consequently prevent diseases [16]; the purchase of appliances to facilitate household tasks; improved purchase planning; and social concern for those who do not have enough to eat due to the pandemic, among others.

Some of these measures have led to an increase in food waste (FW) during the pandemic [17], such as household stockpiling and a greater use of food delivery services, which usually deliver larger portions. On the other hand, some of these behavioral changes may also lead to a reduction in waste. One example is the fact that people are staying at home for longer and consuming more self-prepared food, which is usually healthier and can be reused more easily in other meals [18].

The aforementioned changes justify the need to understand the impact of the COVID-19 pandemic on the population's FW behavior [16], especially in households. Therefore, the objective of this paper is to investigate the impact of the pandemic on Brazilian household's FW behavior. The following research question was addressed: how has risk perception regarding the pandemic influenced household food waste? To achieve this goal, the Theory of Planned Behavior (TPB) was employed to develop and test hypotheses about Brazilian consumers' behavior and how they perceived household FW during the pandemic.

2. Theoretical background and research hypotheses

2.1. Theoretical background

Food loss and waste refers to the disposal of food at different stages of a food supply chain (FSC): production and harvest, transportation and storage, processing, distribution/retail, and consumption [19–21]. The definition of food loss and FW differs among authors, generally depending on which point in the FSC the loss occurs [22].

An important portion of food loss is called FW, which refers to the removal of food that is still fit for consumption or has spoiled or passed its use-by date, and which is mainly caused by consumer behavior [23]. The current study, however, assumes that FW only refers to what exclusively happens at the distribution, retail, and consumption levels, while everything that is prior to these stages will be classified as loss [24].

The COVID-19 outbreak provides a great opportunity to understand how consumers behave when it comes to FW. Due to social isolation, both individuals and households drastically changed their food consumption habits and behavior [25,26]. Families spent more money on groceries during confinement, as they were prone to stay at home. However, many families experienced financial hardship due to reduced household income and the risk of bankruptcy or unemployment [27]. In conjunction with restrictions in relation to mobility, these aspects made it difficult for many consumers to access food [28].

Conversely, larger purchases of non-perishable foods were observed around the world (e.g., pasta, rice, canned goods, flour, frozen foods, etc.) [29]. For instance, American consumers increased their spending during the COVID-19 pandemic to stockpile essential household goods, especially food [30]. With the closing of restaurants and cafés, food purchases shifted to grocery stores. In addition, since physical shopping created a perceived risk and induced fear of being in the proximity of others, consumers' shopping behavior rapidly switched to online shopping [29]. Ref. [30] states a significant growth in food delivery, which is consistent with the substitution of meals in restaurants by meals at home.

By going to supermarkets less often, consumers may buy food in larger quantities, plan meals to avoid leftover food, or even prepare new meals from the leftovers, thus reducing household FW [31]. Conversely, consumers may consume more food by staying at home longer due to social isolation, which can lead to larger-than-normal purchases and preparations, increasing household FW [32]. For instance, consumers who go shopping fewer times per week may also need to buy food in larger quantities to stock at home, which can lead to overstocking and overpreparation. While having food in bulk available can potentially

save time, without planning the subsequent meals, it is unpredictable when the food might actually be consumed [33].

2.2. Proposed framework

The TPB [34] was used to comprehend consumer behavior regarding FW during the COVID-19 pandemic. Many studies on FW behavior have already employed the TPB. The model has been expanded to understand the FW behavior of Spanish and Italian youth [35]. It has also been employed to examine FW-reduction behavior in Iranian households [36] as well as to measure self-reported food wastage and its behavioral determinants indirectly from Canadian consumers [37].

The basic paradigms of the TPB are that people are most likely to conduct a certain type of behavior if they believe that such behavior will result in an outcome that they value, if their important referents also value and approve it, and if they have the resources, abilities, and opportunities to perform such behavior [38]. The TPB model determines that attitudes, subjective norms, and perceived behavioral control are the critical components of behavioral intent and actual behavior [34]. For the current research, the perceived risk regarding the COVID-19 outbreak was integrated into the TPB to determine the effect size between the endogenous and exogenous latent variables. Fig. 1 represents the framework proposed for the current study.

2.3. Hypotheses

2.3.1. Risk perception (COVID-19)

When compared to other fields, such as environmental risks, far less is known about how the public perceives risks related to emerging infectious diseases [39]. Risk perception mainly involves uncertainty and the consequences or probability of a loss, and the importance of that loss [40]. The risks involved in shopping during the COVID-19 outbreak are not only health and social risks but also shortages caused by price changes and product scarcities [41]. Changes in shopping behavior could be observed regarding certain aspects, including changes in frequency and the choice of supermarkets and brands, a shift from in-person to online shopping, and the stockpiling of food items. Therefore, the following hypotheses were posited:

H1a. Risk perception (COVID-19) has a positive effect on consumers' attitudes towards household FW during the pandemic.

H1b. Risk perception (COVID-19) has a positive effect on household FW behavior during the pandemic.

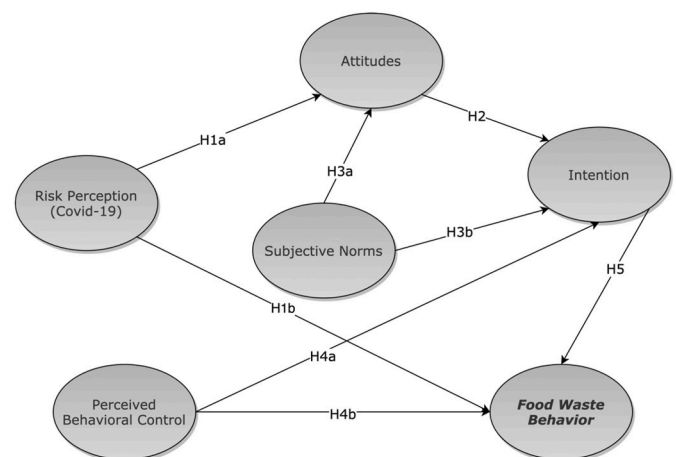


Fig. 1. Proposed framework to evaluate household FW behavior during the COVID-19 pandemic.

2.3.2. Attitude

Attitude is considered a vital factor in shaping the intention of a behavior. In the best known articles on the TPB, attitude is defined as the degree to which an individual makes a negative or positive evaluation or appreciation of the behavior in question [42]. According to the TPB, it refers to an individual's attitude towards his or her involvement in a particular behavior [43]. In accordance with Ref. [17], attitude is regarded as a favorable or unfavorable predisposition, or as indifference, which is common in FW studies, in relation to a product, service, or any other aspect of social life. A feeling of guilt may influence an individual's decision to waste food or not [44]. During the COVID-19 pandemic, this feeling of "obligation" or "guilt," for example, could be a favorable influencer on waste, especially when it led the individual to think that it is immoral to waste food while many people are starving. Thus, the second hypothesis of this research was as follows:

H2. Consumer attitudes have a positive effect on the consumers' intention to reduce household FW during the COVID-19 pandemic.

2.3.3. Subjective norms

As the second antecedent of intention, subjective norms refer to individuals' perception of the social environment in which they behave in a certain way or not [34,42]. In other words, subjective norms deal with how someone's personal beliefs would be interpreted by one's referents if a certain behavior is performed [45]. This construct, therefore, exerts some sort of third-party pressure on the individual [46].

The TPB postulates that an attitude towards a behavior is closely related to subjective norms. In fact, solid evidence that reinforces this association has been reported in the literature [45,47]. The literature on FSC suggests that subjective norms predict attitude. When it comes to FW management behavior, empirical evidence suggests that social pressure has a positive effect on individuals' intentions to reduce FW [48]. In this paper, the concept of subjective norms should be understood as the extent to which people deemed important by an individual approve or disapprove of the individual's wasteful behavior [49] during the COVID-19 pandemic. Therefore, the following were hypothesized:

H3a. Subjective norms has a positive effect on consumers' attitudes towards household FW during the COVID-19 pandemic

H3b. Subjective norms has a positive effect on consumers' intention to reduce household FW during the COVID-19 pandemic.

2.3.4. Perceived behavioral control

Perceived behavioral control (PBC) is the third determinant of intention of a behavior of interest [42]. The concept of PBC refers to the perceived ease or difficulty of performing a given behavior; it is supposed to reflect not only past experiences but also anticipate impediments and obstacles [34]. PBC can either influence behavior indirectly through intentions or predict a behavior directly [50].

PBC may function as an antecedent of intention, as well as a determinant of food-wasting behavior [51]. It was, for instance, found that PBC significantly and positively impacted on the intention not to waste food [52], while at the same time it was considered a strong predictor of household FW behavior [48]. In this research, PBC should be understood as a consumer's perception of the ease or difficulty regarding his or her control over how to reduce FW during the COVID-19 pandemic. Therefore, the following hypotheses were also prepared:

H4a. Perceived behavioral control has a positive effect on consumers' intentions to reduce household FW during the COVID-19 pandemic.

H4b. Perceived behavioral control has a negative effect on household FW behavior during the COVID-19 pandemic.

2.3.5. Intention

Intention is a key predictor of a behavior according to the TPB [42]. Behavioral intention can be defined as the subjective probability that an

individual will perform a certain behavior [53]. Ref. [54] described it as being the best possible predictor of an individual's action, even though diverse factors may influence the effectiveness of the intention-behavior relationship. Intention can be understood as a set of motivational factors that affect behavior; that can also be an indication of how much individuals are willing to try, and how much effort they are planning to make to perform a behavior [42]. Thus, a consumer's intention to avoid household FW during the COVID-19 pandemic can be defined as the strength of the individual's motivation to at least try to avoid waste. For example, because of social isolation, people may try to plan their meals more [29]. Thus, the last hypothesis examined in this article is as follows:

H5. Consumers' intention to reduce household FW has a negative effect on consumer's FW behavior.

3. Methodology

3.1. Questionnaire design

Multiple measurement indicators were employed to investigate all latent variables. The indicators were measured on a seven-point Likert scale, ranging from 1 ("strongly disagree") to 7 ("strongly agree"). Risk perception (COVID-19) was measured by using three indicators based on Ref. [55]. To evaluate attitudes, five items from Ref. [56] were adapted. For subjective norms, four indicators were developed based on the study in Ref. [57]. Four indicators were modified from Refs. [58,59] to assess perceived behavioral control. Six indicators were adapted from Refs. [48,60] to corroborate the latent variable of intention. Finally, food waste behavior throughout the COVID-19 pandemic was evaluated using four indicators adapted from Refs. [61,62].

The first section of the questionnaire introduced the study and provided the informed consent form. Section 2 was used to collect data on the measurement items and their respective constructs. The last section was devoted to collecting data regarding the demographic characteristics of the respondents. The questionnaire was hosted on SurveyMonkey and distributed to respondents via e-mail and social media (LinkedIn, Facebook, and WhatsApp). To avoid any problems with the clarity, reading and interpretation of the questions, a pretest was first conducted with a team of five specialists in the research area and fifty respondents. Participants took approximately 7–8 min to answer the questionnaire completely. The final instrument is presented in Table 1.

3.2. Sampling design

This study's sampling frame comprises individuals living in Brazil who were responsible for decisions regarding buying and/or preparing food in their household. Data collection was performed throughout May 2021. During this period, participants from 21 out of 27 Brazilian federal states agreed to answer the questionnaire. Incomplete questionnaires and outliers were excluded to ensure the quality of data analysis. In the end, 452 questionnaires were considered for further data analysis. It should be pointed out that according to the minimum size stipulated by G*power (146 respondents), the study had more than a sufficient sample size. The demographic characteristics of the respondents are shown in Table 2. Ethical approval for the study was obtained from the Ethics Committee of the Fluminense Federal University (approval no. 4.695.152).

The gender statistics revealed that males represented 33.4% and females 66.2% of the sample. Most of the respondents (28.1%) were from the 33–44 age group. Most of the respondents (31.4%) had an average monthly household income of more than nine times the minimum wage (more than R\$9900.01). Finally, 55.6% of the respondents had two or three family members.

Table 1
Constructs and measurement items related to food waste behavior during the COVID-19 outbreak.

Variables	Item	References
Risk Perception (COVID-19)		
RP1	I have been buying larger quantities of food to avoid eating out.	[55]
RP2	I have been buying larger quantities of food to reduce my shopping trips to the supermarket.	
RP3	I have been buying larger quantities of food due to social isolation.	
Attitudes		
AT1	It is important to reduce household food waste during the pandemic.	[56]
AT2	It is immoral to waste food during the pandemic while many people are starving.	
AT3	I feel bad about wasting food during the pandemic while many people do not have guaranteed access to it.	
AT4	It bothers me to waste food during the pandemic.	
AT5	I feel I should reduce food waste during the pandemic.	
Subjective Norms		
SN1	I believe my family members think it is important to reduce food waste during the pandemic.	[57]
SN2	I believe my closest friends think that it is important to reduce food waste during the pandemic.	
SN3	I believe my family members think it is important to prepare new meals from leftovers.	
SN4	I believe my closest friends think that it is important to prepare new meals from leftovers.	
Perceived Behavioral Control		
BC1	I can decrease food waste during the pandemic.	[52,58]
BC2	I have the capability to decrease food waste during the pandemic.	
BC3	I can help reduce food waste during the pandemic.	
BC4	I can plan my meals to reduce waste during the pandemic better.	
Intention		
IN1	I have tried to avoid wasting food during the pandemic.	[48,60]
IN2	During the pandemic, I have been trying to eat all the food purchased.	
IN3	During the pandemic, I have been trying to eat food leftovers.	
IN4	During the pandemic, I have been trying to buy only what I will consume.	
IN5	During the pandemic, I have been trying to plan my grocery shopping.	
IN6	During the pandemic, I have been trying to plan my meals.	
Food Waste Behavior		
FW1	Food leftovers on the plate after a meal.	[61,62]
FW2	Food made in larger quantities than you need.	
FW3	Food stored and eventually consumed.	
FW4	Products opened (cans, sauces, etc.) and not consumed.	

3.3. Analytical procedure

Structural equation modeling (SEM) was selected to evaluate both the measurement model and the structural model. This data analysis technique is popular in several fields of scientific research, including psychology, sociology, and business research. SEM is used as a way of analyzing hypothetical relationships, starting with a theoretical model, which is transformed into a path diagram. There are two main approaches in SEM: covariance-based (CB-SEM) and variance-based (PLS-SEM). The aim of CB-SEM is to reproduce the theoretical covariance matrix without focusing on the explained variance, whereas PLS-SEM applies a method of partial least squares, based on regression [63].

Taking into consideration the objectives of the present study, PLS-SEM was considered the most suitable. Data processing and statistical analysis were performed with SmartPLS 3.3.3 software. The evaluation of the measurement model was performed using an analysis of the questionnaire's internal reliability, convergent validity, and discriminant validity [63]. Reliability was tested using Cronbach's alpha (α) and composite reliability (ρ_c). The scale's convergent validity was tested

Table 2
Demographic characteristics of the respondents (N = 452).

Characteristic	Profile	Frequency	Percentage (%)
Gender	Male	151	33.4
	Female	299	66.2
	Prefer not to say	2	0.4
Age	18–24	40	10.8
	25–34	115	25.4
	35–44	127	28.1
	45–60	124	27.4
	60 +	37	8.2
	Household's average monthly income ^a	No income	9
	Up to 1 minimum wage (up to R\$1100.00)	46	10.2
	From 1 to 3 minimum wages (from R\$1100.01 to R\$3300.00)	93	20.6
	From 3 to 6 minimum wages (from R\$3300.01 to R\$6600.00)	84	18.4
	From 6 to 9 minimum wages (from R\$6600.01 to R\$9900.00)	56	12.4
	More than 9 minimum wages (more than R \$9900.01)	142	31.4
	Prefer not to say	22	4.9
Number of family members	1	41	9.1
	2	125	27.7
	3	126	27.9
	4	115	25.4
	5 +	45	10.0

^a Note: Based on the exchange rate for July 12th, 2022, on which 1 US\$ was equal to 5.44 BRL.

using the outer loading and the average variance extracted (AVE). The discriminant validity was verified using the analysis of cross-loadings, Fornell-Larcker, and the heterotrait-monotrait ratio of correlations (HTMT).

To evaluate the structural model, multicollinearity, coefficient of determination (R^2), significance of path coefficients, and predictive relevance (Q^2) were analyzed. Multicollinearity was verified using inner variance inflation factors (VIFs). The model's power was explained using the coefficient of determination (R^2). The value of R^2 ranges from 0 to 1; and the higher the value, the greater the model's power. Path coefficients and p-values were analyzed to verify the strength of the relationship between the constructs. The path coefficient outcomes were obtained using the bootstrapping technique. To verify predictive relevance (Q^2), a blindfolding procedure was used.

4. Data analysis and results

4.1. Descriptive analysis

This subsection describes the analysis of the responses to the constructs in the questionnaire. Altogether, 26 indicators were analyzed in terms of mean, standard deviation (SD), and frequency of responses distributed on a 7-point Likert scale (Table 3). The Shapiro-Wilk test confirmed that all 26 items had a non-normal distribution (p-value = 0.000). The frequency of responses was divided into three parts: (1–3), representing negative responses; (4), representing neutral responses; and (5–7), representing positive responses.

4.2. Evaluation of the measurement model

The internal reliability of the model was assessed using Cronbach's alpha and composite reliability (Table 4). All Cronbach's alpha and composite reliability values were higher than 0.7, indicating an adequate reliability [63].

Table 3
Descriptive analysis of construct indicators.

Construct	Item	Mean	SD	Distribution on a 7-point Likert scale (%)		
				1-3	4	5-7
Attitudes	AT1	6261	1208	2.4	2.9	94.7
	AT2	6265	1183	2.9	2.9	94.2
	AT3	6343	1049	1.1	3.8	95.1
	AT4	6273	1126	2.2	2.7	95.1
	AT5	5907	1414	6.0	6.9	87.2
Food Waste Behavior	FW1	2.053	1.119	89.2	7.3	3.5
	FW2	2.334	1.534	80.8	8.2	11.1
	FW3	2.670	1.631	74.1	9.1	16.8
	FW4	2.108	1.511	83.4	6.6	10.0
Intention	IN1	5.810	1.323	5.1	6.4	88.5
	IN2	5.741	1.421	8.6	3.1	88.3
	IN3	5.907	1.246	4.9	4.2	90.9
	IN4	5.724	1.344	7.1	7.1	85.8
	IN5	5.839	1.268	5.5	5.1	89.4
	IN6	5.604	1.352	8.2	7.1	84.7
Perceived Behavioral Control	BC1	5.677	1.280	5.3	6.4	88.3
	BC2	5.772	1.223	4.4	5.3	90.3
	BC3	5.874	1.110	2.0	5.1	92.9
	BC4	5.903	1.222	3.5	4.6	91.8
Risk Perception (COVID-19)	RP1	4.469	1.988	34.1	9.3	56.6
	RP2	4.591	1.820	29.2	8.2	62.6
	RP3	4.029	1.825	44.5	8.6	46.9
Subjective Norms	SN1	5.502	1.275	5.8	10.4	83.8
	SN2	5.175	1.222	5.8	12.8	81.4
	SN3	5.323	1.232	6.0	12.8	81.2
	SN4	4.993	1.245	7.3	12.8	79.9

Table 4
Reliability and convergent validity analysis.

Construct	Items	Outer loading	Cronbach's alpha	Composite reliability	AVE
Attitudes	AT1	0.679	0.807	0.867	0.569
	AT2	0.737			
	AT3	0.855			
	AT4	0.836			
	AT5	0.642			
Food Waste Behavior	FW1	0.770	0.805	0.872	0.630
	FW2	0.820			
	FW3	0.827			
	FW4	0.754			
Intention	IN1	0.768	0.864	0.899	0.596
	IN2	0.756			
	IN3	0.769			
	IN4	0.742			
	IN5	0.779			
	IN6	0.818			
Perceived Behavioral Control	BC1	0.830	0.865	0.908	0.711
	BC2	0.862			
	BC3	0.856			
	BC4	0.823			
Risk Perception (COVID-19)	RP1	0.894	0.823	0.890	0.731
	RP2	0.872			
	RP3	0.794			
Subjective Norms	SN1	0.779	0.825	0.884	0.656
	SN2	0.830			
	SN3	0.803			
	SN4	0.828			

Convergent validity was confirmed through AVE and an analysis of the outer loadings. As shown in Table 3, all AVE values were greater than 0.500, ranging from 0.569 to 0.731, which implies that all constructs describe more than half of the variance of their items. Therefore, AVE was satisfactory without the need to exclude indicators. The analysis of the outer loadings was also demonstrated to be acceptable. Most indicators presented outer loading values higher than 0.7 [63]. There were two indicators with outer loading values lower than 0.7, but higher than 0.5 (AT1 = 0.679; AT5 = 0.642). For these specific indicators, the

impact that their exclusion would have on reliability and AVE was tested. The exclusion of these indicators did not substantially increase the reliability and AVE values; consequently, it was decided not to remove them from the model.

Discriminant validity was primarily confirmed by analyzing the cross-loadings (Table 5). Cross-loadings analysis demonstrated that each indicator's loadings, in its respective construct, were higher than the loadings of those indicators in other constructs.

Subsequently, the discriminant validity was evaluated using Fornell and Larcker's criterion. As can be observed in Table 6, the square root of the AVE of each construct (diagonal highlighted values) are greater than the values of the correlations of the constructs [63]. Therefore, discriminant validity was also confirmed by Fornell and Larcker's criterion.

Finally, the HTMT was employed to check discriminant validity. This analysis was performed to address some criticisms regarding Fornell and Larcker's criterion [64]. The values reported in Table 7 are lower than 0.9, as indicated by Ref. [65]. Consequently, discriminant validity was also confirmed by the HTMT.

With all evaluations of the measurement model concluded, its structural evaluation was performed.

4.3. Evaluation of the structural model

First, the model was checked for the presence of multicollinearity (Table 8). No multicollinearity was identified in the model, since all values of the VIFs were below the critical value of 5 [66].

SmartPLS employs a nonparametric technique. The software provides t-statistics for testing the significance of the model using a procedure called bootstrapping. In this process, many subsamples are produced from the original sample, in order to obtain bootstrap standard errors. It is then possible to obtain an approximate estimation of t-values for the significance testing of structural paths. Five thousand subsamples were used to test the significance of the model. The results are presented in Table 9.

According to Table 9:

- Risk perception (COVID-19) had a positive ($\beta = 0.146$) and significant (t-value greater than 1.96; $p < 0.05$) influence on attitudes: H1a is supported.
- Risk perception (COVID-19) had a positive ($\beta = 0.132$) and significant (t-value greater than 1.96; $p < 0.05$) influence on FW Behavior: H1b is supported.
- Attitudes had a positive ($\beta = 0.231$) and significant (t-value greater than 1.96; $p < 0.05$) influence on intention: H2 is supported.
- Subjective norms had a positive ($\beta = 0.286$) and significant (t-value greater than 1.96; $p < 0.05$) influence on attitudes: H3a is supported.
- Subjective norms had a positive ($\beta = 0.186$) and significant (t-value greater than 1.96; $p < 0.05$) influence on intention: H3b is supported.
- Perceived behavioral control had a positive ($\beta = 0.344$) and significant (t-value greater than 1.96; $p < 0.05$) influence on intention: H4a is supported.
- Perceived behavioral control had a positive ($\beta = 0.202$) and significant (t-value greater than 1.96; $p < 0.05$) influence on FW behavior: H4b is rejected.
- Intention had a negative ($\beta = -0.436$) and significant (t-value greater than 1.96; $p < 0.05$) influence on FW behavior: H5 is supported.

Fig. 2 illustrates a summary of the structural model used for this research.

After evaluating the relationship between latent variables, the coefficient of determination (R^2) and predictive relevance (Q^2) were calculated (Table 10).

The R^2 was measured to determine the predictive power of the research model. Here, attitudes, food waste behavior, intention, and

Table 5
Cross-loadings analysis.

Construct	Items	1	2	3	4	5	6
1 Attitudes	AT1	0.679	-0.040	0.323	0.278	0.106	0.229
	AT2	0.737	-0.106	0.347	0.321	0.133	0.187
	AT3	0.855	-0.083	0.397	0.450	0.125	0.211
	AT4	0.836	-0.036	0.403	0.493	0.107	0.248
	AT5	0.642	0.099	0.289	0.501	0.078	0.201
2 Food Waste Behavior	FW1	-0.082	0.770	-0.263	-0.003	0.105	-0.129
	FW2	-0.092	0.820	-0.280	-0.054	0.149	-0.115
	FW3	-0.061	0.827	-0.267	-0.009	0.073	-0.183
	FW4	-0.029	0.754	-0.193	0.023	0.055	-0.098
3 Intention	IN1	0.395	-0.266	0.768	0.444	0.070	0.289
	IN2	0.314	-0.227	0.756	0.398	0.135	0.197
	IN3	0.337	-0.254	0.769	0.387	0.107	0.316
	IN4	0.338	-0.264	0.742	0.396	-0.141	0.225
	IN5	0.358	-0.198	0.779	0.420	0.042	0.303
	IN6	0.326	-0.271	0.818	0.379	0.057	0.294
4 Perceived Behavioral Control	BC1	0.419	0.009	0.388	0.830	0.027	0.187
	BC2	0.405	-0.015	0.410	0.862	0.040	0.261
	BC3	0.445	-0.043	0.520	0.856	0.045	0.324
	BC4	0.402	0.000	0.427	0.823	0.109	0.215
5 Risk Perception (COVID-19)	RP1	0.146	0.136	0.050	0.059	0.894	0.013
	RP2	0.136	0.072	0.068	0.082	0.872	-0.019
	RP3	0.074	0.071	0.083	0.047	0.794	0.002
6 Subjective Norms	SN1	0.207	-0.139	0.316	0.235	-0.025	0.779
	SN2	0.214	-0.080	0.272	0.284	-0.017	0.830
	SN3	0.216	-0.144	0.276	0.231	-0.003	0.803
	SN4	0.180	-0.177	0.271	0.217	0.033	0.828

Table 6
Formell and Larcker’s criterion.

Construct	1	2	3	4	5	6
1 Attitudes	0.755					
2 Food Waste Behavior	-0.050	0.794				
3 Intention	0.470	-0.320	0.772			
4 Perceived Behavioral Control	0.541	-0.017	0.524	0.843		
5 Risk Perception (COVID-19)	0.146	0.115	0.073	0.074	0.855	
6 Subjective Norms	0.286	-0.166	0.352	0.300	0.000	0.810

Table 7
Heterotrait-monotrait ratio of correlations (HTMT).

Construct	1	2	3	4	5	6
1 Attitudes						
2 Food Waste Behavior	0.119					
3 Intention	0.558	0.378				
4 Perceived Behavioral Control	0.650	0.046	0.597			
5 Risk Perception (COVID-19)	0.170	0.128	0.152	0.086		
6 Subjective Norms	0.349	0.202	0.412	0.346	0.039	

Table 8
Inner VIFs.

Construct	1	2	3
1 Attitudes			1.448
2 Food Waste Behavior			
3 Intention		1.381	
4 Perceived Behavioral Control		1.381	1.461
5 Risk Perception (COVID-19)	1.000	1.007	
6 Subjective Norms	1.000		1.125

perceived behavioral control were the endogenous variables of interest. Therefore, a substantial amount of variance in these variables was expected to demonstrate the strength of the model. As can be seen in Table 10, the R² value was 0.103 for attitudes, 0.152 for food waste behavior, and 0.345 for intention.

This means that attitudes, subjective norms, and perceived behavioral control explain 35.4% of the intention to reduce household FW. Finally, the potential explanatory power of FW behavior equals 15.2%. Furthermore, all R² values may be considered satisfactory. The R² value was expected to be greater than 0.10 to explain the endogenous construct [67]. The variance found here to explain FW behavior was similar to the values found in previous household FW studies [35,51, 68]. According to Ref. [69], values around 0.20 for the coefficient of determination in studies concerning consumer behavior can be considered high.

Lastly, Stone-Geisser’s Q² [63] was calculated to ensure the predictive accuracy of the endogenous constructs’ indicators. Q² values were measured using a blindfolding procedure. All Q² values were greater than zero, confirming the good predictive relevance of the model.

5. Discussion

The COVID-19 outbreak imposed a range of new behavioral patterns around the world. Despite the considerable number of studies conducted on the topic, many findings are expected to be published in the coming months and years, further advancing the frontier of knowledge about the real social, environmental, and economic impacts of the pandemic. To the authors’ knowledge, this is the first study to investigate how risk perception during the pandemic, concerning either coronavirus contamination or food supply, affected FW behavior and its predictors.

This study shows that risk perception positively affected consumers’ attitudes (H1a). People who felt a higher perception of risk similarly presented higher positive attitudes concerning FW reduction. It was also found that people were positively more inclined to buy more food to avoid eating out, reduce shopping trips and reinforce social isolation, which is in line with Ref. [70]. Even when overbuying food, the respondents adopted a positive attitude towards reducing FW, since guilt is a strong driver for not wasting food [48].

Our findings also indicate that risk perception (COVID-19) had a

Table 9
Significance analysis of the structural model.

Hypotheses	Path	β	Sample Mean (M)	SD	T-Statistics	p-values	Decision
H1a	RP → AT	0.146	0.149	0.045	3278	0.001	✓
H1b	RP → FW	0.132	0.134	0.043	3083	0.002	✓
H2	AT → IN	0.231	0.233	0.055	4199	0.000	✓
H3a	SN → AT	0.286	0.291	0.041	7192	0.000	✓
H3b	SN → IN	0.183	0.185	0.041	4305	0.000	✓
H4a	BC → IN	0.344	0.346	0.057	6067	0.000	✓
H4b	BC → FW	0.202	0.205	0.049	4070	0.000	×
H5	IN → FW	-0.436	-0.440	0.050	8744	0.000	✓

Note: β : standard beta; SD: standard deviation; RP: risk perception (COVID-19); AT: attitudes; SN: subjective norms; BC: perceived behavioral control; IN: intention; FW: food waste behavior.

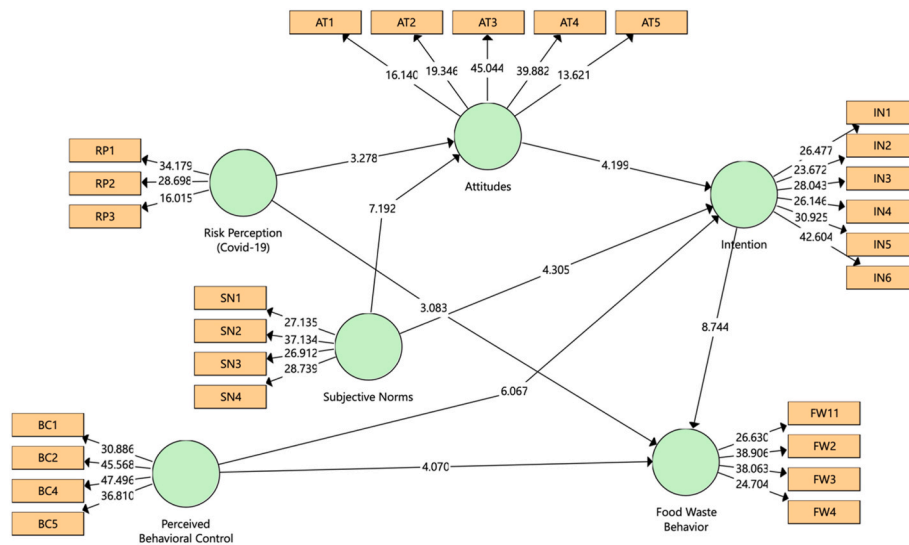


Fig. 2. Structural model of the research.

Table 10
Coefficient of determination and predictive relevance.

Endogenous Variables	Coefficient of determination (R ²)	Predictive relevance (Q ²)
Attitudes	0.103	0.056
Food Waste Behavior	0.152	0.091
Intention	0.354	0.205

positive and significant influence on FW behavior (H1b). Therefore, buying or storing food in larger quantities without proper planning to avoid eating out or to reduce shopping trips to the supermarket may increase household FW. This is similar to the findings of Ref. [71], which highlighted that all forms of exaggerated food purchasing and storage are directly related to FW in a non-pandemic context.

Another finding that is worthy of observation is the positive and significant influence of consumer attitudes on intentions to reduce household FW during the COVID-19 pandemic (H2). Prior to the pandemic reaching Brazil, the country was already facing a crisis situation that included economic, social, and political elements. This situation became highly visible with the increase in unemployment, poverty, and hunger; and exposed a number of vulnerabilities that had already been worsening in recent years [72]. Brazil has 14.8 million unemployed people [73] and is ranked among the countries with the highest levels of FW in the world [74]. Furthermore, more than 60% of its population has some level of food insecurity [75]. Hence, these facts might increase the consumers' intentions to reduce FW. In periods of crisis and uncertainty, consumers are more motivated to minimize FW, demonstrating higher levels of awareness and changes in attitudes [76,

77]. This is in accordance with Ref. [78], which found that during the lockdown, people experienced higher levels of awareness and changes in their attitudes toward FW. According to the authors, these behaviors were, apparently, more related to socioeconomic than environmental concerns. The results, therefore, show that high levels of awareness and changes are important conditions to increase the intention to reduce household FW.

Subsequently, subjective norms were found to have a positive and significant effect on both consumers' attitudes (H3a) and intentions (H3b) towards reducing FW, which is in line with previous findings [48, 57,60]. Accordingly, consumers were encouraged to reduce household FW due to the expected approval or pressure from others they considered important. Individuals can be motivated to possess and show multiple forms of so-called "correct" attitudes [79]. Given their social ties (family, friends, social influencers, etc.), individuals' attitudes towards a behavior are significantly influenced by their referents [80,81]. The hypothesis that subjective norms influence consumers' intentions has also been confirmed in other articles that investigated other contexts. Ref. [82] confirms that subjective norms positively affected people's intention to adopt a "stay-at-home" policy during the pandemic, while Ref. [83] confirmed that subjective norms positively influenced the intention to self-protect against the influenza A (H1N1) virus.

Our findings indicate a significant and positive impact of PBC on the intention to reduce household FW during the COVID-19 pandemic (H4a). The fact that consumers have the skills to reduce FW makes them increase their intentions to reduce it. In this study, control refers to the ability to reduce waste and prepare and cook appropriate portions for consumption (without waste) and improve supermarket planning and shopping. Therefore, the greater the individual's PBC, the stronger his or

her intention is to reduce household FW. This is in line with previous studies [58,84], which found that PBC is one important predictor that positively affects the intention to reduce household FW. This relationship was corroborated during the COVID-19 pandemic, even taking other objects of study into consideration. For example, it was found that people with higher levels of PBC also demonstrated greater intentions to maintain social isolation during the pandemic [85].

It was expected to find a negative and significant relationship between PBC and household FW behavior (H4b) in this study, as reported in studies conducted in a non-pandemic context [49,60]. However, when analyzing the relationship between both variables, our results indicated a positive and significant relationship ($\beta = 0.202$). Therefore, our data curiously suggested that the more individuals considered that they had control through the ability to reduce waste, the greater the reported FW behavior was. It is important to highlight that this study was conducted during the COVID-19 outbreak and with a questionnaire that prompted respondents to reflect on such a context. Due to the risks and uncertainties of the pandemic, individuals may have overestimated their effective ability to perform a behavior [86]. Recent studies [87,88] have discovered, for example, that individuals may present an impulsive approach to buying food or do so without planning, due to the psychological pressure caused by the COVID-19 pandemic. Such impulsive behavior may lead to higher levels of FW. Lessons on domestic economics [89] and planned behaviors [90] could enhance food management behaviors, creating sustainable habits by reducing food waste.

Finally, the intention to reduce FW negatively affects FW behavior in households (H5). Here, intention was found to be the strongest predictor of FW behavior. This indicates that those individuals with greater intentions to reduce food waste during the COVID-19 pandemic tended to report lower quantities of waste. A recent study [91] also found that Brazilian people showed a positive intention to reduce the economic value of household FW during the COVID-19 outbreak. In fact, individuals tended to adopt a positive approach towards reducing FW during the pandemic [11,92]. Some examples of this positive approach involved eating all the food purchased, eating leftovers, planning grocery shopping, and planning meals.

5.1. Managerial implications

This study could provide a learning experience for similar scenarios in the future. Governmental organizations and public and private institutions, as well as public figures, could communicate and provide awareness campaigns about the impact of FW on the population's food security, taking into consideration that many people could lose their jobs or food purchasing capacity during this period. In addition, retailers in general could also help reduce FW during this period by providing a safe environment for customers to shop in, thus discouraging stockpiling. Changes in eating habits during the outbreak, information campaigns, the provision of recipes, providing information about proper food handling and storage during the pandemic, increased shelf-life of food, and making products with smaller packages available for small families and products with easy-to-handle packaging could all be measures to mitigate the problem of FW. Meanwhile, consumers, who have changed their purchasing, preparation, and food-consumption habits during the pandemic, should be encouraged to look for ways to reduce, reuse, and recycle food (e.g., planning purchases and meals, reusing leftovers, composting, donating, etc.). Individual and collective actions should be leveraged not only to reduce food wastage but to keep food supply chains working at proper levels of efficiency [93].

5.2. Theoretical implications

From a theoretical perspective, this study identifies key precedents of FW behavior in households during the period of the COVID-19 pandemic. Few studies have investigated FW in such a context. Besides this, previous works have also not covered the variable of

perceived risk (COVID-19) to evaluate changes in consumer behavior throughout the pandemic. The proposed model proved to be robust enough to be applied in other countries, as the empirical results revealed a satisfactory predictive power of R^2 and Q^2 . Additionally, most research has addressed the problem of FW in developed countries. This study provides a different view, approaching the problem in the context of an emerging country, which faces one of the highest numbers of confirmed COVID-19 deaths and infections.

6. Conclusion

The results of our study show that all the predictors evaluated had a significant effect on household FW during the COVID-19 pandemic in Brazil. Several conclusions can be reached concerning this study. Firstly, this study has expanded the TPB by including the variable of risk perception (COVID-19). Through this variable, it was found that people overpurchased food to avoid risks of contamination and the scarcity of food. Consequently, risk perception showed a positive relationship to FW.

Secondly, intention was demonstrated to be a major predictor of FW reduction. Curiously, only one hypothesis (H4a (-): perceived behavioral control \rightarrow FW behavior) was rejected, as it showed a contrary path coefficient to what was expected. This shows that the pandemic may have influenced the positive control that individuals think they have regarding reducing FW. Future studies should verify how the pandemic changed the ability of individuals to be in control.

Because of the pandemic, this study only collected data online. This leads to another limitation, concerning the fact that the sample may be subject to bias. Individuals with access to the internet are considered to have higher education and/or income. Socioeconomic variables may explain the FW behavior of different groups. Further studies, therefore, could explore the same variable in different contexts in a postpandemic scenario, since individual behaviors vary in different social, economic, and political contexts. Finally, the findings may be useful in designing specific public and private policies to reduce household FW during crisis scenarios.

CRedit authorship contribution statement

Lucas Rodrigues Deliberador: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Writing – original draft, Writing – review & editing. **Alexandre Borges Santos:** Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Validation, Writing – original draft, Writing – review & editing. **Pâmella Rodrigues Silva Carrijo:** Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Validation, Writing – original draft, Writing – review & editing. **Mário Otávio Batalha:** Conceptualization, Formal analysis, Supervision, Project administration, Writing – review & editing. **Aldara da Silva César:** Conceptualization, Formal analysis, Supervision, Project administration, Writing – review & editing. **Luís Miguel D.F. Ferreira:** Conceptualization, Methodology, Formal analysis.

Data availability

The authors do not have permission to share data.

Acknowledgments

This research was funded by the National Council for Scientific and Technological (CNPq) (grant number: 140717/2019-6), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001, and Fundação para a Ciência e a Tecnologia (FCT), under the project number: UIDB/00285/2020.

References

- [1] Perlman S. Another decade, another coronavirus. *N Engl J Med* 2020;382:760–2. <https://doi.org/10.1056/NEJMe2001126>.
- [2] Worldometer. Coronavirus Update. <https://www.worldometers.info/coronavirus/>. [Accessed 14 July 2021]. accessed.
- [3] Gibney E. Whose coronavirus strategy worked best? Scientists hunt most effective policies. *Nature* 2020;581:15–6. <https://doi.org/10.1038/d41586-020-01248-1>.
- [4] Yan B, Zhang X, Wu L, Zhu H, Chen B. Why do countries respond differently to COVID-19? A comparative study of Sweden, China, France, and Japan. *Am Rev Publ Adm* 2020;50:762–9. <https://doi.org/10.1177/0275074020942445>.
- [5] Islam SN, Wai H, Cheng J, Helgason KS, Hunt N, Kawamura H, et al. *Variations in COVID strategies: determinants and lessons*. 2020.
- [6] Barnes SJ. Information management research and practice in the post-COVID-19 world. *Int J Inf Manag* 2020;55:102175. <https://doi.org/10.1016/j.ijinfomgt.2020.102175>.
- [7] McCloskey B, Zumla A, Ippolito G, Blumberg L, Arbon P, Cicero A, et al. Mass gathering events and reducing further global spread of COVID-19: a political and public health dilemma. *Lancet* 2020;395:1096–9. [https://doi.org/10.1016/S0140-6736\(20\)30681-4](https://doi.org/10.1016/S0140-6736(20)30681-4).
- [8] Venkatesh V. Impacts of COVID-19: a research agenda to support people in their fight. *Int J Inf Manag* 2020;55:102197. <https://doi.org/10.1016/j.ijinfomgt.2020.102197>.
- [9] Robertson M, Duffy F, Newman E, Prieto Bravo C, Ates HH, Sharpe H. Exploring changes in body image, eating and exercise during the COVID-19 lockdown: a UK survey. *Appetite* 2021;159:105062. <https://doi.org/10.1016/j.appet.2020.105062>.
- [10] Aguilera JM. The concept of alimentation and transdisciplinary research. *J Sci Food Agric* 2021;101:1727–31. <https://doi.org/10.1002/jsfa.10823>.
- [11] Fanelli RM. Changes in the food-related behaviour of Italian consumers during the COVID-19 pandemic. *Foods* 2021;10:169. <https://doi.org/10.3390/foods10010169>.
- [12] Dondi A, Candela E, Morigi F, Lenzi J, Pierantoni L, Lanari M. Parents' perception of food insecurity and its effects on their children in Italy six months after the COVID-19 pandemic outbreak. *Nutrients* 2020;13:121. <https://doi.org/10.3390/nu13010121>.
- [13] Galali Y. The impact of COVID-19 confinement on the eating habits and lifestyle changes: a cross sectional study. *Food Sci Nutr* 2021;9:2105–13. <https://doi.org/10.1002/fsn3.2179>.
- [14] Ben Hassen T, El Bilali H, Allahyari MS, Berjan S, Fotina O. Food purchase and eating behavior during the COVID-19 pandemic: a cross-sectional survey of Russian adults. *Appetite* 2021;165:105309. <https://doi.org/10.1016/j.appet.2021.105309>.
- [15] de Andrade ML, Stedefeldt E, Zanin LM, da Cunha DT. Food safety culture in food services with different degrees of risk for foodborne diseases in Brazil. *Food Control* 2020;112:107152. <https://doi.org/10.1016/j.foodcont.2020.107152>.
- [16] Steele CM, Peladeau-Pigeon M, Barrett E, Wolkin TS. The risk of penetration–aspiration related to residue in the pharynx. *Am J Speech Lang Pathol* 2020;29:1608–17. https://doi.org/10.1044/2020_AJSLP-20-00042.
- [17] Burlea-Schiopoiu A, Ogarca RF, Barbu CM, Craciun L, Baloi IC, Mihai LS. The impact of COVID-19 pandemic on food waste behaviour of young people. *J Clean Prod* 2021;294:126333. <https://doi.org/10.1016/j.jclepro.2021.126333>.
- [18] Principato L, Secondi L, Cicatiello C, Mattia G. Caring more about food: the unexpected positive effect of the Covid-19 lockdown on household food management and waste. *Socioecon Plann Sci* 2020;100953. <https://doi.org/10.1016/j.seps.2020.100953>.
- [19] Porat R, Lichter A, Terry LA, Harker R, Buzby J. Postharvest losses of fruit and vegetables during retail and in consumers' homes: quantifications, causes, and means of prevention. *Postharvest Biol Technol* 2018;139:135–49. <https://doi.org/10.1016/j.postharvbio.2017.11.019>.
- [20] Magalhães VSM, Ferreira LMDF, César A da S, Bonfim RM, Silva C. Food loss and waste in the Brazilian beef supply chain: an empirical analysis. *Int J Logist Manag* 2020;32:214–36. <https://doi.org/10.1108/IJLM-01-2020-0038>.
- [21] Magalhães VSM, Ferreira LMDF, Ferreira LMDF, Silva C. Causes and mitigation strategies of food loss and waste: a systematic literature review and framework development. *Sustain Prod Consum* 2021;28:1580–99. <https://doi.org/10.1016/j.spc.2021.08.004>.
- [22] Nonomura M. Reasons for food losses during home preparation. *Br Food J* 2019;122:574–85. <https://doi.org/10.1108/BFJ-06-2019-0457>.
- [23] FAO. *State of Food and Agriculture. Moving forward on food loss and waste reduction*. Rome: Licence: CC BY-NC-SA 3.0 IGO; 2019. 2019.
- [24] Bernstad SSA, Andersson T. Food waste minimization from a life-cycle perspective. *J Environ Manag* 2015;147:219–26. <https://doi.org/10.1016/j.jenvman.2014.07.048>.
- [25] Principato L, Mattia G, Di Leo A, Pratesi CA. The household wasteful behaviour framework: a systematic review of consumer food waste. *Ind Market Manag* 2021;93:641–9. <https://doi.org/10.1016/j.indmarman.2020.07.010>.
- [26] Filimonau V, Vi LH, Beer S, Ermolaev VA. The Covid-19 pandemic and food consumption at home and away: an exploratory study of English households. *Socioecon Plann Sci* 2021:101125. <https://doi.org/10.1016/j.seps.2021.101125>.
- [27] Gungoraydinoglu A, Öztekin İ, Öztekin Ö. The impact of COVID-19 and its policy responses on local economy and health conditions. *J Risk Financ Manag* 2021;14:233. <https://doi.org/10.3390/jrfm14060233>.
- [28] Cattivelli V, Rusciano V. Social innovation and food provisioning during covid-19: the case of urban–rural initiatives in the province of naples. *Sustainability* 2020;12:4444. <https://doi.org/10.3390/su12114444>.
- [29] Ben Hassen T, El Bilali H, Allahyari MS. Impact of COVID-19 on food behavior and consumption in Qatar. *Sustainability* 2020;12:6973. <https://doi.org/10.3390/su12176973>.
- [30] Baker SR, Farrokhnia RA, Meyer S, Pagel M, Yannellis C. How does household spending respond to an epidemic? Consumption during the 2020 COVID-19 pandemic. *Rev Asset Pricing Stud* 2020;10:834–62. <https://doi.org/10.1093/rapstu/raaa009>.
- [31] Stefan V, van Herpen E, Tudoran AA, Lähteenmäki L. Avoiding food waste by Romanian consumers: the importance of planning and shopping routines. *Food Qual Prefer* 2013;28:375–81. <https://doi.org/10.1016/j.foodqual.2012.11.001>.
- [32] Aldaco R, Hoehn D, Laso J, Margallo M, Ruiz-Salmón J, Cristobal J, et al. Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach. *Sci Total Environ* 2020;742:140524. <https://doi.org/10.1016/j.scitotenv.2020.140524>.
- [33] Hebrok M, Boks C. Household food waste: drivers and potential intervention points for design – an extensive review. *J Clean Prod* 2017;151:380–92. <https://doi.org/10.1016/j.jclepro.2017.03.069>.
- [34] Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process* 1991;50:179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T).
- [35] Mondéjar-Jiménez J-A, Ferrari G, Secondi L, Principato L. From the table to waste: an exploratory study on behaviour towards food waste of Spanish and Italian youths. *J Clean Prod* 2016;138:8–18. <https://doi.org/10.1016/j.jclepro.2016.06.018>.
- [36] Heidari A, Kolahi M, Behravesht N, Ghorbanyan M, Ehsanmansh F, Hashemolhosini N, et al. Youth and sustainable waste management: a SEM approach and extended theory of planned behavior. *J Mater Cycles Waste Manag* 2018;20:2041–53. <https://doi.org/10.1007/s10163-018-0754-1>.
- [37] van der Werf P, Larsen K, Seabrook JA, Gilliland J. How neighbourhood food environments and a pay-as-you-throw (PAYT) waste program impact household food waste disposal in the city of toronto. *Sustainability* 2020;12:7016. <https://doi.org/10.3390/su12177016>.
- [38] Lam T, Hsu CHC. Predicting behavioral intention of choosing a travel destination. *Tourism Manag* 2006;27:589–99. <https://doi.org/10.1016/j.tourman.2005.02.003>.
- [39] de Zwart O, Veldhuijzen IK, Elam G, Aro AR, Abraham T, Bishop GD, et al. Perceived threat, risk perception, and efficacy beliefs related to SARS and other (emerging) infectious diseases: results of an international survey. *Int J Behav Med* 2009;16:30–40. <https://doi.org/10.1007/s12529-008-9008-2>.
- [40] Dowling GR, Staelin R. A model of perceived risk and intended risk-handling activity. *J Consum Res* 1994;21:119–34. <https://doi.org/10.1086/209386>.
- [41] Sheth J. Impact of Covid-19 on consumer behavior: will the old habits return or die? *J Bus Res* 2020;117:280–3. <https://doi.org/10.1016/j.jbusres.2020.05.059>.
- [42] Ajzen I. From intentions to actions: a theory of planned behavior. *Action Control* 1985:11–39. https://doi.org/10.1007/978-3-642-69746-3_2.
- [43] Hamdah DFL, Rahmadya RR, Nurlaela L. The effect of attitude, subjective norm, and perceived behavior control of taxpayer compliance of private person in tax office garut, Indonesia. *Rev Integr Bus Econ Res* 2020;9:298–306.
- [44] Olsen NV. The convenience consumer's dilemma. *Br Food J* 2012;114:1613–25. <https://doi.org/10.1108/00070701211273090>.
- [45] Al-Swidi A, Mohammed Rafiq Huque S, Haroon Hafeez M, Noor Mohd Shariff M. The role of subjective norms in theory of planned behavior in the context of organic food consumption. *Br Food J* 2014;116:1561–80. <https://doi.org/10.1108/BFJ-05-2013-0105>.
- [46] Chen MF. An integrated research framework to understand consumer attitudes and purchase intentions toward genetically modified foods. *Br Food J* 2008;110:559–79. <https://doi.org/10.1108/00070700810877889>.
- [47] Nguyen TTM, Phan TH, Nguyen HL, Dang TKT, Nguyen ND. Antecedents of purchase intention toward organic food in an Asian emerging market: a study of urban Vietnamese consumers. *Sustain* 2019;11. <https://doi.org/10.3390/su11174773>.
- [48] Soorani F, Ahmadvand M. Determinants of consumers' food management behavior: applying and extending the theory of planned behavior. *Waste Manag* 2019;98:151–9. <https://doi.org/10.1016/j.wasman.2019.08.025>.
- [49] Barone AM, Grappi S, Romani S. The road to food waste is paved with good intentions": when consumers' goals inhibit the minimization of household food waste. *Resour Conserv Recycl* 2019;149:97–105. <https://doi.org/10.1016/j.resconrec.2019.05.037>.
- [50] Ajzen I. *Attitudes, personality and behavior*. New York: McGraw-Hill Education; 2005. UK.
- [51] Stancu V, Haugaard P, Lähteenmäki L. Determinants of consumer food waste behaviour: two routes to food waste. *Appetite* 2016;96:7–17. <https://doi.org/10.1016/j.appet.2015.08.025>.
- [52] Tsai WC, Chen X, Yang C. Consumer food waste behavior among emerging adults: evidence from China. *Foods* 2020;9:961. <https://doi.org/10.3390/foods9070961>.
- [53] Mahardika H, Thomas D, Ewing MT, Japutra A. Comparing the temporal stability of behavioural expectation and behavioural intention in the prediction of consumers pro-environmental behaviour. *J Retailing Consum Serv* 2020;54:101943. <https://doi.org/10.1016/j.jretconser.2019.101943>.
- [54] Bentler PM, Speckart G. Models of attitude-behavior relations. *Psychol Rev* 1979;86:452–64. <https://doi.org/10.1037/0033-295X.86.5.452>.
- [55] Long NN, Khoi BH. An empirical study about the intention to hoard food during COVID-19 pandemic. *Eurasia J Math Sci Technol Educ* 2020;16:em1857. <https://doi.org/10.29333/ejmste/8207>.
- [56] van der Werf P, Seabrook JA, Gilliland JA. Food for thought: comparing self-reported versus curbside measurements of household food wasting behavior and

- the predictive capacity of behavioral determinants. *Waste Manag* 2020;101:18–27. <https://doi.org/10.1016/j.wasman.2019.09.032>.
- [57] Canova L, Bobbio A, Manganello AM. Buying organic food products: the role of trust in the theory of planned behavior. *Front Psychol* 2020;11. <https://doi.org/10.3389/fpsyg.2020.575820>.
- [58] Visschers VHM, Wickli N, Siegrist M. Sorting out food waste behaviour: a survey on the motivators and barriers of self-reported amounts of food waste in households. *J Environ Psychol* 2016;45:66–78. <https://doi.org/10.1016/j.jenvp.2015.11.007>.
- [59] Wang Y, Long X, Li L, Wang Q, Ding X, Cai S. Extending theory of planned behavior in household waste sorting in China: the moderating effect of knowledge, personal involvement, and moral responsibility. *Environ Dev Sustain* 2021;23:7230–50. <https://doi.org/10.1007/s10668-020-00913-9>.
- [60] Aktas E, Sahin H, Topaloglu Z, Oledinma A, Huda AKS, Irani Z, et al. A consumer behavioural approach to food waste. *J Enterprise Inf Manag* 2018;31:658–73. <https://doi.org/10.1108/JEIM-03-2018-0051>.
- [61] Abdelradi F. Food waste behaviour at the household level: a conceptual framework. *Waste Manag* 2018;71:485–93. <https://doi.org/10.1016/j.wasman.2017.10.001>.
- [62] Teng CC, Chih C, Wang YC. Decisional factors driving household food waste prevention: evidence from Taiwanese families. *Sustain Times* 2020;12. <https://doi.org/10.3390/su12166666>.
- [63] Hair JF, Hult GTM, Ringle CM, Sarstedt M. *A primer on partial least squares structural equation modeling (PLS-SEM)*. Los Angeles: SAGE Publications; 2017.
- [64] Ramayah T, Cheah J, Chuah F, Ting H, Memon MA. *Partial least squares structural equation modeling (PLS-SEM) using SmartPLS 3.0: an updated guide and practical guide to statistical analysis*. second ed. Kuala Lumpur, Malaysia: Pearson; 2018.
- [65] Gold AH, Malhotra A, Segars AH. Knowledge management: an organizational capabilities perspective. *J Manag Inf Syst* 2001;18:185–214. <https://doi.org/10.1080/07421222.2001.11045669>.
- [66] Hair JF, Sarstedt M, Hopkins L, Kuppelwieser V G. Partial least squares structural equation modeling (PLS-SEM). *Eur Bus Rev* 2014;26:106–21. <https://doi.org/10.1108/EBR-10-2013-0128>.
- [67] Falk RF, Miller NB. *A Primer for Soft Modeling*. Akron: The University of Akron Press; 1992.
- [68] Diaz-Ruiz R, Costa-Font M, Gil JM. Moving ahead from food-related behaviour: an alternative approach to understand household food waste generation. *J Clean Prod* 2018;172:1140–51. <https://doi.org/10.1016/j.jclepro.2017.10.148>.
- [69] Hair JF, Ringle CM, Sarstedt M. PLS-SEM: indeed a silver bullet. *J Market Theor Pract* 2011;19:139–52. <https://doi.org/10.2753/MTP1069-6679190202>.
- [70] Dou Z, Stefanovski D, Galligan D, Lindem M, Rozin P, Chen T, et al. Household food dynamics and food system resilience amid the COVID-19 pandemic: a cross-national comparison of China and the United States. *Front Sustain Food Syst* 2021; 4:1–11. <https://doi.org/10.3389/fsufs.2020.577153>.
- [71] Parizeau K, von Massow M, Martin R. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. *Waste Manag* 2015;35:207–17. <https://doi.org/10.1016/j.wasman.2014.09.019>.
- [72] Carvalho CA, Viola PC, de AF, Sperandio N. How is Brazil facing the crisis of Food and Nutrition Security during the COVID-19 pandemic? *Publ Health Nutr* 2021;24: 561–4. <https://doi.org/10.1017/S1368980020003973>.
- [73] IBGE. Desemprego. <https://www.ibge.gov.br/explica/desemprego.php>. [Accessed 14 July 2021]. accessed.
- [74] Henz GP, Porpino G. Perdas e desperdício de alimentos: como o Brasil tem enfrentado este desafio global? *Hortic Bras* 2017;35:472–82. <https://doi.org/10.1590/s0102-053620170402>.
- [75] Galindo E, Teixeira MA, De Araújo M, Motta R, Pessoa M, Mendes L, et al. Efeitos da pandemia na alimentação e na situação de segurança alimentar no Brasil. *IELA - Freie Universität Berlin - Berlin*; 2021.
- [76] Romeo-Arroyo E, Mora M, Vázquez-Araújo L. Consumer behavior in confinement times: food choice and cooking attitudes in Spain. *Int J Gastron Food Sci* 2020;21: 100226. <https://doi.org/10.1016/j.ijgfs.2020.100226>.
- [77] Bogevska Z, Berjan S, El Bilali H, Sadegh Allahyari M, Radosavac A, Davitkovska M. Exploring food shopping, consumption and waste habits in North Macedonia during the COVID-19 pandemic. *Socioecon Plann Sci* 2021:101150. <https://doi.org/10.1016/j.seps.2021.101150>.
- [78] Jribi S, Ben Ismail H, Doggui D, Debbabi H. COVID-19 virus outbreak lockdown: what impacts on household food wastage? *Environ Dev Sustain* 2020;22:3939–55. <https://doi.org/10.1007/s10668-020-00740-y>.
- [79] Park J, Ha S. Understanding consumer recycling behavior: combining the theory of planned behavior and the norm activation model. *Fam Consum Sci Res J* 2014;42: 278–91. <https://doi.org/10.1111/fcsr.12061>.
- [80] Zhao L, Yin J, Song Y. An exploration of rumor combating behavior on social media in the context of social crises. *Comput Hum Behav* 2016;58:25–36. <https://doi.org/10.1016/j.chb.2015.11.054>.
- [81] Lahath A, Omar NA, Ali MH, Tseng M-L, Yazid Z. Exploring food waste during the COVID-19 pandemic among Malaysian consumers: the effect of social media, neuroticism, and impulse buying on food waste. *Sustain Prod Consum* 2021;28: 519–31. <https://doi.org/10.1016/j.spc.2021.06.008>.
- [82] Sumaedi S, Bakti IGM, Rakhmawati T, Widiyanti T, Astrini NJ, Damayanti S, et al. Factors influencing intention to follow the “stay at home” policy during the COVID-19 pandemic. *Int J Heal Gov* 2021;26:13–27. <https://doi.org/10.1108/IJHG-05-2020-0046>.
- [83] Cho H, Lee JS. The influence of self-efficacy, subjective norms, and risk perception on behavioral intentions related to the H1N1 flu pandemic: a comparison between Korea and the US. *Asian J Soc Psychol* 2015;18:311–24. <https://doi.org/10.1111/ajsp.12104>.
- [84] Graham-Rowe E, Jessop DC, Sparks P. Predicting household food waste reduction using an extended theory of planned behaviour. *Resour Conserv Recycl* 2015;101: 194–202. <https://doi.org/10.1016/j.resconrec.2015.05.020>.
- [85] Das AK, Abdul Kader Jilani MM, Uddin MS, Uddin MA, Ghosh AK. Fighting ahead: adoption of social distancing in COVID-19 outbreak through the lens of theory of planned behavior. *J Hum Behav Soc Environ* 2021;31:373–93. <https://doi.org/10.1080/10911359.2020.1833804>.
- [86] Babbitt CW, Babbitt GA, Oehman JM. Behavioral impacts on residential food provisioning, use, and waste during the COVID-19 pandemic. *Sustain Prod Consum* 2021;28:315–25. <https://doi.org/10.1016/j.spc.2021.04.012>.
- [87] Russo C, Simeone M, Demartini E, Marescotti ME, Gaviglio A. Psychological pressure and changes in food consumption: the effect of COVID-19 crisis. *Heliyon* 2021;7:e06607. <https://doi.org/10.1016/j.heliyon.2021.e06607>.
- [88] Yetkin Özbük RM, Coşkun A, Filimonau V. The impact of COVID-19 on food management in households of an emerging economy. *Socioecon Plann Sci* 2021. <https://doi.org/10.1016/j.seps.2021.101094>.
- [89] Amicarelli V, Lagioia G, Sampietro S, Bux C. Has the COVID-19 pandemic changed food waste perception and behavior? Evidence from Italian consumers. *Socioecon Plann Sci* 2021:101095. <https://doi.org/10.1016/j.seps.2021.101095>.
- [90] Bravi L, Francioni B, Murrura F, Savelli E. Factors affecting household food waste among young consumers and actions to prevent it. A comparison among UK, Spain and Italy. *Resour Conserv Recycl* 2020;153:104586. <https://doi.org/10.1016/j.resconrec.2019.104586>.
- [91] Schmitt VGH, Cequea MM, Neyra JMV, Ferraso M. Consumption behavior and residential food waste during the COVID-19 pandemic outbreak in Brazil. *Sustain Times* 2021;13:1–21. <https://doi.org/10.3390/su13073702>.
- [92] Rodgers RF, Lombardo C, Cerolini S, Franko DL, Omori M, Linardon J, et al. Waste not and stay at home” evidence of decreased food waste during the COVID-19 pandemic from the U.S. and Italy. *Appetite* 2021;160:105110. <https://doi.org/10.1016/j.appet.2021.105110>.
- [93] Bender KE, Badiger A, Roe BE, Shu Y, Qi D. Consumer behavior during the COVID-19 pandemic: an analysis of food purchasing and management behaviors in U.S. households through the lens of food system resilience. *Socioecon Plann Sci* 2021: 101107. <https://doi.org/10.1016/j.seps.2021.101107>.

Lucas Rodrigues Deliberador has a bachelor's degree in Industrial Engineering from the Federal University of Grande Dourados (UFGD), a master's degree in Industrial Engineering from the Federal University of São Carlos (UFSCar), where he is currently a PhD candidate in Industrial Engineering. He performed part of his undergraduate studies in the Department of Industrial and Systems Engineering at the University of Tennessee/Knoxville (USA). He is a member of the Agroindustrial Studies and Research Group (GEPAL) at the Department of Industrial Engineering at UFSCar.

Alexandre Borges Santos is a Postdoctoral Researcher in the Department of Industrial Engineering at Federal University of São Carlos, Brazil. He has been studying agribusiness management for over a decade. His main interests are concerned with Sustainability, Strategic Management, International Business, and Logistics. He has authored several manuscripts in peer-reviewed journals, and written two book chapters. He has conducted consulting projects for important organizations, including the United Nations Economic Commission for Latin America and the Caribbean (ECLAC-UN).

Pâmella Rodrigues Silva Carrijo is graduated in Industrial Engineering and is a specialist in Project Management from Uni-FACEF (Brazil). She also has a MS in Industrial Engineering from the Federal University of São Carlos (Brazil). Her areas of expertise and interest are research related to the benefits of using tools and techniques of Lean Manufacturing in the management of rural properties.

Mário Otávio Batalha is full professor of Industrial Engineering at the University of São Carlos (UFSCar), where he is also coordinates Agroindustrial Studies and Research Group (GEPAL). He received his PhD in Industrial Systems Engineering from the National Polytechnic Institute of Lorraine (France). He was visiting professor at the Department of Agroecconomics and Consumer Sciences at Université Laval, Canada. National and international speaker, author and organizer of 27 books that have agribusiness as the main theme, having published about a hundred scientific articles in national and international journals.

Aldara da Silva César is Associate Professor of Agribusiness Engineering at the Fluminense Federal University (UFF) and responsible for the Agroindustrial Systems Analysis Group (GASA) - Research Group. She received her PhD from the Federal University of São Carlos (UFSCar). She conducted research at the University of New England (NSW-Australia) for one year (2018–2019) as visiting professor to study the theme of Food Waste. Her main studies focus on support and sustainability options in agribusiness production chains, addressing topics such as inclusion of family candidates, bioenergy and food waste mitigation.

Luís Miguel D. F. Ferreira is an Assistant Professor of Operations and Supply Chain Management with the Mechanical Engineering Department of the University of Coimbra. He received his PhD from the Technical University of Lisboa. He participated in several national and European research projects and his research interests include topics related to Sustainability and Supply Chain Management, and has published in journals as Supply Chain Management: an International Journal, Journal of Cleaner Production, Production Planning and Control, Sustainable Production and Consumption, Journal of Manufacturing Systems among others.