Agri-food supply chain sustainability from the consumer perspective: a survey-based study in the Tunisian context

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Abstract

Agri-food supply chain (AFSC) has been dramatically affected by COVID-19 crisis which justifies the need to develop sustainable behavior and management of agri-food production and consumption. In this study, the perception of the consumer about AFSC sustainability is studied. For this purpose, a survey-based study is conducted while considering the Tunisian context. Data analysis techniques such as correlation and principal component analysis were applied to the collected data. The results highlighted the most important sustainability capitals for the Tunisian consumers (the environmental and financial capitals). Strong correlations were identified between financial and social, human, and intellectual capitals. Finally, clustering was conducted to classify the major sustainability dimensions according to the Tunisian consumer behavior and his/her sustainability perception. Three major clusters were identified reflecting the awareness of Tunisian consumer toward food waste issues, food quality and freshness; local markets and producers as well as purchasing power and budgetary difficulties related to food expenditure.

Keywords: Sustainability, Agri-food supply chain, multi-capital approach, statistical data analysis methods, food consumer survey

1. Introduction

The COVID-19 pandemic affected various supply networks. Moreover, it pointed out the fragilities that characterize various supply chain actors (Queiroz et al., 2020; Longo et al., 2023). Agri-food supply chains (AFSCs) are no exception to these issues. The supply of agri-food products has been highly affected by the recent pandemic (Voglhuber-Slavinsky et al., 2021). For instance, the great spread of the disease increased the waste of agri-food products (fresh fruit and vegetables as well as processed food), job losses among smallholders, retailers, and food processors, as well as food insecurity (Secondi et al., 2022). The temporary closure of multiple distribution channels, as well as the unavailability of manpower for harvesting activities, which were not conducted at the right time, could explain these impacts (Burgos and Ivanov, 2021; Longo et al., 2023). As can be seen, the COVID-19 crisis has significantly impacted AFSC basically on the economic, environmental, and social levels as well as all AFSC actors, including the consumer. Food consumption patterns such as how food is purchased, prepared and stored have been highly affected by the pandemic (Faour-Klinbeil et al., 2021; Güney et al., 2021; Pulighe et al., 2020). That is why, many studies investigated the changes in consumer preferences and behavior. The most highlighted ones were changes towards i) specific modes of food purchasing, like online versus offline

(Gao et al., 2020), ii) types of food products consumed or iii) organic food (such as bio/eco-labels) (Cancello et al., 2020; Filimonau et al., 2022). This evolving behavior reflects an increasing consumer interest in sustainability in food production and consumption. Hence, a better understanding of sustainability and environmental, social, and economic implications of food consumption behavior at the different stages of AFSC is required (Secondi et al., 2022). According to Tom et al. (2017), "the consumers' understanding of sustainability is more diverse than the companies' view or they favor certain sustainability dimensions over others".

Considering these premises, this paper investigates the consumer understanding, awareness, and behavioral patterns related to AFSC multi-dimensional sustainability. Through an online-based survey and data analysis, Tunisian consumer perception of agri-food sustainability is investigated. Most studies that conducted consumer surveys have focused on behavior related to food waste as well as food insecurity especially in the post-COVID 19 (Faour-Klinbeil et al., 2021; Güney et al., 2021; Pulighe et al., 2020; Gao et al., 2020, Cancello et al., 2020; Filimonau et al., 2022; Secondi et al., 2022; Amicarelli et al., 2022). Especially only (Jerbi et al., 2020) studied Tunisian consumer attitudes, behaviors and awareness, related to food wastage. The originality of this paper lies in a multidimensional evaluation of sustainability related to food consumption defined in a holistic way. For the sustainability assessment, new research trends are currently oriented toward a multi-capital framework, (Fordham et al., 2018; Longo et al., 2018, Longo et al., 2023). Indeed, the value of a sustainability multi-capital framework allows a better understanding of the contribution and interconnections between sustainability capitals in order to better understand and analyze consumer behavior. This represents the purpose of our paper where our contributions are enumerated as follows:

i) To our knowledge, sustainability-based multi-capital framework is applied for the first time to understand the perception of food consumer.

ii) A Tunisian case study is considered and oriented to the responsiveness of food consumer.

iii) An empirical approach is applied based on survey and data analysis tools.

The reminder of the paper is organized as follows. In the following section, the methodology of survey and data analysis is described. In section 3 the results of the survey and their discussion are presented.

2.   Materials and Methods

An empirical study is carried out to analyze the AFSC sustainability based on a multi-capital approach from the consumer perspective. The research methodology applied in this study consisted of four steps: survey design, data collection, data pre-processing, and data analysis as illustrated in Figure 1. Each step is described in the following subsections.
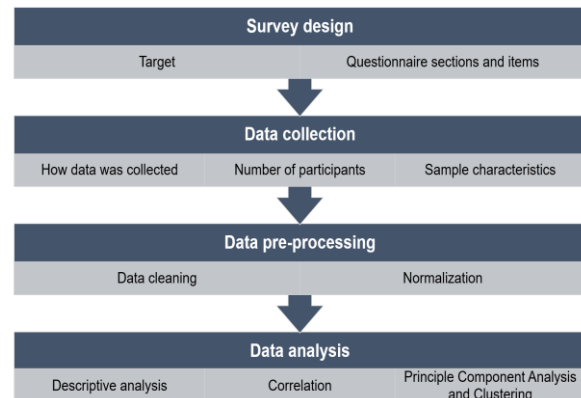

Figure 1 Methodology of the survey and data analysis

2.1.   Survey design

The questionnaire (available on demand) consisted of 35 questions divided among 7 sections: 1) 6 questions for the information of consumers' demographic characteristics (gender, age, marital status, employment, and frequency of consumption/purchase per agri-food product category); 2) 15 questions for the environmental capital: environmental issues related to food consumption (e.g., category of food waste, maximum distance for purchasing products, energy consumption, bio label product consumption, packaging …); 3) 4 questions for the financial capital (e.g., budget for food consumption, e-commerce use …) 4) 4 questions for the social capital (e.g., purchasing and consumption habits, job search within agrifood field); 5) 3 questions for the human capital; 6) 2 questions for the intellectual capital, and 7) 1 question for the degree of importance of sustainability capitals for the consumer.

Several types of questions were used in the questionnaire including single and multiple-option queries, dichotomous questions (yes or no) and 5-point Likert scale questions. The questionnaire was written and supplied in French language (i.e., the academic language in Tunisia) and designed in the online platform Google Forms. The questionnaire link was disseminated online from September to November 2022 on social media (e.g., Facebook and LinkedIn,) and distributed via email. Participants were asked to respond to the questionnaire and to share the survey as much as possible.

2.2.   Data collection and sample characteristics

The data were collected via the online survey. Instructions on the survey portal were provided to minimize wrong entries. 143 replies were collected. Figure 2 illustrates the sample characteristics. Most of them were females (65%), while men represented a quota of 35%. This ratio is in line with several studies (Amicarelli et al., 2022; Principato et al., 2020). It can be justified by the traditional responsibility for home

management, family care and culinary activities still attributed to women (Amicarelli et al., 2022). In terms of age, respondents were heterogeneously distributed, with higher percentages of young adults between 26 and 40 years old (53.8%). This age group is often considered to have a stable income and some work experience, which allows them to have more financial means. As a result, this age group is often targeted by companies as the group with the greatest purchasing power. The distribution of marital status is balanced with 52% married and 48% single. At the socio-professional level, 43.3% of respondents were managers, 31.21% employees, 23.16% students and 21.15% were without professional activity. The concentration of managers in this group suggests high purchasing power and financial affluence. In addition, the presence of students may indicate a younger and more forward-looking population, which may have different consumer expectations. In terms of geographic distribution, respondents are concentrated in the Tunis (44%) and Sfax (28) regions (among the most urbanized and crowded cities in Tunisia). which may suggest that these regions are the most economically dynamic and offer greater employment and consumption opportunities. However, it is important to note that consumers in other regions may have different purchasing behaviors.

2.3. Data preprocessing

Data preprocessing was conducted in the first stage to store only the useful data about the consumer's preferences. To avoid the adverse impact of the invalid data on the study accuracy therefore data cleaning from missing and invalid samples is performed. In the second stage, the data normalization is carried out based on the min-max method (Miles et al., 2020). Thanks to the normalized data which helps to eliminate the bad influence of the outliers and data scale, the data were reduced to a common scale of 0 to 1, which facilitates comparison between different variables that have different units of measurement (Pimpler et al., 2018).

2.4. Data analysis

Data analysis methods used in this paper are illustrated in Figure 3. Descriptive as well as Exploratory data analysis were applied to the collected data.
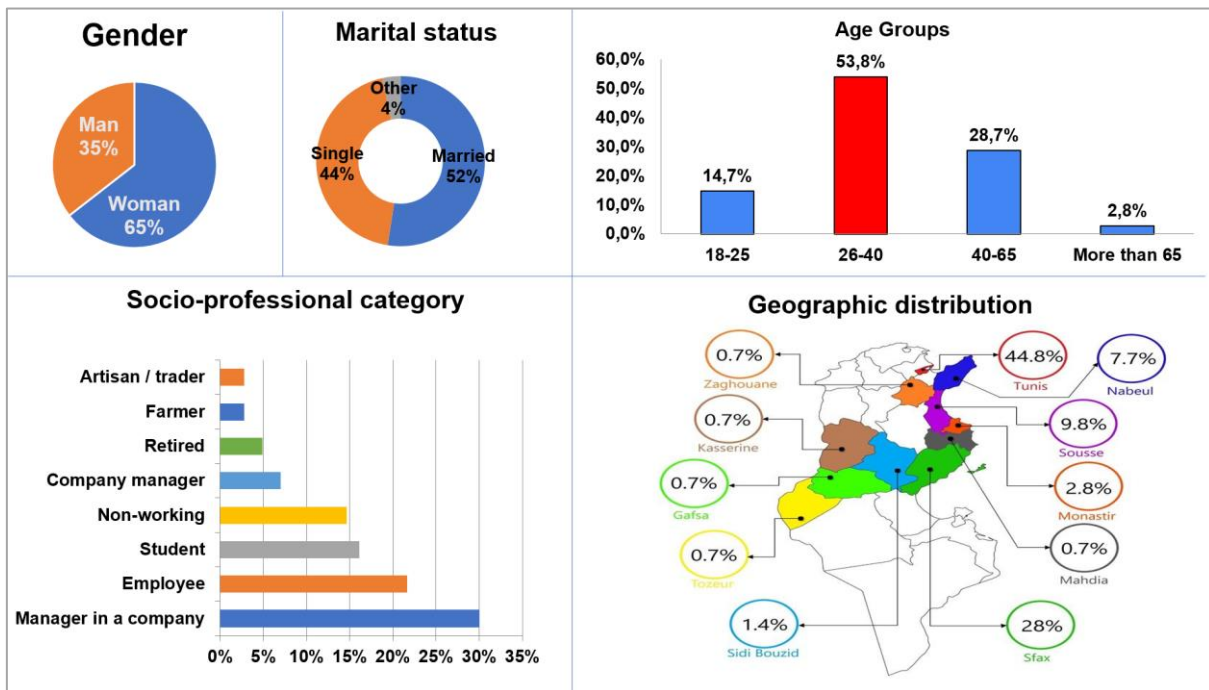

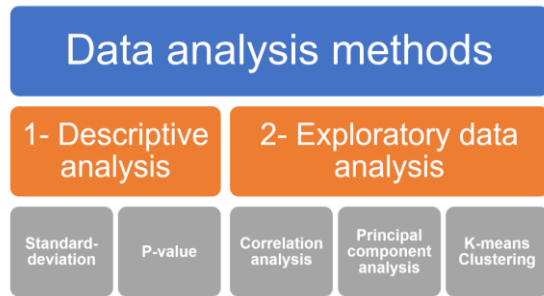Figure 2 Socio-economic characteristics of respondents

Figure 3 Data analysis methods applied in this study.

Descriptive analysis uses statistics to analyze the collected data numerically. It includes measurements of central tendency (e.g., the mean) and measurements of variability (e.g., standard deviation dispersion). These measurements offer valuable information about the corresponding characteristics of the population. P-value calculation is also conducted to conclude about the statistical significance of results.

Exploratory data analysis aims at investigating data sets and summarizing their main characteristics by applying data visualization methods. In our study, correlation analysis, Principal Component Analysis (PCA) and k-means clustering were conducted to draw conclusions and about Tunisian consumer perception of sustainability capitals for the agri-food field.

Correlation analysis aims at studying and identifying the degree of the linear relationship between sustainability capitals and between the different indicators per capital.

PCA (Paul et al., 2013) is used to reduce the dimensionality of collected data while preserving as much variability as possible. In PCA, a component is a linear combination of the original variables that have been transformed to represent the information contained in the data into a reduced number of synthetic variables. Each component represents a share of the total variance in the data and allows the dimensionality of the problem to be reduced while retaining the essential information. Each original variable contributes to the formation of each component with a different weight, which is determined when the PCA is performed. In our study, PCA aims at identifying the most important components regarding sustainability capitals and indicators according to the Tunisian consumer. In effect, the dimensions obtained from ACP allow us to i) identify the priorities of the consumer in relation to different capitals of sustainability and ii) analyze further these trends to easily conclude the perception of the Tunisian consumer.

Finally, clustering aims at classifying the major sustainability dimension according to the Tunisian consumer behavior and their sustainability perception. K-means method was used for this purpose (Hartigan and Wong, 1979) and Elbow method was applied to determine the number of clusters (Syakur et al., 2018),

The results of data analysis and their discussion is provided in the next section.

3. Results and discussion

R software was used to carry out data analysis.

3.1. Descriptive Analysis

In this analysis, the focus was on the determination of standard deviations per capital (sections 2 to 7 of the questionnaire) as well as p-values. Measures of standard deviation (std) per capital are presented in Figure 4. Deviation form normality in the distributions of survey responses are not significant (mean std around 0,3). Moreover, the obtained p-value per capital did not reach 0,05 which proves the statistical significance of the data.
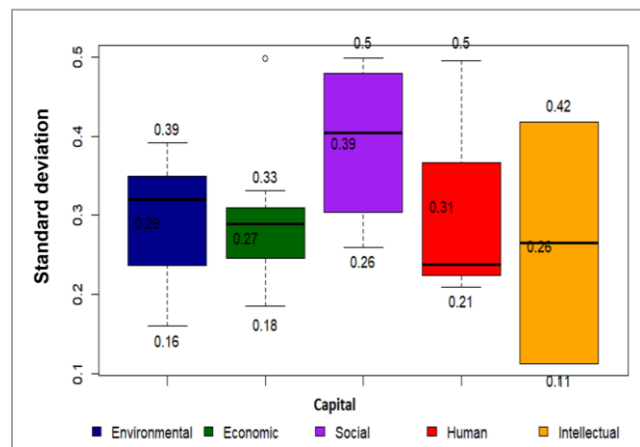

Figure 4 Boxplots of standard deviation values per capital or section of the questionnaire (from section 2 to section 7)

3.2. Correlation analysis

In this subsection, the correlation between sustainability capitals is analyzed. Figure 5 illustrates the relation between the different capitals where environmental and financial capitals are represented by their relative indicators' categories. A strong correlation (value larger than 0.7) can be noticed between i) the financial capital indicators especially the share of expenses (i.e., the share of food expenditure) and each of the social, human, and intellectual capitals; and ii) each pair of the social, human, and intellectual capitals. These results can be explained as follows.

Food expenditure is an important indicator of a person's standard of living and ability to participate actively in society. In other words, a person who can afford to spend more on food also tends to have a more developed and diverse social network, which strengthens their social capital. Moreover, food expenditure can also be seen as an expression of social values, such as support for local producers and the promotion of healthy and sustainable food, which are often key elements of social capital (Luzzani et al., 2019; Langellier et al., 2012). In addition, individuals

who place a high value on their share of food expenditure are more likely to seek information, acquire knowledge and develop skills related to food. They are likely to seek information about food products, understand the sustainability and health issues associated with their consumption, and adopt more conscious eating practices. Studies have also highlighted the correlation between education, knowledge level and food choices, s!howing that people with higher levels of education were more likely to spend a greater proportion of their food expenditure on nutritious and higher quality food.
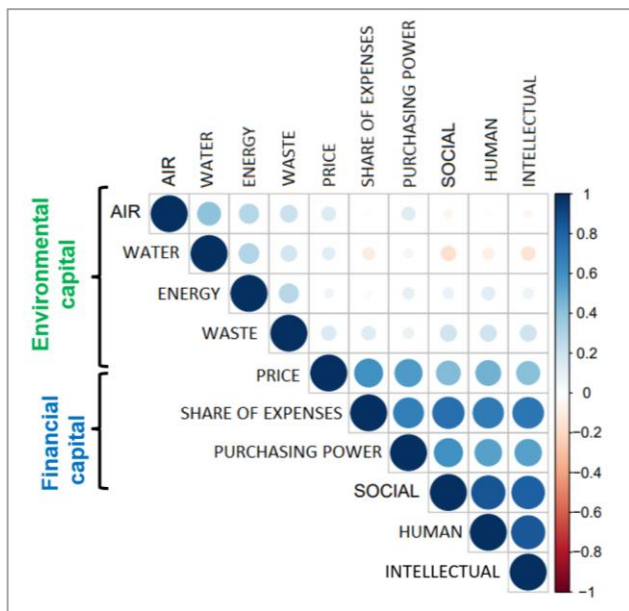

Figure 5 Correlation analysis of sustainability capitals

The correlation between social capital and intellectual capital can be explained by the fact that individuals who have frequent and quality social interactions tend to be exposed to a wider range of information, ideas and perspectives. This fosters intellectual development by allowing them to acquire new knowledge, share ideas, discuss a variety of topics, and learn from each other. In addition, social capital can play an important role in accessing intellectual resources. Individuals who have a large and diverse social network are more likely to have access to a variety of information and knowledge, learning opportunities and intellectual resources such as books, training, or mentors (Alper and Kwon, 2002). Thus, the high correlation value between both social and intellectual capital may suggest that individuals with high social capital also tend to develop higher intellectual capital due to their enriching social interactions and access to a wide range of knowledge and resources.

3.3. Principal component and clustering analysis

3.3.1.   Principal component analysis

To determine the principal components of the data, the eigenvectors and the eigenvalues were first calculated. As a result, 47 variables were identified in our study and 22 principal components (PCs) were found.

Second, the percentage of explained variance of each identified principal component (PC) is determined which allows the identification of the most representative PCs among the 22 PCs. The percentage of explained variance of each identified principal component (PC) is shown in Figure 6. The first principal component explains the largest proportion of variance (≈21%), followed by the second principal component (≈16%), and so on. In general, a number of principal components is chosen that explains most of the variance in the data, while minimizing the number of components needed to achieve this goal. Seven principal components can be chosen from the principal variables because together they account for almost 70% of the total importance of the data. This means that these 7 principal components contain most of the important information in data and can be used to summarize the underlying structure of the data.
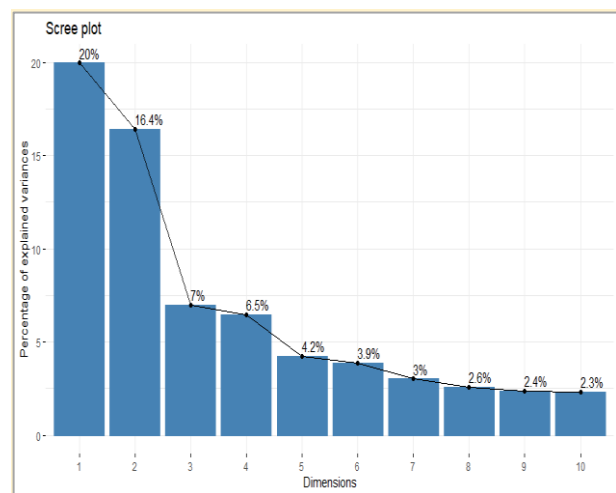

Figure 6 Percentage of Variance explained by each component.

Third, the loading matrix of these seven PC is examined. It gives the coefficients (eigenvectors) for each variable. From this matrix, the variables with the highest absolute values of coefficients have the greatest influence on that component. Table 1 indicates the major contributing variables to be considered for each principal component. The first 4-5 variables per component in decreasing order of contribution were presented in the second column of the table. For instance, the principal component 1 refers to consumers that purchase from groceries, artisans, local markets and local producers, care about the product quality and consider environmental and financial sustainability issues (i.e., food waste and green energy use and budget for food respectively. While the principal component 2 encompasses consumers that purchase food products from supermarkets and are interested by the availability of purchased products. Environmental issues like food waste and use of green energy contribute also to this

PC. PC3 is related to consumers who seek and purchase organic products and accord importance to product composition and its packaging. These results highlight different patterns of food purchasing behavior of individuals, which can help businesses and public policies to better understand consumers' preferences and needs.

Table 1 Principal components' variables

Principal Component	Major contributing variables
PC1	1) Frequency of purchasing from Grocery, minimarkets, Artisan and Local market and local producers, 2) Quality of the food product 3) The use of green energy, 4) Type of food waste and of containers for food leftovers 5) Income allocated to food and Budgetary difficulties
PC2	1) Frequency of purchasing from Supermarkets and in a less degree from Grocery, minimarkets, and Artisans 2) Frequency and type of food waste 3) Importance of the practical aspect of the product and its availability 4) Maximum distance to purchase food products. 5) Use of green energy
PC3	1) Frequency of purchasing from Supermarkets 2) Consumption of organic products 3) Type of food waste 4) ·Number of plastic bags used and Filtering of packages for recycling 5) Importance of product composition
PC4	1) Frequency of purchasing from Supermarkets and to a lesser degree from grocery, minimarket, Artisan and Loca markets and l Local produce!rs 2) Maximum distance to purchase food products 3) Number of plastic bags used and minimizing the impact of plastic wastes 4) Consumption of organic products 5) Importance of packaging
PC5	1) Frequency of purchasing from Supermarkets and Local market 2) Consumption of organic products 3) Impact of prices on food purchasing power 4) Frequency of food waste and Type of containers for food waste 5) Use of green energy
PC6	1) Frequency of purchasing from Supermarkets and Grocery, minimarkets 2) Maximum distance to purchase food products. 3) Consumption of organic products

| 4) The use of green energy |
| 5) Type of food waste and type of containers for food leftovers |

3.3.2. Clustering analysis

Based on clustering methods defined above, three clusters were identified and are illustrated in Figure 7 (using the plan composed of the first two principal components obtained from the PCA analysis).
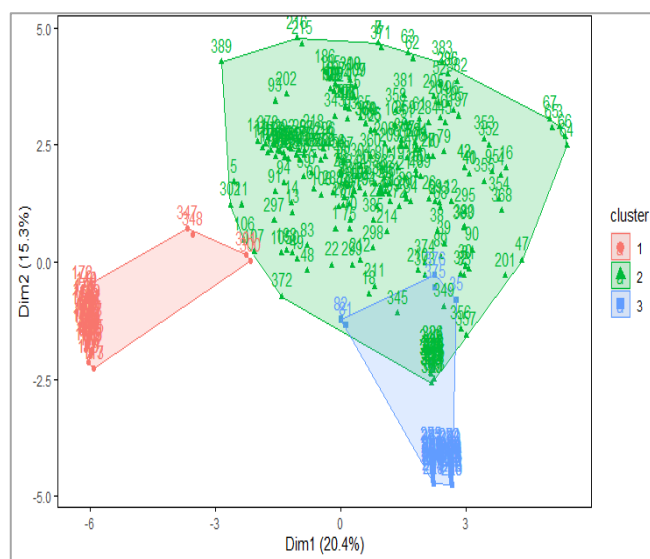

Figure 7 Clustering of individuals according to PC1 and PC2

Cluster 1 (in red) presents 17% of the responses. Individuals within this cluster are found in the left part of the graph characterized by low values of PC1 and low to middle values of PC2. It is composed of young women who tend to favor large supermarkets for their food purchases over small local shops. In addition, this group presents certain particularities. On the one hand, they do not encounter any food budgetary difficulties, which means that they have a certain financial ease for their purchases. On the other hand, they attach less importance to the price of food products, which indicates that cost is not a determining factor in their purchasing decisions. The product availability and convenience are more important. In addition, this group has a low incidence of food waste, which underlines their concern for the conservation and efficient use of food.

Cluster 2 (in green) represents the largest proportion of responses, with around 65% of observations and consists mostly of women older than 26 years. These individuals are found in the upper right quadrant of the graph, characterized by high values of PC1 and PC2. People in this group have a high frequency of purchases from groceries, artisans' markets and local producers which suggests that they favor local purchases and fresh products. This suggests a sensitivity to product quality and an interest in supporting small local traders. Conversely, they also

have high frequency of purchase from supermarkets while caring for the practical aspects of the product and its availability. In terms of other characteristics, this group has high interest in food waste and saving food leftovers, and in the use of green energy. This cluster reflects environmental awareness and an interest in quality and sustainable food. People in this grouping also appear to have a higher-than-average income allocated to food, which may indicate financial affluence. However, those favoring local shops, are more likely to experience food budget difficulties and care about share of expenditure allocated to food. Overall, this cluster represents a group of young women who value local purchases, fresh products, environmental sustainability, and healthy eating. They are aware of the impact of their food choices on the environment and attach importance to product quality.

The rest of the data are grouped in cluster 3 (colored in blue in Figure 7). It is mainly composed of older people (over 40 years). It occupies the right part of the graph, with a high value for PC1 and a low value for PC2. They have a lower frequency of shopping in large stores, preferring instead to shop in small local shops such as craftsmen and markets and local producers. This preference for local shops may be motivated by cultural, environmental, or geographical reasons. In terms of other characteristics, this group has high values for the use of green energy, food wastes awareness (a lower frequency of food waste) which could be attributed to their choice to make more regular purchases in small shops, allowing them to better control their quantities and avoid waste. Finally, individuals in this cluster are more likely to experience food budget difficulties and care about share of expenditure allocated to food.

4. Conclusions

In this paper, the Tunisian consumer perception of AFSC sustainability was analyzed through a survey-based study. Based on our study; the consumer profile can be divided into three types:

i) preference for supermarkets favoring product availability,

ii) preference for both local/small shops as well as supermarkets searching for both product availability and quality (local and fresh products) with an environmental awareness (regarding food waste and green energy), and

iii) Preference for small local shops and adopt more responsible behaviors regarding food waste, packaging (plastics) and food expenditure

These clusters provide a snapshot of different food consumer profiles, ranging from young, convenience-oriented consumers to older ones committed to more sustainable food purchasing practices. These results highlight the awareness of the Tunisian consumer regarding sustainability. Moreover, the environmental and financial capitals were the most important

sustainability capitals for the consumer. In addition, financial capital especially the share of food expenditure indicator was strongly correlated with social, human, and intellectual capitals which were considered less important.

In conclusion, this study shows that the Tunisian consumer has a relative awareness of AFSC sustainability, and there is a potential to increase this awareness and encourage sustainability practices. Our findings highlight different patterns of food purchasing behavior of individuals, which can help businesses and public policies to better understand consumers' preferences and needs while integrating and encouraging sustainable behaviors.

As any research study, this work presents some limitations. The largest drawback is related to the method of data collection: online survey. One major disadvantage of online surveys is the potential for sample bias due to the inequality of access to the internet throughout the population for example in the lower socio-economic groups, or the incapacity to respond to the questionnaire for older individuals for example. In our case, respondents belonged mostly to the most urbanized and crowded cities in Tunisia and were with a certain educational level (students, managers) which corresponds to some slices of Tunisian society. Hence the results of the study could not represent all the Tunisian consumers. To overcome this limitation, the online survey could be generalized and communicated to the rural regions and population with lower education level in order to visualize the whole picture of the consumer perception of AFSC sustainability. Besides enlarging the sample of consumer, the future research directions involve investigating the other AFSC actors' perception of sustainability including smallholders (almost the most impacted by the covid 19 crisis), transport companies, critical stakeholders such as food processors, retailers, restaurants hospitals, etc. and policy makers. The consideration and study of these perspectives allow to draw a holistic view of the AFSC sustainability perception. Moreover, it will serve as input for developing strategies to move towards sustainable food production and consumption.

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