



Impacts of COVID-19 on changing patterns of household food consumption: An intercultural study of three countries

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ABSTRACT

In light of COVID-19's effects on individuals' social, economic, political, and psychological values, this paper aims to investigate the pandemic's role in possible changes to people's food consumption and meal habits in three countries, namely China, Portugal, and Turkey. The sample includes individuals from the three countries, exploratory factor analysis and non-parametric tests were used to test the differences. Results suggest that coronavirus has played a strong part in altering households' food consumption and meal habits within these countries. The pandemic has particularly led to greater consumption of fresh fruits and vegetables and spending more time eating meals at home. Portugal appears to be consuming more seafood, bread, and butter whereas China features higher consumption of rice and meat products; Turkey is consuming more meat and eggs. The study closes with a set of recommendations for the society and future research.

1. Introduction

First reported in Wuhan, China in late December 2019, the World Health Organization (WHO) declared the novel coronavirus (COVID-19) a global pandemic on March 11, 2020 (World Health Organization, 2020a). To limit the spread of the virus, many governments imposed nationwide lockdowns. More than half of the world's population was forced to quarantine (Meo et al., 2020). Lockdown restrictions greatly limited the time people spent outside the home. In some countries, people were allowed to leave home only for essential shopping or for sports. Many people also shifted to working from home and found themselves facing varying degrees of social isolation (Lima et al., 2020).

The vaccine rollout is ongoing, and no antiviral treatment currently exists for COVID-19. Following a healthy diet during the pandemic could help individuals strengthen their immune system and overall wellbeing (Muscogiuri et al., 2020). In the early days of the pandemic, the WHO published nutritional guidance that recommended consuming fresh vegetables, fruits, pulses, and whole-grain foods to obtain adequate dietary fiber (WHO, 2020b). High consumption of fruits and vegetables is one fundamental of a healthy diet (WHO, 2005). However, market data have shown that the initial shock of the pandemic caused people to buy

food with a long shelf life, such as canned and frozen items, ultra-high-temperature milk, pasta flour, and eggs; sales of fresh and perishable foods (e.g., fruits and vegetables) declined (Bracale and Vaccaro, 2020).

The Food and Agriculture Organization (FAO) (2020) also reported that household purchases of long-shelf-life foods and less perishable foods increased at the start of the pandemic (FAO, 2020). Moreover, panic shopping arose due to concerns about food security during the initial outbreak (FAO, 2020). While some studies have indicated that people are eating fewer fruits and vegetables (Giacalone et al., 2020; Jia et al., 2021), others have reported that people's fruit and vegetable consumption remains unchanged (Di Renzo et al., 2020; Poelman et al., 2021; Rodríguez-Pérez et al., 2020). Still others have found that people have increased their fruit and vegetable consumption to cope with the pandemic (Canello et al., 2020; Coulthard et al., 2021; Lamarche et al., 2021; Marty et al., 2021).

Amid world market globalization, understanding inter-cultural similarities and differences has become vital to managing supply and demand. However, a solid methodology and effective tools are needed to reach concrete empirical conclusions. Therefore, by assuming an inter-cultural perspective (Hofstede, 1980), this paper aims to investigate

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the role of COVID-19 on possible changes to individuals' eating/food habits in three countries: China, Portugal, and Turkey. The study sample includes individuals as well as households with at least two people living together. Specifically, this study examined possible increases or decreases in the consumption patterns of six food categories: (1) fruits and vegetables; (2) snacks, sugar-sweetened beverages, and alcoholic beverages; (3) meat and eggs; (4) rice and meat products; (5) bread, legumes, and butter; and (6) fish and seafood. The study also sought to investigate possible changes in meal habits between and within the focal countries as a consequence of a "new normal." This paper closes with a set of recommendations to adapt the supply food chain to the new normal and diet habits of populations as well as for future studies to extend this line of research.

2. Literature review

Food is a basic necessity in sustaining human existence. As a result of the industrial revolution and civilization, the function of food has transcended from satisfying physiological needs to offering health benefits beyond mere nutritional value (Firth et al., 2020). As a result, this work draws upon the theory of Edward T. Hall, a well-known scholar in inter-cultural communication, who states that "the activities of living matter are functions neither of chance nor of design, but of direct and dynamic interaction of the organism with its environment. This interaction is specialized or limited by the presence of other organisms of the same kind, in association" (Hall and Trager, 1953, p.8). Taking this as departure point, Hall (1959, 1992) created his own theory, called the information systems. According to Hall, all societies have the same 10 "basic focal systems of culture". Of these, the "subsistence" includes food procurement and consumption. Specifically, food consumption is expected to satisfy the hunger need, but fulfillment of this need can manifest in various ways. Methods include consuming fresh, fast, or frozen food; cooking at home or dining out; or ordering food.

In fact, several scholars have pointed out that culture has the most compelling influence on one's food choices and eating habits (Tse and Crotts, 2005). Culture defines how food should be prepared and cooked (Long, 2004). However, humans' eating behavior varies due to differences in race, sex, and physical activity (Ma, 2015). Taking this as a departure point, this study's authors considered Hofstede's (1980) theory of cultural dimensions when selecting the sample countries of China,

Turkey, and Portugal. As indicated in Fig. 1, with the highest scores, China holds distinct positions in power distance, masculinity, and long-term orientation; Portugal takes the leading position in uncertainty avoidance, followed by Turkey. These countries represent different cultural orientations to reveal potential culture-based influences on people's dining behavior (see Fig. 2).

For instance, with its long-standing history, the Chinese cuisine in particular can be traced back about 5000 years. Food holds symbolic meaning to the Chinese (Ma, 2015) and has long been considered an art imbued with diversity, flexibility, and creativity (Chang, 1977; Li and Hsieh, 2004). A typical Chinese meal includes rice or noodles as staples, vegetables and meat as side dishes, and soup (Chang, 2010). What further distinguishes Chinese cuisine is its cooking techniques and flavor principles (Chang, 2010). Different from the salads or baked vegetables commonly found in Western countries (Lv and Brown, 2010), frying, stewing, boiling, and steaming with soy sauce, garlic, and ginger undergird Chinese food culture (Rozin, 1983). Also, rice and noodles are essential to the Chinese diet, whereas potatoes and pasta are valued more in the West (Lv and Brown, 2010).

For the Chinese, food is closely tied to the social context (Chang, 2010), as observed in greeting styles: rather than saying "How are you?", Chinese people are accustomed to asking "Have you eaten yet?" (Zhang, 2014). The value of food consumption thus lies in its social functions, which include but are not limited to networking, sharing, and business purposes (Zhu and Liu, 2020). As such, the Chinese normally eat communally at round tables, symbolizing the unity of family and society (Zhu and Liu, 2020).

The symbolic meaning of food is further evident in the roots of Chinese culture. Inspired by the Han custom, Chinese people eat noodles, which denote longevity, on their birthday (Zhang and Ma, 2016). Likewise, the homophonic nature of Mandarin Chinese implies that some foods signal bad luck (Ma, 2015). For example, eating a pear could connote separation. In addition, different types of food are served during specific Chinese events and festivals (Ma, 2015): moon cakes are served at the Mid-Autumn Festival while rice dumplings are served at the Dragon Boat Festival. Although essential nutrients can be obtained from a wide range of foods and ingredients (Kaur and Das, 2011), individuals' nutrient intake depends on cultural and social factors that subsequently shape one's eating habits, food choices, and preferences (Ma, 2015).

In Turkey, a country marked by a blend of Eastern and Western

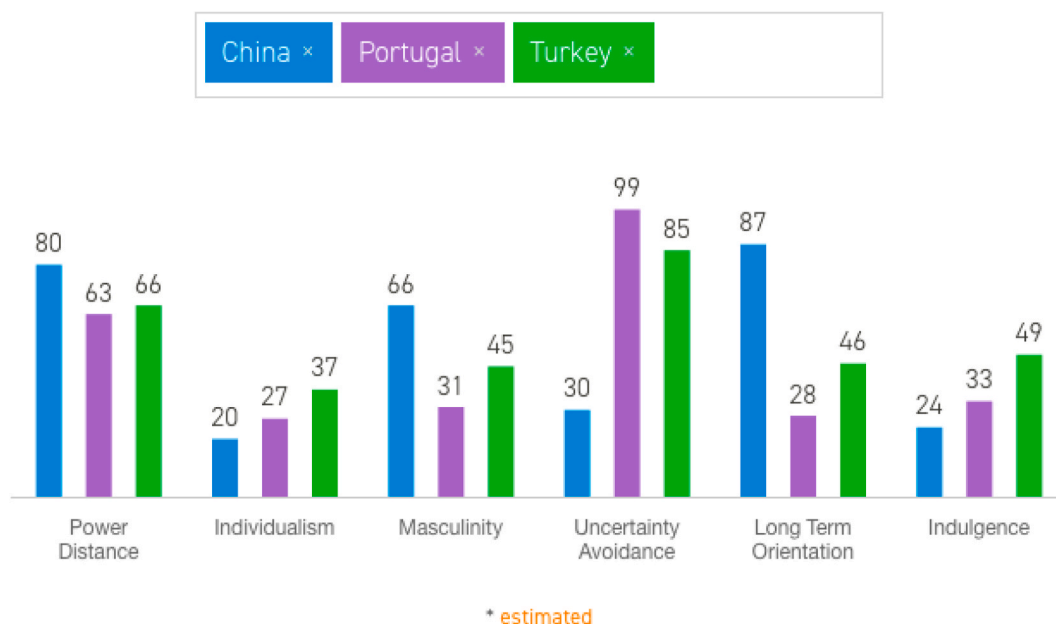


Fig. 1. Comparison of sample countries by Hofstede's cultural dimensions.

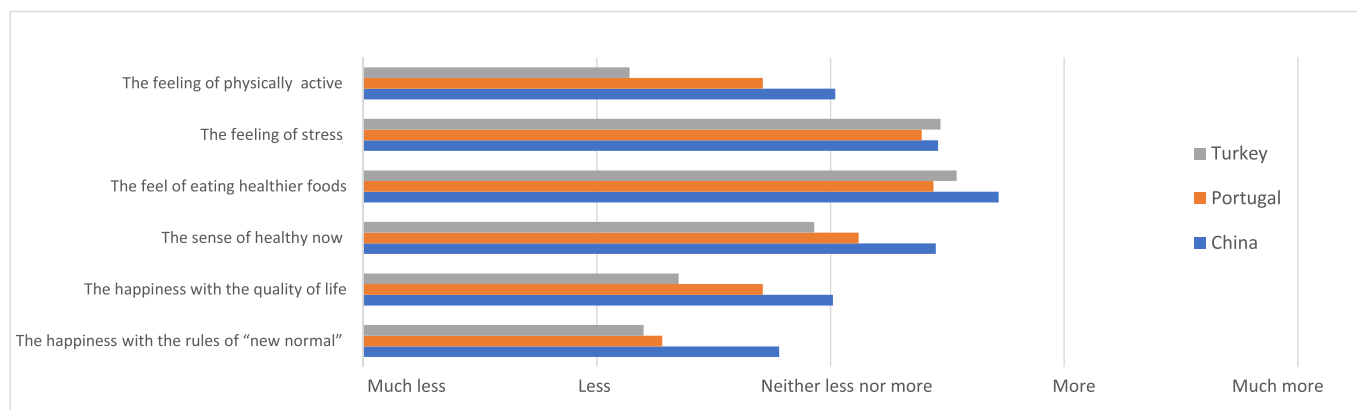


Fig. 2. Means of sentiments and perceptions about life during the pandemic.

cultures and that feels uncomfortable with risk taking, wheat is a staple of national cuisine. The grain is often consumed through bread, bulgur, and pasta. The country’s climate allows for ready access to fruits and vegetables in all seasons. These ingredients also constitute key components of Turkish cuisine (Pekcan and Karaagaoglu, 2000); fruits and vegetables represent one leaf of the “four-leaf clover” Turkish food guide, which stresses the importance of fruit and vegetable consumption (MOH, 2016). Legumes such as chickpeas, lentils, and fava beans are main dietary protein sources and are often cooked in soups and stews. In terms of dairy products, the Turkish people primarily consume yogurt and cheese. Lamb and goat are popular meats in the eastern part of the country, whereas fish and seafood are more representative of Turkey’s coastal region.

Another regional difference is seen in the consumption of fats and oils. While olive oil is common in olive-growing areas of Turkey, sunflower oil, margarine, or butter are more often consumed in the east (Chambers et al., 2016). The Turkish diet revolves around three meals per day (FAO, 2010). Turkish cooking includes various techniques such as stewing, frying, grilling, roasting, and baking. A typical Turkish lunch and dinner starts with soup (hot soups in winter and cold soups in summer), followed by a main dish of vegetables, meat, or legumes. Rice, bulgur, or pasta is served with the main entree. Salads, *cacik* (diluted yogurt with cucumber and garlic), or *compote* are also consumed during the meal (Batu and Batu, 2018).

As an example of a Western Mediterranean culture, the Portuguese diet is considered a Mediterranean diet based on the country’s location and climate. Pork, legumes, olive oil, and garlic hold important places in Portuguese cuisine. Fish and seafood are frequently consumed along the coast, and Portugal’s rivers provide trout and other stream fishes to residents of the inner part of the country (Charzyński et al., 2017). Wheat, rye, and corn are the main cereals in Portuguese cuisine; bread is

another core component of the Portuguese diet (Guine et al., 2016). The Portuguese tend to eat one or two daily snacks in addition to the three main meals of breakfast, lunch, and dinner (Andrade et al., 2020). A traditional Portuguese lunch opens with an appetizer (*acepipes*) like fresh cheese or codfish; this is followed by a meat and vegetable dish and dessert. Dinner commonly includes soup, a fish course, and fruit (Howe, 2003). Back to the Mediterranean tradition meat or fish are usually served with rice and potatoes to provide the carbohydrates that the farm workers need to work 12 h a day in the farm (Rodrigues et al., 2006). In fact, the Portuguese diet is full of carbohydrates due the deprivation population suffered during the world wars and the dictatorship (de Morais et al., 2010). Traditions kept until nowadays, for instance “Açorda”, is a very typical dish with bread. Furthermore, meals are seen as the family time as such traditionally the weekends and the festive days are spent at the same table with the family (de Morais et al., 2010). This is mostly related with the feminist culture of the Portuguese people. Dietary characteristics of these three countries are presented in Table 1.

3. How has food consumption changed?

In addition to its sweeping effects on several life domains, research has confirmed the pandemic’s impacts on households’ food consumption patterns. For instance, changes in eating behavior during lockdowns have been found to vary with people’s age (Cancello et al., 2020; Di Renzo et al., 2020; Poelman et al., 2021), body mass index (Coulthard et al., 2021; Huber et al., 2020; Poelman et al., 2021), gender (Carroll et al., 2020), and educational level (Jia et al., 2021; Rodríguez-Pérez et al., 2020). Older adults’ eating behavior during COVID-19 appears less likely to be influenced by lockdowns compared with younger adults (Di Renzo et al., 2020; Poelman et al., 2021). Having a higher body mass index has been associated with greater consumption of unhealthy snacks

Table 1
Dietary characteristics of China, Portugal and Turkey.

Countries	Staples	Cooking techniques	Spices	Protein source	Oil source	Carbohydrate source	Major food crops
Chinese cuisine	Rice and noodles	Stir-frying, stewing, boiling, and steaming	Soy sauce, garlic, ginger, pepper, fermented soybean, chili peppers	Pork, poultry, soybean	Soybeans, peanuts, corn oil	Rice and noodles	Rice, maize, wheat, soybeans
Portuguese cuisine	Wheat bread	Boiled, frying, stewing, and pan-braising	Pepper, saffron, cumin, curry powder, paprika, cinnamon, cloves, nutmeg, garlic, coriander, mint, bay leaves, parsley, sage, oregano, and red chili peppers	Sea food, poultry, pork and beef	Olive oil	Wheat (bread), tuber (potato)	Olives, tomato, maize, potatoes, orange, rice, wheat
Turkish cuisine	Wheat bread, bulgur, pasta and rice	Grilling, sautéing, boiling, frying and braising	Cumin, pepper, mint, oregano, parsley, paprika, cinnamon, cloves, and garlic	Beef, poultry, lamb, legumes	Olive oil, sunflower oil, corn oil	Wheat (bread, bulgur, pasta) and rice	Wheat, tomato, maize, olives, hazelnut, apricots, figs

Source: Information was obtained from the FAOSTAT.

(Di Renzo et al., 2020; Coulthard et al., 2021) and lower diet quality (Robinson et al., 2021) during the pandemic.

During the COVID-19 lockdown in Spain, adults consumed more fruits, vegetables, and legumes whereas consumption of red meat, alcohol, fried foods, and pastries declined compared with usual habits (Rodríguez-Pérez et al., 2020). A study conducted in Italy during the first lockdown between 5 and April 24, 2020 indicated that consumption of homemade bread, desserts, and pizza increased while consumption of processed meat, snacks, and sugar-sweetened beverages fell (Di Renzo et al., 2020). The same research showed that, regardless of barriers to accessing fresh fruits and vegetables, the intake of these foods did not decline among the Italian population (Di Renzo et al., 2020).

The UK is one country where fruit and vegetable consumption increased during lockdown (Buckland et al., 2021). Lower fruit and vegetable intake was conversely observed among Danes (Giacalone et al., 2020). In Poland, one-third of the study population reported low intake of fruits and vegetables (Sidor and Rzymiski, 2020). Among Chinese youth, the consumption of rice, meat, poultry, fresh vegetables and fruit, soybean products, and dairy products decreased whereas the intake of wheat products, other staple foods, and preserved vegetables increased (Jia et al., 2021). Another study conducted in China during March 2020 revealed low consumption of fish and seafood and high consumption of cereals, fruits, and vegetables. This study also indicated low consumption of processed foods (Zhao et al., 2020).

Food availability has varied internationally during the pandemic as well. One study indicated challenges in obtaining meat, vegetables, and fish from markets during the COVID-19 lockdown in Spain (Rodríguez-Pérez et al., 2020). Other research has pointed to difficulties in accessing fish and seafood in China (Zhao et al., 2020). Moreover, people seem to have shifted to less healthy diets due to the limited availability of fresh foods like fruits, vegetables, and seafood in China (Jia et al., 2021).

4. Eating habits

Eating habits tend to be stable in adults, although changes in one's environment or daily routine can alter eating behavior (Jastran et al., 2009). Because routines such as going to work/school or engaging in outdoor activities were impossible during lockdowns, many scholars reported changes in individuals' meal habits. Błaszczyk-Bebenek et al. (2020) observed that more people were eating five meals per day in Poland, whereas Di Renzo et al. (2020) noted that more than half of Italians did not change their meal habits and consumed the same number of meals per day during lockdown. The amount of food consumed (as snacks) during lockdown increased in Canada (Carroll et al., 2020), Denmark (Giacalone et al., 2020), Poland (Sidor and Rzymiski, 2020), and the UK (Buckland et al., 2021). Food intake did not change considerably in the Netherlands (Poelman et al., 2021) or Germany (Huber et al., 2020).

The most noticeable change in eating behavior during the pandemic has involved home cooking. Lockdowns forced people to stay at home, leading to lifestyle changes. Many people suddenly had more time to cook and plan meals. Studies indicated that the amount of time individuals are devoting to food preparation and cooking has increased (Ben Hassen et al., 2020; Canello et al., 2020; Carroll et al., 2020; Coulthard et al., 2021; Di Renzo et al., 2020; Giacalone et al., 2020; Lamarche et al., 2021; Marty et al., 2021; Sidor and Rzymiski, 2020; Zhang et al., 2020). Home cooking is also generally associated with a lower intake of total calories, carbohydrates, fat, and sugar (Wolfson and Bleich, 2015).

Lockdowns have affected food consumption outside the home as well. Many restaurants are only open for food delivery and takeaway. Many people apparently prefer home cooking, as eating out and takeaway orders have decreased during the pandemic (Ben Hassen et al., 2020; Błaszczyk-Bebenek et al., 2020; Carroll et al., 2020; Chenarides et al., 2020; Lamarche et al., 2021; Zhang et al., 2020). Dining outside

the home is positively associated with high fat and calorie intake and negatively associated with micronutrient consumption (Lachat et al., 2012).

At the same time, lockdown has negatively affected some individuals' eating habits: relatively unlimited access to food and boredom can increase the frequency of snacking. Many studies have revealed higher snack consumption during lockdowns (Błaszczyk-Bebenek et al., 2020; Buckland et al., 2021; Carroll et al., 2020; Giacalone et al., 2020; Sidor and Rzymiski, 2020). Snacks often contain fewer micronutrients than meals, and frequent snacking is associated with a higher caloric intake and risk of obesity (Ovaskainen et al., 2006). Furthermore, due to the economic situation of families and the uncertainty related with their professional situation, eating out was avoided in Portugal (DGS, 2020) – the behavior that we anticipated in the three focal countries under this study.

5. Methodology

Based on the findings of earlier studies regarding the pandemic's effects on consumer behavior (e.g. Gössling, Scott and Hall, 2020; Sigala, 2020; Wen et al., 2021), the survey distributed as part of the present research was intended to investigate how COVID-19 may have inspired possible changes in individuals' food consumption and eating habits. The questionnaire adopted in this study was developed through seven steps. First, relevant references, as indicated in the literature review (Di Renzo et al., 2020; Poelman et al., 2021; Zhang et al., 2020), were scanned to produce an initial pool of questions. Second, the authors reflected upon their personal experiences to refine the list of items in quality and quantity. Third, the authors developed the initial questionnaire form by sharing their opinions via e-mail and virtual meetings. Fourth, the final survey version was drafted in English and distributed to 30 respondents for a pilot study. As the study was planned to include three countries, the authors obtained a list of new items for inclusion in the survey to address cultural heterogeneity of the chosen countries. Fifth, all authors reviewed the amended version of the survey to ensure items flowed well. Next, the questionnaire was translated into Chinese, Portuguese, and Turkish for distribution among citizens of the focal countries. Finally, each translated form was sent to five academics per country to verify that the items read well in their own language and that the survey measured what it was intended to regarding meaning and cultural values. Some items were reworded to enhance clarity and comprehensibility, but no additional items were included at this stage.

The final survey consisted of four parts. The first section focused on how respondents' food consumption patterns have changed amid their "new normal" compared with before the pandemic. The second section aimed to investigate the likelihood that respondents' cooking, meal time, and food waste habits have changed. The next section was intended to provide a snapshot of respondents' general psychological and physical mindsets compared with before the pandemic. The last section solicited respondents' demographics.

This questionnaire was uploaded onto an online platform with unique links for automatic distribution to respondents in each country. Data for the main survey were collected between 3 January and February 1, 2021. Each author was responsible for approaching potential respondents in their respective country by sending separate emails to each respondent. Using snowball sampling, the authors leveraged their social networks by asking friends and colleagues to distribute the survey to potentially interested individuals. Only one person per household was asked to participate in the survey. Once data collection was discontinued, all questionnaires were checked for missing variables. Surveys containing more than five unanswered items and 11 respondents who responded incorrectly to an attention-check question were discarded from analysis. The remaining items were merged into a single table to run statistical analysis and explore possible differences within or between countries. The authors ultimately gathered 319 useable surveys from China, 351 from Portugal, and 449 from Turkey.

Empirical data were analyzed using factor analysis and non-parametric tests to examine differences among the countries. Analysis consisted of five steps. Exploratory factor analysis (EFA) was conducted to identify dimensions and constructs in the data, as no prior studies had tested all these items together. Factor extraction involved maximum likelihood estimation with VARIMAX rotation. The analysis applied a latent root criterion of 1.0 for factor insertion; 0.5 was the cut-off criterion for factor extraction. The second step involved rescaling the constructs extracted using a 5-point scale. The means of all components within each construct were used. The third step entailed independent-samples Kruskal-Wallis tests of the extracted components to determine whether distribution of all samples was the same. The fourth step comprised pairwise comparisons of groups of two countries to test whether each sample distribution coincided. The fifth step consisted of sign tests for dependent samples to ensure that within-country behavior before and after COVID-19 was similar.

6. Results

Data were gathered in China, Portugal, and Turkey from largely similar samples. The authors aimed to approach 314 respondents in each country, following the assumption of a binomial distribution with a maximum dispersion; that is, at least half of the population would presumably change their food habits during lockdown with a confidence interval of 95% and a sample error of 2.5%. The 319 questionnaires from China, 351 from Portugal, and 449 from Turkey led to a low sample error and ensured better generalizability of the results.

The distribution of the sample profile appears in Table 2. Respondents' average mean ages were 30.0 years in China, 43.0 years in Portugal, and 42.5 years in Turkey. More specifically, most Chinese respondents were between 18 and 34 years old (76.4%); three-quarters of Portuguese (75.8%) and two-thirds of Turkish (65.7%) respondents

Table 2
The distribution of the sample profile in each country.

	China	Portugal	Turkey	Total	χ^2 or p value
N (%)	319 (28.5)	351 (31.4)	449 (40.1)	1119	
Age average (years)	30.03	43.03	42.51	39.14	<0.001
Age Groups					<0.001
less than 25 years	33.3	6.8	5.4	13.8	
25–34 years	43.1	15.1	22.7	26.1	
35–44 years old	12.9	30.2	33.2	26.5	
45–64	9.8	45.6	32.5	30.1	
more than 64	0.9	2.3	6.2	3.5	
Gender					<0.001
Male	34.2	32.5	35.0	34.0	
Female	65.8	67.5	65.0	66.0	
Profession					<0.001
Full-time	57.4	82.3	60.8	66.6	
Part-time	6.3	0.9	3.6	3.5	
Student	25.7	6.3	9.1	13.0	
Unemployed	6.0	6.0	9.6	7.4	
Retired	4.7	4.6	16.9	9.6	
People living in the household with you					<0.001
0	2.2	8.3	11.9	8.0	
1	4.4	24.8	26.5	19.7	
2	27.9	26.8	27.6	27.4	
3	30.7	27.4	23.1	26.6	
4	21.6	10.3	9.0	13.0	
5 and more	13.2	2.6	1.8	5.3	
Have you or your family member tested positive for COVID-19?		<0.001			
No	99.1	92.9	87.5	92.5	
Yes	0.9	7.1	12.5	7.5	

Demographic and lifestyle characteristics and differences tested by χ^2 . Differences across means were evaluated by using analysis of variance.

were between the ages of 35 and 64. Female representation in each country sample was nearly identical: 66.0% in China, 67.0% in Portugal, and 65.0% in Turkey. Many respondents held full-time employment: 57.0% in China, 82.0% in Portugal, and 61.0% in Turkey. Proportionally, a fair number of Chinese respondents were students (25.0%). Some Turkish respondents were retired (17.0%). Nearly half of the respondents were living with two or three other people. In China, about one-third of respondents (33.8%) lived with four to six other people. Roughly one-quarter lived with another person in Portugal and Turkey. Regarding the risk of spreading COVID-19, Turkey was ranked first in the number of family members who had tested positive for the virus (12.5%), followed by Portugal (7%) and China (0.5%).

As indicated in Table 3, this unprecedented crisis and resultant lockdowns led to high stress across all country samples ($M = 3.5$). This homogeneity was tested with a Kruskal-Wallis test for independent subsamples ($t = 1.182, p = 0.554$). In terms of respondents' extent of happiness with their life conditions, the authors observed differences in quality of life due to the "new normal." Pairwise comparison tests were performed to better understand this heterogeneity. Respondents from Portugal and Turkey exhibited similar levels of unhappiness ($t = 19.133, p = 0.384$); both countries had an average mean score of 2.20. Chinese respondents seemed more comfortable with their conditions ($M = 2.78$) and reported feelings distinct from respondents in Portugal ($t = 165.875, p = 0.000$) and Turkey ($t = 185.007, p = 0.000$). Quality-of-life perceptions also differed across the three countries ($t = 70.388, p = 0.000$): the Chinese were the most pleased with their quality of life ($M = 3.01$), followed by the Portuguese ($M = 2.71$) and Turkish ($M = 2.35$).

As indicated in Table 4, pairwise comparison tests were run for Turkey–Portugal ($t = 102.336, p = 0.000$), Turkey–China ($t = 187.969, p = 0.000$), and Portugal–China ($t = 85.633, p = 0.000$). These differences may be related to respondents' sense of being healthy ($t = 50.028, p = 0.000$), eating healthy food ($t = 27.672, p = 0.000$), and being physically active ($t = 131.877, p = 0.000$). These perceptions all varied across the three countries. Portugal and Turkey were similar in respondents' perceptions of leading a healthy life ($t = 43.980, p = 0.043$) but differed in perceptions of eating healthy food ($t = 57.110, p = 0.024$) and of being physically active ($t = 158.133, p = 0.000$). China was distinct from Portugal and Turkey, ranking as the country with a more optimistic outlook regarding leading a healthy life ($M = 3.45$), eating healthy food ($M = 3.72$), and engaging in physical activity ($M = 3.02$). China was followed by Portugal in life perceptions ($M = 3.12$) and physical activity ($M = 2.71$), whereas Turkey ranked highest in respondents' perceptions of eating healthy food ($M = 3.54$). Accordingly with DGS (2020), the consumption of fruits and legumes increased but still there are a number of persons with unhealthy food habits in Portugal.

7. Possible changes in food consumption patterns

Respondents' perceptions of their food consumption patterns varied compared with before the pandemic. The 24 food items that constituted the food wheel were submitted to EFA to depict food patterns. Results showed that six factors were extracted from the 24 items, collectively accounting for 59.2% of the total variance ($KMO = 0.842$; Bartlett's test of sphericity: $p = 0.00$). Based on the items grouped with higher loadings (i.e., between 0.60 and 0.80), identified food consumption patterns were as follows: (1) fruits and vegetables; (2) snacks, sugar-sweetened beverages, and alcohol; (3) meat and eggs; (4) rice and meat products; (5) bread, legumes, and butter; and (6) fish and seafood (see Fig. 3). These factors' internal consistency was measured using Cronbach's alpha coefficients, which were adequate (i.e., equal or superior to 0.57 in all cases). These food consumption patterns were classified under several well-known diets. Table 5 presents a summary of the EFA results.

Table 6 lists the results of Kruskal-Wallis analysis to test the asymptotic significance of observations; Table 7 presents the results of paired comparisons. Each country's fruit and vegetable intake increased ($M = 3.5$ for all three countries) compared with before the pandemic.

Table 3
Sentiments and perceptions about their life during the pandemic.

Items	Kruskal-Wallis tests					China	Portugal	Turkey
	Total N	Test Statistic	df	Asymptotic Sig.(2-sided test)	Observations	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
The happiness with the rules of "new normal" is the same across countries	1111	76.203 ^a	2	<0.0001	Reject	2.78 (0.83)	2.28 (1.09)	2.20 (1.03)
The happiness with the quality of my/our life is the same across countries	1108	70.388 ^a	2	<0.0001	Reject	3.01 (0.93)	2.71 (1.11)	2.35 (1.14)
The sense of healthy now is the same across countries	1108	50.028 ^a	2	<0.0001	Reject	3.45 (0.94)	3.12 (0.94)	2.93 (1.07)
The feel of eating healthier foods is the same across countries	1105	27.672 ^a	2	<0.0001	Reject	3.72 (0.84)	3.44 (0.79)	3.54 (0.96)
The feeling of stress now is the same across countries	1106	1.182 ^{a,b}	2	0.554	Retain	3.46 (0.90)	3.39 (1.10)	3.47 (1.15)
The feeling of physically active now is the same across countries	1113	131.877 ^a	2	<0.0001	Reject	3.02 (0.89)	2.71 (1.10)	2.14 (1.13)

^a The test statistic is adjusted for ties.

^b Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Table 4
Sentiments and perceptions about their life during the pandemic (pairwise comparison tests).

	Turkey-Portugal			Turkey-China			Portugal-China			
	Test Statistic	Std. Error	Sig.	Test Statistic	Std. Error	Sig.	Test Statistic	Std. Error	Test Statistic	Sig.
The happiness with the rules of "new normal" is the same across countries	19.133	21.961	0.384	185.007	22.496	<0.0001	165.875	23.786	6.974	<0.0001
The happiness with the quality of my/our life is the same across countries	102.336	22.112	<0.0001	187.969	22.631	<0.0001	85.633	23.922	3.580	<0.0001
The sense of healthy now is the same across countries	43.980	21.768	0.043	155.538	22.244	<0.0001	111.558	23.568	4.734	<0.0001
The feel of eating healthier foods is the same across countries	57.110	21.534	0.008	65.462	21.951	0.003	122.572	23.307	5.259	<0.0001
The feeling of stress now is the same across countries	no differences									
The feeling of physically active now is the same across countries	158.133	22.223	<0.0001	254.695	22.765	<0.001	96.562	24.093	4.008	<0.0001

The distribution mean was identical for all countries ($t = 0.937$, $p = 0.626$). In Portugal and Turkey, people generally appeared to follow the Mediterranean diet, which emphasizes consumption of fruits and vegetables. Fish and seafood consumption patterns differed across the three countries ($t = 70.785$, $p = 0.000$). Portugal showed a slight increase ($M = 3.2$), whereas Turkey ($M = 2.8$) and China ($M = 2.6$) demonstrated a decline. Despite the closure of fish shops in local markets, steady consumption of fish and seafood in Portugal reflected that seafood is an important staple in Portuguese cuisine. While MD pyramid suggests two or more servings of fish and shellfish per week (Serra-Majem et al., 2020; Bach-Faig et al., 2011), in Portugal, fish consumption per week was reported as five (Almeida et al., 2015).

The pandemic led to an emphasis on the need for a healthy lifestyle, including calls to limit the intake of salty and sweet snacks, sugar-sweetened beverages, and alcohol. This trend held overall, albeit with some nuances ($t = 33.698$, $p = 0.000$): Chinese respondents reduced their consumption of these foods ($M = 2.3$). Turkey and China did not demonstrate a significant difference in their consumption ($t = 43.981$, $p = 0.052$); both countries had low intake (Turkey: $M = 2.4$; China: $M = 2.3$). Portugal presented a consumption pattern similar to that prior to COVID-19 ($M = 2.7$). The reputation of Portuguese wines coupled with free time at home resulted in consumption of alcohol, salty snacks (e.g., appetizers), and homemade cakes at levels close to before the pandemic. This result is in accordance with those of DGS (2020) pointing out that mostly men and young populations have kept their unhealthy food habits.

Meat and egg consumption differed across the three countries ($t = 18.913$, $p = 0.000$), with Turkey registering the highest increase ($M = 3.3$) followed by Portugal ($M = 3.2$) and China ($M = 3.1$). Pairwise comparison tests suggested that Portugal and China ($t = 69.083$, $p =$

0.005) and Turkey and China ($t = 98.408$, $p = 0.000$) varied whereas Turkish and Portuguese patterns were more similar ($t = 29.325$, $p = 0.194$), the Mediterranean diet that is used in both countries may explain this homogeneity. Only egg consumption rose in all countries. Meat consumption increased slightly in Turkey ($M = 3.11$), did not change in China ($M = 2.97$), and fell in Portugal ($M = 2.78$).

The consumption of rice and meat products was higher in China ($M = 3.5$). Portugal's ($M = 3.0$) consumption remained the same, and Turkey's rice and meat products intake declined ($M = 2.4$). These differences were significant in all countries ($t = 271.269$, $p = 0.000$) and in pairwise country comparisons. Portuguese meals typically include meat, rice, and potatoes, which may explain why citizens' consumption patterns remained the same as before the pandemic. This tradition was implemented to provide high levels of carbohydrates to agricultural workers and to segments of the population requiring warmth from food due to poverty. Thus, rice, potatoes, and meat served in one meal has become a cultural value.

The category of bread, legumes, and butter also showed significant differences within all countries ($t = 173.326$, $p = 0.000$) and in pairwise comparisons. On average, the consumption of these items increased most in Portugal ($M = 3.3$). Turkey appeared to maintain a similar level of consumption ($M = 2.96$) while China's intake lessened ($M = 2.6$) during the lockdown. In Portugal, more frequent bread baking at home may have led to this jump.

8. Possible changes in meal habits

Meal habits were also submitted to an EFA to reduce the data dimensionality. As indicated in Table 8, the nine items under consideration were grouped across three components: (1) having meals with

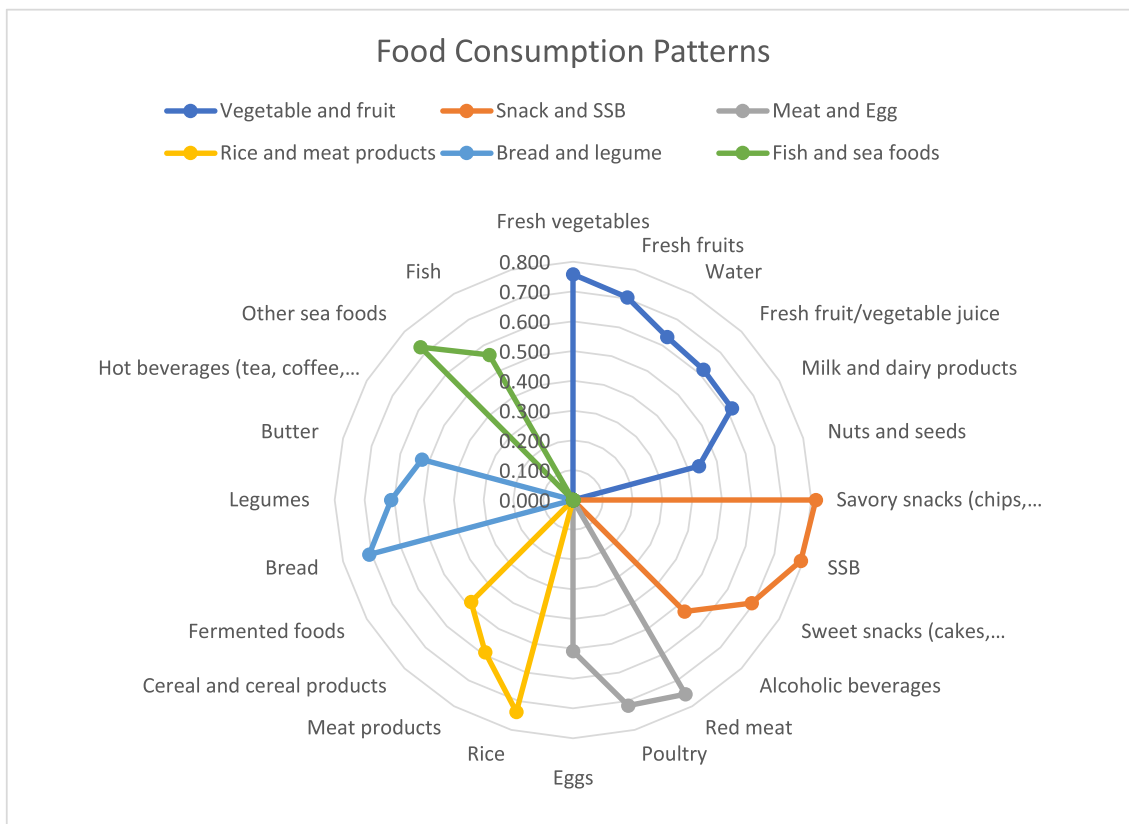


Fig. 3. Food consumption patterns.

Table 5
EFA for Food consumption patterns.

Factor labels	Factor loadings	Mean	Variance explained	Alpha
Vegetables and fruits			15.249	0.755
Fresh vegetables	0.757	3.65		
Fresh fruits	0.704	3.61		
Water	0.632	3.86		
Fresh fruit/vegetable juice	0.619	3.02		
Milk and dairy products	0.616	3.28		
Nuts and seeds	0.438	3.19		
Snacks, SSB and alcohol			12.634	0.757
Salty/fried snacks (chips, crackers etc.)	0.815	2.46		
Sugar sweetened beverages (SSB) (soda, sport drinks, energy drinks etc.)	0.792	2.23		
Sweet snacks (cakes, pastries, sweets, chocolates etc.)	0.692	2.81		
Alcoholic beverages	0.530	2.37		
Meat and eggs			9.422	0.606
Red meat	0.754	2.97		
Poultry	0.715	3.05		
Eggs	0.508	3.63		
Rice and meat products			8.097	0.57
Rice	0.737	3.14		
Meat products	0.591	2.64		
Cereal and cereal products	0.484	2.98		
Bread, legumes and butter			7.214	0.622
Bread	0.709	2.93		
Legumes	0.611	3.20		
Butter	0.525	2.75		
Fish and seafood			6.629	0.684
Seafood	0.725	2.54		
Fish	0.563	3.10		

KMO=0.842 Sig.=<0.0001

family and friends; (2) more meal times; and (3) home-cooked meals. Together, these components explained 74.154% of variance in the data (KMO = 0.730, $p = 0.000$; all reliability coefficients were greater than 0.8).

The likelihood of eating meals with family and friends increased in Portugal ($M = 3.5$), remained the same in Turkey ($M = 3.0$), and declined in China ($M = 2.5$). These differences held across countries, with pairwise comparisons revealing that all country pairs differed ($t = 103.022, p = 0.000$). Such discrepancies were due to the countries' lockdowns and culture. For example, in Portugal, family meals are essentially mandatory, at least on weekends. The amount of time spent on meals also varied ($t = 97.677, p = 0.000$), although Portugal and China demonstrated similar patterns ($t = 4.787, p = 0.844$). The Turkish spent more time on meals ($M = 3.96$), followed by Portugal ($M = 3.4$) and China ($M = 3.4$). Intentions to eat at home differed among countries as well ($t = 65.879, p = 0.000$): Portugal ($M = 3.9$) and China ($M = 3.9$) were again similar ($t = 1.899, p = 0.938$) while Turkish respondents expressed lower intentions to have at-home meals ($M = 3.4$). This difference may have arisen because the restaurants were closed, people feared the virus, individuals were under lockdown or even because they felt the need to save money due to the instability of the business life (Table 7).

The last step of analysis involved a dependent sample test of the distribution of median attitudes before and during the pandemic. A sign test was conducted to understand how attitudes changed situationally within countries. Results revealed slight within-country differences before and during the pandemic. For instance, the Portuguese ate more meals daily ($t = 68, p = 0.000$): 68 of 351 respondents reported having more meals (positive difference), 14 of 351 had fewer (negative difference), and 269 had the same number of meals. In China, the habit of sharing family meals diminished ($t = 72, p = 0.000$): 96 out of 319 respondents ate fewer meals with family whereas 51 ate more. The opposite pattern was observed in Turkey ($t = 109, p = 0.012$), where 109

Table 6
Results of Kruskal-Wallis tests.

Factor labels		Kruskal-Wallis test					Portugal	Turkey	China
		Total N	Test Statistic	df	Asymptotic Sig. (2-sided test)	Observations	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
Food Consumption Patterns	The consumption of vegetables and fruits is the same across the countries	1074	0.937 ^{a,b}	2	0.626	Retain	3.48 (0.55)	3.47 (0.82)	3.50 (0.69)
	The consumption of snack (salty and sweet), SSB and alcohol is the same across the countries	1058	33.698 ^a	2	<0.0001	Reject	2.66 (0.75)	2.44 (0.96)	2.30 (0.78)
	The consumption of meat & eggs is the same across the countries	1091	18.913 ^a	2	<0.0001	Reject	3.24 (0.61)	3.27 (0.89)	3.11 (0.65)
	The consumption of rice & meat products is the same across the countries	1084	271.269 ^a	2	<0.0001	Reject	3.02 (0.62)	2.38 (0.89)	3.45 (0.670)
	The consumption of bread & legumes is the same across the countries	1101	173.326 ^a	2	<0.0001	Reject	3.32 (0.60)	2.96 (0.77)	2.57 (0.68)
	The consumption of fish & sea food is the same across the countries	1101	70.785 ^a	2	<0.0001	Reject	3.16 (0.82)	2.75 (1.03)	2.56 (0.79)
	Meal Habits	Having meals with family and friends is the same across the countries	1064	103.022 ^a	2	<0.0001	Reject	3.46 (1.20)	3.00 (1.24)
	Having more meal time is the same across the countries	1087	97.677 ^a	2	<0.0001	Reject	3.48 (0.70)	3.96 (0.96)	3.39 (0.81)
	Having meals at home is the same across the countries	1106	65.879 ^a	2	<0.0001	Reject	3.93 (0.92)	3.40 (1.11)	3.95 (0.77)

Asymptotic significances are displayed.

The significance level is 0.05.

^a The test statistic is adjusted for ties.

^b Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Table 7
Results of pairwise comparison tests.

Factor Labels		Turkey-Portugal			Turkey-China			Portugal-China		
		Test Statistic	Std. Error	Sig.	Test Statistic	Std. Error	Sig.	Test Statistic	Std. Error	Sig.
Food Consumption Patterns	The consumption of fruits and vegetables is the same across the countries	no differences								
	The consumption of snack (salty and sweet), SSB and alcohol is the same across the countries	92.349	22.584	<0.0001	43.981	22.604	0.052	136.330	24.068	<0.0001
	The consumption of meat & eggs is the same across the countries	29.325	22.561	0.194	98.408	22.841	0.000	69.083	24.323	0.005
	The consumption of rice & meat products is the same across the countries	201.882	22.318	<0.0001	366.801	22.497	0.000	164.919	24.023	<0.0001
	The consumption of bread & legumes is the same across the countries	143.673	22.545	<0.0001	176.410	23.016	0.000	320.083	24.334	<0.0001
	The consumption of fish & sea food is the same across the countries	117.342	22.400	<0.0001	84.478	22.868	0.000	201.820	24.177	<0.0001
	Meal Habits	Having meals with family and friends is the same across the countries	117.983	22.714	<0.0001	128.899	22.611	0.000	246.883	24.337
	Having more meal time is the same across the countries	186.292	22.539	<0.0001	191.079	22.720	0.000	4.787	24.296	0.844
	Having meals at home is the same across the countries	154.909	22.452	<0.0001	156.808	22.978	0.000	1.899	24.266	0.938

Asymptotic significances are displayed. The significance level is 0.050.

^a The test statistic is adjusted for ties.

^b Multiple comparisons are not performed because the overall test does not show significant differences across samples.

of 433 respondents ate more meals with family and 74 ate fewer. Regarding the intention to eat meals alone, differences emerged in Turkey ($t = 56, p = 0.033$) where 82 respondents ate fewer meals individually than before the pandemic. In China ($t = 67, p = 0.003$), the data reflected a slight increase in that 67 of 319 respondents ate more meals alone. These results could be related to national lockdowns (Table 9).

9. Conclusion and implications

The COVID-19 pandemic has radically altered individuals' routines and quality of life. Homes have become a hub for socialization and family gatherings due to mobility restrictions. Even rampant

modernization (e.g., food delivery) has not dethroned some traditional ways of life, especially around food preparation and consumption. For example, individuals in this study reported consuming less processed food and/or frozen food. Because pandemic precautionary measures vary nationally, it is critical to understand how inter-cultural similarities and differences influence possible changes in individuals' eating/food habits from supply and demand perspectives.

First, study findings are elaborated to showcase the theoretical contributions by using Hofstede theory to understand food consumption differences across different countries at a national level. Our overall findings suggest that individuals' level of happiness and perceived quality of life (e.g., in terms of a healthy lifestyle, healthy food, and physical activity) were higher among the Chinese than the Portuguese or

Table 8
Results of EFA analysis for meal habits.

Factor labels	Factor loadings	Mean	Variance explained	Alpha
Family and friends			32.945	0.913
Happier with dining out with my close family	0.869	3.02		
Happier with dining out with my friends/relatives.	0.890	3.07		
Happier to invite my friends/relatives for dining at home	0.870	2.97		
Happier that my friends/relatives do invite me/us for dining at their house.	0.891	2.93		
Meal time			23.503	0.844
Breakfast time at home	0.897	3.62		
Lunch time at home	0.840	3.54		
Dinner time at home	0.862	3.79		
Home meals			17.706	0.854
Stay at home	0.937	3.66		
Eating at home	0.922	3.81		
KMO=0.730 Sig.=< 0.001				

Turkish. This phenomenon can be partially explained by China's position as a high-power distance culture and long-term-oriented society (Hofstede, 1980; Yoon, 2009). Because the Chinese tend to obey governmental regulations, complying with the rules of their "new normal" can lead to a more positive post-COVID situation compared with Portugal and Turkey.

Regarding changes in food consumption patterns, this study identified an increase across cultures in fruit and vegetable intake. These findings suggest that COVID-19 may promote healthy eating, as dietary guidelines of the countries where the study was conducted (CNS, 2016; MOH, 2016; FCNAUP, 2003) promote a higher degree of fruit and vegetable consumption in all three countries. Meat and seafood consumption also shifted due to the pandemic. Our results showed that intake of red meat among Portuguese people decreased. This is in line with the results of Górska et al. (2021) who reported that the respondents from Portugal declared the lower consumption of red meat during pandemic whereas red meat consumption practices remained similar among the Chinese and Turkish during the pandemic. This finding was consistent with another study among adults in Turkey, which showed that the majority of the participants did not change their meat consumption habits (Haskaraca et al., 2021). However, our findings were inconsistent with another study conducted in China reporting a decrease in meat consumption among Chinese adults (Luo et al., 2021). Concerning staple food, it was unsurprising to find that rice consumption was higher in China while bread consumption was higher in Portugal and Turkey. Since cereals can be stored long, many studies reported higher consumption of cereals during pandemic (Górska et al., 2021; Güney and Sangün, 2021; Di Renzo et al., 2020). Moreover, during pandemic a rise in home prepared bread were observed (Bracale

and Vaccaro, 2020; Di Renzo et al., 2020; Eftimov et al., 2020).

Although COVID-19 has altered people's eating habits (Laguna et al., 2020), this study indicates that habits and cultural preferences are difficult to change. People have spent longer at home during the pandemic, yet they appear to be relying on what they are accustomed to eating rather than trying new types of food. This propensity may be explained by the concept of uncertainty avoidance: for instance, because Portugal has a high uncertainty avoidance culture (Ferreira et al., 2013), the Portuguese may generally prefer to continue eating what they ate before the pandemic. Regarding sweets and alcohol, our results show that COVID-19 had compelling impacts, especially on the Chinese. A higher level of alcohol consumption was reported also in many other countries like Poland, Denmark and Italy during pandemic (Skotnicka et al., 2021; Di Renzo et al., 2020; Giacalone et al., 2020; Sidor and Rzymiski, 2020). However, this is not consistent with the earlier findings. While alcohol intake unchanged in Canada (Lamarche et al., 2021), more than half of the respondents declare lower alcohol consumption during confinement (Rodríguez-Pérez et al., 2020).

Furthermore, dining with friends and family only increased in Portugal during the study period—even though family reunions and gatherings are highly valued in countries such as China (Chang, 2010). In addition to fear of the virus, this phenomenon may have arisen because most restaurants were closed in China during the pandemic. Subsequent analysis confirmed this assumption, demonstrating that Chinese individuals' intentions to share meals with family diminished substantially amid the outbreak.

The empirical evidence of this study reinforces the cultural food habits and their diet habits with a special focus on the healthy lifestyle. With the patterns of healthy food consumption and spending more time to cook, this paper suggests that life has changed in all countries and even though the population feels depressed and anxious they accept the new normal and use the time they have now to adopt sustainable and healthy lifestyles. Many studies reported more frequent home cooking during pandemic (Skotnicka et al., 2021; Pfeifer et al., 2021; Rodríguez-Pérez et al., 2020; Sidor and Rzymiski, 2020; Zhang et al., 2020). Moreover, a higher frequency of home cooking was associated with greater adherence to the Mediterranean Diet in Croatia (Pfeifer et al., 2021). Having provided the evidence of positive sights of this unprecedented crisis, the study also presents important cues that need to be taken into account in what concerns the supply and distribution of food as well as helping to reinforce the endeavor of being more sustainable and healthier.

Second, as to the implications for the society, this study focuses on cultural aspects to explain possible changes in food consumption before and during the pandemic. Theoretically, this research highlights the need to understand inter-cultural similarities and differences to satisfy people's needs amid a "new normal." The findings provide further implications for sociologists well as for practitioners engaged in commercial/business activities. For instance, our results can help food delivery operators optimize in-app restaurant recommendations. This study also

Table 9
Sign tests for median distribution within the same country (pre- and post-corona era).

Items	Country	Total N	Test Statistic	Standard Error	df	Asymptotic Sig. (2-sided test)	Observations	Positive differences	Negative differences	Ties
The median of differences between number of daily meals before and now	China	319	41.000	4.213	1.187	0.235	Retain	no differences		
	Portugal	351	68.000	4.528	5.853	<0.0001	Reject	68.00	14.00	269.00
	Turkey	442	97.000	6.964	0.000	1.000	Retain	no differences		
Median of differences between meals taken with all the family in the same table before and now	China	319	51.000	6.062	-3.629	<0.0001	Reject	51.00	96.00	172.00
	Portugal	326	72.000	6.225	-0.803	0.422	Retain	no differences		
	Turkey	433	109.000	6.764	2.513	0.012	Reject	109.00	74.00	250.00
Median of differences between meals taken individually before and now	China	319	60.000	5.568	-0.269	0.788	Retain	no differences		
	Portugal	308	31.000	4.472	-1.901	0.057	Retain	no differences		
	Turkey	423	56.000	5.874	-2.128	0.033	Reject	56.00	82.00	285.00
Median of differences between meals taken alone before and now	China	319	67.000	5.074	2.956	0.003	Reject	67.00	36.00	216.00
	Portugal	190	18.000	3.000	0.000	1.000	Retain	no differences		
	Turkey	381	36.000	4.359	-0.344	0.731	Retain	no differences		

provides valuable insight for restaurateurs in terms of designing menus to suit target customers' characteristics.

However, this study is not without limitations. First, our work only assessed habit changes in people from three countries. Although the sample contained a heterogeneous group based on respondents' geographical distribution across each country, one limitation of this study is that the survey was only distributed to people with access to a computer or smartphone. Respondents were also limited to those living in urban cities who were educated; residents of rural areas and those under 18 years old were excluded. Moreover, the three chosen countries have different population sizes, which warrants caution: China is home to almost 1.5 billion people while Portugal has about 10 million. In terms of China's population, attention should be paid to regional differences in national cuisine and food choices. As a result, the findings cannot be generalized to other populations. Future studies are suggested to extend this research on a more global level. Moreover, because changes in food consumption preferences occur through a long-term process, we recommend that longitudinal studies be conducted to more thoroughly understand how the pandemic's impacts apply to individuals' broader life contexts.

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Authors' contributions

AK and MK designed research; all authors collected the data; AC analyzed data; AK, MK, AEÖ, JL and AC wrote and reviewed the paper. All authors read and approved the final manuscript.

Implications for gastronomy

- This paper aims to investigate the pandemic's role in possible changes to people's food consumption and meal habits.
- The sample includes those citizens in three countries, namely China, Portugal, and Turkey.
- The sample includes individuals as well as households with at least two people living together.
- Coronavirus has played a strong part in altering households' food consumption and meal habits.
- The pandemic has particularly led to greater consumption of fresh fruits and vegetables and spending more time eating meals at home.
- Portugal appears to be consuming more seafood, bread, and butter.
- China features higher consumption of rice and meat products.
- Turkey is consuming more meat and eggs.

Ethical Statement

Hereby, we, Asker Kartari, Asli Ozen, Antonia Correia, Jun Wen, & Metin Kozak, consciously assure that for the manuscript "Impacts of COVID-19 on changing patterns of household food consumption:

An intercultural study of three countries" the following is fulfilled:

- 1) This material is the authors' own original work, which has not been previously published elsewhere.
- 2) The paper is not currently being considered for publication elsewhere.
- 3) This study followed human ethics and consent has been obtained before collecting data.
- 3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
- 4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
- 5) The results are appropriately placed in the context of prior and existing research.

- 6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
- 7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

I agree with the above statements and declare that this submission follows the policies of Solid State Ionics as outlined in the Guide for Authors and in the Ethical Statement.

Declaration of competing interest

All authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijgfs.2021.100420>.

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