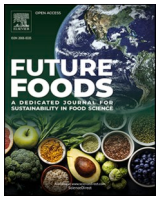
Future Foods 10 (2024) 100491

Contents lists available at ScienceDirect

Future Foods

journal homepage: www.elsevier.com/locate/fufo



Perception of dehydrated products by Mexican consumers

Blanca Isabel Sánchez-Toledano [a,*], Mercedes Borja-Bravo [b], Jorge A. Zegbe [b,*], Silvia Xóchitl-Almeraya Quintero [c]

[a] Campo Experimental Zacatecas, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, km 24.5 Carretera Zacatecas-Fresnillo, CP 9500, Calera de V. R., Zacatecas, México
[b] Campo Experimental Pabellón, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, km 32.5 Carretera Aguas-calientes-Zacatecas, CP 20668, Pabellón de Arteaga, Aguascalientes, México
[c] Campus Montecillos, Colegio de Postgraduados, km 36.5 Carretera México – Texcoco, CP 56230, Montecillo, Texcoco, Estado de México, México

ARTICLE INFO

Keywords:
Food
Dehydration
Consumption factors
Marketing

ABSTRACT

Food loss and waste are well documented in Mexico and worldwide. Food insecurity is particularly common in developing countries. Regardless of available drying technologies, primary product dehydration can be an alternative to minimize the loss of highly perishable fresh food products (e.g., fruit and vegetables) and contribute to food security programs, mainly in rural regions where food conservation infrastructures are scarce. Through an online survey from a calculated sample of 885 participants, the Mexican consumers' perception of plant-based dehydrated products mainly was studied. Overall, the primary reasons for consuming dehydrated products were: practicality (22.2 %), flavor (20.4 %), nutritional value (18.0 %), and health benefits (14.0 %). Consumers were also interested in products made from fruit powders. In contrast, 21.1 % of non-consumers found dehydrated products hard to obtain, while 15.9 % were unfamiliar with these products. In conclusion, this study found that the major factors limiting the consumption of dehydrated foods are their low availability, a lack of global knowledge regarding these products, and misconceptions about their cost. This research explored only the consumption of plant-based dehydrated products in Mexico. Therefore, the next step must include animal-based dehydrated products and the socioeconomic stratification of the population.

1. Introduction

The environmental, economic, and social consequences of food loss and waste have generated global concern (Santagata et al., 2021). Correcting inefficient use of natural resources such as water, energy, and agricultural lands requires implementing initiatives that reverse this situation without compromising present and future food security. This is understood as the global capacity to provide nutritious, healthy food in sufficient quantity for a growing population (Porat et al., 2018).

Among food items subject to loss and waste, fruits and vegetables rank second, globally. FAO (2019) noted that between 45 % and 55 % of fruits and vegetables are lost or wasted globally along the food supply chain (Lipinski et al., 2013). The causes include factors such as climate change, ripening aspects, harvesting, product quality, transportation and conservation, and changes in consumer acceptance and preferences (Mejia et al., 2021).

In general, developed and developing countries contribute to food loss and waste for different reasons. Developing countries lose food at higher rates during agricultural production and harvest, mainly due to poor quality of fresh products measured as color, size, shape, and texture, in addition to a lack of the infrastructure needed for product preservation. In developed countries, there are losses during trade, at home, and during consumption. In the United States of America, Great Britain, and Spain, families waste around 35 % of purchased food. There is a trend, in almost all countries, to waste $>$ 40 % of tubers, roots, fruits, and vegetables and 30 % of cereals and fish (World Bank, 2017).

In Mexico, annually, $>$ 20.4 million t of food are lost and wasted; this represents 34 % of Mexican agricultural production (World Bank, 2017). For instance, avocado (54.0 %), tomato (28.8 %), onion (32.0 %), melon (41.0 %), guavas (57.7 %), mango (54.5 %), and apple (49.0 %) production have particularly high rates of loss or waste. However, up to 40 % of fruits and vegetables are also estimated to be lost because of their physical appearance (De Hooge et al., 2018). If such high percentages of food produced were not lost or discarded, this could help partially feed

* Corresponding authors.
E-mail addresses: sanchez.blanca@inifap.gob.mx (B.I. Sánchez-Toledano), borja.mercedes@inifap.gob.mx (M. Borja-Bravo), zegbe.jorge@inifap.gob.mx (J.A. Zegbe), xalmeraya@colpos.com (S.X.-A. Quintero).

https://doi.org/10.1016/j.fufo.2024.100491
Received 5 April 2024; Received in revised form 10 October 2024; Accepted 2 November 2024
Available online 3 November 2024

7.4 million Mexicans in moderate to extreme poverty (Secretary of Welfare, 2022). An alternative to the loss and waste of fresh products could be conserving fruits and vegetables through water removal from their tissues by applying an energy source (Sagar et al., 2010). Therefore, based on the energy source, drying technologies are classified as those using non-renewable (e.g., fuel oil, diesel, LP gas, natural gas, wood, coal, etc.) and renewable energy sources dryers (e.g., solar, geothermal, and biomass) (Ortiz-Rodríguez et al., 2022). These methods not only minimize the loss and waste of fresh products but also maintain, to some extent, a wide diversity of functional and high-quality products (Martins et al., 2017). Particularly, solar energy (sun and solar drying food techniques) is considered an eco-friendly alternative for diverse applications such as power generation, industrial heating, desalination, domestic cooking, and food dehydration (Prabhu et al., 2023). So, food dehydration (solar drying) extends also storability, and diminishes both the mass and packaging requirements of fruits (e.g., apples, apricots, bananas, cantaloupe, peaches, pears, plums, strawberries, etc.) and vegetables (e.g., carrots, celery, corn, green beans, garlic, onion, potatoes, and tomatoes, etc.,) (Prabhu et al., 2023, Johansen et al., 2011, Hii et al., 2021), turning them into products with great export potential (Global Industry Analysts, 2022). Additionally, compared to non-renewable energy sources methods, clean energy sources have a positive impact on social and economic sectors as well as environmental health (Jaiswal et al, 2022). However, depending on the energy sources and infrastructure required, their implementations can be either expensive or not. For example, rustic solar dehydrators are easy to transport and build in rural regions of Mexico (Figueroa-González et al., 2022) compared with other drying technologies (e.g., non-renewable, thermal and electrical energies, heat supply, etc.) (Ekechukwu and Norton, 1999).

Natarajan et al. (2022) predicted that world consumption of dehydrated fruits would reach 4 million t by 2020. Furthermore, the United States would become the main importer and consumer of dehydrated products (e.g., pineapple, mango, peach, golden berries, and strawberries, among others), representing 12.9 % of total imports. Subsequently, Germany (8.8 %), Russia (5.8 %), the Netherlands (5.6 %), and the United Kingdom (5.4 %) would be also among the major importers. Moreover, the United Kingdom (18.8 %), followed by Kazakhstan (11.7 %), Germany (9.8 %), France (8.1 %), and Belgium (5.5 %) would consume the most dehydrated fruit mixtures (two or more fruits). Meanwhile, in northwestern Europe, the demand for pure and organic products would continue increasing, mainly for dehydrated fruit items, due to little or no additives added during their elaboration (Torres-León and Aguilar, 2022). In Mexico, the most-imported dehydrated products were Chilean raisins (52.6 % of total raisins imported) followed by peaches and rose hips from the United States with a 65.6 % market share in 2020 (FAOSTAT, 2020).

Food choice is a complex decision due to multifactorial aspects associated with the product *per se* (extrinsic and intrinsic attributes), consumption environment, and consumer (age, attitudes, knowledge, beliefs, and motivation) (Kaya, 2016). Food choice motivation is another multifactorial aspect that must be considered (e.g., consumers' age, sensory attributes, obesity, health concerns, etc.) (Kovács et al., 2022).

To increase the consumption of dried products, it is necessary to understand consumers' food choices. For instance, it is important to know when and why these products are consumed, and so, to promote their consumption. As for dehydrated fruits and vegetables, the main attributes valued by consumers are the taste, aroma, color, appearance, texture, chewiness, and healthiness of the food (Encalada-Rojas & Sosa-León, 2024; Andaluz, 2022; López et al., 2019; García-Soto et al., 2014). Unfortunately, no information that analyzes the acceptance, preferences, and purchasing behavior of consumers of dehydrated products in Mexico, except of those analyzing only one product in a specific region (López et al., 2019a; Guazi, et al., 2019; Pérez-González et al., 2023). Hence, an academic article about how Mexican consumers perceive dehydrated produce is necessary for its implications on public health until food industry innovation. Furthermore, it contributes to cultural and sociological understanding of how food is perceived and consumed within specific contexts such as the Mexican. So, this study examined Mexican consumers' perception of mainly plant-based dehydrated products. Therefore, it is expected this research will contribute to the knowledge of the preferences and repeated purchasing behavior of the final consumers and reorient the manufacturing and marketing of these products not only in Mexico but also in other countries with lower dehydrated product consumption.

2. Materials and methods

2.1. Survey questionnaire and information sources

The methodology used in this investigation started with a face-to-face pilot survey to identify the most relevant variables and categories related to habits and consumption of dehydrated products ($n = 15$). This test allowed keeping 15 questions out of 20 initially included in the questionnaire. Once the questionnaire was improved in all items, we decided to apply it online nationwide because of the SARS-COV-2 pandemic. To ensure the survey was fully completed, promptly, and pleasantly, a minimum response time of three seconds per question was set to prevent participants from rushing through the questions. The questionnaire consists of four parts: the first part performs the selection function. After reading about the concept of each dehydrated product and looking at several pictures of products marked as "dehydrated products". Interviewees had to answer whether or not they had consumed dehydrated products. The evaluated dehydrated products are described in question four of the questionnaire (see supplementary material). The last also contributed to the questionnaire being answered quickly and pleasantly.

The second section of the survey explored information from respondents who did not consume dry products and were asked if they would like to consume them in the future. The questions to non-consumers are noted in the Non-Consumer Questionnaire (question two) and Participants' sociodemographic information section (question ten) on the supplementary material. These participants represent a potential market for dehydrated products, but it is imperative to know the barriers that limit the consumption of this type of product.

In the third section, the dehydrated products preferred by consumers were identified (starting from number four on the questionnaire), the reasons for their consumption, how frequently they are consumed, where they are purchased, why they are purchased in a specific place, and aspects that the companies or producers that produce the products must have dehydrated products.

In the fourth section, socioeconomic information was collected from all respondents. This section included questions about gender, age, educational level, monthly disposable income, profession, and other information. The complete survey is presented as supplementary material.

Information was collected through a structured questionnaire of closed-ended questions with dichotomous and multiple responses (Schnettler et al., 2012). The questionnaire was elaborated following Malhotra's classification (2008) (Malhotra, 2008). Before data collection, pilot tests were conducted to ensure question clarity and avoid interview mistakes ($n = 15$). To validate the instrument, the internal consistency analysis was performed employing Cronbach's alpha. The scales had a coefficient of $\alpha = 0.82$, which means that the internal consistency was good and eliminating items was unnecessary (Table 1).

The design and implementation of the questionnaire were carried out using the Google Apps server through Drive®. First, the name of the questionnaire was stated followed by the questions with their respective answer choices. Subsequently, a URL link was generated to log on to the questionnaire electronically which was spread out among social networks. The information collected was tabulated in Excel 2016

Table 1
Sociodemographic characteristics.

Population sample (Years old)	(%)	Official Mexican population (Years old)	(%)
Age			
20-24	16.15	20-24	14.67
25-29	10.96	25-29	13.03
30-34	13.44	30-34	12.56
35-39	15.36	35-39	12.30
40-44	15.81	40-44	10.39
45-49	8.36	45-49	8.79
50-54	5.42	50-54	7.51
55-59	6.44	55-59	5.77
60-64	6.10	60-64s	4.62
65-69	1.46	65-69	3.43
70-74	0.33	70-74	2.78
Gender			
Female	62.0	Female	51.2
Male	38.0	Male	48.8
Academic achievement			
Elementary school	0.3	Elementary school	28.15
High school	3.5	High school	23.2
High school	12.2	High school	18.9
Undergraduate	47.6	Undergraduate	13.1
Graduate	36.3	Graduate	8.0

*Source: own elaboration with data obtained from the sample and INEGI statistics in 2021

spreadsheets for statistical analysis.

2.2. Sample size

The sample size was calculated using official government data on the number of people over 20 years old (67′ 397,224 inhabitants) (INEGI, 2021). The sample was calculated through finite population sampling with a significance level of 1 % ($Z = 2.58$) and a maximum error level of 4.3 % (Cochran et al., 1980). The calculation suggested a sample of 885 individuals from around Mexico. This was done between July and September 2021. The questionnaire applied was validated and approved by a social science ethics committee (protocol code 2021-1 dated Jun 2021). It was conducted according to the principles given in the Declaration of Helsinki, with particular care to protect personal information as required by Mexican regulations.

2.3. Data analysis

Data analysis was conducted in two stages. As the study identified consumers and non-consumers, a t-test ($p \leq 0.05$) was performed among segments to distinguish statistically between these two groups (Hair et al., 1998). Finally, a correspondence analysis (CA) was applied to the surveyed group that consumed dehydrated products to determine a potential simultaneous association (Hair et al., 1998). Product, frequency of consumption, place of purchase, and reason for purchase of the dehydrated products were the variables used in the analysis. Data was analyzed using Windows (IBM Corporation) SPSS 27.0 and the statistical analysis system [SAS Institute ver. 9.4, 2016, Cary, NC, USA).

3. Results and discussion

3.1. Sociodemographic characterization

The interviewed sample was made up of 38 % men and 62 % women. Most were between 20 and 24 years old (16.5 %), followed by those between 40 and 44 years old (15.8 %). This was consistent with official population statistics (INEGI, 2021) (Table 1). However, the sample included a greater proportion of individuals with a higher academic degree than in the official population statistics (Table 1). This may have occurred mostly due to the sampling method (online survey), which is only used by the social sector that has access (Mancilla, 2018). In Mexico, consumers who answer online surveys through a mobile device or computer tend to have either a medium-upper or upper educational level and/or a medium-high or high socioeconomic status (Díaz de Rada and Domínguez, 2019.) (Tables 1 and 2). This consumer block comprises a part of the social sector known as the knowledgeable society, characterized by making outstanding use of information through new available technologies. The use of this technology goes beyond face-to-face communication, resulting in new methods of learning and researching (Martín et al., 2021).

3.2. Segmentation of people surveyed about dehydrated products in Mexico

After collecting the questionnaires, it was noticed that 234 out of 885 participants (≈ 26.4 %) had not consumed dehydrated products, while 73.6 % of the participants had consumed dehydrated products at some time (651 individuals). Thus, except for gender (sex), the remaining segmentation variables were different between consumers and non-consumers (Table 2). The consumers of dehydrated products performed their food shopping (purchase places) at supermarket, their ages were between 35 and 39 years old, and they were professionals or service providers with an undergraduate academic degree and monthly incomes between $10,001 and 15,000 MXN. Consumers with higher education pay more attention to nutritional properties and environmental care (e.g., fresh products conventionally dehydrated or solar dehydrated products) from which the product comes. For this reason, they observe the nutritional labels (Grunert and Wills, 2007). The nutritional label of the food product specifically the caloric, fat, and carbohydrate value, is important in choosing and purchasing a product (Silva et al., 2022). In contrast, non-consumers of dehydrated products were younger, with lower academic achievement and monthly income ($5,001 to $ 10,000 MXN).

3.3. Segments description based on consumption

3.3.1. Consumers of dehydrated products

The consumer group stated that their primary reasons for consuming these kinds of products were their easy preparation and versatility since they can be consumed as a snack, added to salads, soups, stews, yogurt, or pastries (22.0 %), flavor (19.0 %), nutritional value (18.0 %), and health benefits (14.0 %) (Fig. 1). These percentages are associated with consumers being more informed about these products as key to purchase intention, where product labeling is also an important key (Chang and Chen, 2022). In contrast, other studies on dehydrated products concluded that appearance was the most influential sensory attribute, which is directly related to product color. This has been explained because consumers are receptive to striking aspects, usually based on visual characteristics, as a criterion of product quality (Ramirez and Castro, 2014). A positive consumer attitude toward acquiring nutritional and functional food products also influences purchasing decisions (Shepherd et al., 2005). Thus, the consumption of healthy products creates the intention of repeated purchases (Fayolle et al., 2014; Naughton et al., 2015; Ham et al., 2018). Attributes indirectly related to

Table 2
Key variables between groups.

Segments	Consumers	Non-consumers
Purchase places	Supermarket[a]	Street market[b]
Sex	Women[a]	Women[a]
Activity	Professionals/service providers[a]	Administrative[b]
Age	35 to 39-year-old[a]	20 to 24-year-old[b]
Academic degree	Undergraduate[a]	High School[b]
Monthly income	$10,001-15,000[a]	$5,001-10,000[b]

[a,b] By segment, different lowercase letters indicate statistical differences between groups at 95 %

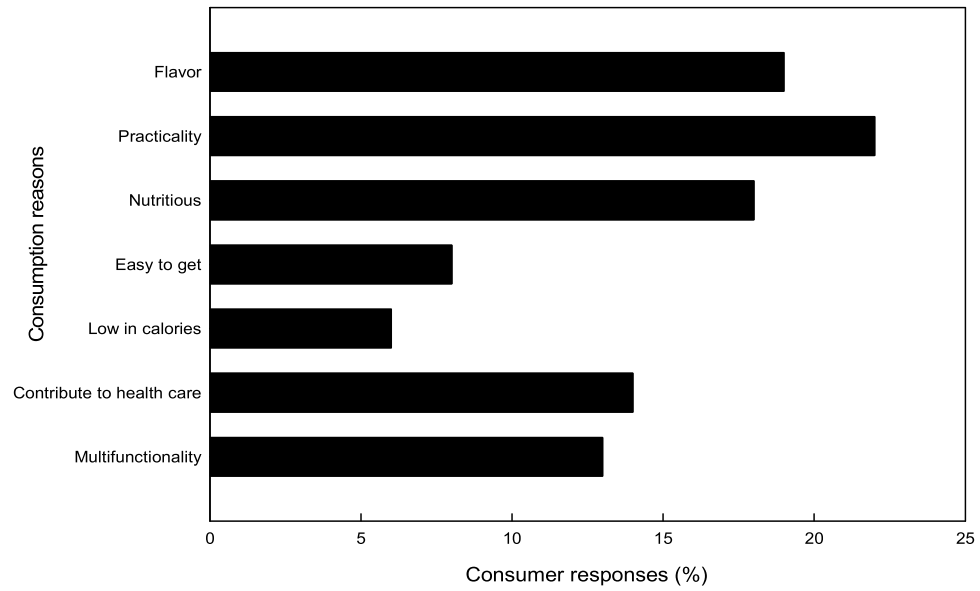


Fig. 1. Reasons for consuming dehydrated products.

the sensory aspect of the food are increasingly important, such as the absence of food additives, preservatives and residues, nutritional value, and cultural beliefs and attitudes that are developing around the consumption of certain foods, an aspect that is constantly changing according to megatrends (Parra and Saavedra, 2013).

The consumer group pointed out that they would consume, for instance, fruit powders (16.0 %), healthy snacks (14.0 %), nutritious soups (13.0 %), dehydrated sauces (12 %), and energy powders (11.0 %). In contrast, the lowest percentages were reported for cornflakes, seafood, punches, teas and tisane, jam, and meat (Fig. 2). The information was obtained through an online survey and responded to by mature consumers (ages between 30 and 44 years) with the highest academic achievements (84 %). Therefore, the results suggest that this group of consumers is loaded toward more healthy food and lower animal protein and high-calorie food. This last assertion could be supported, in part, by Lonnie et al. (2018), who consider that as people age, they look for sustainable sources of protein rather than those from animals. Therefore, as countries develop, their food systems become more efficient at acquiring healthy and low-cost food in parallel (Soares et al., 2020).

In less developed countries, low-income populations also live in poor food systems. In the latter countries, nutritional products such as eggs, milk, fruits, and vegetables are often expensive and inaccessible. The resulting orientation is toward basic diets consisting of foods with lower nutritional value such as cereals, pasta, and bread. In addition, trading fresh food becomes difficult due to its perishable nature (Riici et al., 2020). Processed foods could have an advantage in consumer acceptance and preference, particularly for dehydrated products. Thoughtful and rational decisions may appear, but many food choices are habitual, automatic, and governed by social and physical environmental cues. Additionally, food choices are driven by larger social forces such as globalization, well-being, and urbanization (Riici et al., 2020).

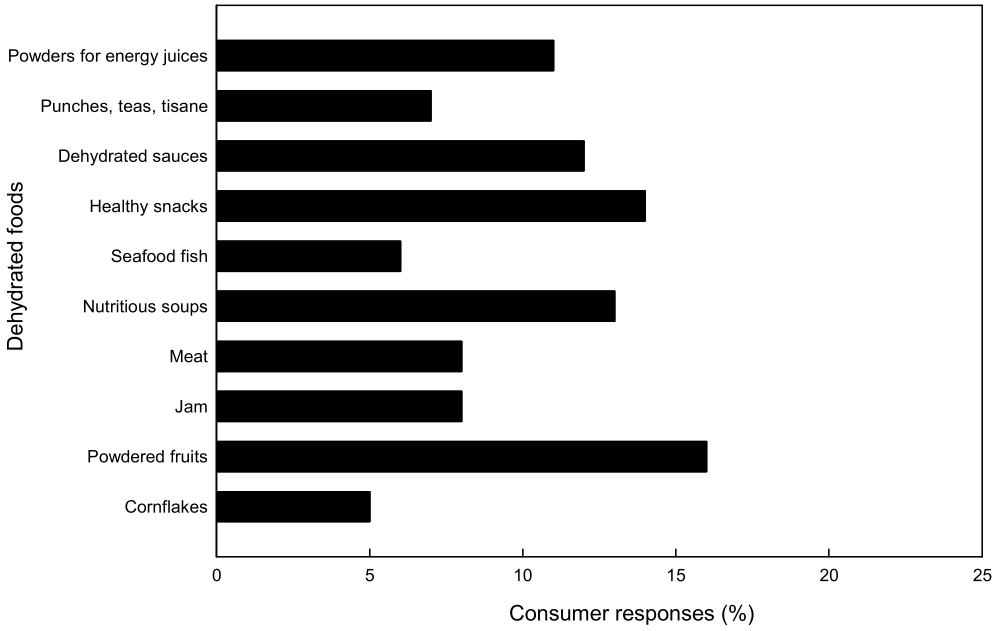


Fig. 2. Dehydrated products preferred by consumers.

The interest in the beneficial aspects of dehydrated food consumption on human health has been endorsed by epidemiologic studies that relate the frequent consumption of dried fruit with the risk reduction of cardiovascular diseases (Fraser et al., 1992; Sabaté, 1999). On the other hand, it has been proven that consumption of dehydrated products is an easy measure to prevent diseases that cause the highest mortality and morbidity rates in the Western world (Krauss et al., 2000), thus dried fruit is highly nutritious because of how simply it provides a wide range of beneficial substances (minerals, fiber, vitamins, etc.). Nevertheless, some highly energetic dehydrated foods containing high fat levels were avoided for years as it was believed that their consumption led to weight gain. However, when participants consumed dried fruits as a diet supplement, they did not gain mass or their mass did not experience changes over time (McManus et al., 2001).

Several studies highlight the nutritional and functional advantages of dehydrated products. Dried fruits are healthier alternatives than popular snacks high in either salt or sugar (Morais et al., 2018). Due to their preparation process, many natural compounds are concentrated, especially sugars and starches, minerals, antioxidants, and fiber, which are associated with high nutritional values, energy, and sensory appeal (Jeszka-skowron et al., 2017). A healthy snack should be prepared with natural products such as fruit (73 %), quinoa (55 %), nut oil (almond, walnuts, cashew, hazelnuts 47 %), and *aloe vera* (41 %) (Tylewicz et al., 2020). Thus, a healthy snack can be defined as one containing many nutritional and functional ingredients that provide human health benefits. This creates a window of opportunity to reduce food loss and waste by dehydrating (using solar energy technologies) those fresh products that fetch low prices or are undersized to be commercialized. Depending on the drying technology used, functional properties for human health maintenance may be conserved, as documented in tomato slices (Herrera et al., 2023). In developing countries, agriculture is predominantly practiced in remote rural areas with expensive conventional technologies. Here, the implementation of renewable energy technologies for sustainable agriculture and dried product elaboration is urgent. Lamidi et al. (2019) mentioned that solar dryers play a paramount role in the sustainable drying of primary farm products to preserve food and market them in both rural and urban locations.

Consumers mentioned that companies or producers dedicated to dehydrated products must improve certain market aspects such as market availability (19 %), price (18 %), quality (15 %), product distribution (12 %), packing (7 %), product (5 %), and over labeling (3 %) (Fig. 3). The questionnaire was completed during the SARS-COV-2 pandemic when many dehydrated and non-dehydrated food products were in short supply. Therefore, these responses were probably affected by the prevailing health situation when most consumers were online looking for either ready-to-cook or ready-to-consume dried and fresh products. Therefore, food choice could be affected by the consumption context (pandemic situation), the consumer (e.g., attitudes, beliefs, knowledge), and the enhancement of dried product issues (Fig. 4) (Kovács et al., 2022; Sánchez-Toledano et al., 2021). Nevertheless, better distribution would particularly enhance market opportunities for selling dehydrated products. Competitiveness is linked to understanding the relationship between products and consumers (Ripoll et al., 2018). It is very important to have a product catalog for any product or commercial brand. Dehydrated products' availability and accessibility are determining factors for their repeated purchase (Sun and Liang, 2020). In addition to the product, consumers also consider its presentation, price, place, promotion, and even the market strategies used by marketers. The purchase decision process is a long path that begins with a wide range of products and ends at the moment which the customer decides to purchase a particular product, convinced that its attributes satisfy their requirements (Mercado et al., 2019).

To find out and display the association between the categories studied here, the correspondence analysis (CA) was used. The CA output rejected the null hypothesis ($\chi^2 = 1252.9; p < 0.0001$) between purchase frequency and dehydrated products. This was explained by the first two dimensions, which collectively accounted for 92 % of the total inertia (Fig. 5). First, dried meats and salts seemed to be associated with purchases every six months, while supplements and flours were associated with annual purchase frequencies (Quadrant I). Next, dried fruit consumption was associated with monthly shopping frequencies (Quadrant II); while seed consumption was associated with weekday consumption (Quadrant III). Finally, the consumption of dehydrated herbs was associated with daily consumption frequencies (Quadrant IV). In Mexico, there is a great diversity of culinary preparations that include herbs to enhance flavor. Purchase frequency increases if a positive relationship exists between information quality, perceived usefulness, and significant trust relationships with the customer (Kang and Namkung, 2019). In contrast, dehydrated vegetables, chilies, teas, and dried berries had no association or did not follow a purchase frequency pattern. This became

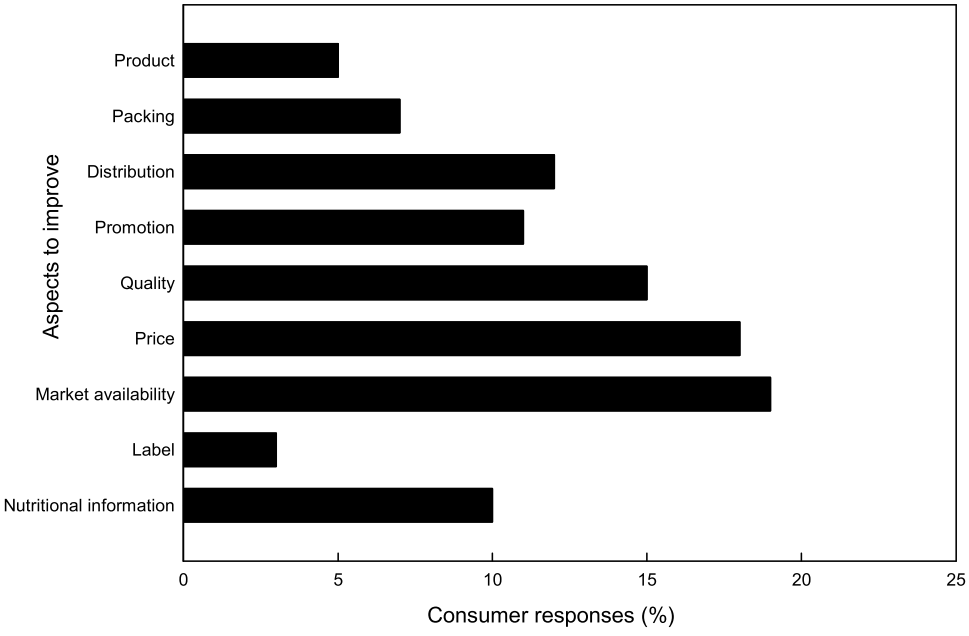


Fig. 3. Aspects that must be improved by companies or producers that produce dehydrated products.

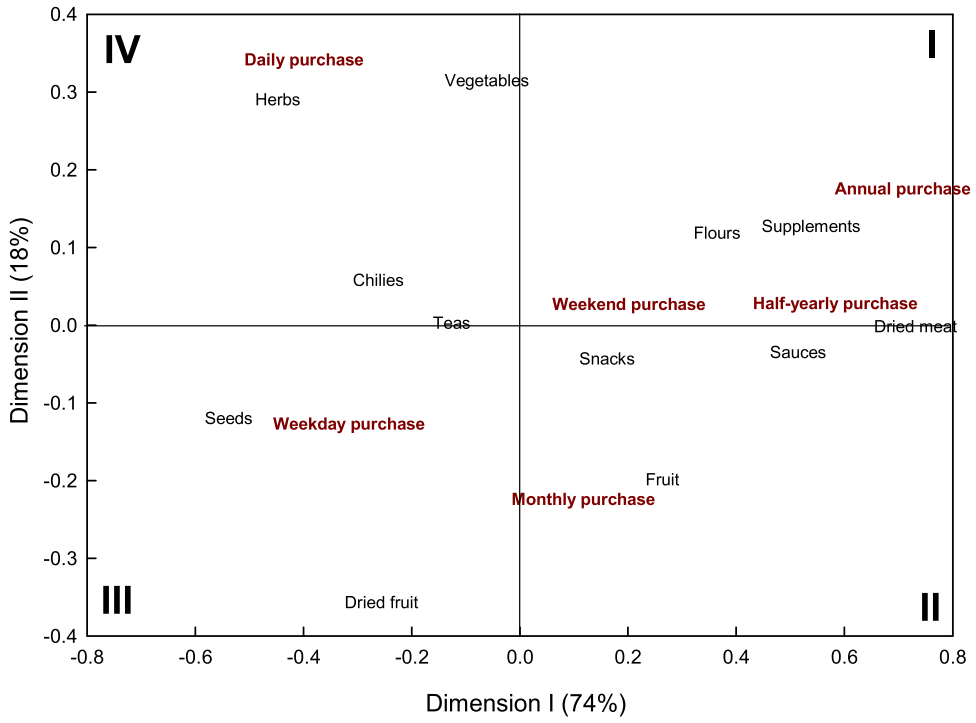


Fig. 4. Association between purchasing frequencies and dehydrated products.

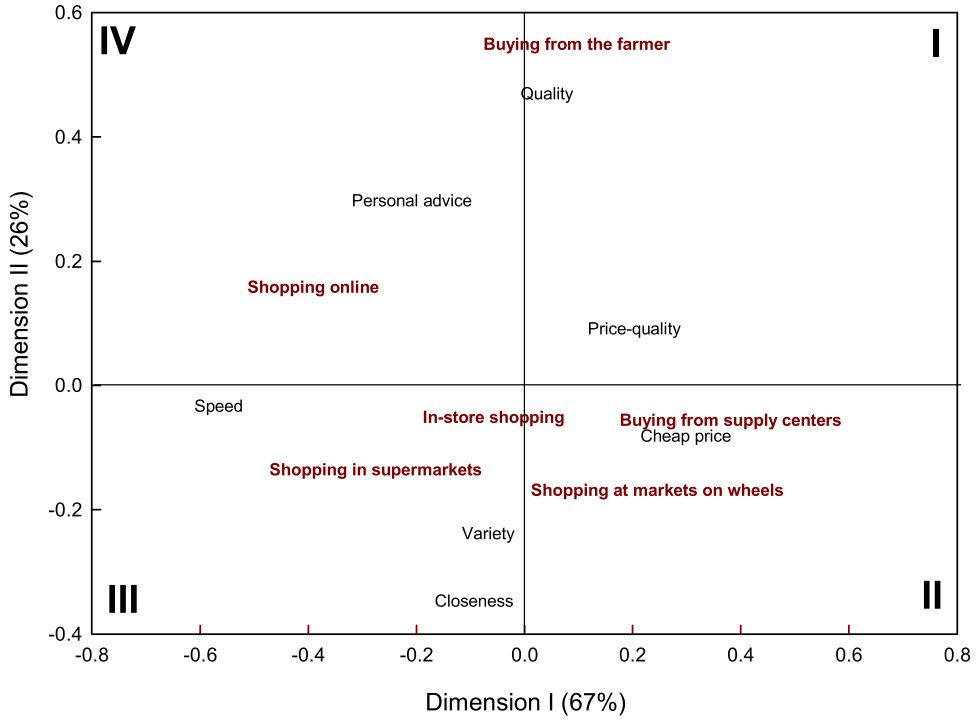


Fig. 5. Relationship between places and reasons for purchasing dehydrated products.

evident as their position in either dimension contributed little to the total inertia (Fig. 4). This is because, in Mexico, there is a wide variety of vegetables and fruits most of the year. These seasonal fruits and vegetables are cheaper, which is why Mexican consumers buy them fresh. However, demand for non-perishable food products in Mexico, especially dehydrated products, increased during the SARS-COV-2 pandemic. This was primarily due to consumer stockpiling during the pandemic, caused by a prolonged lockdown during which consumers avoided public areas to protect themselves (Butu et al., 2020). Although the pandemic has been declared over, this trend continues because of the extended shelf life of dehydrated products, which can be purchased in large quantities to ease hectic work schedules, rather than fresh food products, which require frequent purchases in smaller quantities and which have greater volumes and storage requirements.

The CA rejected the null hypothesis ($\chi^2 = 920.8$; $p < 0.0001$) between place and purchase reason. This association was explained by the

first two dimensions, collectively accounting for 93 % of the total inertia (Fig. 5). This suggests that consumers prefer making purchases directly from growers, as they perceive a higher product quality (Quadrant I). A study with Romanian consumers found that 88 % of respondents had stopped buying vegetables directly from growers before the SARS-COV-2 pandemic (Butu et al., 2020). However, after the pandemic, the percentage of consumers buying vegetables directly from growers increased by 60 %. The latter had the great advantage that the virus' dissemination and dispersion negatively influenced the perishables available in larger markets and that consumers avoided supermarkets to evade contact with possibly virus-infected other buyers where social distancing was difficult or impossible.

Consumers of dehydrated products made their purchases at bulk markets and open-air markets due to their relatively lower prices (Quadrant II). Those low-income consumers spent three-quarters of their incomes on basic foods, limiting their purchase of high-priced food options (Cordero-Ahiman et al., 2018). Thus, people who opted for low-cost foods with high energy density limited their acquisition of other healthy foods due to their high cost. This might explain the high consumption of sugary drinks and non-essential energy-rich foods which accounted for 26 % of the total energy intake in Mexico (Aburto et al., 2016).

In contrast, consumers who tended to purchase products in traditional stores and supermarkets considered that these places were conveniently located and offered a greater product diversity for their regular purchases (Quadrant III). In contrast, online purchases seem to be associated with personalized shopping (Quadrant IV). The latter may have been motivated by the SARS-COV-2 pandemic and, thus, used to benefit human health for consumers (Fig. 6). There is a new way of buying online called personal shopper, which is helping companies to focus on the consumer and their needs, by giving them a unique space so they can resolve all their doubts regarding products and services, or recommend other alternatives, as a kind of remote advisor. Online consumers are active buyers driven by the desire to socialize (Allred et al., 2006). In general, this consumer segment is young, well-educated, more technologically familiar, and likes to minimize risk; they are consumers who invest considerable amounts of time in computers. However, uncertainty about product quality is the main concern among buyers of online purchases (Kanani and Buvik, 2018). However, the speed of purchases was not associated with any place of purchase (Quadrant II).

3.3.2. *Non-consumers of dehydrated products*

The non-consumer group indicated that they do not purchase dehydrated products because they prefer fresh products (25.0 %), dehydrated products are difficult to get (22.0 %), they are unaware of dehydrated products (16.0 %), and high prices (16.0 %) (Fig. 6). Mexican consumers are accustomed to consuming fresh fruits and vegetables since Mexico's climatic advantages allow them to have a wide variety of them throughout the year. According to Arvola et al. (2007), a major barrier to eating dehydrated products is that consumers associate these food options with bad taste and a less pleasant dining experience. Along the same lines, Crofton and Scannell (2020) concluded that the next important step for manufacturers is to strengthen the link between hedonic and healthy dimensions by using flavor and texture to create healthy and tasty products. Lack of knowledge regarding these products, such as the production process, adds to consumer indecision. This can lead to consumers developing an attitude of distrust (López et al., 2019). However, publications on the human health benefits and production processes associated with dehydrated products might change consumer perspectives and preferences.

Another point to keep in mind is market segmentation. Svisco et al. (2019) conducted a study of ultra-processed snacks, a type of food whose consumption is increasing worldwide with detrimental implications for human health. Their research characterized options, consumption, and flavor preferences in teenagers who were offered apple snacks that varied throughout a continuous processing level (unprocessed, minimally processed, processed, and ultra-processed). These authors concluded that processed and ultra-processed foods are highly appealing to teenagers. This could lead to teenagers making poor health decisions and starting an excessive consumption of said products.

Among the non-consumer group, 50.4 % of them would like to consume dehydrated products, 41.5 % would consider purchasing them, and 8.1 % showed no interest in these products. To persuade non-consumers, it is suggested to establish a communication strategy highlighting the nutritional and functional benefits of dehydrated products to humans. Offering product samples is a way to invite potential customers to make a purchase, which is part of introducing and positioning such products in the market. In addition, socially responsible strategies can be developed such as social programs in vulnerable sectors to promote dehydrated products as a means to reduce food insecurity (Díaz-Méndez et al., 2018). Another option is fair trading, which is a way of trade that seeks to promote dialogue, respect, and transparency between socially responsible growers and consumers. Fair trading focuses

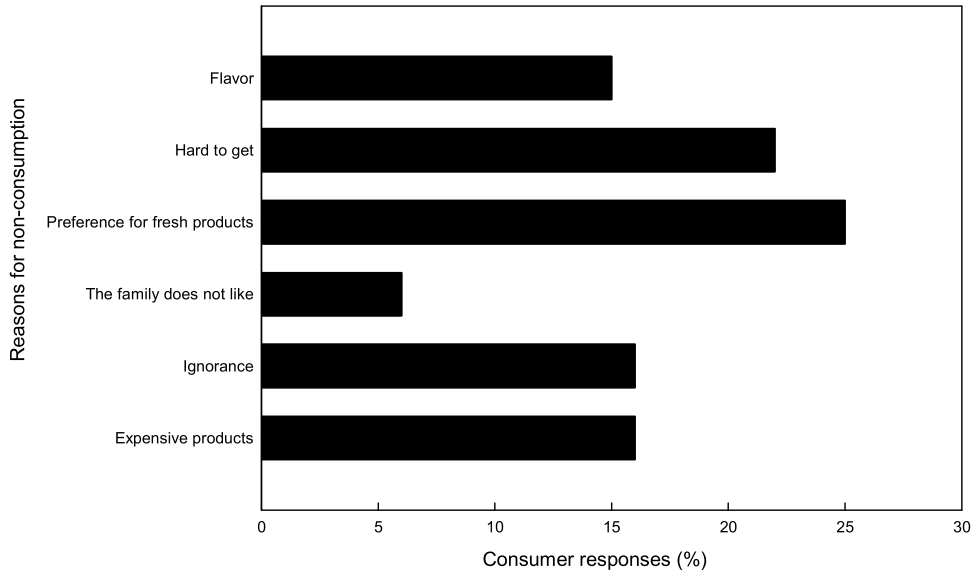


Fig. 6. Reasons not to consume dehydrated products.

on sustainable development and improvements in the living conditions of small growers, especially low-income or marginalized workers (Bach, 2011).

4. Conclusions

Conversely, from the sample, 26.4 % and 73.6 % of the interviewees were non-consumers and consumers of dehydrated products. Of those consumers, 18.0 % consider these products nutritious, and 14.0 %, as beneficial to health. The primary limitation for dehydrated products to reach consumers is low availability, which may be one reason dehydrated products are not being acquired. This was confirmed by the perception of non-consumers, where 21.1 % indicated that these products are difficult to obtain and 15.9 % had no prior knowledge of these food types. However, 50.4 % of this group mentioned a willingness to consume dehydrated products. Therefore, according to the objective of this research, the study offered a good picture of Mexican consumers' perceptions of mainly plant-based dehydrated products.

This research is the first consumer analysis of the consumption of mainly plant-based dehydrated products in Mexico as an alternative to initially reduce the loss of primary products and the subsequent waste of these during the supplement chain. Expanding this research using population stratification to examine socioeconomic and sectoral aspects, including animal-based dehydrated products is recommended

CRediT authorship contribution statement

Blanca Isabel Sánchez-Toledano: Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Mercedes Borja-Bravo:** Writing – review & editing. **Jorge A. Zegbe:** Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis. **Silvia Xóchitl-Almeraya Quintero:** Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

CONAHCYT FORDECYT-PRONACES funded this study. Ref.: 315108 "Feasibility of the use of solar systems to mitigate loss in post-harvest processes and generate added value in agricultural products".

Acknowledgments

CONAHCYT FORDECYT-PRONACES No. funded this study. Ref.: 315108 "Feasibility of the use of solar systems to mitigate loss in post-harvest processes and generate added value in agricultural products". We thank Dr Mary Lou Mendum (University of California, Davis) and the suggestions of the Editor and Reviewers that improved the final presentation of this document.

Ethical statement

The questionnaire applied was validated and approved by a social science ethics committee (protocol code 2021-1 dated Jun 2021). It was conducted according to the principles given in the Declaration of Helsinki, with particular care to protect personal information as required by Mexican regulations.

Participants gave informed consent via the statement "I am aware that my responses are confidential, and I agree to participate in this survey" where an affirmative reply was required to enter the survey. They were able to withdraw from the survey at any time without giving a reason.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2024.100491.

Data availability

The data are publicly available and we have shared the link.

References

Aburto, T., Sánchez-Pimienta, T., Batis, C., Rivera-Dommarco, A., 2016. Discretionary foods have a high contribution, and fruit, vegetables, and legumes have a low contribution to the total energy intake of the Mexican Population. J. Nutr. 146, 1881S–1887S.

Allred, C., Smith, S., Swinyard, W., 2006. E-shopping lovers and fearful conservatives: a market segmentation analysis. Int J Retail Distrib Manag 34 (5), 308–333. https://doi.org/10.1108/09590550610660251.

Andaluz, M., 2022. Elaboración y evaluación sensorial de galleta a base de harina de cáscara de pitahaya amarilla (Selenicereus megalanthus) saborizada con albahaca (Ocimum basilicum) y romero (Rosmarinus officinalis). MLS Health and Nutrition Research 1 (1).

Arvola, A., Lähteenmäki, L., Dean, M., Vassallo, M., Winkelmann, M., Claupein, E., Saba, A., Shepherd, R., 2007. Consumers beliefs about whole and refined grain products in the UK, Italy and Finland. J. Cereal Sci. 46, 197–206.

Bach, R., 2011. What is fair trade? Good business. Retrieved from: https://www.buenosnegocios.com/notas/impacto-social/que-es-el-comercio-justo-n392. (Accessed November 2023).

Butu, A., Brumă, S., Tanasă, L., Rodino, S., Dinu, C., Doboș, S., Butu, M., 2020. The impact of COVID-19 crisis upon the consumer buying behavior of fresh vegetables directly from local producers. Case study: the quarantined area of suceava county. Romania. Int. J. Env. Res. Pub. He. 17 (15).

Chang, Y., Chen, S., 2022. Understanding consumers' intentions to purchase clean label products: evidence from Taiwan. Nutrients 14, 3684. https://doi.org/10.3390/nu14183684.

Cochran, G., Díaz, E., 1980. Sampling Techniques, 1st. Ed. Compañía Editorial Continental, Mexico, p. 513.

Cordero-Ahiman, V., Santellano-Estrada, E., Garrido, A., 2018. Food access and coping strategies adopted by households to fight hunger among indigenous communities of Sierra Tarahumara in Mexico. Sustainability 10 (2), 473.

Crofton, C., Scannell, A., 2020. Snack foods from brewing waste: Consumer-led approach to developing sustainable snack options. Br. Food J. 122, 3899–3916.

Díaz de Rada, V., Domínguez, J., Pasadas del Amo, S., 2019. Internet as a mode of survey administration. Rev Soc 59, 1.

Díaz-Méndez, C., García-Espejo, I., Otero-Estévez, S., 2018. Discourses on scarcity: strategies for managing food deprivation in times of crisis. EMPIRIA. J Soc Sci Methodol 40, 85–105.

De Hooge, I., Van Dulm, E., Trijp, H., 2018. Cosmetic specifications in the food waste issue: supply chain considerations and practices concerning suboptimal food products. J Clean Prod. 183, 698–709.

Ekechukwu, V., Norton, B., 1999. Review of solar-energy drying systems II: an overview of solar drying technology. Energy Convers. Manag. 40, 615–655.

Encalada-Rojas, J., Sosa-León, L., 2024. Efecto combinado de la temperatura y el espesor de la pulpa sobre el proceso de deshidratación del mango (Mangifera indica L.) variedad Kent. Revista de investigación Agropecuaria Science and Biotechnology 4 (2), 11–21.

FAO, 2019. The state of food and agriculture: moving forward on food loss and waste reduction. FAO, Rome, p. 156.

FAOSTAT, 2020. Available online: http://faostat.fao.org. (Accessed July 2022).

Fayolle, A., Liñán, F., Moriano, J., 2014. Beyond entrepreneurial intentions: values and motivations in entrepreneurship. Int Entrepreneurship Manage J 10 (4), 679–689. https://doi.org/10.1007/s11365-014-0306-7.

Figueroa-González, J., Servin-Palestina, M., Zegbe, J., Martínez-Ruiz, A., 2022. Drying kinetics models for guava slices dried with a rustic solar dehydrator. J Exp Syst 9-27, 9–16.

Fraser, G.E., Sabaté, J., Beeson, W.L., Strahan, T.M., 1992. A possible protective effect of nut consumption on risk of coronary heart disease. The Adventist health study. Arch Intern Med 152 (7), 1416–1424.

García-Soto, A., Pérez-Pérez, E., Romero, N., Sandoval, L., 2014. Evaluación de la calidad sensorial de frutos tropica-les deshidratados. Rev. Fac. Agron (Supl 1), 719–729.

Global Industry Analysts, 2022. Dehydrated fruits. https://www.marketresearch.com/Global-Industry-Analysts-v1039/. (Accessed February 2023).

Grunert, G., Wills, M., 2007. A review of European research on consumer response to nutrition information on food labels. J. Public Health 15, 385–399.

Guazi, S., Lago-Vanzela, S., Conti-Silva, C., 2019. Development of smoothies from dehydrated products of strawberry and banana pulps obtained through foam-mat drying. Int. J. Food Sci. Technol. 54 (1), 54–61.

Hair, J., Anderson, R., Tatham, R., Black, W., 1998. Multivariate Data Analysis. Prentice-Hall International, Inc, Upper Saddle River, New Jersey, USA, p. 730.

Ham, M., Pap, A., Stanic, M., 2018. What drives organic food purchasing? Evidence from Croatia. British Food J 120 (4), 734–748. https://doi.org/10.1108/BFJ-02-2017-0090.
Herrera, M., Álvarez-Sánchez, I., Ortiz-Rodríguez, N., Flores-Prieto, J., 2023. Solar drying modes of saladette tomatoes slices on phytochemicals and functional properties. Sol. Energy 262, 111903.
Hii, L., Ong, P., Yap, Y., Putranto, A., Mangindaan, D., 2021. Hybrid drying of food and bioproducts: a review. Dry Technol 39, 1554–1576.
Jaiswal, K., Chowdhury, R., Yadav, D., Verma, R., Dutta, S., Jaiswa, S., Karuppasamy, K., 2022. Renewable and sustainable clean energy development and impact on social, economic, and environmental health. Energy Nexus 7, 100118.
Jeszka-Skowron, M., Zgoła-Grześkowiak, A., Stanis, E., Waśkiewicz, A., 2017. Potential health benefits and quality of dried fruits: Goji fruits, cranberries and raisins. Food Chem. 221, 228–236.
Johansen, B., Næs, T., Hersleth, M., 2011. Motivation for choice and healthiness perception of calorie-reduced dairy products. A cross-cultural study. Appetite 56, 15–24.
Kanani, R., Buvik, A., 2018. The effect of product quality uncertainty on quality-screening efforts: does the purchase frequency and procurement channel choice matter? Int J Procure Manag 11 (4), 495–517.
Kang, J., Namkung, Y., 2019. The information quality and source credibility matter in customers' evaluation toward food O2O commerce. Int J Hospitality Manage 78, 189–198.
Kaya, H., 2016. Motivation Factors of Consumers' Food Choice. Food Nutr Sci 7, 149–154.
Kovács, I., Balázsné, M., Beke, J., 2022. The importance of food attributes and motivational factors for purchasing local food products: segmentation of young local food consumers in Hungary. Sustainability 14, 3224.
Krauss, R.M., Eckel, R.H., Howard, B., Appel, L.J., Daniels, S.R., Deckelbaum, R.J., Erdman Jr., J.W., Kris-Etherton, P., Goldberg, I.J., Kotchen, T.A., Lichtenstein, A.H., Mitch, W.E., Mullis, R., Robinson, K., Wylie-Rosett, J., St Jeor, S, Suttie, J., Tribble, D.L., Bazzarre, T.L., 2000. AHA Dietary Guidelines: revision 2000: A statement for healthcare professionals from the Nutrition Committee of the American Heart Association. Circulation 102 (18), 2284–2299. https://doi.org/10.1161/01.cir.102.18.2284.
López, G., León, L., Espejel, J., 2019. Dehydrated sweet potato as a new alternative for healthy consumption for Sonorans. Inc Magazine 50–65.
López, G., López, L.P.L., Blanco, E., 2019. El camote deshidratado como una nueva alternativa de consumo saludable para los sonorenses. Revista Inclusiones 6, 50–65.
Lamidi, R., Jiang, L., Pathare, B., Wang, D., Roskilly, A., 2019. Recent advances in sustainable drying of agricultural produce: a review Appl. Energy 233–234, 367–385. https://doi.org/10.1016/j.apenergy.2018.10.044.
Lipinski, B., Hanson, C., Waite, R., Searchinger, T., Lomax, J., 2013. Reducing food loss and waste. World Resources Institute, Washington (DC), p. 40. Available from: https://bit.ly/2WaQdyo (Accessed September 2023).
Lonnie, M., Hooker, E., Brunstrom, M., Corfe, M., Green, A., Watson, W., Williams, A., Stevenson, J., Penson, S., Johnstone, M., 2018. Protein for life: review of optimal protein intake, sustainable dietary sources and the effect on appetite in ageing adults. Nutrients 10 (3), 360, 16.
Malhotra, K., 2008. Market research, 5th ed. Pearson Prentice Hall, Mexico, p. 805.
Mancilla, R., 2018. Unequal and heterogeneous internet access in the indigenous peoples of the Sierra Norte de Puebla (Mexico). Rev Española Antropol Amer 48, 9.
Martín, D., Solano, M., Serrano, J., Medina, M., 2021. Fashion consumption habits through influencers in Generation. Z. Rev Cien Soc. 3, 55–71.
Martins, E., Pinho, O., Ferreira, I., 2017. Food industry by-products used as functional ingredients of bakery products. Trends Food Sci. Technol. 67, 106–128.
McManus, K., Antinoro, L., Sacks, F., 2001. A randomized controlled trial of a moderate-fat, low-energy diet compared with a low fat, low-energy diet for weight loss in overweight adults. Int J Obes 25, 1503–1511. https://doi.org/10.1038/sj.ijo.0801796.
Mejia, D., Diaz, M., Charry, A., Enciso, K., Ramírez, O., Burkart, S., 2021. Stay at Home": the effects of the COVID-19 lockdown on household food waste in Colombia. Frontiers in Psychology 12, 764715.
Mercado, K., Pérez, C., Castro, L., Macias, A., 2019. Estudios cualitativos sobre comportamiento del consumidor en las compras en linea. Info Tecnol 30 (1), 109–120.
Morais, C., Morais, B., Dammak, I., Bonilla, J., Sobral, A., Laguerre, C., Afonso, J., Ramalhosa, D., 2018. Functional Dehydrated Foods for Health Preservation. J. Food Qual. 3, 1–29.
Natarajan, K., Elangovan, E., Elavarasan, M., Balaraman, A., Sundaram, S., 2022. Review on solar dryers for drying fish, fruits, and vegetables. Environmental Science and Pollution Research 29 (27), 40478–40506.
National Institute of Statistics and Geography (INEGI), 2021. Mexico in figures. Available in: https://www.inegi.org.mx/app/areasgeograficas/?ag=32. (Accessed: November 2023).
Naughton, P., McCarthy, S., McCarthy, M., 2015. The creation of a healthy eating motivation score and its association with food choice and physical activity in a cross-sectional sample of Irish adults. Int. J Behav Nutr Phys Act. 12 (1), 74–83. https://doi.org/10.1186/s12966-015-0234-0.
Ortiz-Rodríguez, N., Condorí, M., Durán, G., García-Valladares, O., 2022. Solar drying technologies: A review and future research directions with a focus on agroindustrial applications in medium and large scale. Appl. Therm. Eng. 215, 118993.
Pérez-González, E., Severiano-Pérez, P., Aviña-Jiménez, M., Velázquez-Madrazo, C., 2023. Geothermal food dehydrator system, operation and sensory analysis, and dehydrated pineapple quality. Food Science & Nutrition 11 (11), 6711–6727.
Parra, A., Saavedra, L., 2013. Comportamiento del consumidor y posicionamiento de los medios de comunicación impresos. Marketing Visionario 2 (1), 55–73.
Porat, R., Lichter, A., Terry, A., Harker, R., Buzby, J., 2018. Postharvest losses of fruit and vegetables during retail and in consumers' homes: Quantifications, causes, and means of prevention. Postharvest Biol & Technol 139, 135–149.
Prabhu, N., Saravanan, D., Kumarasamy, S., 2023. Eco-friendly drying techniques: a comparison of solar, biomass, and hybrid dryers. Environ Sci Pollut Res 30, 95086–95105.
Ramirez, J., Castro, V., 2014. Analysis of Acceptance and Preference of the White Delicacy of the Valley. Biotechnol Agric Agroindust Sec 12 (1), 20–27.
Riici, F., Izzicupo, P., Moscucci, F., Sciomer, S., Maffei, S., Di Baldassarrer, B., Gallina, S., 2020. Recommendations for physical inactivity and sedentary behavior during the coronavirus disease (COVID-19) Pandemic. Front Public Health 8 (1), 1. https://doi.org/10.3389/fpubh.2020.00199.
Ripoll, G., Joy, M., Panea, B., 2018. Consumer perception of the quality of lamb and lamb confit. Foods. 7, 80.
Sánchez-Toledano, B.1., Cuevas-Reyes, V., Kallas, Z., Zegbe, J.A., 2021. Preferences in 'Jalapeño' pepper attributes: A choice study in Mexico. In: Foods, 10. Correspondencia, pp. 1–12. https://doi.org/10.3390/foods10123111.
Sabaté, J., 1999. Nut consumption, vegetarian diets, ischemic heart disease risk, and all-cause mortality: evidence from epidemiologic studies. Am J Clin Nutr. 70 (3 Suppl), 500S–503S. https://doi.org/10.1093/ajcn/70.3.500s.
Sagar, R., Suresh, P., 2010. Recent advances in drying and dehydration of fruits and vegetables: a review. J. Food Sci. Technol. 47, 15–26.
Santagata, R., Ripa, M., Genovese, A., Ulgiati, S., 2021. Food waste recovery pathways: challenges and opportunities for an emerging bio-based circular economy. A systematic review and an assessment. J. Clean. Prod 286, 125490.
Schnettler, B., Mora, M., Mills, N., Miranda, H., Sepúlveda, J., Denegri, M., Lobos, G., 2012. Typologies of consumers according to lifestyle in relation to food: an exploratory study in southern Chile. Rev Chilena Nut 39 (4), 165–172.
Secretary of Welfare, 2022. Desperdicio de alimentos. https://www.gob.mx/bienestar (Ac). (Accessed April 2023).
Shepherd, R., Magnusson, M., Sjödén, S., 2005. Determinants of consumer behavior related to organic foods. BIO: A J Hum Environ 34 (4), 352–359.
Silva, B., Lima, M., Baltazar, L., Pinto, E., Fialho, S., 2022. Perception of Portuguese consumers regarding food labeling. Nutrients 14, 2944.
Soares, P., Almendra-Pegueros, R., Benítez, N., Fernández-Villa, T., Lozano-Lorca, M., Valera-Gran, D., Navarrete-Muñoz, E., 2020. Sustainable food systems for healthy eating. Rev Española Nutr Hum y Diet 24 (2), 87–89.
Sun, Y., Liang, C., 2020. Factors Determining Consumers' Purchase Intentions Towards Dried Fruits. Int J Fruit Sci 20, S1072–S1096. https://doi.org/10.1080/15538362.2020.177447.
Svisco, E., Byker-Shanks, C., Ahmed, S., Bark, K., 2019. Variation of adolescent snack food choices and preferences along a continuum of processing levels: the case of apples. Foods (Basel, Switzerland) 8 (2), 1–16. https://doi.org/10.3390/foods8020050.
Torres-León, C., Aguilar, M., 2022. Food Preservation. Quantitative Methods and Analytical Techniques in Food Microbiology. Apple Academic Press, pp. 39–55.
Tylewicz, U., Nowacka, M., Rybak, K., Drozdzal, K., Dalla-Rosa, M., Mozzon, M., 2020. Design of healthy snack based on kiwifruit. Molecules 25 (14), 3309.
World Bank, 2017. Squanders 24% of its food production. [Online]. Available in: https://www.efe.com/efe/america/mexico/banco-mundial-mexico-despilfarra%20-el-34-de-su-produccion-alimentaria/50000545-3461427. (Accessed April 2023).