

Research Article

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Customer knowledge and behavior on the use of food refrigerated display cabinets: A Portuguese case

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Abstract: This article presents a study on customer knowledge and habits regarding the use of refrigerated display cabinets (RDC). The study was carried out on a sample of Portuguese retail stores' customers, using a questionnaire survey available through an Internet platform. The sample consisted of 136 individuals, who voluntarily participated in the study. Questions included the characterization of the sociodemographic population involved. The questionnaire included different questions to related with RDC, namely customer knowledge about the appearance of each RDC equipment, questions to evaluate the respondents' perception about the advantages and disadvantages related to open or glass-door closed RDC, questions to assess the participants' habits and behavior when purchasing food products from glass-door closed RDC (frequency and duration of door open), questions to characterize the consumers' habits on purchasing food products from RDC, and also questions to characterize the consumers' shopping attitudes in the context of the COVID-19 pandemic, caused by SARS-CoV-2. The results seem to indicate that customers prefer closed RDC; for example, 61.8% of participants prefer products preserved in glass-door closed RDC, against 6.6% that admit to preferring products preserved in open RDC. Therefore, we can deduce that the existence of doors does not

appear to be an obstacle to purchasing food products. Regarding the use of glass-door closed RDC, 80.1% of the participants say they just open the door once, and 53.7% of the costumers believe they keep the door open in the interval [4–6 s]. This indicates that Portuguese customers are quite well informed about food safety issues and seem to follow assertive attitudes when purchasing food products from RDC. This study reinforces the benefits of replacing open RDC by closed glass-doors allowing significant energy savings.

Keywords: refrigerated display cabinets, supermarkets, customer habits, energy efficiency, safety food

1 Introduction

Currently, the rational and efficient use of energy is one of the most important concerns and a worldwide challenge. Retail food stores are places where energy consumption is quite considerable. A substantial amount of electricity consumption in supermarkets is related to the refrigeration cabinets used in the storage and conservation of perishable food products [1]. Storage in retail food store displays seems to be the least efficient part of the food supply chain, in contrast to what has been verified from production to distribution [2].

In retail food stores, refrigerated display cabinets (RDC) are normally used simultaneously to exhibit and preserve food products. This type of equipment is usually open at the front, with a considerable area for displaying food products that can be quickly and easily accessed by customers without inconvenience [3–5]. This type of cabinet can also be equipped with one or more air curtains at the front, acting as a barrier between the products and the warmer surrounding ambient air [3]. According to some authors, without air curtain installed, warm air infiltration across the air curtain of a vertical open RDC represents about 70% of the total refrigeration load [4,6,7].

The installation of doors on open RDC is one of the simple and effective methods to improve the cabinet

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performance [8]. The inclusion of glass doors on these cabinets also offers other advantages, such as lower temperatures and better temperature control in the display space [9,10]. However, in closed RDC, the ambient air moisture can condense on the inside of the glass-door preventing customers from getting a good view of the products.

The RDC can also be horizontal (especially for freezing products), as assessed by users from the top. Cabinets that combine vertical and horizontal access are also used. Serve over cabinets are commonly used in bakeries, pastries, butchers, and cafés to display food products but cannot be directly accessed by customers.

Regarding the commercialization and display of perishable products, fresh or processed, requirements in terms of safety and quality of food must be fulfilled, namely to ensure that the storage temperature of the food product is continuously maintained below the maximum recommended value. Despite the strict criteria imposed by the legislation in terms of Food Safety, studies carried out in European Union countries have revealed that the maximum admissible temperatures of food products stored in refrigerated cabinets are often exceeded, as reported by earlier studies in France [11,12], in the United Kingdom [6,9], in Sweden [2], and in Greece [13].

Recently, the use of phase change materials (PCM) in refrigerated food storage and cabinets have attracted the attention of researchers and developers worldwide. Optimum placement of PCM material inside refrigerated cabinets can ensure product temperature within an acceptable range, thereby assuring food quality [14].

In the choice between open or closed RDC, other aspects must be considered, such as the balance between the commercial or energy aspects. In commercial terms, it is relevant to evaluate if sales decrease or not, with close displays cabinets and customer's accessibility to the products.

In an earlier study [15], the author presents an extensive literature review of research on open and closed RDC, in terms of energy efficiency, chilled groceries, and customer behavior and perception when shopping in retail stores.

The main goal of the present study is to characterize the Portuguese customer knowledge about the RDC, their perception concerning the advantages/disadvantages linked with each one, and identify the customer habits on the use of these cabinets when handling or purchasing the food product, as well as their sensitivity to the rational and efficient energy use. Moreover, safety and quality food issues are evaluated.

2 Material and methods

The methodology used in this study consisted of collecting information through a questionnaire. The questionnaire was divided into three groups of questions. In the first group, sociodemographic information was collected to characterize the sample at study. Another group was dedicated to characterizing the participants' knowledge about the different types of food RDC. Questions to characterize the behavior on the use of open and closed food RDC were included in a third group.

The questionnaire was disclosed on different Internet platforms, such as e-mail and social networks, and the data were collected between 20th June and 10th July 2020. Some assumptions were used to calculate the minimum number of responses in the sample: 95% confidence interval, corresponding to a z score equal to 1.96; the power of the test corresponds to an error of 10%. The Portuguese population in 2019 was 10,283,822 people, resulting in a universe of nearly 7.5 million adults, and the target population would be 50% of that universe. Under these conditions, the minimum sample size for the present research to be statistically meaningful was calculated as 97 adult individuals. The sample dimension consisted of 136 validated questionnaires. The validation ensured that only completed questionnaires were included. The participation was voluntary, and confidentiality of the answers obtained was guaranteed. Ethical issues were respected in the design and application of the questionnaire. This research was validated by the CERNAS Research Centre for implementation in Portuguese territory.

3 Results and discussion

3.1 Sociodemographic aspects of the inquired sample

The participants were mostly women (59%), and their age varied from 19 to 71 years old (Figure 1a).

Concerning the geographical distribution, the survey included participants from almost all the districts of Portugal mainland, and also from island regions (Figure 1b), but almost half of the participants lived in regions of central Portugal (Coimbra and Viseu).

Another important variable about the participants is their education level. It was verified that 79% of the participants have university graduation.

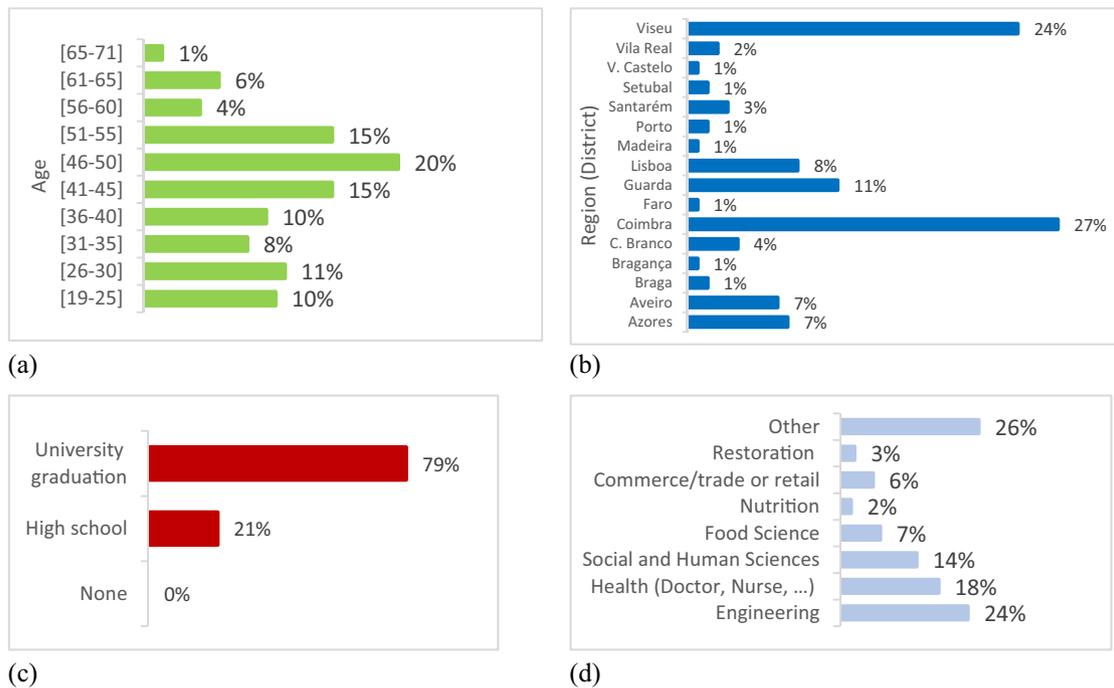


Figure 1: Sociodemographic information about the sample: (a) age distribution (%) of the participants (years), (b) geographical distribution of participants, (c) participants academic graduation, and (d) main education or professional activity area. Values are presented in percentage, representing a sample of 136 individuals.

Concerning the main academic formation area or present professional activity, it was observed that 24% of the participants belong to the engineering area. This can be an important issue in the correlation results because several questions are related to refrigerated cabinets and their functional aspects. It was also found that food science, commerce/trade or retail, and restoration (includes cafés, bars, hotels, etc.) professional areas, all together, represent only about 16% of the participants. A total of 26% of participants were classified as professors or students. Participants from the health area (doctor, nurse, etc.) represent 18%.

3.2 Customers' knowledge about food display cabinets

The first question asked the participants was to indicate their level of knowledge about food RDC used on food conservation applications, in general. In this stage, without any references to the different types, appearance, or configuration of the food RDC, as can be observed in Figure 2, around 60% of the participants answered that they “know what it is”, the cabinets used in the conservation of each type of food (almost equal percentage for the conservation

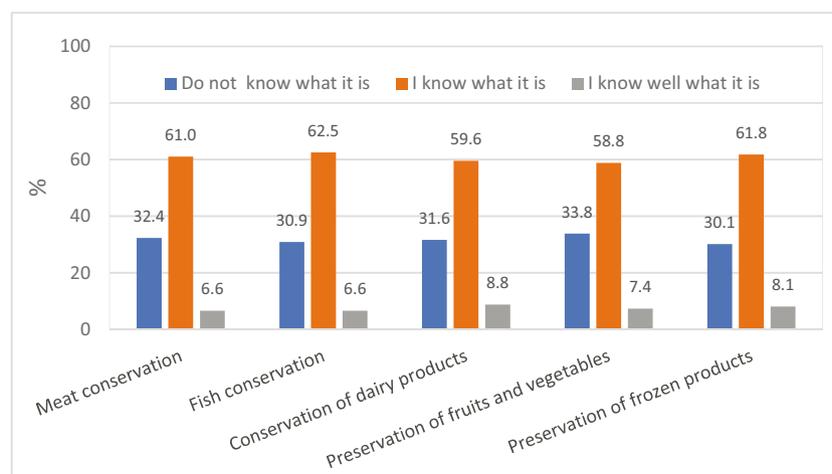


Figure 2: Results for the question: “Indicate your level of knowledge about the RDC used in each of the food conservation applications”.

of meat, fish, dairy products, fruits and vegetables, or frozen products). Slightly more than 30% of the participants answered “Do not know what it is”, which means they do not even have a rough idea of the display and conservation cabinets used in the preservation of the different food products. Only 6.6–8.8% of participants declare “know well what it is”.

In the next stage, the participants were asked to indicate their level of knowledge about each type of RDC. The results show that a large percentage, 60.3% of respondents referred that they “know the appearance well”, for a glass-door display cabinet and 16.2% also knew “how it looks and works” (Figure 3). Globally, similar results were found regarding the knowledge of the closed vertical and horizontal RDC. However, some differences were verified about knowledge of “Open vertical display cabinet + air curtain”. In this case, 12.5% declare “Do not know what it is”, and a smaller portion, compared with other types of cabinets, referred that they “know the appearance well” (41.9%). This may be a bit surprising result. However, we suspect that some customers do not know what the air curtain is and that might have confused the respondents. Moreover, 33.8% of participants answered “only have an idea of the appearance” but 11.8% referred “know how it looks and works”. Similar results were obtained for the open horizontal display cabinet + air curtain.

Concerning the layout or disposition of the cabinets in the supermarket, two main configurations are used, vertical against a wall or back to back with other cabinets, or island (horizontal) when it is located in the middle of the store and can be surrounded by the user. It was verified that 43.4 and 30.1% of participants answered “Do not

know what it is” regarding mural and island, respectively (Figure 4). Just about 8% declared “know how it looks and works”, for both configurations.

3.3 Customers perception about advantages and disadvantages of the different type of food RDC

3.3.1 Global perception of food RDC

In an earlier study [16], the authors conclude that, when shopping chilled groceries, customers’ behavior and perceptions differ according to the existence or not of doors on RDC.

This section presents the results about the participants’ opinion/perception about possible advantages or drawbacks of open and closed RDC (Table 1). The methodology was asking the participant to classify different affirmations according to five agreement levels, fixed at the extremes with “strongly disagree” and “strongly agree”. A “do not know” option was also available.

The results to statement 1 reveal that 40.4% of the respondents agree that “The best cabinet is the one that has glass-doors because they are most energy-efficient”, and 16.2% of the respondents strongly agree (Table 1). From this, we may deduce that customers know which types of cabinets are more efficient. Several studies comparing the performance (energy savings) of RDC with and without doors reveal that energy saving by installing doors can reach 70% [17,18]. Energy savings seems to be

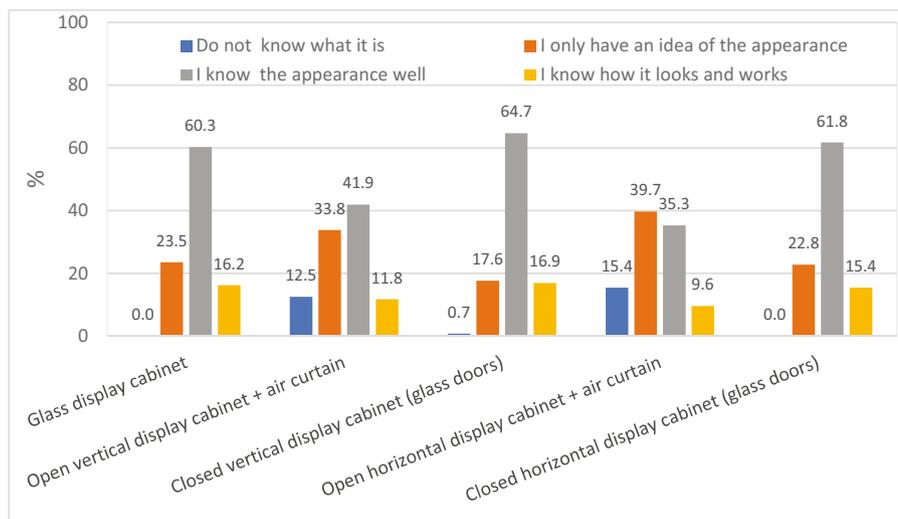


Figure 3: Results for the question: “Indicate your level of knowledge about each type of RDC”.

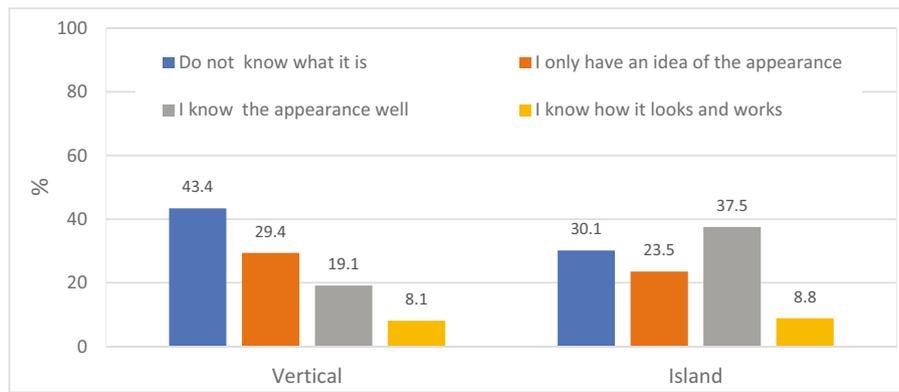


Figure 4: Results for the question: “Indicate your level of knowledge about each RDC, concerning the disposition in the supermarket”.

an important issue also to the customer, not only related to retail stores but also in their homes. In ref. [19], for a study about customers’ behavior with domestic refrigerators, the author observed that reducing energy consumption played a crucial role for the customer.

To statement 2, a significant number of respondents, 39%, “agree” and 16.2% “strongly agree”. This reveals that majority of customers seem to be aware that closed cabinets are the best to maintain more homogeneous temperatures of the inside air and food products. The Portuguese customer’s perceptions are aligned with those reported in different studies [3,9,10].

Quite surprising are the results related to statement 3. In this, a very significant percentage of participants answered “disagree (41.9%)” or “strongly disagree (14.0%)”. The open RDC is very popular in retail food stores because it allows the customer unrestricted access to the displayed products. However, these results seem to indicate that customers do not consider easy access as the most important factor to classify the open cabinets as the best. Therefore, the results of the present survey show that Portuguese customers prefer closed RDC (glass-doors), contrary to what was reported in ref. [20], in which English customers prefer to purchase products from cabinets without doors. Indirectly, we can conclude that Portuguese customers are concern with efficient energy use.

To statement 4, 44.9 and 34.9% of the participants declare they “disagree” and “strongly disagree”, respectively. These are important results and aligned with those of the previous statements, and reveal that, for the majority of Portuguese customers, the existence of doors on RDC is not an obstacle to purchasing the food products and thus does not reduce product sales. These results are divergent with an earlier study [3] referring that barriers between customers and groceries are described as having a negative impact on sales. This can indicate that customer tends to be more concerned about other issues than the easy access to the products.

3.3.2 Possible inconveniences or obstacles associated with the use of closed RDC

Table 2 presents the results on the possible inconveniences or obstacles to the use of closed RDC (glass-doors), in which participants were asked to classify five statements according to the importance they attribute to them. Regarding the statement 1 “Difficulty in purchasing the products, owing to the need to open the door”, 39.4% of the participants considered “irrelevant” and 37.2% “of little importance”. There were, however, 18.2% of participants who answered “important”, so these participants considered this as an actual inconvenience. Similar results were observed for the statement 2 “Difficulty in purchasing the products, because the hands are busy (shopping list or basket, etc.)”. For the statement 3 “Difficulty in seeing/choosing products, due to fogging of the front glass”, despite approximately 50% of the participants considering it “irrelevant” or “of little importance”, significant percentages (38.4%) answered “important” and 5.1% “very important”. This means that fogging at the front glass of closed RDC can be an important inconvenience and special attention must be given to this issue.

In the context of the current pandemic COVID-19 caused by the coronavirus SARS-CoV-2, respondents were asked about the possible “Fear to touch the door, due to possible contamination by the new coronavirus (SARS-CoV-2)”. A total of 55.4% of the inquired participants considered this issue “important” or “very important”.

3.3.3 Possible inconveniences or obstacles in the use of open RDC

Following the same previous strategy, the participants were asked to classify four statements according to the importance they attribute to them, but now regarding

Table 1: Response frequency (%) according to five agreement levels for statements related to characteristics of different types of food RDC

Statement	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
1. The best cabinets are the one that has glass doors, because they are more energy-efficient	16.2	40.4	16.9	5.1	2.9	18.4
2. The best cabinet is the one that has glass doors, because it better ensures the minimum storage temperature required	16.2	39.0	19.9	5.1	2.9	16.9
3. The best cabinet is open, because there are no physical obstacles to reach the desired product	0.7	10.3	23.5	41.9	14.0	9.6
4. The existence of glass doors in RDC is an obstacle to the purchase of refrigerated food products	1.5	5.9	12.5	44.9	30.9	4.4

Table 2: Response frequency (%), importance level that customers attribute to statements reporting possible inconveniences or obstacles in the use of closed RDC

Statement	Very important	Important	Irrelevant	Of little importance	Don't know
1. Difficulty in purchasing the products, due to having to open the door	2.9	18.2	39.4	37.2	2.2
2. Difficulty in purchasing the products, due to having hands are busy (shopping list or basket, etc.)	4.4	27.0	32.8	33.6	2.2
3. Difficulty in seeing/choosing products, due to fogging of the front glass	5.1	38.4	31.2	23.2	2.2
4. Afraid to touch the door, due to possible contamination by the new coronavirus (SARS-CoV-2)	25.2	30.2	28.1	14.4	2.2

possible advantages or disadvantages/obstacles of the use of open RDC (Table 3).

Concerning statement 1 “Better visibility of food products, even without touching them”, a very large majority of participants consider this an advantage, with 23.2% of participants answered “very important” and 46.4% answered “important”. Very similar results were found to the statement 2 “Ease in purchasing the desired products”, thus considering this as an advantage as well.

Concerning the statement 3 “Thermal discomfort, due to the lower air temperature in these aisles...”. It can be verified that 13.9% of participants consider this aspect important and 46.0% consider it very important. This means that the majority of participants admit worrying about the thermal discomfort in the corridor where these open RDC are installed. Customers and staff discomfort in the vicinity of vertical open RDC, due to cold air transfer into the aisles of the supermarket, is reported by other authors, for example, refs. [16,21]. Regarding the statement 4 “Lack of confidence that food is maintained within the recommended storage temperature limits”, results indicate that 39.0% of participants considered this important and 16.2% very important. Therefore, most participants do not fully trust those food products are maintained under adequate conservation temperatures.

3.4 Behavior of customers regarding the use of closed doors RDC

3.4.1 Frequency, duration, and reasons to keep the door open of a RDC during the shopping

The frequency and duration of door openings in closed RDC are important factors, which can increase the overall energy consumption of these cabinets [22,23]. Hence, the participants were asked to indicate, on average, how many times they open the door until choosing, deciding, or reaching the desired product. According to the results (Figure 5a) most of the customers believe just open the door once (80.1%), pick up the product, and then close the door. Customers who admit they “open the door twice” are 18.4%. Additionally, most of the customers declare to maintain the door open for less than 6 s (Figure 5b). This customers’ behavior reveals their great determination on the product choice. If this behavior really occurs, it will contribute to considerable energy savings, reducing the infiltration into the cabinets, and maintaining a lower and uniform inside temperature, which benefits food conservation.

Table 3: Response frequency (%), importance level that customers attribute to statements reporting possible inconveniences or obstacles in the use of open RDC

Statement	Very important	Important	Irrelevant	Little importance	Don't know
1. Better visibility of food products, even without touching them	23.2	46.4	17.4	10.9	2.2
2. Ease in purchasing the desired products	20.1	45.3	22.3	10.1	2.2
3. Thermal discomfort, due to the lower air temperature in these aisles, compared to the rest of the supermarket	13.9	46.0	22.6	14.6	2.9
4. Lack of confidence that food is maintained into the recommended storage temperature limits	16.2	39.0	22.8	16.2	5.9

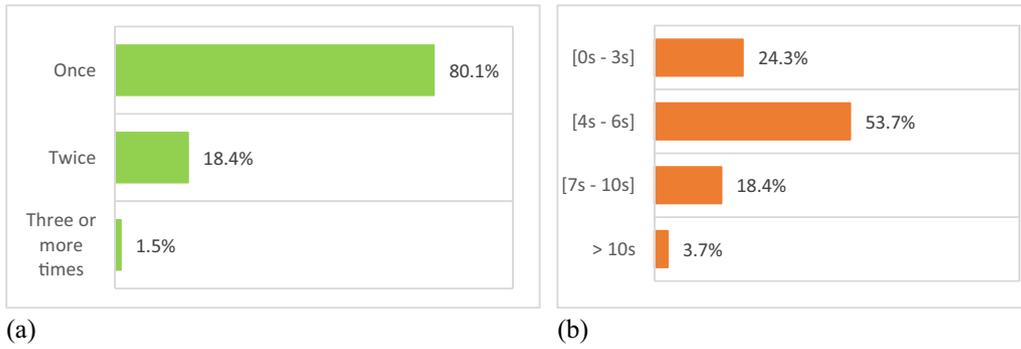


Figure 5: Results for the questions: “During shopping in a supermarket, when choosing food products displayed in a refrigerated or frozen cabinet on an average, how many times do you open the door until you choose, decide, or reach the desired product?” (a) and “...on an average, how long do you keep the door open (from open to close) to reach the desired product?” (b).

To investigate possible reasons why the users maintain the door of the refrigerated cabinets open while choosing or deciding to purchase a food product, some options were suggested, from which the respondents could select up to three. The results (Figure 6) indicate that the main reasons to maintain the door open are as follows: “To check the product’s expiration date” (24.5%), “To check if really is the product I want to buy” (19.3%), “To check the general condition of the product and packaging” (15.5%), and 24.4% of the inquired declared to “immediately close the door after getting the product”.

3.4.2 Customers’ habits on purchasing food products from vertical and horizontal RDC display cabinets

This section explores the customers’ behavior/habits on purchasing food products from RDC. The participants were invited to select the statement that best represents

their behavior when choosing and/or purchasing food products from RDC in supermarkets. Figure 7 presents the results for the vertical RDC. The statement more frequently selected (33.8%) was “I choose and purchase the product at the back, because, in principle, it has a longer shelf life”. In second with 26.5% was the statement

“I choose and purchase the product at the back, because, in principle, it will be at a lower temperature...”. From the results, most of the customers declare to choose the food products located at the back, and the main reason is that they believe that the products have a longer shelf life or because they are stored at a lower temperature. This customer behavior appears to be good practice, as reported by some researchers [6,24,25], according to which the product position in the cabinet is an important factor of its temperature, and that products located at the front of the cabinet (most exposed to surrounding ambient) have higher temperatures than those at the back of the cabinet. Therefore, it is expected that during conservation, lower temperatures provide better food quality.

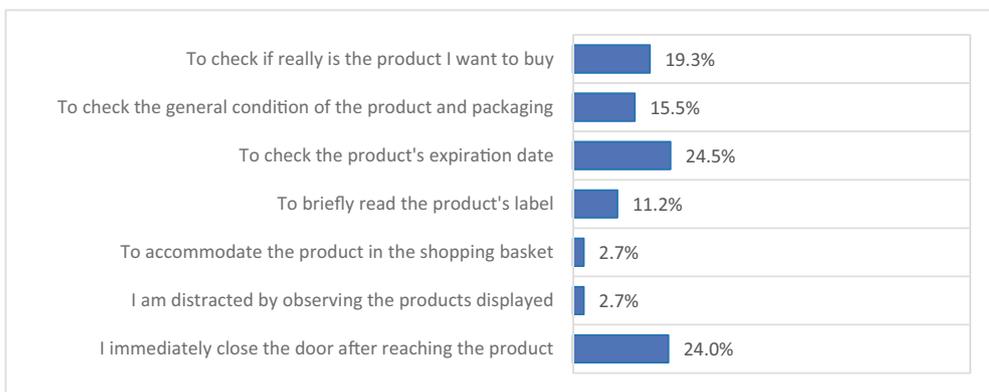


Figure 6: Results for the question: “Indicate up to three of the possible main reasons to maintain the door open of the refrigerated display cabinet, while deciding catch up the desired product?”.

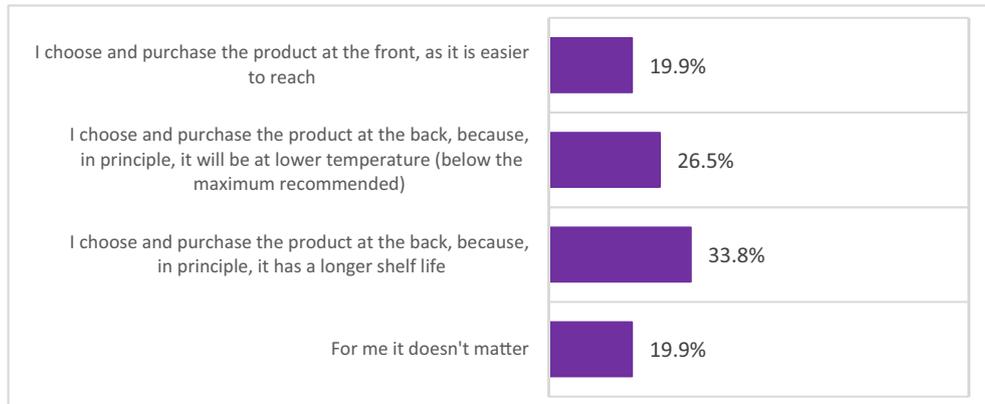


Figure 7: Results for the question: “Select the statement that best represents your behavior when choosing and/or purchasing food products from *vertical RDC*”.

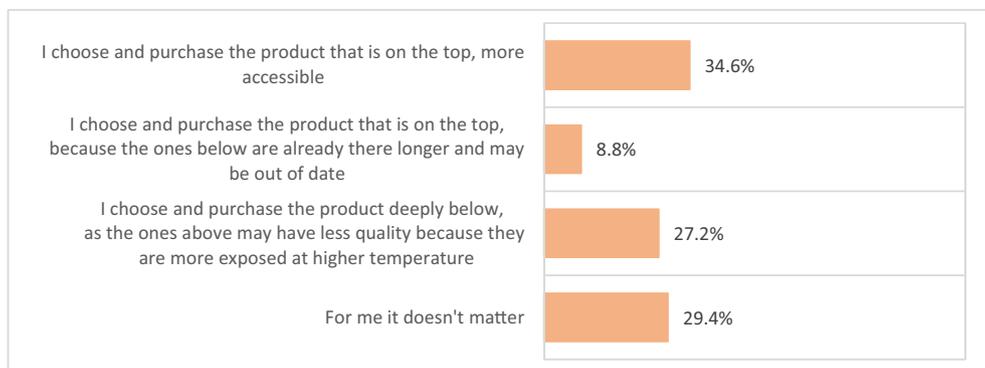


Figure 8: Results for the question: “Select the statement that best represents your behavior when choosing and/or purchasing frozen food products from *horizontal RDC*”.

The results on customer behavior when choosing and/or purchasing frozen food products from horizontal display cabinets are shown in Figure 8. The most selected statement (34.6%) was “I choose and purchase the product that is on the top, more accessible”, followed by 29.4% that answered that “it does not matter”. In this case, the easiness to get the product seems to be the main reason for choosing the product from the top.

3.4.3 Global opinion or preference for food RDC type

It was asked to the participants to indicate their general opinion or preference regarding the products displayed in refrigeration or freezing cabinets. According to the results (Figure 9), participants declare their preference for products preserved in closed RDC (61.8%). These results combined with those in the previous section

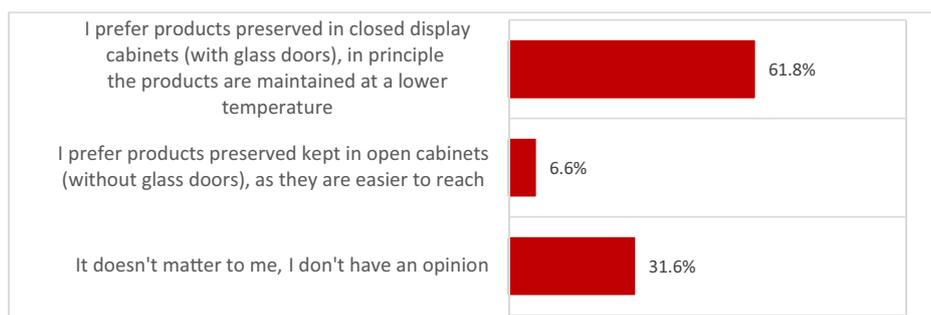


Figure 9: Results for the question: “Indicate your general opinion or preference regarding the products displayed in refrigeration or freezing cabinets”.

indicate that a great majority of customers seem to be more concerned with issues related to the efficient use of energy or related to food safety, than with the facility in getting the food products from RDC. This is one important conclusion of the present study showing the disposition of customers to sacrifice the comfort in the ease of access to food products in favor of issues addressed to efficient energy use or safety and food quality.

4 Conclusion

From the results, participants/customers in this survey are quite well-informed about food safety issues, and seems to follow assertive attitudes when they purchase food products, namely considering the reasonable use of refrigerated cabinets (e.g. frequency and duration of door opening in closed cabinets), or the selection of the desired food product.

Globally, the results indicate that a great majority of customers prefer closed glass doors RDC. However, an important percentage of customers also consider that fogging at the front glass of closed RDC can be an important inconvenience, so special attention should be devoted to this issue.

We may conclude that a great majority of participants/customers give more importance to the efficient use of energy or safety and food quality associated to close RDC than the easiness of access to food products by the absence of physical barriers on open display cabinets.

Based on the present results, besides participants/customers preferring closed refrigerated food display cabinets, the existence of doors is not an obstacle to customers purchasing the food products and thus does not reduce sales.

In several countries, including Portugal, open RDC are being replaced by glass closed RDC. This study shows that customers are receptive to this change, without affecting sales. However, for good visibility of the products, no formation of glass fogging must be assured.

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Conflict of interest: The authors state no conflict of interest.

Data availability statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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