Consumer perception of vacuum frying and a snack made with potatoes and sweet potatoes

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Summary
Vacuum frying, a new technology involving an alternative to the conventional process, reduces the fat content and preserves the sensory characteristics of a fried snack. The success of any new product in the market depends on consumer interest and perception. In this context, the objective of the work was to analyse the consumer perception of vacuum frying and a snack made with potatoes and sweet potatoes. A sample of 1 070 respondents answered an online survey. Correspondence analysis was applied to visualize the relationship among the categories and the willingness to buy and try the vacuum-fried snack. The results revealed that potato chips were the most frequently consumed commercial vegetable fried snack. Participants associated aspects related to cooking and unfamiliarity with vacuum frying. Likewise, appearance, sensory and nutritional characteristics were the main aspects that the participants would consider at buying and trying the product. The acceptability of the snack's colour fried under vacuum indicated no significant differences with that fried at atmospheric pressure. It is recommended that the food industry expand the offer of snacks and develop strategies for introducing the products in the market according to consumer expectations.

Keywords
consumption; word association; food technology; alternative processing technology; vegetables

In recent decades, the frequency and type of habitual meals of the world population have significantly changed [1, 2]. Snacking, defined as the intake of food outside the three or four main meals, is a habit established in people's eating pattern that is increasing worldwide [3, 4]. Generally, snack foods are consumed to satisfy hunger between meals or for pleasure [5]. The changes that have occurred in the dietary pattern involve an increase in the overall consumption of snacks and the type of between-meal products consumed [1], possibly because of the growing interest in ready-to-eat foods [6].

Salty snacks are among the categories that have experienced the highest growth in Latin America [7]. In particular fried foods have been highly appreciated by consumers owing to a combination of their flavour and texture [8]. French fries are one of the most popular snack foods around the world [1]. Potato chips are therefore expected to continue to retain a privileged spot in the competitive market, though new products made with other raw materials are being developed as a result of the growing consumer interest in trying novelties and varied snacks [1, 7]. Fried sweet-potato chips are a recent product in the domestic market but are also widespread in certain countries in the Americas and Asia [9].

In general, fried products often contain large amounts of fat, reaching up to 40–45 % of the total product weight [10]. Many studies revealed that excessive consumption of fat, one of the main components of fried products, is a key dietary element provoking the development of obesity, car-

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diovascular diseases and certain types of cancer [11–13]. The cautionary aspect, coupled with the growing consumer interest in less harmful snacks, motivated the research and development of products that contribute to a lower fat intake while preserving the sensory characteristics of the original formulations [11].

In Argentina, approximately 80 % of the population regularly consumes food in addition to the four main meals [4]. Within the category of salty fried snacks, approximately 15 % of the Argentine population consumes potato chips, among other snack products, at a frequency of two or more times per week [14]. According to Dietary Guidelines for the Argentinian Population, these products are classified as "occasional foods" due to their low nutritional quality [15].

Nowadays, the snack industry is in a state of constant innovation, not only with respect to processing technology but also in the development of new products [1]. New technologies offer advantages compared to conventional thermal processes, as those novel approaches enable the development of products with positive effects on health while retaining traditional sensory characteristics [16]. Within this context, vacuum frying is an alternative method to conventional frying that has great potential for producing vegetable snacks with highly developed nutritional and sensory characteristics [8].

During vacuum frying, the food is immersed in oil in a closed system at subatmospheric pressures, which allows the use of reduced temperature [17]. Vacuum frying is a relatively new processing technology that is not yet widely available on the market and is gradually gaining more popularity due to the lower oil absorption of the product; the preservation of the characteristic texture of the fried snack, together with the colour, flavour, and nutritional characteristics of food [11, 18–20].

Numerous articles were published on vacuum frying potatoes' nutritional or sensory benefits [17, 18, 20–22] and certain sweet potato varieties [12, 13, 23]. However, no consumer perception studies on vacuum frying or snacks made with that technique are available. Such studies are needed, as understanding consumer perception plays an essential role in product success [24], as knowledge contributes to identifying potential barriers to acceptance of certain food [25].

In the absence of knowledge and experience, consumer perception can be studied through projective techniques [25, 26]. These qualitative methods facilitate gathering of information that would not be obtained through traditional methods [24]. Word-association is the most widely used method to learn about consumers' perceptions of various food products. In this technique, verbal or visual stimuli are presented to consumers, who must write down the first words or phrases that come to mind [26]. In food products, the first associations can be considered as the most relevant in the selection-and-purchase process [24]. According to García-Segovia et al. [27], visual appeal is a determinant of positive affective responses to food. Within this category, colour is the first attribute evaluated by the consumer, which influences consumer's acceptability and perception of the quality of fried products [28]. In the early stages of snack development, awareness of the consumer's opinion is essential in order to offer products that meet the expected nutritional and sensory characteristics [1, 5].

In view of these considerations, the objectives of this study were: i) to analyse the consumption of fried vegetable snacks, ii) to determine the perception of vacuum frying and a snack made with potatoes and sweet potatoes, iii) assess willingness to buy and try the product and iv) evaluate acceptability of the colour of the snack.

MATERIALS AND METHODS

Participants

The participants were recruited through social networks. For recruitment, the participants were not regular consumers of vacuum-fried snacks because, in the Argentine market, this category is not available. This particular study was not directed to obtain information from a sample population corresponding to one in the real market [24], but rather to determine the consumption, perception and willingness of participants to buy and try the given product. The study involved 1 070 people over 18 years of age residing in various provinces of Argentina. Institutional approval for conducting the study was obtained. The respondents accepted to participate by a consent before starting the survey.

Questionnaire design and data collection

The approach to data collection was through the design of an on-line questionnaire. The participants received an e-mail with the link to the questionnaire that was available on-line between July and August 2021. The questionnaire consisted of questions involving sociodemographics and the consumption of commercial fried vegetable snacks. The survey also included two word-association tests and a question about willingness to buy and try a vacuum-fried mixture made with po-

tatoes and sweet potatoes. Finally, a hedonic scale of visual acceptability of the colour of mixtures made by vacuum frying and frying at atmospheric pressure was applied. The questionnaire had clear and eye-catching questions and instructions in order to motivate the participant to complete the exercise.

Commercial fried vegetable snack consumption

To determine the consumption of fried vegetable snacks, inquiries about the frequency, reasons, times and places of consumption were evaluated. All these aspects of consumption were assessed with different multiple-choice questions elaborated from previous studies [4, 5, 7] and adapted to the objective of this study. Initially, participants had to indicate the frequency of consumption of the 6 types of snacks most often found in the Argentine market (fried potato chips, sweet potato chips, cassava chips, carrot chips, beet chips and vegetable mixture). The question posed had response options ranging from "Never" to "Every day". To find out the main reasons for snack consumption, a question with the following response options was used: "Because I was hungry", "Because of its taste", "Because of its texture", "Because I saw it in an advertisement", "All my classmates eat it", "Because it is cheap", "For convenience". The question on the times of consumption had the following response options: "At breakfast", "During the morning", "In replacement of lunch", "As a snack", "In the evening", "On special occasions". Finally, the places where these types of products are consumed were studied through a question with the following response options: "At home", "At school or university", "At work", "While commuting", "Outside the home", "At social gatherings", "Other".

Word-association test

Two word-association techniques were used to determine consumer perception of vacuum frying and a vacuum fried mixture made with potatoes and sweet potatoes. First, the participants were asked to "write the first thing that comes to your mind when you think of vacuum frying". Then, they were asked to „write the first thing that comes to your mind when you think of vacuum-fried potato and sweet potato mixture", which was accompanied by an image of a portion of the product. In each task, a blank space was provided, in which the participant had to write what was requested.

Preparation of snacks

The vacuum-fried snack was prepared by Spunta-variety potatoes and Gem-variety sweet potatoes, peeled and cut to slices 1.5–1.8 mm thick and blanched in hot water at 70 °C for 10 min [11] in a Gastrovac vacuum-cooking culinary oven (International Cooking Concepts, Valencia, Spain). They were then vacuum-fried in sunflower oil at 140 °C for 5 min [20] in the same oven. After frying and before vacuum rupture, the samples were removed from the oil and manually centrifuged for 2 min using the equipment handle to avoid oil impregnation. The size of the portion of the product (30 g) was established according to current national regulations [29]. For the conventional snack, potatoes and sweet potatoes were peeled, cut and blanched in the same way as the previous product. After, were atmospheric fried in sunflower oil at 180 °C for 5 min [11] in a frying pan with a frying basket and the process temperature monitored with a K-Type Thermocouple Thermometer HI 935005 (Hanna Instruments, Woonsocket, Rhode Island, USA). After frying, the samples were removed from the oil and centrifuged for 2 min with a manual vegetable spinner.

Willingness to buy and try vacuum-fried snacks

After completing the word-association test, a question on the willingness to buy and try the vacuum-fried potato and sweet potato chip mixture was asked, assessed by a 7-point scale ranging from "Strongly no" to "Strongly yes".

Snack-colour acceptability

The vacuum-fried snack and the mixture cooked by frying at atmospheric pressure were evaluated. A 7-point hedonic scale ranging from "I dislike it very much" (1 point) to "I like it very much" (7 points) was used. Each scale was presented together with an actual image of the product and the question "How much do you like the colour of the snack in the image?". The use of images in consumer studies has increased during the last few years because such illustrations could affect the acceptance of food products [27].

Statistical analysis

The responses obtained from the word-association tests were analysed qualitatively. Initially, a recurrent-term analysis was performed, grouping terms with similar meanings into the same category. The same procedure was used to group the categories into dimensions. The classification was performed by two investigators who considered word synonymy. After an individual evaluation of the data, the final categories were obtained by a consensus between the two investigators. The percent consumers who provided responses within each category and dimension was calculated.

Tab. 1. Sociodemographic characteristics of the participants.

Characteristics	Participants [%]
Gender	
Female	83
Male	17
Age group	
18–23 years	19
24–29 years	35
30–35 years	20
36–41 years	10
42–47 years	6
48–53 years	4
54–59 years	4
60 years or over	2
Occupation	
Working	62
Studying	28
Unemployed	4
Retired	2
Other	4
Level of education attained	
Primary education	2
Secondary education	18
Tertiary or high education	80
Region of residence*	
Central	93
Northeast	2
Southern	2
Western	2
Northwestern	1

* – Argentina is divided into five geographical regions: Central (Santa Fé, Entre Ríos, Córdoba, Buenos Aires), Northeast (Formosa, Chaco, Misiones, Corrientes), Southern (Neuquén, Rio Negro, Chubut, Santa Cruz, Tierra del Fuego), Western (San Juan, San Luis, Mendoza) and Northwestern (Jujuy, Salta, Tucumán, Santiago del Estero, Catamarca, La Rioja).

Tab. 2. Frequency of consumption of fried vegetable snacks.

Commercial fried snacks	Frequency of consumption [%]		
	Frequent*	Occasional**	Never
Potato chips	28	69	3
Sweet potato chips	3	28	69
Vegetable mixture	3	11	86
Carrot chips	0	7	93
Beet chips	1	5	94
Cassava chips	0	7	93

* – participants who consumed fried vegetable snacks: “Once a week”, “Two or three times a week”, “Every day”.
** – participants who consumed fried vegetable snacks: “Once a month” and “Occasionally”.

Two correspondence analyses were performed to observe the relationship between the categories and the willingness to buy and try the product. The significance of differences between the vacuum-fried and conventionaly fried snacks was determined by the analysis of variance (ANOVA) followed by Tukey’s multiple-comparison test. Comparison of the means was carried out at a 5% level of significance ($p < 0.05$). The data analysis was performed with R Core Team software 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS AND DISCUSSION

Participant sociodemographic characterization

Tab. 1 summarizes the sociodemographic characteristics of the 1 070 people who participated in the study. Most of the respondents were women (83 %), of ages between 18 and 35 years (74 %), working (62 %) and with a higher educational level (80 %). Regarding the place of residence, 93 % of the participants lived in the Central Region, mainly in the province of Entre Ríos. As the questionnaire was a convenience sample, the answers indicated a bias towards the female gender, individuals with a higher level of education and residents of Entre Ríos since these were the groups most likely to answer the survey.

Commercial fried vegetable snack consumption

The results revealed that fried potato chips (97 %) and sweet-potato fried chips (31 %) were the most frequently consumed snacks. As previously reported by Pedreschi et al. [1], potato chips belong to the most popular snacks worldwide, while sweet potato snacks were recently introduced into the Argentinian market [9]. Tab. 2 summarizes the information obtained on the frequency of consumption of various types of snacks grouped as frequent, occasional and never. Sixty-nine percent of the participants reported occasional consumption of potato chips, 28 % frequent consumption and 3 % indicated that they had never consumed that snack. According to Nielsen Company [7], 44 % of global consumers have consumed potato chips in the last 30 days. In Argentina, 15 % of consumers consume potato chips, among other snacks, twice or thrice a week [14]. Within this context, the reasons why consumers choose and decide to consume food are complex [5].

Tab. 3 shows the reasons why participants reported consuming fried-vegetable snacks. Thirty-four percent indicated that they consumed this

product mainly for pleasure, 28 % for taste and 13 % for sociability. The results coincide with a global survey [7], which revealed that most Latin Americans consume snacks for pleasure (56 %). The results are also consistent with the report of ALBERTOS et al. [8], who stated that the taste of fried snacks was a highly appreciated attribute by consumers worldwide.

Regarding the times when consumption occured (Tab. 3), the results documented that more than a half of the participants consumed snacks on special occasions (52 %) and, to a lesser extent, at night (37 %). The data obtained corresponded to the findings of the studies of ZAPATA et al. [4], who reported that approximately half of Argentinians consumed snacks at night. As to places of consumption, 43 % and 41 % of the participants reported consuming fried vegetable snacks at home and when attending social gatherings, respectively. In agreement with this finding, the Nielsen company survey reported that 79 % of consumers choose to consume snacks at home and 68 % to share them with family and friends [7].

Tab. 3. Consumption characteristics of fried vegetable snacks.

Characteristics	Participants [%]
Consumption motives	
For pleasure	34
For its taste	28
For sociability	13
For its texture	9
For convenience	7
For hunger	6
Because I saw in some advertisement	1
All my classmates eat it	1
Because it is cheap	1
Times of consumption	
On special occasions	52
At night	36
For a snack	8
In the morning	2
Instead of lunch	2
Places of consumption	
At home	43
At social gatherings	41
Away from home	8
At work	3
While I move	3
At school or university	2

Perception of vacuum-frying

A total of 1 083 different words and associations were mentioned by the participants when they were asked to write the first thing that came to mind when they thought of vacuum frying. Tab. 4 itemizes the percent mention of each of the dimensions and categories for vacuum frying and shows textual examples of the responses. The most frequently mentioned dimension (38 %) was related to the preparation of the fried products. That association could be attributed to the finding that frying is one of the most popular food processing methods [1]. Within this dimension, 40 % of the participants perceived vacuum frying as a type of "unusual cooking" that is carried out "without the presence of oxygen" and "without oil" or using "less oil" than atmospheric frying. This result coincides with the study by GARCÍA-SEGOVIA et al. [11], who stated that vacuum frying is a process that is carried out at sub-atmospheric pressures, thus enabling lowering of the frying temperature and a lower exposure to oxygen during cooking.

Another group of participants (35 %) mentioned their lack of knowledge regarding vacuum frying, exemplified by comments such as "I don't know what it is", "I don't know", "I have no idea", "I have never tried". This unfamiliarity could be attributed to the relative newness of the technology and its lack of wide distribution within the global market [19, 20]. A smaller proportion of the participants (25 %) incorrectly associated vacuum frying with "vacuum-packed", "packing" and "package", possibly because they related the concept to the word "vacuum". These results demonstrate that the name of the technology can influence consumer associations [25].

The second most outstanding dimension (26 %) was related to foods that are used as raw material and with preparations, or drinks that are consumed as an accompaniment to snacks. Within this dimension, 71 % of the participants associated vacuum frying with "french fries". As stated by ANDRÉS-BELLO et al. [30], potato is possibly the vegetable most frequently associated with frying because it is used to make popular consumer products, such as French fries or potato chips. Moreover, most of the published research on vacuum frying regarded potatoes [31].

The third most outstanding dimension (17 %) was mainly associated with aspects of nutrition and health. This response could be attributed to the increased consumer awareness of the relationship between food and health [25]. Most of the answers (65 %) were related to negative nutritional characteristics of the product obtained from this technology, perceiving it as "unhealthy", "junk food", "ultraprocessed", which means "greater oil impregnation" and "contains preservatives", "too

much salt", "cholesterol" and "lots of calories". These results suggested that the participants associated this method of frying with processed food products that have a caloric, fat and sodium content similar to those produced by atmospheric frying [18]. In general, consumers have a limited knowledge of the technological processes applied to food [25]. As a consequence, perception of those individuals is usually unfavourable due to negative associations with industrial processing [16]. Food cannot be classified as "healthy" or "unhealthy", however, simply based on the degree of processing [32]. Regarding this, for example, French fries are obtained by frying thin slices of potatoes in vegetable oil [6], thus ensuring that they do not contain cholesterol or additives. Crosa et al. [18] concluded that vacuum frying stands out among the thermal processing technologies that improve the nutritional quality of fried foods. This cooking method reduces the fat content and the amount of salt that adheres to the surface of the food [18].

Only a few participants (35 %) could identify vacuum frying as a technology that allows preparing products with clearly advantageous nutritional properties [8]. They perceived that this type of frying allows obtaining a "healthy" product, "without oil", "with less oil", and "without additives". This lower percentage could be attributed to the average participant's limited knowledge of vacuum frying, which emphasizes the need to provide information on the advantages detailing the new processing technology in order to increase consumer awareness and perception of reliability [25].

The fourth most mentioned dimension (14 %) was related to sensory characteristics. The results revealed that the participants (77 %) positively associated the concept of vacuum frying with a product that would have a "good taste" and "crispy", "crunchy" and "dry" texture. This response suggests that vacuum frying was perceived as a technology that would result in products with the desired flavour and texture characteristics [8].

Perception of a vacuum-fried snack

A total of 1 073 different words and expressions were mentioned by the participants. Tab. 5 lists the percent mention of each of the dimensions and categories for the vacuum-fried mixture made with potatoes and sweet potatoes and provides textual examples of those responses. The most frequently mentioned answers could be considered as the most relevant to the product and, therefore, the most influential in consumer decisions [24]. Thus, Araujo Martins et al. [25] considered that this information could be useful for enhancing product's positioning in the market.

The most frequently mentioned dimension (60 %) was related to the sensory characteristics of the snack. According to Deliza and Ares [16], the sensory quality of a product is a key determinant of consumer acceptance. The vacuum-fried snack was mainly perceived as "tasty" (45 %). Mielby

Tab. 4. Perception of vacuum-frying identified in the word-association task.

Dimension/Category	Examples of individual responses	Percentage of mention [%]
Elaboration process		38
Cooking	Without oil, less oil, unusual cooking, without the presence of oxygen	40
Ignorance	I don't know what it is, I don't know, I have no idea, I have never tried	35
Packing	Vacuum-packed, packing, package	25
Food and beverages		26
Snacks	French fries	71
Food and beverages	Potato, breaded veal cutlet, meat	29
Nutrition and health		17
Negative nutritional characteristics	Greater oil impregnation, too much salt, cholesterol, lots of calories, unhealthy, junk food, ultra-processed, contains preservatives	65
Positive nutritional characteristics	Healthy, without oil, less oil, without additives	35
Sensory characteristics		14
Taste	Tasty, good taste	45
Texture	Crispy, crunchy, dry	32
Attitudes and feelings	Desire to eat, addictive, temptation, I like it	23
Other characteristics		
	Innovator, innovative	5

Tab. 5. Perception of a vacuum-fried snack identified in the word-association task.

Dimension/Category	Examples of individual responses	Percentage of mention [%]
Sensory characteristics		60
Taste	Tasty	45
Attitudes and feelings	Desire to eat, addictive, temptation, I like it	27
Texture	Crispy, crunchy, dry	17
Appearance	Very similar to the traditional ones, good appearance, good presentation	9
Colour	Good colour, bright colours	2
Elaboration process		15
Ignorance	I don't know, never consumed, never heard of it	48
Cooking	Cooking method that does not use oil, less oil, vacuum cooking, unusual cooking	32
Packing	Vacuum-packed, package	20
Nutrition and health		10
Negative nutritional characteristics	Fatty, too much salt, too high in calories, cholesterol, junk food, unhealthy, preservatives	68
Positive nutritional characteristics	Reduced calories, lower fat, fat-free, healthy	32
Foods and beverages		8
Snacks	French fries, snack	58
Foods and beverages	Potatoes, beer, barbecue, meat, breaded veal cutlet	42
Consumption habit		4
Special occasions	Birthdays, get-togethers with friends, social gatherings	57
Frequency and portion	Small amount	43
Other characteristics		
	Interesting, innovative	3

et al. [33] expressed that several properties besides taste contribute to food liking. In accordance with this principle, another 27 % of the participants made mention of their attitude and perceived sensations regarding the vacuum-fried snack, noting that it was presented as an appealing product: "tempting", "addictive", "desire to eat", and "I like it". A smaller proportion of participants (17 %) also perceived the product as having a "crunchy", "crispy" and "dry" texture. According to Caro Cabarcas et al. [28], texture and flavour are attributes that determine the acceptance and perception of the product's quality. Other authors also reported that fried snacks are highly appreciated by consumers because of their unique combination of flavour and texture [8].

The second most significant dimension (15 %) was related to the form of the snack production. Most of the participants indicated that they knew nothing about the product, stating "I don't know", "never consumed", "never heard". This failure could be attributed to the difficulty of the participants to imagine a snack that is not yet available in the national market. Nevertheless, this type of product is indeed available in the regional market. A Uruguayan company, with funding from the National Agency for Research and Innovation, offers vegetable-based snacks fried by vacuum cooking. Furthermore, certain companies around the world, mainly in Asian countries, offer products with similar characteristics [34].

The third dimension stressed (10 %) was mainly associated with nutrition and health. Most of the associations were related to the negative nutritional characteristics of the vacuum-fried snack, such as "very caloric", "unhealthy", "junk food", "fatty" food, or containing "preservatives", "too much salt" and "cholesterol". Such associations could be justified by the growing consumer interest in "healthier" snacks and the scant familiarity with vacuum-fried products [8]. Accordingly, Crosa et al. [18] asseverated that, because chips obtained by vacuum frying involved a 50 % reduction of fat relative to standard commercial potato chips, those products could be considered as a reduced-fat item according to the Mercosur Technical Regulation [35]. Of the participants, 32 % responded with positive wordings about the product, perceiving it as a "healthy", "reduced-calories", "lower-fat" or "fat-free" snack. This approval indicated that at least some participants were able to perceive the vacuum-fried snack as

having an improved nutritional quality compared to the fried snacks sold in the Argentinian market.

Perception, and willingness to buy and try the vacuum-fried snack

The results indicated that a respective 71 % and 75 % of the participants were willing to buy and try the product. According to Nielsen company survey [7], a respective 63 % and 65 % of consumers globally like to buy and try new and varied snacks. Fig. 1 and Fig. 2 illustrate the representation of the relationship between the perception of the participants and the willingness to buy and try a vacuum-fried snack, respectively. The variance of the experimental data was represented by an 86 % (willingness to buy) and an 84 % (willingness to try). Regarding willingness to buy, Fig. 1 demonstrates that the participants would definitely buy the vacuum-fried snack because they associated it with a "tempting" product, which made them "want to try", "they look the same as the traditional ones" and had "good presentation". As was observed at willingness to try, the participants who were not willing to buy the snack mentioned negative nutritional characteristics. As to the willingness to try, Fig. 2 is consistent with the reaction that the participants who would definitely try the snack related it to categories of texture, attitude and agreeable sensations, appearance, as well as positive nutritional characteristics of the product. The participants who were not willing to try the product mainly mentioned the negative nutritional characteristics, perceiving it as "unhealthy" and "junk" food.

The results suggested that the nutritional and sensory characteristics of the vacuum-fried snack play a principal role in consumer choice. The same was mentioned by Araujo Martins et al. [25]. This is in line with the report of Alarcón-García et al. [5] that 60 % of Ibero-American consumers consider „healthiness" as a key determinant of snack purchasing and consumption. The negative attitude of the participants to try and buy the developed snack could be due to the lack of knowledge about the applied processing technology. Within this context, providing the information on improvement of the nutritional quality of foods by vacuum frying would be helpful in generating a more positive consumers' attitude towards the product. That would improve their perception and motivate their choice.

Snack colour acceptability

The information obtained on colour acceptability for each product was grouped to categories "I do not like" (1–3), "I neither like nor

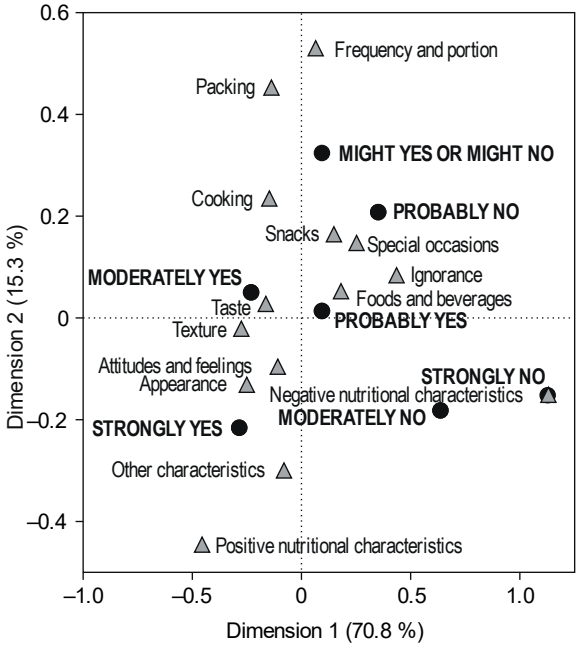

Fig. 1. Correspondence analysis to visualize the relationship between the categories identified (triangle) in the word-association task and the hedonic scale of willingness to buy (circle).

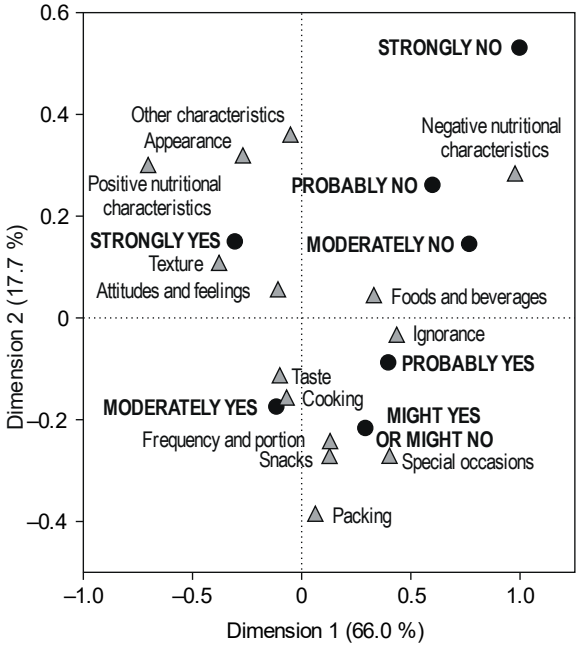

Fig. 2. Correspondence analysis to visualize the relationship between the categories identified (triangle) in the word-association task and hedonic scale of the willingness to try (circle).

dislike" (4) and "I like" (5–7). Approximately 65 % of the participants rated the snacks with the highest scores on the scale ("I like"), regardless of the frying method applied. According to MIELBY et al. [33], the visual properties of food can produce positive consumer feelings that lead to food acceptance. The results indicated that no significant differences ($p > 0.05$) were perceived in colour acceptability between snacks fried in vacuum and atmospheric pressure. The respective mean values ranged between 3.86 ± 1.08 and 3.88 ± 1.05. In general, colour of food changes significantly depending on the type of frying applied [18], but the results suggested that the colour of both products elicited similar affective reactions in the participants.

CONCLUSIONS

This exploratory study provided information to understand the relationship between the perception and the willingness to buy and try a snack made with potatoes and sweet potatoes. Potato chips were the participants' most frequently consumed commercial-vegetable-fried snack, mainly chosen on special occasions, at home and in social gatherings, motivated by pleasure and taste. Aspects related to cooking were the concepts most associated with vacuum frying, followed by a lack of awareness. In contrast, sensory characteristics were the most frequently associated with the vacuum-fried snack made with potatoes and sweet potatoes. The results of correspondence analysis showed that appearance together with sensory and nutritional characteristics of the developed snack are the main aspects that the participants will have when buying and trying the product. The acceptability of the colour through images of the snack fried under vacuum indicated similar perceptions as those fried at atmospheric pressure. More studies will be needed to assess product acceptability by a given population of potential consumers through sensory evaluation. A complementary study with physico-chemical and sensory analyses would be informative for determining the effect of vacuum frying on the quality parameters of the developed snack. The results of this study contribute to the existing literature on the consumption of fried vegetable snacks and expand our understanding of the main reasons why consumers choose this type of product, along with where and when they most frequently consume it. Providing reliable information on the advantages of the processing technology would be a valuable strategy to increase participants' confidence and knowledge of the favourable health-related features of the product.

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REFERENCES

1. Pedreschi, F. – Cortés, P. – Mariotti, M. S.: Potato crips and snacks foods. In: Reference module in food science. Amsterdam : Elsevier, 2018. ISBN: 9780081005965. DOI: 10.1016/B978-0-08-100596-5.21137-2.
2. Zapata, M. E. – Rovirosa, A. – Carmuega, E.: Cambios en el patrón de consumo de alimentos y bebidas en Argentina, 1996–2013. (Changes in the food and beverage consumption pattern in Argentina, 1996–2013.) Buenos Aires : Center for Studies on Child Nutrition Dr. Alejandro O'Donnell, 2016. ISBN: 978-950-99708-5-4. In Spanish.
3. Almoraie, N. M. – Saqaan, R. – Alharthi, R. – Alamoudi, A. – Badh, L. – Shatwan, I. M.: Snacking patterns throughout the life span: potential implications on health. Nutrition Research, *91*, 2021, pp. 81–94. DOI: 10.1016/j.nutres.2021.05.001.
4. Zapata, M. E. – Rovirosa, A. – Carmuega, E.: Patrones de snackeo de la población Argentina. (Snacking patterns of the Argentine population.) In: Center for Studies on Child Nutrition Dr. Alejandro O'Donnell [online]. Buenos Aires : Center for Studies on Child Nutrition Dr. Alejandro O'Donnell, 2015 [cited 07 July 2021]. <https://cesni.org.ar/archivos/Patronesdesnackeoweb16515.pdf>. In Spanish.
5. Alarcón-García, M. A. – Perez-Alvarez, J. A. – López-Vargas, J. H. – Pagán-Moreno, M. J.: Meat snacks consumption: Aspects that the consumer looks for to consider them a healthy food. Proceedings, *70*, 2021, article 82. DOI: 10.3390/foods_2020-07738.
6. Carbonell-Capella, J. M. – Esteve, M. J. – Frígola, A.: Snacks de patatas fritas y productos derivados, estudio de mercado. Aceptación en una alimentación saludable. (Snacks of chips and derived product, study market: Acceptance in a healthy diet.) Revista Española de Nutrición Comunitaria - Spanish Journal of Community Nutrition, 20, 2014, pp. 99–108. DOI: https://doi.org/10.14642/RENC.2014.20.3.5020. In Spanish.
7. Snack attack: What consumers are reaching for around the world. In: Nielsen [online]. New York : The Nielsen Company, 2014 [cited 07 July 2021]. <https://www.nielsen.com/wp-content/uploads/sites/2/2019/04/nielsen-global-snacking-report-september-2014.pdf>.
8. Albertos, I. – Rico, D. – Martín-Diana, A. B.: Improving the texture of healthy apple snacks by combining processing and technology (high pressure and vacuum frying). Journal of Food Processing and Preservation, *44*, 2019, article e14352. DOI: 10.1111/

jfpp.14352.
9. Martí, H. R.: Producción de batata. (Sweet potato production.) Buenos Aires : Ediciones INTA, 2018. ISBN: 978-987-521-963-2. In Spanish.
10. Oginni, O. – Sobukola, O. P. – Henshaw, F. O. – Afolabi, W. A. O. – Muñoz, L.: Effect of starch gelatinization and vacuum frying conditions on structure development and associated quality attributes of cassava-gluten based snack. Food Structure, *3*, 2015, pp. 12–20. DOI: 10.1016/j.foostr.2014.12.001.
11. García-Segovia, P. – Urbano-Ramos, A. M. – Fiszman, S. – Martínez-Monzó, J.: Effects of processing conditions on the quality of vacuum fried cassava chips (*Manihot esculenta* Crantz). LWT – Food Science and Technology, *69*, 2016, pp. 515–521. DOI: 10.1016/j.lwt.2016.02.014.
12. Giri, N. – Pradeepika, C. – Sajeev, M. S.: Process optimization by response surface methodology and quality attributes of orange-fleshed sweet potato (*Ipomoea batatas* L.) vacuum fried chips. Journal of Food Measurement and Characterization, *13*, 2019, pp. 2367–2376. DOI: 10.1007/s11694-019-00156-x.
13. Yang, J. H. – Park, H. Y. – Kim, Y. S. – Choi, I. W. – Kim, S. S. – Choi, H. D.: Quality characteristics of vacuum-fried snacks prepared from various sweet potato cultivars. Food Science and Biotechnology, *21*, 2012, pp. 525–530. DOI: 10.1007/s10068-012-0067-4.
14. Segunda Encuesta de Nutrición y Salud. (Second National Nutrition and Health Survey.) In: Ministerio de Salud Argentina [online]. Buenos Aires : Ministry of Health and Social Development of Argentina, 2019 [cited 07 July 2021]. <https://bancos.salud.gob.ar/sites/default/files/2020-01/encuesta-nac-nutricion-salud_resumen-ejecutivo.pdf>. In Spanish.
15. Guías alimentarias para la población Argentina. (Dietary guidelines for the Argentinian population.) In: Ministerio de Salud Argentina [online]. Buenos Aires : Ministry of Health of Argentina, 2016 [cited 07 July 2021].<https://bancos.salud.gob.ar/sites/default/files/2020-08/guias-alimentarias-para-la-poblacion-argentina.pdf>. In Spanish.
16. Deliza, R – Ares, G.: Consumer perception of novel technologies. In: Rosenthal, A. –Deliza, R. – Welti-Chanes, J. – Barbosa-Cánovas, G. V. (Eds.): Fruit preservation: Novel and conventional technologies. Food Engineering Series. New York : Springer, 2018, pp. 1–20. DOI: 10.1007/978-1-4939-3311-2_1.
17. Mariotti-Celis, M. S. – Cortés, P. – Dueik, V. – Bouchon, P. – Pedreschi, F.: Application of vacuum frying as a furan and acrylamide mitigation technology in potato chips. Food and Bioprocess Technology, *10*, 2017, pp. 2092–2099. DOI: 10.1007/s11947-017-1981-5.
18. Crosa, M. J. – Elichalt, M. – Skerl, V. – Cadenazzi, M. – Olazábal, L. – Silva, R. – Suburú, G. – Torres, M. – Vilaró, F. – Estellano, G.: Chips de papa, la fritura en vacío y beneficios para la salud. (Potatoes chips, vacuum frying and health profits.) INNOTEC – Journal of the Technological Laboratory of Uruguay, *9*, 2014, pp. 70–74. DOI: 10.26461/09.09. In Spanish.
19. Diamante, L. M. – Shi, S. – Hellmann, A. – Busch, V.: Vacuum frying foods: products, process and optimization. International Food Research Journal, *22*, 2015, pp. 15–22. ISSN: 2231-7546. <http://www.ifrj.upm.edu.my/22%20(01)%202015/(3).pdf>
20. Trejo-Escobar, D. – Cortés, M. – Mejía-España, D. F.: Efecto de la fritura al vacío sobre el contenido de los glicoalcaloides α-solanina y α-chaconina en papa cv Botella Roja. (Effect of vacuum frying on the content of the glycoalkaloids α-solanine and α-chaconine in potato cv Botella Roja.) Información Tecnológica, *30*, 2019, pp. 23–30. DOI: 10.4067/S0718-07642019000400023. In Spanish.
21. Belkova, B. – Hradecky, J. – Hurkova, K. – Forstova, V. – Vaclavik, L. – Hajslova, J.: Impact of vacuum frying on quality of potato crisps and frying oil. Food Chemistry, *241*, 2018, pp. 51–59. DOI: 10.1016/j.foodchem.2017.08.062.
22. Pandey, A. – Moreira, R. G.: Batch vacuum frying system analysis for potato chips. Journal of Food Process Engineering, *35*, 2011, pp. 863–873. DOI: 10.1111/j.1745-4530.2011.00635.x.
23. Esan, T. A. – Sobukola, O. P. – Sanni, L. O. – Bakare, H. A. – Muńoz, L.: Process optimization by response surface methodology and quality attributes of vacuum fried yellow fleshed sweet potato (*Ipomoea batatas* L.) chips. Food and Bioproducts Processing, *95*, 2019, pp. 27–37. DOI: 10.1016/j.fbp.2015.03.008.
24. de Andrade, J. C. – de Aguiar Sobral, L. – Ares, G. – Deliza, R.: Understanding consumers' perception of lamb meat using free word association. Meat Science, *117*, 2016, pp. 68–74. DOI: 10.1016/j.meatsci.2016.02.039.
25. Araujo Martins, I. B. – Olivera, D. – Rosenthal, A. – Ares, G. – Deliza, R.: Brazilian consumer's perception of food processing technologies: A case study with fruit juice. Food Research International, *125*, 2019, article 108555. DOI: 10.1016/j.foodres.2019.108555.
26. Pontual, I. – Amaral, G. V. – Esmerino, E. A. – Pimentel, M. Q. – Freitas, R. K. – Fukuda, R. K. – Sant'Ana, I. L. – Silva, L. G. – Cruz, A. G.: Assessing consumer expectations about pizza: a study on celiac and non-celiac individuals using the word association technique. Food Research International, *94*, 2017, pp. 1–5. DOI: 10.1016/j.foodres.2017.01.018.
27. García-Segovia, P. – Pagán-Moreno, M. – Tárrega, A. – Martínez-Monzó, J.: Photograph based evaluation of consumer expectation on healthiness, fullness, and acceptance of sandwiches as convenience food. Foods, *10*, 2021, article 1102. DOI: 10.3390/foods10051102.
28. Caro Cabarcas, A. D. – Sampayo Rodríguez, S. P. – Acevedo, D.C. – Montero, P. C. – Martelo Gómez, R. J.: Mass transfer and colour analysis during vacuum frying of Colombian coastal carimañola. International Journal of Food Science, *2020*, 2020. article ID 9816204. DOI: 10.1155/2020/9816204.
29. Normas para la rotulación y publicidad de los alimentos. (Standards for food labeling and advertising.) In: Código Alimentario Argentino [online]. Buenos Aires : National Administration of Drugs, Foods and Medical Devices, 2019 [cited 07 July

2021]. <https://www.argentina.gob.ar/sites/default/files/anmat_capitulo_v_rotulacion_14-01-2019.pdf>. In Spanish.
30. Andrés-Bello, A. – García-Segovia, P. – Martínez-Monzó, J.: Vacuum frying: an alternative to obtain high-quality dried products. Food Engineering Reviews, *3*, 2011, pp. 63–78. DOI: 10.1007/s12393-011-9037-5.
31. Juvvi, P. – Chakkaravarthi, A. – Debnath, S.: Emerging technique for healthier frying for production of reduced-fat beetroot (*Beta vulgaris*) chips. Journal Food Science Technology, *53*, 2016, pp. 3502–3511. DOI: 10.1007/s13197-016-2326-5.
32. Ultra-processed food and drink products in Latin America: Trends, impact on obesity, policy implications. Washington D.C.: Pan American Health Organization, 2015. ISBN: 978-92-75-11864-1. <https://iris.paho.org/bitstream/handle/10665.2/7699/9789275118641_eng.pdf>
33. Mielby, L. H. – Kildegaard, H. – Gabrielsen, G. – Edelenbos, M. – Thybo, A. K.: Adolescent and adult visual preferences for pictures of fruit and vegetable mixes – Effect of complexity. Food Quality and Preference, *26*, 2012, pp. 188–195. DOI: 10.1016/j.foodqual.2012.04.014.
34. Bouchon, P. – Dueik, V.: Frying of foods. In: Rosenthal, A. – Deliza, R. – Welti-Chanes, J. – Barbosa-Cánovas, G. V. (Eds.). Fruit preservation: Novel and conventional technologies. Food Engineering Series. New York : Springer, 2018, pp. 275–309. DOI: 10.1007/978-1-4939-3311-2_10.
35. Reglamento Técnico Mercosur sobre información nutricional complementaria. (Mercosur Technical Regulation on complementary nutritional information.) In: Código Alimentario Argentino [online]. Buenos Aires : National Administration of Drugs, Foods and Medical Devices, 2012 [cited 07 July 2021]. <https://www.argentina.gob.ar/normativa/nacional/resoluci%C3%B3n-1-2012-205164/texto> In Spanish.

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