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Acceptance of New Formulations of Extruded Gluten Free Snacks Based on Pulse Flours by Spanish Millennial Consumers

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Abstract: Nowadays, the food industry has developed novel gluten free extruded snack type products made from pulses, which could be good candidates to promote pulse consumption as a sustainable food product, while also satisfying the consumer's demand. Snack type products are a large part of the young people's diets and impact health outcomes, so it is essential to offer them snacks with a better nutritional profile. In this study, 81 Spanish millennial consumers tasted "in situ" six different gluten free snacks based on pulse flour (lentil and chickpea) marketed in Spain. The aim of the present study was: (a) to evaluate the Spanish millennial consumers' acceptance level of new pulse snack type products; (b) to evaluate the segmentation of the millennial consumers and understand the difference between the segments; (c) to evaluate the potential relationship between their nutrition food labelling and consumers' acceptance. In general, the lentil formulations (with more protein, more fat and less fiber) obtained higher scores than those of the chickpea. In addition, a multidimensional statistical analysis, preference mapping, and a statistical analysis of agglomerative hierarchical clustering were performed. Consumers were grouped into three clusters based on their preferences, allowing a detailed study of consumer acceptance of the selected snacks. Cluster 1 like less the samples with less salt, and, on the contrary, these samples were preferred by Cluster 3. Cluster 2 is a group who like lentil snacks, regardless of their flavoring. It was observed that the consumer segments differ at least in their preference for saltiness. The findings of this study also showed that the nutritional composition of the analyzed snacks (as appears in nutrition labelling) was associated with Spanish millennial consumers' acceptance and could provide valuable information to develop new snacks targeted at specific market niches, such as millennials. These data provide valuable insights when trying to anticipate Spanish millennial consumer acceptance of new gluten free pulse snacks.

Keywords: snacks; pulses; gluten free; sustainable food products; millennial consumers; multidimensional statistical analysis

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1. Introduction

Nowadays, consumers tend to look for novel food products with a proper nutritional profile, suitable organoleptic characteristics and with added functional properties. These food products allow the maintenance of the consumers' health status and even its improvement. Following this trend, the food industry has developed new products, many of them based on pulse flour, in order to satisfy consumers' preferences and meet the demand for all sectors of the population (children, adolescents, adults and the elderly), by offering products with a healthier nutritional profile [1,2]. The millennial generation (born between 1982 and 2004) is a unique and influential consumer group, which stands out due to its specific characteristics, and represents a large and prosperous market segment. The research on millennials is still infrequent, although it constitutes an interesting line, as these consumers play their own role in the food consumption process, and it is important to examine the factors that influence their products/services experiences [3].

According to Spanish regulation, snacks are products of variable shape, relatively low density and small weight per unit, manufactured mainly from starch, such as potatoes, corn, rice, wheat, other vegetables, and other food ingredients. They are made by extrusion, heating and/or can be fried in oil or edible fats [4].

Many of the snacks consumed by young people are high in energy density but low in nutrient density. This could be associated with an increased risk of different pathologies, such as obesity, type 2 diabetes, and cardiovascular disease. Obesity is a growing health problem, with a high prevalence among children and adolescents. This pathology is directly related with the diet and eating behaviors of population. Therefore, it is important to establish appropriate eating habits from childhood, in order to prevent obesity and its associated health issues. Due to snack type products being widely included in young people's diet and impacting their health status, it is essential to offer them snacks with a better nutritional profile, which will motivate young people to establish healthy snacking habits before reaching adulthood. However, it should not be forgotten that the consumption of snacks must be always occasional and moderate. Moreover, this type of products usually have a high salt content. Nevertheless, any changes in eating habits, which focuse on improving health, could be important to achieve this purpose, especially in our society, where obesity is a major problem [5].

The commercialization of snack type products in the market has increased over the years. This increase has been particularly noted in the gluten free sector, in order to satisfy the demands of the celiac population. Among the different technologies employed for the production of snacks, extrusion cooking is one of the most interesting and innovative processes [6]. This technology consists of applying high temperatures and high shear stress conditions over a short time, making it possible to design the texture, taste and shape, as well as the sensory characteristics of food products [1,6].

Pulses are a food with high nutritional value (relevant amount of proteins, dietary fiber and bioactive compounds) that should be part of people's diets. Besides their nutritional value, pulses are also a relevant alternative as a sustainable food, as they play a key role in cropping systems. These plants increase soil fertility because of their nitrogen-fixing properties. In addition, pulses require less water to grow than other crops and they do not require nitrogen fertilizers. For these reasons, pulses play a major role in addressing future global food security and environmental challenges, since they can help to create sustainable food systems [7]. However, nowadays, the consumption of these interesting foods tends to be low, as the preparation of pulses is usually a laborious process. For this reason, the food industry is focusing its efforts on the development of new and innovative food products, such as extruded snack type products, which constitute an alternative method of pulse consumption in all population sectors, while also satisfying consumers' demand by offering a wide range of healthier snacks [2,8–10]. Most of the snacks found in the market are made out of corn or rice starch, and, hence, they are often products of low nutritional quality due to their low nutrient density, high caloric value and high flavoring agents' content. For this reason, the use of pulses as food ingredients allows the obtainment of healthier snacks characterized by an interesting nutritional profile [10]. However, it is important to highlight that the content of salt in this type of food products is usually high, and consumers must not forget their occasional and moderate consumption. In order to ensure the success of these novel snack type products in the market, it is necessary to ensure consumer acceptance, taking into account that the acceptance is a dynamic process, which changes over time. The acceptance of snacks depends on several attributes, including appearance, texture, nutritional profile, and their easy to eat capacity, amongst others [10,11].

The application of the appropriate sensory analysis techniques and, specifically, the performance of multidimensional statistical analysis provide valuable information about consumers' acceptance. Therefore, these techniques constitute a fundamental tool for developing new food products, with a greater chance of success in the market. These statistical analyses provide key information that allow the food industry to predict the implementation of these products in the diet of consumers, because, although the food

industry makes efforts to develop innovative products, if these products do not satisfy consumers' demands and are not accepted by consumers, they will fail. For these reasons, it is important to study not only the sensorial attributes of food products, but also their nutritional composition, as well as their potential consumption impact on a consumer's diet quality. Despite the fact that snacks are food products whose consumption should be occasional, the food industry should try to improve the nutritional composition profile of this type of ready to eat food products, in order to maintain or even optimize consumers health status.

Nowadays, the manufacture of a wide range of snack type products made from different ingredients constitutes an important research line, so it is essential to carry out studies that aim to evaluate the consumers' acceptance of the new developed pulses snacks as an alternative to the traditional marketed cereal snacks (formulated with wheat and corn). The aim of the present study was to evaluate Spanish millennial consumers' acceptance level of new snack type products based on pulse flours (lentil and chickpea), to evaluate the segmentation of the millennial consumers and understand the difference between the segments, as well as to evaluate the potential relationship between their nutritional composition (values of nutrition labelling information) and their acceptance by consumers. Moreover, Spanish millennial consumers were grouped into different clusters based on their preferences, considering the nutritional parameters of the snacks.

The present work is a scientific study using human beings as a scientific tool in order to get information about human behavior and, specifically, about the acceptance of these newly developed pulse snacks. Therefore, in the present study, different techniques of multidimensional statistical analysis were applied to the results obtained from 81 millennial Spanish consumers, who tasted, "in situ," six different gluten free snacks recently marketed in Spain. Moreover, we would like to know if snacks' acceptance can be potentially correlated with the nutritional composition of the studied snacks (e.g., salt and fat content).

2. Materials and Methods

2.1. Snacks Samples

The consumers evaluated six different Spanish commercial snacks based on pulses (lentil and chickpea), whose characteristics are summarized in Table 1. Snacks were manufactured using extrusion process, which consists in applying high temperature and high shear stress conditions over short times [1,6]. The studied snack type products have been recently marketed in Spain, and, at the time of the study, it was necessary to visit specialized establishments to find them. For this reason, the snacks under study were considered as "new", as they were unknown for most of the consumers.

Table 1. Description of studied extruded gluten free snacks tasted by millennial Spanish consumers.

	Code	Characteristics
Snacks based on lentil	L1	Snack based on lentil with sea salt
	L2	Snack based on lentil with tomato and basil
	L3	Snack based on lentil creamy dill
Snacks based on chickpea	C1	Snack based on chickpea with sea salt
	C2	Snack based on chickpea with tomato and basil
	C3	Snack based on chickpea with creamy dill

Based on the labelling information of the studied snacks, all samples contained pulse flour as principal ingredient (48% of lentil flour in the snacks made from lentil and 45% of chickpea flour in the snacks based on chickpea). Moreover, all samples contained potato starch, rapeseed oil, and salt (sea salt in samples L1 and C1). The composition of snacks made from chickpea (namely, C1, C2, and C3) included rice and corn flour. Furthermore, four of the studied formulations (samples L2, L3, C2, and C3) contained rice flour, dextrose, yeast extract powder, onion powder, herbs (basil in L2 and C2, and dill in L3 and C3),

citric acid and flavorings. In the specific cases of samples L2 and C2 (both with tomato and basil flavor), the composition included sugar, garlic powder, spices and paprika as natural coloring. Finally, samples L3 and C3 (both with creamy dill flavoring) contained dry glucose syrup.

On the other hand, taking into account the nutritional information showed in the labelling of snacks (Table 2), it was observed that the caloric values were very similar in all studied formulations (466 kcal/100 g in snacks based on lentil and 449 kcal/100 g in snacks made from chickpea). The snacks developed from lentil were higher in fat (total fat and saturated fat) and protein, while the content of carbohydrates and dietary fiber were higher in the case of snacks based on chickpea. Sugar content was the same in all formulation (2.2 g/100 g). However, the content of salt differed between different products (1.89 g/100 g in L1; 1.98 g/100 g in C1; 2.6 g/100 g in C2 and C3; and 2.8 g/100 g in L2 and L3).

Table 2. Nutrition information showed in the labelling of the studied extruded gluten free snacks.

Nutrition Information	Code Sample					
	Snacks Based on Lentil			Snacks Based on Chickpea		
	L1	L2	L3	C1	C2	C3
Energy (kcal/100 g)	466	466	466	449	449	449
Fat (g/100 g)	19.5	19.9	19.5	17	17	17
Saturated Fat (g/100 g)	1.4	1.4	1.4	1.2	1.2	1.2
Carbohydrates (g/100 g)	66	66	66	68.4	68.4	68.4
Sugar (g/100 g)	2.2	2.2	2.2	2.2	2.2	2.2
Fiber (g/100 g)	3.2	3.2	3.2	4.5	4.5	4.5
Protein (g/100 g)	9.3	9.3	9.3	6.5	6.5	6.5
Salt (g/100 g)	1.89	2.8	2.8	1.98	2.6	2.6

L1: snack based on lentil with sea salt; L2: snack based on lentil with tomato and basil; L3: snack based on lentil with creamy dill; C1: snack based on chickpea with sea salt; C2: snack based on chickpea with tomato and basil; C3: snack based on chickpea with creamy dill.

2.2. Participants

The consumers study consisted of 81 young Spanish consumers (ages ranging from 20 to 35), 52% females and 48% males, recruited from Complutense University of Madrid, Spain, according to the University requirements and following the criteria to estimate the number of consumers necessary for sensory acceptability studies, described by Hough et al. (2006) [12]. Consumers' data concerning sex, age, nationality, and frequency of consumption of snack type products were recorded prior to the tests. Exclusion criteria for their participation were allergies to any ingredients of the samples and suffering from any food allergy or food intolerance.

2.3. Experimental Procedure

The participants tasted the 6 snacks based on pulses performing the test with a 9-point hedonic scale [13]. To carry out the acceptance study of new snack type products based on pulses, the researchers contacted the consumers on the campus of the Complutense University of Madrid, Spain. This study was performed by meeting the legal requirements of the Complutense University of Madrid, Spain. Once the consumers agreed to participate voluntarily, they signed an informed consent document and they received information about the procedure. Consumer data relating to sex, age, nationality and frequency of snack consumption were recorded prior to conducting the test. Each consumer performed the blind test with six coded samples of a fixed amount of snacks, rating the overall liking with 9-point hedonic scale anchored with "like extremely" and "dislike extremely" at either end and with a neutral point of "neither like nor dislike" in the middle, following the specific protocols included in the Sensory analysis–Methodology–General guidance for conducting

hedonic tests with consumers in a controlled area, UNE–EN ISO 11136:2014 [14]. This international standard describes approaches for measuring, within a controlled area, the degree to which consumers like or relatively like products. Consumers were asked to gargle with water between samples and no information concerning the products or the experiment was given before the test. Consumer tests were generally conducted in specific rooms, equipped temporarily in a "task specific" way for assessing products that require little preparation. The area was arranged in two separate parts, one dedicated to conducting the tests and the other to preparing and coding the products. In all cases requirements such as good lighting and isolation from noise and odors were fulfilled [14–16]. All the snack samples were prepared before each test and in each test and for each consumer, order of presentation of samples was randomly assigned in order to minimize learning bias. The amount of product presented to consumers corresponded to a portion specified and was equal for all members of the panel. The consumers were informed about the minimum amount of the sample to be tested and also about the maximum amount to be tested [14].

2.4. Statistical Analysis

Mean ± standard deviations (SD) of obtained hedonic scores were determined using the Statgraphics Plus 5.1 software to analyze the data at 95% confidence level. The data were statistically analyzed by mixed model ANOVA, followed by Duncan's test when significant results were found. The statistical significance level was set at $p < 0.05$. With the objective of interpreting and understanding the consumer's preferences for each sample, multidimensional analysis was applied to the data obtained. Agglomerative hierarchical clustering (AHC) was conducted on the consumers using the overall liking data. AHC, principal components analysis (PCA), and internal and external preference maps were performed with XLSTAT® 2021.

3. Results

3.1. Consumer Acceptance

The results obtained in the acceptance study of the evaluated extruded gluten free snacks based on pulse flour by Spanish millennial consumers are detailed in Table 3. It was observed that Spanish millennial consumers are able to find differences between the tested snack type products. Moreover, the snack C1, based on chickpea with sea salt, obtained significantly lower ($p < 0.05$) scores, compared to the other samples (in each row of Table 3, different small superscript letters ("a" and "b") mean statistically significant differences ($p < 0.05$) among the hedonic scores of snacks, compared by Duncan's test). Overall, the lentil snacks obtained higher scores than those of chickpea, with C3 and L3 samples (both with creamy dill flavoring) being the best valued by Spanish millennial consumers, with an average score of 7.1 and 7.0, respectively. It is noteworthy that consumers who participated in the study used the majority of the range of the hedonic scale of nine points, with the mean scores of snacks between 5.8 and 7.1 points.

Table 3. Mean scores obtained by using the hedonic scale of nine points for extruded gluten-free snacks.

		Sample Code					
		Lentil Snacks			**Chickpea Snacks**		
		L1	**L2**	**L3**	**C1**	**C2**	**C3**
Average Score		6.8 ± 1.7^{b}	6.8 ± 2.1^{b}	7.0 ± 1.8^{b}	5.8 ± 2.3^{a}	6.5 ± 2.3^{b}	7.1 ± 1.9^{b}
Score by Gender	Male	$7.1 \pm 1.5^{b,A}$	$7.0 \pm 2.2^{ab,A}$	$7.4 \pm 1.6^{b,B}$	$6.1 \pm 2.4^{a,A}$	$6.9 \pm 2.4^{ab,A}$	$7.1 \pm 2.1^{b,A}$
	Female	$6.5 \pm 1.9^{b,A}$	$6.6 \pm 2.1^{b,A}$	$6.4 \pm 1.9^{b,A}$	$5.5 \pm 2.2^{a,A}$	$6.2 \pm 2.4^{ab,A}$	$7.1 \pm 1.8^{b,A}$

In each row, different small superscript letters ("a" and "b") mean statistically significant differences ($p < 0.05$) among hedonic scores of snacks, compared by Duncan's test. In each column, a different capital superscript letter ("A" and "B") means statistically significant differences ($p < 0.05$) due to the gender of consumers, compared by Duncan's test. L1: snack based on lentil with sea salt; L2: snack based on lentil with tomato and basil; L3: snack based on lentil with creamy dill; C1: snack based on chickpea with sea salt; C2: snack based on chickpea with tomato and basil; C3: snack based on chickpea with creamy dill.

Millennial consumers rated lentil formulations higher, characterized by higher protein and fat content and lower dietary fiber content, while chickpea formulations were valued lower.

In addition, our study revealed differences attributed to the participants' genders. It was observed that men generally had a greater preference for snacks, and they scored snack type products higher than women did. These differences were statistically significant ($p < 0.05$) in the case of sample L3 (snack based on lentil with creamy dill) (in each column of Table 3, different capital superscript letter ("A" and "B") mean statistically significant differences ($p < 0.05$) due to gender of consumers, compared by Duncan's test).

3.2. Multidimensional Statistical Analysis

The principal components analysis (PCA) was performed considering all nutritional parameters shown in the snack nutrition labelling and explained 99.89% of the total variation of the data. From the results obtained from this PCA, the samples are positioned on the graph according to their nutritional profile, as shown in Figure 1. Component 1 (characterized by saturated fat, carbohydrates, dietary fiber, and protein content) showed 83.65% of the total variation of the data. On the other hand, component 2 (characterized by salt content) explained 16.24% of the total variation of the data.

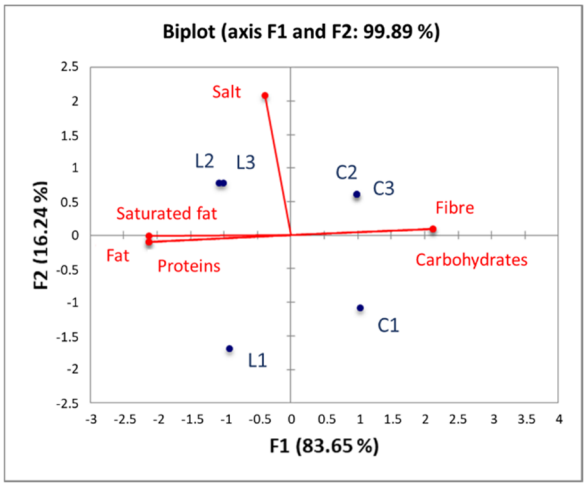

Figure 1. Principal components analysis (PCA) of nutritional composition of extruded gluten free snacks. F1: component 1, axis X; F2: component 2, axis Y; L1: snack based on lentil with sea salt; L2: snack based on lentil with tomato and basil; L3: snack based on lentil with creamy dill; C1: snack based on chickpea with sea salt; C2: snack based on chickpea with tomato and basil; C3: snack based on chickpea with creamy dill.

Using PCA, the analyzed snacks are graphically represented in a two dimensional space, introducing their nutritional composition and explaining a high percentage of the variance. The products are distributed according to their composition in the four quadrants showing their differences in terms of their nutritional value. Samples C2 (snack based on chickpea with tomato and basil) and C3 (snack based on chickpea with creamy dill) are located in the first quadrant, more characterized by axis or component 1, with a higher content of carbohydrates and dietary fiber. While the snacks that are graphically represented in the second quadrant (L2 and L3, which correspond to samples based on lentils with tomato and basil and with creamy dill, respectively) have a higher content of total fat, saturated fat, and salt. In contrast, samples formulated with sea salt, such as C1 (based on chickpea; rich in fiber and carbohydrates) and sample L1 (based on lentils) are found in third and fourth quadrants, respectively. These samples are principally characterized by axis or component 2, and are products with the lowest salt content.

In the present study, agglomerative hierarchical clustering (AHC) was performed and consumers were classified into three main clusters (cluster 1 with 26 consumers, cluster 2

with 29 consumers, and cluster 3 with 26 consumers) according to the hedonic scores (acceptability) (Figure 2). Figure 3 shows their ratings averaged by snack type product. The results indicated that cluster 1 preferred snack L2 (sample of lentils with tomato and basil flavoring), while cluster 2 favored L2 and L3 products (snacks based on lentil with tomato and basil and with creamy dill, respectively). In addition, consumers of cluster 2 gave a low score to the C1 sample (chickpea snack with creamy sea salt). Finally, cluster 3 was the group of consumers that gave the lowest scores and the product they preferred was C3 (chickpea sample with creamy dill flavoring). Based on the results from Figure 3, it appears that the consumer segments differ at least in their preference for saltiness: Cluster 1 like less the samples L1 and C1, with less salt, and on the contrary, these samples were preferred by Cluster 3. Cluster 2 seems to consist of lentil-likers, who liked lentil based snacks regardless of their flavoring.

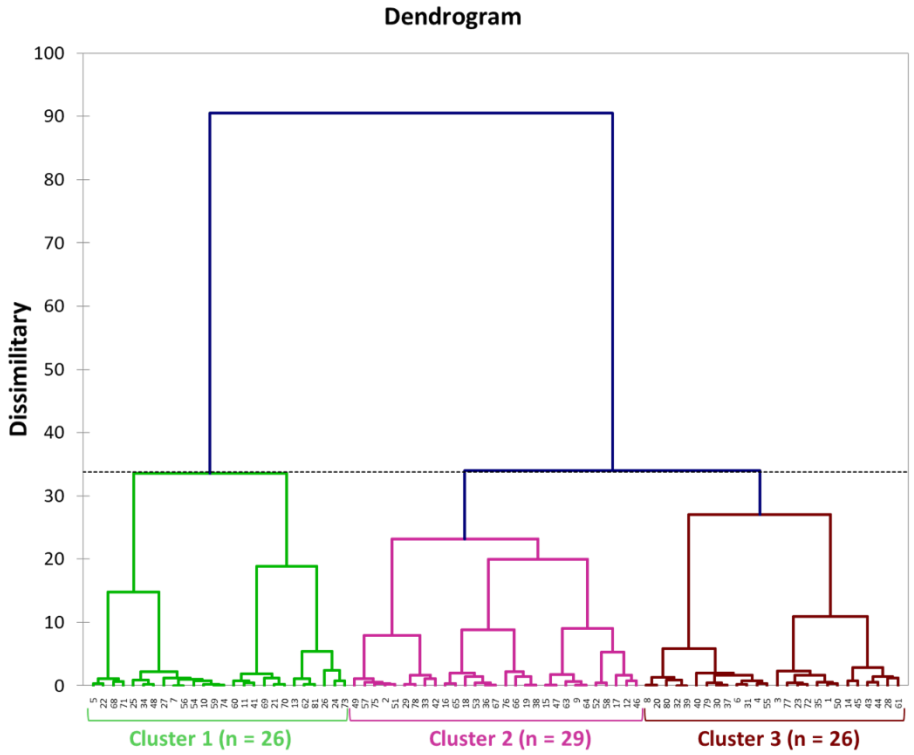

Figure 2. Agglomerative hierarchical clustering (AHC) of consumers taking into account their extruded gluten free snacks preferences.

The individual preferences of the millennial consumers were analyzed by internal preference mapping (Figure 4), by performing a principal component analysis (PCA) of the matrix of hedonic scores across the gluten free extruded snacks (the observations) and the millennial consumers (the variables). This statistical technique allows the appreciation of differences in the magnitude of consumer preferences, as this method identifies individual consumer's preferences by mapping their location nearest to snacks they rated highest. The factor scores explain the amount of the variation in the results, which is explained by that axis on the biplot. Component 1 accounts for 28.04% of the variation, and component 2 accounts for 20.27% of the variation, accounting for 48.31% of the total variation. Consumer preferences were widely spread across the plot, especially across F1. Samples were grouped depending on their nutritional composition, and the results showed that samples C2 and L2 (characterized by high salt content) were preferred by the majority of the millennial consumers.

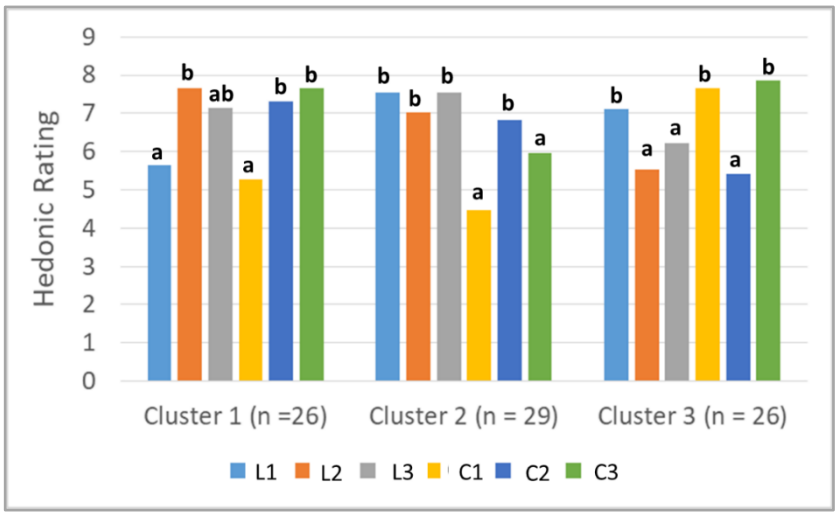

Figure 3. Mean scores obtained by using the hedonic scale of nine points for analyzed snacks, evaluated by 81 consumers grouped by agglomerative hierarchical clustering. (Different small superscript let-ters (a, b) mean statistically significant differences ($p < 0.05$) among each consumer cluster due to the hedonic scores of the extruded gluten free snacks, com-pared by Duncan's test). L1: snack based on lentil with sea salt; L2: snack based on lentil with to-mato and basil; L3: snack based on lentil with creamy dill; C1: snack based on chickpea with sea salt; C2: snack based on chickpea with tomato and basil; C3: snack based on chickpea with creamy dill.

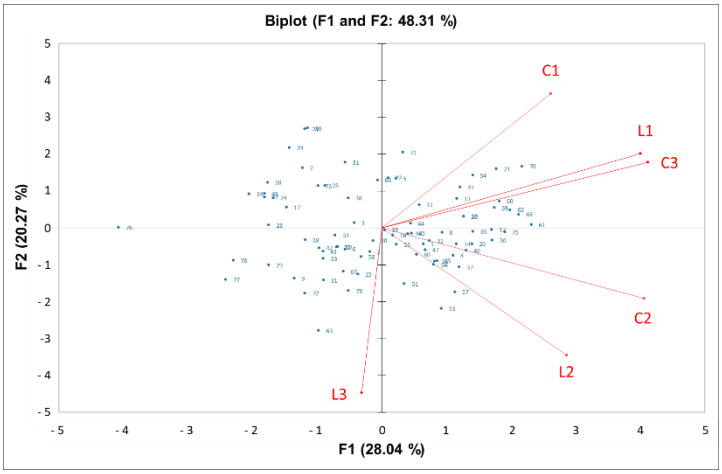

Figure 4. Internal preference map of six extruded gluten free snacks tasted by 81 consumers. F1: component 1, axis X; F2: component 2, axis Y; L1: snack based on lentil with sea salt; L2: snack based on lentil with tomato and basil; L3: snack based on lentil with creamy dill; C1: snack based on chickpea with sea salt; C2: snack based on chickpea with tomato and basil; C3: snack based on chickpea with creamy dill.

In this study, the external preference map was performed by using the hedonic data, grouped into three clusters and related with the snacks' compositions. The aim of this analysis was to relate the preferences of consumers and the nutritional composition of the food products. As Figure 5 shows, the consumers of cluster 1 preferred snack L2 (high in fat), while cluster 2 favored L2 and L3 products, which are characterized by a higher fat content, which increases their palatability. In addition, consumers of cluster 2 gave a low score to the C1 sample (sample with less fat and salt content). Finally, the consumers of cluster 3 preferred the snack C3, characterized by a higher fiber content. Figure 5 shows that clusters 1 and 3 differ in their liking for snacks depending on their salt content. As appears

in this graph, cluster 3 likes one of the snacks with less salt content (C1). These results provide valuable information about human behavior and, specifically, about food choices.

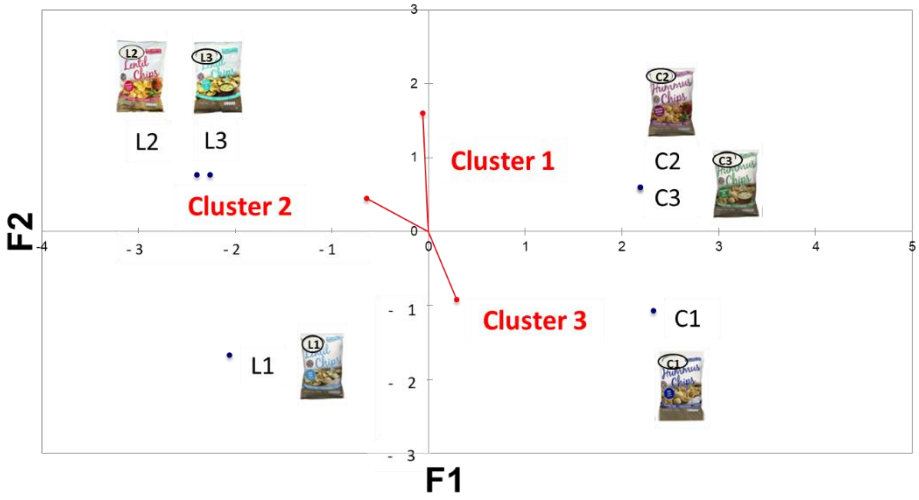

Figure 5. External preference map of six extruded gluten free snacks tasted by 81 consumers, grouped into three clusters. F1: component 1, axis X; F2: component 2, axis Y; L1: snack based on lentil with sea salt; L2: snack based on lentil with tomato and basil; L3: snack based on lentil with creamy dill; C1: snack based on chickpea with sea salt; C2: snack based on chickpea with tomato and basil; C3: snack based on chickpea with creamy dill.

4. Discussion

Pulse consumption has progressively decreased over time [17] and among the potential barriers to its consumption the perceived difficulty of preparation and their long cooking time are highlighted [18]. In order to increase pulse consumption, different strategies have been identified. Melendrez-Ruiz et al. (2019) considered that the development of trendy innovative products to fit consumer profiles could prove effective to increase the consumption of pulses. In this sense, snacks based on pulses are good candidates and their consumer acceptance is key to ensuring their success in the market [18].

At this point, in this work, a hedonic test has been performed in order to evaluate the Spanish millennial consumers' acceptance of gluten free extruded snacks based on pulses. Although there are many research consumers acceptance studies in the scientific literature in the last years, there are scarce studies that focus on the Spanish consumer acceptance of snacks and, to our knowledge, there are no studies on snacks based on chickpea and lentils. As previously mentioned, consumers who participated in the present study used the majority of the range of the hedonic scale of nine points, which means that millennial participants showed a great level of acceptability/displeasure for the tasted snacks. On the contrary, other authors who have studied the acceptance of different snacks made from corn flour and enriched with different sources of protein, such as soy protein or serum proteins, reported that consumers rated the samples using a small range of the nine-point hedonic scale, giving scores close to the midpoint of the same [19]. As was previously mentioned, a consumer's acceptance is a dynamic process that changes over time, and the differences observed in the present work could be related with the specific population (Spanish millennials) as well as with the type of products that they tasted (snacks based on pulses flours).

As previously stated, the food industry is working hard on the development of new food products, as today's society has a growing interest in finding healthy products in the market with high nutritional quality. In a similar study, Suknark et al. (1998) evaluated the acceptance of different extruded snacks (fish snacks and peanut snacks) among American and Asian consumers. These authors found that, in general, American consumers scored higher for peanut snacks while Asian consumers rated fish snacks more positively. These results indicated that the incorporation of pulses in the development of snacks could

be a good strategy to improve the nutritional quality of this type of products, which could be accepted by occidental consumers. Moreover, it was observed that participants of the stated study rated the analyzed products with average scores of 6.7–6.9 (on the nine-point hedonic scale) [20]. These scores are similar to those obtained in our study. Saint-Eve et al. (2019) used a nine-point hedonic scale in order to assess the liking for eight high plant protein snacks developed by extrusion and based on different blends of pea, rice, and wheat flours [21]. Considering that all snacks tested in the study performed by Saint-Eve et al. (2019) were unflavored, participants liked them rather well (with a mean score of 5.6) and snacks made from pea and wheat were more appreciated than those made from rice and wheat. In addition, extruded snacks with the highest pea content tended to be less liked than snacks with a low pea content [21]. Comparing these results with those obtained in the present work, it is observed that flavored products, such as the snacks analyzed, received higher scores, and hence are better accepted than those that are unflavored. Rapando et al. (2020) evaluated consumers' acceptance of three formulations of soy fortified snacks subjected to different fermentation periods and they observed that samples fermented without soy were better appreciated (using nine-point hedonic scale) than the samples that incorporated soy and were subjected to fermentation [22]. As previously mentioned, one of the lines of research that shows high current interest consists of the development of gluten free snack type products, such as the samples analyzed in the present study. In this sense, Arribas et al. (2019) evaluated the overall quality (according to a nine-point hedonic scale) of six extruded formulations based on rice/bean/whole carob fruit flour blends and their results showed that the overall quality of the extrudates was not affected by the amount of bean in the formulations. Moreover, they observed that samples formulated only with rice and bean (without carob fruit) had the highest score [8].

In modern environments, taste driven decisions of what to eat must be examined, as our sense of taste could lead us to eat highly palatable foods, which are high in calories but low in nutrients, an action that, if repeated, often will affect health status negatively [23]. In our study, millennial consumers rated higher lentil formulations, characterized by higher protein and fat content and lower fiber content, while chickpea formulations were rated low. Higher fat content is related to the higher palatability of food products [24,25], and this fact could justify that the snacks based on lentil were the preferred by participants in the study. This fact has also been observed by Holmer et al. (2012), who used a seven-point hedonic scale in order to investigate the degree of acceptance of different types of snack (bar type) by Danish and Swedish children aged between 8 and 11 years. The results obtained by these authors showed that the preferred snacks for school children of both nationalities were kamut/pumpkin bar and an oat/cranberry bar. Specifically, these snacks were the richest in fat (20 and 19 g/100 g, respectively) and lowest in carbohydrates (39 and 54 g/100 g, respectively). In contrast, the lowest rating formulation was the pumpernickel/sea buckthorn bar, which contained 1 g of fat per 100 g and 65 g of carbohydrates per 100 g [26]. Moreover, it is reported that protein content had a significant effect on the sensorial attributes of extruded snacks, as higher levels of protein inhibit the expansion of the snacks after exiting, resulting in snacks that are less puffed, less porous, and less uniform in overall appearance [19].

Regarding the impact of gender on the acceptance of these extruded gluten free snacks, the present work revealed statistically significant differences ($p < 0.05$) attributed to the participants' genders, as it was observed that men had a greater preference for these snacks. In previous studies, it has also been shown that snack consumption is higher in the case of the male population, both in Argentine university students [27] and in Spanish university students [28]. Moreover, Raptou (2021) has recently investigated the relationship between behavioral factors, including snack choices, and adolescents' body weight. These authors observed that snack choices seem to be gender specific, since boys show stronger preference for more energy dense foods, such as deep fried foods (similar to the snacks analyzed in the present study), while girls preferred other healthier alternatives, such as dairy products [29]. This observation indicates that it is important that the food industry

pays special attention to improving the nutritional profile of snack type products, as well as that nutrition professionals should provide information about healthy snack options in order to contribute to the maintenance of adolescents' body weight and, hence, contribute to the maintenance of their health status.

Principal component analysis (PCA) is a statistical technique used to describe a set of data, increasing interpretability and minimizing information loss, and explaining the variance structure of a set of variables. This tool provides comprehensive visual information about the nutritional composition of the six different extruded gluten free snacks analyzed. Arribas et al. (2019) and García-Herrera et al. (2020) performed PCA based on the nutritional composition of the food products [8,30]. On the other hand, Neely et al. (2010) performed PCA based on the different sensorial attributes of the products [31]. In our study, the PCA was performed using the values of nutrition labelling in order to describe the different snacks according to their nutrition information. The food labelling is the link between the food industry and the consumers, so it is important to analyze the impact of nutritional information on the consumers' perception and choice of foods. Recently, Velázquez et al. (2021) have evaluated the impact of label information on parents' health perception and choices of two popular snack products. These authors reported that label information has a strong effect on mothers' health perceptions and choices of snacks for their children [32]. The research in this area is important for the food industry, as, nowadays, consumers tend to look for food products with a proper nutritional profile, and not only with suitable organoleptic characteristics.

Agglomerative hierarchical clustering (AHC) is a classification methodology that works from dissimilarities between the subjects grouped together. The classification of consumers in different groups allows a detailed study in order to find differences in the acceptability of the different snacks based on pulse flour and currently marketed in Spain. ACH allowed the classification of the consumers based on their preferences for different snacks. This type of analysis provides interesting information about the development and optimization of new food products for the different consumers profile.

The results obtained showed that the preference differs between the three clusters of millennial consumers. Cluster 1 (26 consumers) and cluster 2 (29 consumers) preferred lentil snacks, while cluster 3 (26 consumers) preferred chickpea snack with creamy dill flavoring. Moreover, clusters 1 and 3 differ in their liking for snacks depending on their salt content. At this point, it is important to highlight that a standard portion of snacks is 30 g, and one portion of the studied snacks contributes 0.57–0.84 g of salt. Taking into account that the recommendation of WHO [33] indicates that the intake of salt must be les of 5 g/day, the consumption of one snack portion contributes 11.4–16.8% of the daily recommended intake of salt. For this reason, it is important to indicate to consumers that, to achieve proper eating habits, the consumption of snacks must be occasional and moderate. Salt content is a factor directly related to the palatability and acceptance of food products and it is known that small differences in salt content significantly affect consumer hedonic reactions. In previous studies, a positive association has been found between perceived saltiness and consumers preferences, and a positive link has been also found between liking salty food products and dietary sodium intake [34,35]. Moreover, it has been reported that saltiness affected preferences differently depending on the type of food tested, suggesting that there are food specific preferences for high salt content [34]. Indeed, it has been described that small differences in salt content significantly affect consumer hedonic reaction [36].

Kreger et al. (2012) have evaluated consumers' acceptance of different high protein extruded snack foods by using AHC. Their results showed that panelists were grouped into four preference segments by their overall acceptance ratings. Cluster 1 (34 panelists), showed a slight preference toward samples comprised of mainly whey protein, and had moderately low acceptance scores. Cluster 2 (13 panelists), showed a higher preference for samples comprised mainly of soy protein, and less preference for samples lower in total protein content. Cluster 3 (31 panelists) preferred samples comprised mainly of soy protein,

while showing a higher acceptance than cluster 2 towards samples comprised of mainly whey protein. Finally, cluster 4 (22 panelists) had the highest overall acceptance ratings and showed a slight preference toward samples comprised mainly of whey protein and the lowest drop in liking scores for samples highest in total protein content [19]. Saint-Eve et al. (2019) evaluated the consumer acceptance and the sensory drivers of the liking of extruded snacks formulated with a high level of plant proteins. They observed that consumers of clusters 1 and 3 tended to reject products with a high level of pea (characterized by a more intense odor and stronger pea flavor), while consumers of cluster 2 preferred products with a higher pea content, with an intense pea flavor, puffy appearance and crispy texture [21].

Preference mapping allows displaying of observations on a sensory map as vectors. It is a valuable tool for interpreting consumers' preference by projecting the products on the various vectors (product preference). Preference mapping is a multivariate statistical tool that provides a map in which you can see the preferences of consumers for a specific food product. Internal preference mapping is based on PCA and identifying products related to groups of consumers using the hedonic scores. External preference mapping is a multidimensional representation of the products based on sensory profile or a set of other external data. This representation is obtained from the PCA of the data matrix, with products as rows and external data as columns. In this analysis, the consumers' data fits in the sensory space [37]. In the present study, external preference mapping was developed using a data matrix with snacks as rows and nutrition labelling information as columns, in order to explore the potential relationship between the nutritional composition of the analyzed gluten free snacks and millennial consumers' acceptance. The results of the internal preference mapping showed that samples L2 and L3 (characterized by high salt content) were preferred by the majority of the millennial consumers. Moreover, an external preference map was created by using the hedonic data, and relating the preference of three clusters of consumers with the snacks composition. The results showed that consumers of clusters 1 and 2 preferred lentil snacks characterized by a higher fat content, while the consumers of cluster 3 preferred the snacks C3 (formulated with chickpea and flavored with creamy dill), characterized by a higher fiber content.

External preference mapping is a key tool in the product development stages to obtain a better understanding of consumer preferences for various products of the same category. Moreover, the results of the external preference mapping could be applied for the reformulation of new products, as their nutritional composition is critical to influencing their sensory perception and, hence, their consumer acceptance. The results obtained in the present study are quite difficult to compare with previously reported preference maps because of the lack of reporting on snack type products. Other authors have applied this statistical tool with the aim of relating the consumer liking data to different food product compositions. Recently, Mahato et al. (2021) applied external preference mapping to the consumer liking data in order to reveal the ideal product composition of chocolate milk acceptability. These authors reported that the content of fat, salt, and sugar were associated with a liking for chocolate milk, while protein did not affect liking [38]. In other work, Volpini-Rapina et al. (2012) evaluated the sensory profile of orange cakes with added prebiotic compounds (inulin and inulin/oligofructose) and standard cake (without prebiotics). These authors concluded that the addition of prebiotics in the analyzed cakes were feasible, since the results of preference mapping showed that cakes with prebiotics were preferred to commercial cakes [39]. Preference mapping has also been performed to determine which kind of reduced fat Havarti type cheeses were most liked by Finnish consumers, showing that the cheeses with the highest salt content were the preferred [40]. In the specific case of gluten free products, Alencar et al. (2017) evaluated the acceptance of gluten free and sucrose free breads with the addition of pseudo cereals and sweeteners. These authors correlated the data obtained in the sensory studies by performing external preference mapping, which showed that samples containing amaranth and the sweeteners sucralose, stevia, and sucralose–acesulfame-K were the most accepted by consumers. Their

results indicated that amaranth constitutes a potential substitute for incorporation in gluten free bakery products, which seems be accepted by celiac patients [41].

The present study provides valuable information for the development of extruded gluten free snacks based on pulses. Preference mapping of pulse snacks' attributes is very useful for a better understanding of these consumers' preferences, and allows the obtainment of valuable information to anticipate their reactions and segment them. The results obtained in this study revealed that the nutritional composition of snacks' labelling is also related to the consumer acceptance of snacks based on pulses. This information could be useful for the food industry in the development of new food products with better nutritional profile.

5. Conclusions

Snack type products are an important part of young people's diets and can impact health outcomes. The use of pulses in the snack´s design could be a potential alternative to the consumption of wheat and corn, promoting the consumption of other, more sustainable, crops and, at the same time, provide added nutritional value (e.g., prebiotic oligosaccharides) with functional properties. The novelty of our study resides in the study of Spanish millennial consumers acceptance of new snacks based on chickpea and lentils, as a potential alternative for the celiac population.

It was observed that millennial Spanish consumers are able to find differences among some of the different gluten free snacks under study. In general, the lentil formulations (with more protein, more fat and less fiber) obtained higher hedonic scores than those of chickpea. This research identified three clusters of millennial consumers with varying preference patterns. Cluster 1 likes less the samples with less salt, and, on the contrary, these samples were preferred by Cluster 3. Cluster 2 is a group that likes lentil snacks, regardless of their flavoring. These consumer segments differ at least in their preference for saltiness. These data provide valuable insights when trying to anticipate Spanish millennial consumer acceptance of new gluten free pulse snacks. The findings of this study also showed that the nutritional composition of the analyzed snacks (as appears in nutrition labelling), was associated with Spanish millennial consumers' acceptance and could provide valuable information to develop new snacks targeted at specific market niches, such as millennials.

Future cross cultural studies in this line should be developed in order to make it possible to anticipate the degree of consumer acceptance of these interesting novel gluten-free snacks.

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