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Article

Attitudes and Sensory Perceptions of Food Consumers towards Sustainable Technological Innovation in Mexico

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Abstract: Sustainable innovation in the agro-food system has become a strategy increasingly used by companies as a means to increase their competitiveness and position themselves in the market. In this context, the objective of this work is to identify the attitudes and sensory perceptions of consumers towards sustainable food technology through two scales (Food Technology Neophobia and Domain Specific Innovativeness) and hedonic tastings. For this, a new product was selected in the market: powder to prepare rice with milk. Most consumers have attitudes toward low neophobia to products with food technology, but there is also some caution, situation that is corroborated by the moderate predisposition towards innovations. Color and flavor attributes can make the difference in positive perceptions. It should not be forgotten that there is a segment of innovative sustainable consumers that represent a key market.

Keywords: food sustainable innovation; rice with milk; hedonic tasting

1. Introduction

Innovation in products is a strategy to achieve competitiveness in the food sector and meet corporate objectives. In order to be carried out, it is necessary that the managers of the company make a large investment of resources, not only economic, but of time and personnel. Hence, before launching this innovation to the market, countless tests and investigations are carried out. Despite this, failure rates remain very high, around 80% [1, 2, 3, 4, 5]. In the particular case of Mexico it is 85% [6].

The success or failure of an innovation can be multifactorial conditioned by culture, by rejection of new products, ethnocentrism, economic and social aspects, among others [7]. In this sense, when talking about new foods, many of them implement food technologies, a concept that some consumers generate aversion, so in recent years, the trend of research have focused on the analysis of consumer phobia toward products with food technology [8, 9, 10, 11, 12, 13].

Cooperative research in food science, engineering and economics can generate technologies and market innovations that can serve as an impulse for commercialization and agro-industrial development. However, simply generating a promising technology is not enough to transform agriculture or consumer perception. Research must address the emerging limitations that the next generation of technology users can face, develop capabilities and continuously provide technical assistance until technology is mature [14].

Identifying population segments that are more or less neo-phobic and early adopters of food technologies plays an essential role in the success of a new product from a marketing standpoint. In this context, the objective of this paper is to identify the attitudes and sensorial perceptions of consumers towards sustainable food technology. To achieve this, we used a traditional dessert with innovative process: powder to prepare rice with milk. This seeks to generate information that is useful to the Mexican agroindustrial sector and to improve competitiveness, since this sector has grown considerably in recent years, mainly due to its productivity, availability of raw materials, and the country's capacity to serve as an export platform for more than 40 countries with which it has trade agreements [15].

The present document is integrated by four more sections: literature review, methodology, results, conclusions and implications

2. Materials and Methods

2.1. Theoretical Background

Neophobia to food technology

In the application of food technologies, public trust is a crucial and a fundamental aspect in their perception [16, 17, 18]. Negative attitudes toward food technologies may prevent widespread adoption and result in product failure [13]. All this forces us to question the future of the implicit categorizations that condition food tastes and rejections [19].

In this line, the neophobia scale to food technology (FTNS) of Cox and Evans [8] arises. The FTNS aims to be a better tool for predicting consumers' willingness to try new foods with technology than the Pliner and Hobden [20] food neophobia scale because it focuses on the use of technology rather than food [21].

The application of FTNS has been mostly limited to developed countries: Australia [8]; [9]; Italy [10,11,22,23,24,25]; Canada [21, 7]; South Korea [26]; Poland [27]. In the case of developing countries we find; Brazil [12]; Uganda [13] and Chile [28]. The evidence on studies in Mexico is scarce, therefore this research is one of the first to provide guidelines in this line and allows to know the preferences of the Mexican consumer towards the products elaborated with food technology.

The most commonly used food technologies in recent studies have been: pasteurized fruit juice, high-pressure fruit juice processing, modified salad atmosphere packaging, triploid prawns, genetically modified oilseeds, and bioactive yoghurt [8, 9], processed organic food, light and frozen [10, 11, 22, 23] and the use of nanotechnology [21,26,12,24], vacuum packaging [7], fortified & functional products [27,25]. Some findings that have been obtained in a comparative way indicate that Brazilians are less neo-phobic than the Australians and Canadians [9, 21, 12], the participants are unfamiliar with genetically modified food and nanotechnology, influenced by risk and perceived benefit as well as the level of confidence in the food industry [24,12], there is also a predictive effect between ethical values and ecological awareness with the intention of buying genetically modified food [26].

Although the FTNS is of recent appearance, it has been validated by Chen et al [7]; Evans et al. [9]; Matin et al. [21]; Verneau et al. [11]; Coppola et al. [22], although the small number of investigations do not allow the validation of their use in different contexts [13], particularly in the case of developing countries such as Chile, where FTNS has been reduced to a single factor which comprises 9 items instead of 13 [28].

Specific Domain Innovation

Innovation is considered a fundamental basis for development and competitiveness, so that ideas, methods, innovative structures, as well as new products or services are seen as important drivers of organizational and economic growth [29, 30, 31]. In this context, innovation is a technological and social change [32]. In order to innovate it is necessary to have a broad knowledge of the needs of consumers and from this perspective, some studies have related the adoption of new

93 products with socioeconomic characteristics [33]. Younger consumers are more innovative than
94 older ones [34,35, 36, 37]; The greater the socioeconomic status of the consumer, as well as the level
95 of education, the greater the possibility of being more innovative.
96 Also the innovation is more accepted the lower the difference is in relation to the system of
97 representations and the pre-existing culture [38] of the consumers, which is presented in a very
98 marginal way and consumer distrust is a primary affective state linked to its survival instinct and is
99 not modified by simple reasoning [39].
100 In this sense, some research indicates that the innovative tendency of the consumer
101 (innovativeness) is a consistent predictor of the adoption of innovations [40,41,42], reflecting a
102 predisposition to learn and adopt innovations (new products) within a Domain-Specific
103 Innovativeness DSI [40], in such a way that innovative consumers have a greater propensity for
104 consumption than the conservatives [43].
105 Falcao et al. [44] in their meta analysis have related the DSI with seven elements based on a
106 meta-analysis: 1) adoption of innovations; 2) attitude; 3) behavioral intent; 4) use of the product; 5)
107 leadership of opinion; 6) opinion search and, 7) perception of risk, with significant results except for
108 the search for opinion. Recent investigations have used it comparatively in different contexts
109 [45,36,46,47,48], particularly in the case of Mexico, analyses have been made on innovative
110 processes in some foods such as table grapes, pecans and maize [49,50). However, from a consumer
111 behavioral perspective, the application of the DSI scale is incipient, we can find the studies of Terán
112 et al. [37] and Salgado et al. [51] with interesting findings for marketing management.

113 Sensory Analysis

114 Sensory analysis of food is an examination of the organoleptic properties of a product feasible
115 with the senses and is divided into three groups: descriptive, discriminative and consumer (hedonic
116 tasting) [52]. In this work only the hedonic tasting was applied, where the consumer is asked to
117 assess the degree of general satisfaction that a product produces using a scale. From this point of
118 view, consumers summarize their perception of ideas about authenticity and quality, this means the
119 perfect adaptation to their culture, to their system of representations [38].
120 Sensory analysis has been an effective instrument for the quality control and acceptability of
121 novel foods in investigations around the world such as: white strawberry [53]; potato chips [54];
122 soybean oil [55]; fresh cheese [56]; maracuya [57]; corn tortilla [58]; daily supplements [59]; mandarin
123 juice [60]; sausages with orange peel flour [61]; wine [62] even in insects [63,64].

124 *2.2. Methodology*

125 The research is cross-sectional, exploratory with a quantitative approach. It consisted of three
126 phases: 1) Product selection; 2) Design of the instrument and 3) Sensory analysis.
127 **1) Product selection**
128 For the selection of the product a linear route was made by the supermarkets in which it was
129 sought to find a product that would satisfy the food technology application feature and also be
130 based on a traditional Mexican food. The powder was selected to prepare rice with milk, although
131 the product is of Spanish heritage, the Mexicans have adopted it. It is an instant dessert that offers
132 time savings in its preparation, which turns out to be a trend in the market given the current needs
133 and changes in consumption patterns. This position is reflected in the sector, in 2014, the processed
134 food industry's production in Mexico was 135.5 billion dollars, which represented 23.4% of the
135 manufacturing GDP and 3.9% of the national GDP. value added is 37.4% [15].
136 From a consumer perspective, desserts represent an important part of Mexico, in recent
137 research of 91.3-95% of respondents like desserts, consider it a good gesture to have dessert when
138 friends and family are invited home [65,66) also accustom to consuming them as part of the
139 breakfast or snack [67].
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142 **2) Instrument design**

143 A measurement instrument was designed that was applied through a personal survey directed
144 to the consumers to know their attitudes towards the new foods with technology, composed by: 1)
145 FTNS scale (food technology neophobia scale) of Cox and Evans [8] ; 2) Goldsmith and Hofacker
146 [40] DSI (Domain-Specific Innovativeness) scale and 3) sociodemographic aspects (gender, age,
147 marital status, income level and educational level). The FTNS is integrated by 13 items that
148 measures 4 factors: 1) technology in new foods is unnecessary, 2) risk perception, 3) healthy option
149 and 4) media information (Table 1) and is evaluated in Likert scale scores of 5 or 7 points, with a
150 range of possible scores of 13-65 and 13-91 [9], respectively. Before performing any analysis, the
151 scores corresponding to the four items indicated with (I) must be inverted in order to obtain the
152 same values. The higher this score, the greater the phobia of the individual to food technology.

153 **Table 1-** FTNS scale

Ítem
F1. New food technologies are unnecessary There are plenty of tasty foods around so we don't need to use new food technologies to produce more.
The benefits of new food technologies are often grossly overstated.
New food technologies decreases the natural quality of food.
There is no sense trying out high-tech food products because the ones I eat are already good enough.
New foods are not healthier than traditional foods.
New food technologies are something I am uncertain about.
F2. Perception of risks
Society should not depend heavily on technologies to solve its food problems.
New food technologies may have long term negative environmental effects.
It can be risky to switch to new food technologies too quickly.
F3. Healthy choice
New food technologies are unlikely to have long term negative health effects. (R).
New products produced using new food technologies can help people have a balanced diet. (R).
New food technologies gives people more control over their food choices. (R).
F4. Information/ media
The media usually provides a balanced and unbiased view of new food technologies. (R).

154 (R) = Indicates reverse scored items. Source: Cox and Evans [8].

155 The DSI scale contains 6 items (Table 2) and is evaluated on a Likert scale of 5 or 7 points, with
156 a range of possible scores of 6-30 and 6-42 respectively. A total score was calculated for each
157 individual, which is obtained from the sum of the scores assigned to each of the items. As in the
158 FTNS scale, it is recommended to invest three of the items (I) that make up the scale, in order to
159 obtain valuations in the same direction. Once the scores have been obtained, consumers are
160 segmented into innovators and followers.

161 **Table 2-** DSI scale

In general, I am among the first in my circle of friends to buy a new food when it appears
If I heard that a new food was available in the store, I would not be interested enought to buy it (R)
Compared to my friends I own a lot of food

In general, I am the first in my circle of friends to know the titles/brands of the latest food
I will not buy a new food if I haven´t heard/tried it yet (R)
Food I do not like to buy before other people do (R)

(R) = Indicates reverse scored items. Source: Goldsmith and Hofacker [40]

Sample

The formula for finite populations was used. For the calculation of the sample, the data of the National Institute of Statistics and Geography (INEGI) was taken as reference, establishing a sample of 266 surveys (95% confidence level and 6% margin of error). The target market was people older than 18 years of age, from the upper middle (C +), middle (C), low middle (D) [68] class of Caborca (Sonora, Mexico). The data collection was carried out in two phases: first, a pilot test for debugging the scales and second, the application of the final survey, carried out in the months of September-October 2015 by means of a simple random sampling.

1) Sensory analysis (hedonic tasting)

In the third stage, a sensorial analysis was performed, on October 24, 2015. A group of people (n = 23) who consumed rice pudding, over 18 years old, were selected. The test was performed in a specific room, with adequate lighting. Two trademark products were handled with different types of processes: a) new process techniques, according to Bigliardi and Galati [69] and, b) traditional, both of similar consistency and color to make the evaluations.

Two tastings were made, in the first without showing the brand (blind tasting) and in the second showing the brand. This in order to detect significant differences between one shot and another. Bottled water was served to be used between the samples. The scoring method was used, that is to say for each defined descriptor (taste, smell, color, texture, appearance and consistency), it was assigned a scale of numerical scores. The hedonic scale used for valuations was 0 (I do not like it at all) to 5 (I really like it).

Data Analysis

In order to measure the internal consistency of the scales used, a reliability analysis was performed using Cronbach's alpha, which allowed the elimination of a series of variables for their adequacy. Univariate analyzes were carried out to study the behavior of the variables individually, bivariate (ANOVA and Chi-square test) to know the differences between groups and multivariate (Factorial) to debug the scale and group the items in several factors.

Once the measurement of both scales were obtained (TFNS and DSI), consumers were segmented in the FTNS scale in high and low food technology phobia and DSI in innovators and followers.

3. Results

The sample is composed of 71.4% women and 28.6% men, 32.7% are 36-44 years old, followed by the range of 25-35 years (25.2%). 41.7% are married and 30.5% single. 41.4% have university studies and the level of family income is concentrated in $ 2,000-8,000 per month (85%). 53.2% know the new powder to prepare rice pudding and the rest (46.8%) do not know of its existence in the market.

Neophobia to food technology

On the FTNS, initially in the pilot test, the scale was eliminated with 9 items out of 13. A factorial analysis was performed to determine the components that the population associates with the FTNS and to verify the original scale by means of the method of extraction of components with Varimax rotation. The Bartlett sphericity test was significant (p <o.ooo) and the Kaiser-Meyer-Olkin (KMO) was 0.827 indicating the relevance of performing the analysis.

Of the 4 factors measured by the FTNS (Technology in new foods is unnecessary, risk perception, healthy choice and media information) in the study we extracted 2 factors as final

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206 solution, similar results are found in: Chen et al. [7] and JeżEwska-Zychowicz and Królak [27]. The
207 two factors explain the 62.24% of the data variability, which Hair et al. [70] consider admissible.
208 Factor 1 (43.95%): Technology in new foods is unnecessary and risk perception is composed of 7
209 items, 4 belong to factor 1 and 3 to factor 2 of the original scale [8]. Factor 2 (18.28%): Healthy choice
210 has both items of the original scale. Both with acceptable internal consistency measured by
211 Cronbach's Alpha (factor 1 $\alpha = 0.869$, factor 2 $\alpha = 0.615$) as proposed by Hair et al. [70] for exploratory
212 studies (Table 3).

213 **Tabla 3.** Factorial Analysis

FTNS Items	Factors		Mean	sd
	New food technologies are unnecessary and Perception of risks	Healthy choice		
New food technologies decreases the natural quality of food.	**0.788**	0.031	**3.71**	1.289
There is no sense trying out high-tech food products because the ones I eat are already good enough	**0.752**	0.325	3.00	1.367
New foods are not healthier than traditional foods.	**0.789**	-0.094	**3.56**	1.325
New food technologies are something I am uncertain about.	**0.708**	-0.041	2.68	1.277
Society should not depend heavily on technologies to solve its food problems.	**0.741**	0.155	3.12	1.29
New food technologies may have long term negative environmental effects.	**0.713**	-0.361	**3.54**	1.39
It can be risky to switch to new food technologies too quickly.	**0.736**	-0.22	2.93	1.246
New products produced using new food technologies can help people have a balanced diet. (R).	0.101	**0.785**	**3.61**	1.209
New food technologies gives people more control over their food choices. (R).	-0.147	**0.852**	3.03	1.456
Cronbach's alpha coefficient	0.869	0.615		
Percentage of total variance explained (62.24%)	43.95	18.28		
Extraction Method: Principal Component Analysis.Rotation Method:Varimax with Kaiser Normalization. Kaiser- Meyer-Olkin (KMO) 0.827.				
Factors loading > 0.4				
a. Rotation converged in 3 iterations.				

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It is observed that the mean values (quantified on a 5-point Likert scale) are centered on: New food technologies reduce the natural quality of food (3.71); New products produced using new food technologies can help people to have a balanced diet (I) (3.61); New foods are no healthier than traditional foods (3.56) and new food technologies can have long-term negative effects on the environment (3.54), which suggests an attitude towards food aversion with technology (Table 3). However, it is a low phobia that the consumer presents, since when extracting the mean value of the FTNS is 29.19 and the median of 30 (typical deviation of 7,064), ie individual scores equal to or below this value indicate that the respondent is relatively less phobic and thus tends less to reject food technology. Higher scores, on the other hand, indicate a relatively greater rejection of this type of product. Thus, the low phobia segment is formed by 66.5% of the sample and the high phobia segment by 33.5%. To know the differences between groups, a chi-square test was performed with significant results between segments at 5% (X2 = 0.000) (Figure 1).

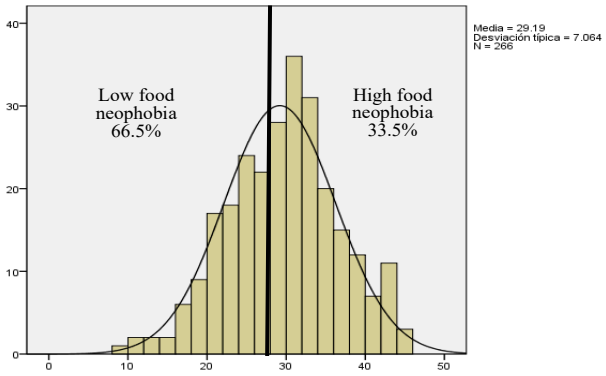

Figure 1- Distribution of FTNS according to consumer ratings

The FTNS has been correlated with sociodemographic variables (age, educational level and income level). It was found that age is positively related to factor 1. The technology in new foods is unnecessary and risk perception, it is inferred that older people tend to perceive that technology in new foods is unnecessary and a perception of risk similar to the study by De Steur et al. [13]. The educational and income level is negatively related to healthy option factor 2, consumers with less studies and low economic level will perceive foods with technology as a healthy option (Table 4).

Some studies have found no significant relationship with the variables age, educational level and income level [8,9,7]. The difference in these results is probably the context of the country where the scale was applied, since they are developed countries and in the particular case that subscribes to this research is a developing country.

Table 4 – Correlation between the FTNS factors and socio-demographic variables

FTNS factors	Age	Education level	Monthly Income
F1 New food technologies are unnecessary and Perception of risks	0.219* (0.000)	-0.071 (0.246)	0.001 (0.985)
F2 Healthy choice	-0.017 (0.783)	-0.199* (0.001)	-0.256* (0.000)

* Significant at 0.01 level.

Domain specific innovation

On the DSI, initially the pilot scale was scrubbed with 3 items out of 6. To verify its unidimensionality [71], a factorial analysis was performed, obtaining a total explained variance of 83.81% in the first factor, given that the value is greater than 40% is considered unidimensional [72], Bartlett's sphericity test was significant and the KMO was 0.742. The internal consistency of the

items measured by Cronbach's alpha coefficient was α = 0.903, similar to that obtained in other studies [40,45,36,51).

The DSI has been correlated with sociodemographic variables (age, educational level and income level). It was found that age is negatively related to the adoption of innovations, that is, the older the innovative character decreases, similar results are presented in: Leek et al. [73]; Rogers [34]; Tellis et al. [35]; Barrena et al.[36]; Terán et al. [37].

In the case of the variables educational level and income there is a positive relation, to greater economic status and academic degree that the individual has, can trigger a greater innovative attitude (Table 5).

Table 5 - Correlation between the DSI factors and socio-demographic variables

	Age	Education level	Monthly Income
Total DSI	-0.144** (0.019)	0.295* (0.000)	0.234*(0.000)

* Significant at 0.01 level.

** Significant at 0.05 level.

On the average values of the DSI (scored on a 5-point Likert scale) the highest is centered on: In general, I am the first of my circle of friends to buy new foods (3.54) (Table 6). There was a moderate attitude towards innovations, the average value of the consumer was 8.41 and the median value was 8 (typical deviation of 1.51). The median was used as the cut-off point, so it was segmented to the consumers surveyed in innovators and followers, finding that 44.7% is innovative and 55.3% follower. To know the differences between groups, a chi-square test was performed with significant results between segments at 5% (X2 = 0.000) (Figure 2).

Table 6- Mean score

Ítems	**Media**	**s.d.**
I do not like to buy new food before other people do	2.39	1.302
In general, I am among the first in my circle of friends to buy a new food when it appears	**3.54**	1.283
Compared to my friends I own a lot of food	2.48	1.321

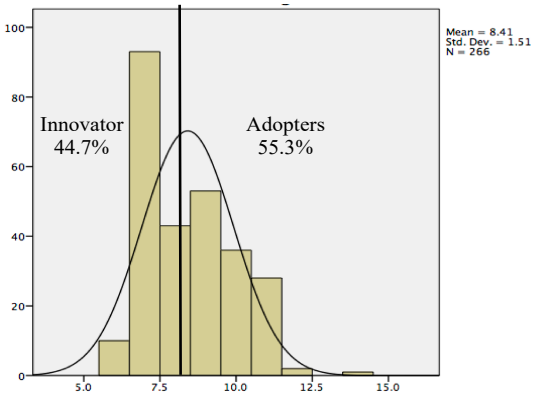

Figure 2- Distribution of DSI according to consumer ratings

Sensory analysis (hedonic tasting)

The 2 blind / open samples were tasted and the ballots delivered were filled. The results show with higher score the color (4.35) and appearance (4.35) of the rice with new milk, on the contrary, the taste (3.22) is the lowest evaluated of the traditional rice with milk. To know the differences between variables, a one-way ANOVA test was performed, which allowed the simultaneous study of the differences with a fixed level of significance. There are significant differences in color and appearance (Table 7).

Table 7- ANOVA (test-blind)

Variable	ANOVA (P VALOR)	Rice wth milk (new)	S.d.	Rice wth milk (traditional)	S.d.
Flavor	.352	3.57	1.037	3.22	1.536
Smell	.156	4.04	1.296	3.48	1.410
Color	.044*	4.35	.885	3.83	1.114
Texture	.072	3.74	.915	3.30	1.363
Appearance	.015*	4.35	.775	3.65	1.301
Consistency	.497	3.83	.937	3.26	1.514

The scale from 1= I do not like to 5= I like very much. *Significant at 0.05 level.

A second open hedonic tasting was carried out, in which the brands of the compared products were made known, with the purpose of knowing if there is influence of the brands in the perception of the consumer. The findings are very interesting, the new rice with milk reduces its score in almost all variables and traditional rice with milk is maintained. Which suggests that consumers do not have a good perception of the innovative product brand. However, the ANOVA does not present significant differences between the attributes (Table 8).

Table 8- ANOVA (open test)

Variable	ANOVA (P VALOR)	Rice wth milk (new)	S.d.	Rice wth milk (traditional)	S.d.
Flavor	.739	3.09	1.240	3.61	1.406
Smell	.241	3.30	1.329	3.13	1.456
Color	.475	3.57	1.343	3.70	1.146
Texture	.160	3.43	1.308	3.30	1.363
Appearance	.425	3.65	1.369	3.39	1.305
Consistency	.473	3.48	1.344	3.22	1.594

The scale from 1= I do not like to 5= I like very much.

4. Discussion

Innovation in the agri-food system has become a strategy increasingly used by companies as a means to increase their competitiveness and position themselves in the market. Thus, some companies have initiated changes to generate what the market requires and thus be able to satisfy the needs and desires of consumers. In this context, the objective of this work was to identify the sensory attitudes and perceptions of consumers towards sustainable food technology through two scales: Neophobia to Food Technology (Food Technology Neophobia) by Cox and Evans [8] and Domain Innovation Specifics (Domain Specific Innovativeness) of Goldsmith and Hofacker [40], and hedonic tastings, using the product rice with milk powder.

The main findings show that most consumers present attitudes towards a low neophobia to products with food technology, being an important segment (66.5%) that manifests a need for innovative foods, but there is also caution, that is, there is a coexistence between a demand for modernity and for the natural [22]. This situation is corroborated by the results of attitudes towards innovations, where there is a moderate predisposition towards new foods and the classification of consumers is in the group of followers (55.3%).

Regarding sensory perceptions, individuals identified the food product with their organs, color and appearance were the attributes most valued in rice with new milk, on the contrary, rice with milk called traditional, had a low valuation in the flavor, suggesting that the new product was more liked by the participating consumers. Therefore, it can happen that a food has a high hedonic valuation but does not succeed in the market, conversely, it would be very difficult for a hedonic valuation to conquer a market for many efforts made by the marketing department.

As business implications, knowing the attitudes and perceptions of consumers presents an advantage for the introduction of new foods in the markets to define differentiated strategies between segments. Strategies should be designed to improve consumer perception and confidence, several studies clearly indicate that there is a general lack of knowledge and understanding of new food technologies (for example: nanotechnology, cloning, genetic modification, agrobiotechnology, etc.) in terms of the presence and its application in food production in the agri-food industry [74]. Additionally, considering the appearance, texture, color and taste of foods, in the particular case of this study, can make a difference in the positive perceptions of consumers and the inclination to purchase, in such a way that there is no need to lose of view that exists a segment of innovative consumers that represent a key market.

Limitations and future investigations

Finally, as a limitation of this research, when focusing on rice with milk powder, the results can not be generalized to other new foods, in the same way it must be taken into account that it is exploratory in nature and is confined to a region specific study, and extrapolation to other settings should be done with caution. Therefore, it would be interesting to extend the scope of the research to other food innovations or to other markets.

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Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

FTNS Food Technology Neophobia Scale
DSI Domain-Specific Innovativeness
ANOVA Analysis Of Variance

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