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Food technology neophobia and consumer attitudes toward foods produced by new and conventional technologies: A case study in Brazil

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ABSTRACT

New food technologies are promoting innovations in the food sector. However, not all technologies are accepted and understood by consumers; some cause resistance. The present work sought to study the behavior of Brazilian consumers in relation to different food technologies. A questionnaire was administered to a representative sample of 389 respondents in Belo Horizonte-MG, Brazil. Questionnaire collected information on consumer perceptions regarding new technologies by means of the Food Technology Neophobia Scale (FTNS), translated and validated into Portuguese, in addition to familiarity and willingness to try yogurts labeled such as traditional, pasteurized, organic, genetically modified, enriched with bioactive proteins and nanotechnology. Results suggested that neophobia regarding food technology is important to explain consumer behavior in relation to new technologies, especially for nanotechnology. Participants were less familiar with foods labeled as GM and nanotechnology, and willingness to try these products was lower. Consumers are still wary of GM and nanotechnology, possibly due to lack of assurance that these foods are safe for human health and the environment. For new food technologies (such as nanotechnology) that are still recent, communication is very important, being decisive for the consolidation of consumer perceptions, and consequently for the acceptance of these innovations on the market.

1. Introduction

In recent years, new food technologies have been promoting innovations in the food sector and the number of new foods has increased considerably. In this context, much research has been devoted to new technologies used in food production and processing. One reason for this interest is the range of benefits that these new technologies can provide to the food industry and the consumer). Advantages include safer, healthier and more nutritious foods using less energy, water and chemicals and producing less waste (Rollin, Kennedy, & Wills, 2011). Some technologies could even enhance environmental sustainability (Matin et al., 2012), and increase food productivity.

In a globalized market, there are two major consumer trends: on one hand, there is a growing demand for modernity (functional foods, convenience foods, health foods such as low-calorie and low-sodium foods), and on the other hand there is a growing demand for natural foods (organic foods, natural foods, local products and typical foods). Although technologies have arisen in response to market needs and the more rigorous consumer demand, it is well documented that consumers are increasingly wary of new technologies due to the risks and lack of perceived benefits (Cox, Evans, & Lease, 2007; Frewer, Bergmann, et al., 2011). Currently, consumers are exposed to various applications of emerging technologies, including genetic modification (GM foods), food irradiation and nanotechnology (Rollin et al., 2011; Siegrist, 2008). However, caution and aversion by consumers has been found for a wide range of food technologies in different countries (Backstrom, Pirttila-Backman, & Tuorila, 2004; Cardello, 2003; Cardello, Schutz, & Lesher, 2007; Cox et al., 2007; Siegrist, 2008; Siegrist, Cousin, Kastenholz, & Wiek, 2007). The preservation technique, food irradiation, although considered safe and effective by the scientific community, was not accepted by consumers (Ronteltap, Van Trijp, Renes, & Frewer, 2007). Literature indicates that the acceptance

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of new technologies applied to food production varies from country to country. Genetically modified foods tend to be more accepted by American consumers than by European and Japanese consumers (Gaskell et al., 2000; Lusk, Roosen, & Fox, 2003). According to Schnettler, Crisóstomo, et al. (2013), among developing countries there are groups of consumers who have a positive attitude towards genetically modified foods, as is the case of Brazil (Da Costa, Deliza, Rosenthal, Hedderley, & Frewer, 2000), China (De Steur et al., 2010) and Kenya (Kimenju & De Groote, 2008), but in other developing countries, perceptions are generally more negative than positive, as in Argentina (Mucci, Hough, & Ziliani, 2004) and Chile (Schnettler, Miranda, Sepúlveda, & Denegri, 2012).

Applications of nanotechnology in the food sector are recent and have been growing rapidly in recent years. However, public perception and attitude towards nanotechnology is not yet clear (Gruère, 2012). Although nanotechnology has great potential to generate new products and processes and is increasingly used in food processing and packaging (Sanguansri & Augustin, 2006), little is known regarding its acceptance by consumers. Studies have shown that currently the population is not familiar with and has little knowledge of nanotechnology (Chaudhry et al., 2008; Matin et al., 2012; Siegrist, Stampfli, Kastenholz, & Keller, 2008). Nevertheless, food and packaging involving nanotechnology are already being marketed, although the number of products is still small (Frewer, Bergmann, et al., 2011). In the near future, nanotechnology may become increasingly important in the food sector, mainly due to investments from government agencies and industry in its development and implementation (Frewer, Fischer, Norde, & Kampers, 2011). Recent studies conducted in European countries indicate that consumers are still skeptical about buying food produced using nanotechnology (Bieberstein, Roosen, Marette, Blanchemanche, & Vandermoere, 2013; Siegrist et al., 2007; Stampfli, Siegrist, & Kastenholz, 2010). No data was found in literature on the perception of Brazilian consumers regarding nanotechnology.

Consumer attitude of new technologies will determine its success or failure in the marketplace. Thus, evaluating the acceptance of new technologies rather than risk a negative reaction from the public is sensible (Frewer, Bergmann, et al., 2011; van Kleef, van Trijp, & Luning, 2005). The food industry and research institutions that develop new technologies, and consequently new food concepts, should promote more interdisciplinary research,

Table 1
English and Portuguese version of the Food Technology Neophobia Scale (FTNS): loadings, item means and standard errors (se).

Item	English	Portuguese	Loadings			Means (SE)
			1 PC (27.6%)	2 PC (15.5%)	3 PC (11.9%)	
1	New food technologies are something I am *uncertain* about.	Eu não estou totalmente familiarizado com novas tecnologias empregadas na produção e/ou processamento de alimentos.	−0.001	−0.026	0.903	4.4 (1.9)
2	New foods are *not healthier* than traditional foods.	Novos alimentos não são mais saudáveis do que os alimentos tradicionais.	0.601	0.114	−0.067	3.7 (2.0)
3	The benefits of new food technologies are often grossly *overstated*.	As afirmações sobre os benefícios de novas tecnologias empregadas na produção e/ou processamento de alimentos são frequentemente muito exageradas.	0.424	0.246	−0.066	3.9 (1.9)
4	There are plenty of tasty foods around so we *do not* need to use new food technologies to produce more.	Já existem inúmeros alimentos saborosos no mercado, então nós não precisamos de novas tecnologias para produzir mais alimentos.	0.622	0.104	0.025	2.1 (1.7)
5	New food technologies *decrease* the natural quality of food.	Novas tecnologias empregadas na produção e/ou processamento de alimentos reduzem a qualidade natural dos alimentos.	0.750	0.057	0.067	3.4 (2.0)
6	New food technologies are *unlikely* to have long term *negative* health effects.[a]	Novas tecnologias empregadas na produção e/ou processamento de alimentos provavelmente não trarão, a longo prazo, efeitos negativos à saúde.[a]	0.407	0.265	0.215	4.3 (1.9)
7	New food technologies give people *more* control over their food choices.[a]	Novas tecnologias empregadas na produção e/ou processamento de alimentos proporcionam às pessoas um maior controle sobre as suas escolhas alimentares.[a]	0.267	0.798	−0.048	3.3 (2.0)
8	New products using new food technologies can help people have a balanced diet.[a]	Novos produtos que utilizam novas tecnologias de alimentos podem ajudar as pessoas a terem uma dieta equilibrada.[a]	0.350	0.688	−0.035	2.9 (1.8)
9	New food technologies may have long term *negative* environmental effects.	Novas tecnologias empregadas na produção e/ou processamento de alimentos podem causar, a longo prazo, efeitos negativos ao meio ambiente.	0.641	0.196	−0.055	3.8 (1.9)
10	It can be risky to switch to new food technologies too quickly.	Pode ser arriscado mudar rapidamente para novas tecnologias empregadas na produção e/ou processamento de alimentos.	0.577	0.278	0.260	4.2 (1.9)
11	Society should *not depend* heavily on technologies to solve its food problems.	A sociedade não deve depender demais de tecnologias para resolver os seus problemas alimentares.	0.523	0.074	0.301	4.1 (2.1)
12	There is no sense trying out high-tech food products because the ones I eat are already good enough.	Não faz sentido experimentar alimentos produzidos a partir de alta tecnologia, porque os que eu consumo já são bons o suficiente.	0.709	0.196	0.219	2.5 (1.8)
13	The media usually provides a *balanced* and *unbiased* view of new food technologies.[a]	A mídia geralmente fornece uma visão equilibrada e imparcial das novas tecnologias empregadas na produção e/ou processamento de alimentos.[a]	0.047	0.590	0.047	4.4 (2.0)
						47.0 (12.0)

[a] Indicates reverse scored items.

including a psychology examination, where it is necessary to investigate and identify the real factors that determine consumer behavior, so as to predict their selection of specific foods (Köster, 2009).

Many studies have shown that consumers present concerns regarding new foods and new technologies (Matin et al., 2012; Ronteltap et al., 2007). Innovations in the food industry are often not well received by the market, partly due to a phenomenon known as neophobia, which is the rejection that some people present towards new or unfamiliar foods. Neophobic people tend to exhibit negative attitudes and have lower expectations regarding the taste of foods (Barrena & Sanchèz, 2012). Food neophobia is usually characterized as a personality trait, indicating a tendency to accept or avoid new foods. At the same time, food neophobia has been discussed as a form of behavior that associates the rejection of new foods with a particular situation (Pliner & Salvy, 2006). According to Rozin and Fallon (1980) and Rozin, Haidt, and Mccauley (1993), there are three main reasons for rejection of food by humans: (a) aversion to sensory characteristics, (b) danger, a fear of negative consequences of eating a food or (c) disgust, arising from the idea of nature or origin of food.

Neophobic personality is a predictive factor for the lack of acceptance of new foods (Henriques, King, & Meiselman, 2009). In this sense, Pliner and Hobden (1992) developed a neophobia food scale to assess consumer reactions in relation to new ethnic or cultural foods, but is less suitable to determine receptivity to foods produced by different technologies. Therefore, a new psychometric tool was developed by Cox and Evans (2008) to identify neophobia in relation to food technology: *Food Technology Neophobia Scale* (FTNS). This instrument was constructed to establish the acceptance limits of foods produced by new technologies, by identifying segments of the population that have greater or lesser neophobia. The ability to determine groups that are willing to accept innovative food produced by new technologies can be helpful, especially when such foods provide benefits (Evans, Kermarrec, Sable, & Cox, 2010).

In this work, the study of neophobia in relation to food technology was conducted with Brazilian consumers, using the FTNS questionnaire translated and validated for the Portuguese language. The relationship between the neophobia level of the participants and the acceptance of new food technologies was also investigated by comparing the familiarity and willingness to try foods produced by conventional and non-conventional technologies, including nanotechnology. Assessing the willingness to try products produced by different technologies is of interest for the food industry, which can predict if these new technologies will succeed on the market. In the present study the influence of socioeconomic characteristics on the attitudes of Brazilian consumers regarding new technologies was also evaluated.

2. Material and methods

2.1. Instrument

The original version (in English) of the instrument developed by Cox and Evans (2008) was constructed in the form of a questionnaire containing 13 items (Table 1), which are presented in the form of statements in which the respondent should express his/her opinion using the concordance scale (7-point scale anchored at the extremes). This questionnaire was translated and validated for the Portuguese language by Vidigal et al. (2014), using the back-translation technique (Prieto, 1992). Three bilingual translators translated all original items of the FTNS (Cox & Evans, 2008), from English to Portuguese. Subsequently, three different bilingual translators translated the Portuguese version back into English. The translated versions were compared with the original version and the necessary adjustments were made in order to obtain the conceptual and linguistic equivalence, thereby arriving at the final version of the questionnaire in Portuguese. For validation and reliability of the questionnaire, 30 bilingual individuals assessed the psychometric properties of the instrument in the original and the new language. The sample size was based on the recommendations of Ohrbach, Bjorner, Jezewski, John, and Lobbezoo (2009). Reproducibility between the English and Portuguese versions was assessed by the intraclass correlation coefficient (ICC). The results showed that for each item that makes up the questionnaire, the ICC values between the versions in English and Portuguese were significantly greater than zero, ranging from 0.362 to 0.866 ($p < 0.05$). The intraclass correlation coefficient between the total sum of items from the two versions was ICC = 0.867 ($p < 0.05$). This result is identical to that found by Evans et al. (2010) when confirming the reliability of the original instrument *Food Technology Neophobia Scale*. To calculate reliability of the instrument, the Cronbach's alpha test (α) was used. Considering the 30 participants, Cronbach's alpha coefficient for the 13 questions of the instrument demonstrated high reliability ($\alpha = 0.756$). Individual iterative elimination was also conduced to validation the option to keep all elements of the questionnaire, and when analyzing each item separately, the values of α remained between 0.720 and 0.774, reflecting a homogeneous profile among the variables. Therefore, it can be affirmed that the items are summable and constitute the representation of the same construct.

2.2. Sample

The interview was conducted in public places of the city of Belo Horizonte (Minas Gerais), Brazil. The number of people interviewed was obtained using the simple random sample equation for infinite populations ($N > 10{,}000$. Belo Horizonte has 2,395,785 inhabitants, 2010 census) (Equation (1)), considering a 95% confidence interval and estimated error of 5% with p and q equal to 0.5 (Gonçalves, Ferreira, Minim, & Minim, 2013). Therefore, a random, statistically significant sample was constructed to perform the study, composed of 389 consumers.

$$n = \frac{Z^2 p \cdot q}{E^2} \quad (1)$$

where:

n = sample size; p = proportion of occurrence of the variable in the population under study; q = considering the characteristic represented by "p", this is the proportion of non-occurrence ($p = 1 - q$); Z = number of standard deviations for the confidence level adopted; and E = precision of the sample or sampling error.

Participants were recruited based on their willingness and availability to conduct the interview and as a prerequisite should be habitual or potential consumers of yogurt, the base product selected for this study, in order to minimize aversion to the food so that it does not interfere in acceptance of the technology. According to Gaino, Amâncio, Oetterer, and Silva (2012), in Brazil the per capita consumption of yogurt was that which presented the highest growth among industrialized foods during the past 30 years. Despite being present in 92.7% of Brazilian households according to the *Kantar World Panel*, per capita consumption of yogurt in the country still has great growth potential. While the per capita consumption of yogurt in Brazil is 6.5 kg/year, in Holland consumption reaches 41.9 kg/year, in France is 20.7 kg/year and in Argentina 9.2 kg/year, according to 2011 data from Euromonitor (ANPEI, 2014).

Table 2
Food technology neophobia by gender, age, marital status, family size, education level and income.

Variables	Category	Total (%)	Means (SE)	% of participants in each FTNGs			χ^2
				Neophilicos	Neutral	Neophobic	
Gender	Female	58.6	47.5 (±12.8)	16.1	67.1	16.8	2.027[ns]
	Male	41.4	46.7 (±11.5)	10.1	81.1	8.8	
Age	Younger than 25	36.0	46.6 (±10.3)[a,b]	12.8	76.4	10.8	
	26–35	32.6	45.3 (±12.3)[b]	19.7	68.9	11.4	11.097[c]
	Older than 36	31.4	49.6 (±13.1)[a]	12.8	65.0	22.2	
Marital status	Single	57.1	45.9 (±12.3)	16.7	70.2	13.1	
	Stable union	38.8	48.9 (±11.1)	11.2	72.9	15.9	6.851[ns]
	Widow	1.3	46.1 (±21.0)	40.0	40.0	20.0	
	Divorced	2.8	46.1 (±13.3)	27.3	54.5	18.2	
Family size	1–2 members	43.4	46.5 (±13.1)	17.8	67.4	14.8	
	3–4 members	42.2	47.4 (±10.8)	11.5	75.8	12.7	4.647[ns]
	5 members or more	14.4	47.5 (±12.3)	18.2	63.6	18.2	
Level of education[a]	Low	40.6	49.9 (±10.6)[a]	7.0	74.8	18.2	15.388[c]
	High	59.4	45.1 (±12.6)[b]	20.8	67.5	11.7	
Income[b]	A	11.1	46.5 (±11.0)[b]	16.7	70.8	12.5	
	B1	22.4	45.7 (±10.7)[b]	17.9	76.1	6.0	18.192[c]
	B2	16.5	46.4 (±12.8)[b]	14.3	76.2	9.5	
	C	45.4	47.6 (±12.8)[b]	15.1	65.8	18.1	
	DE	4.6	52.4 (±11.2)[a]	2.8	72.2	25.0	

[ns] Not significant ($p > 0.05$).
[a] High education: college undergraduate or graduate. Low education: elementary school, high school, vocational school or equivalent (Behrens et al., 2010).
[b] Average family income: A = greater than 15 minimum wages; B1 = 8–15 minimum wages; B2 = 4–7 minimum wages; C = 1–3 minimum wages; DE = less than 1 minimum wage (ABEP – Associação Brasileira de Empresas de Pesquisa, 2011).
[c] Sig. at 0.05 (2-tailed).

The socioeconomic profile of the participants is presented in Table 2. The average age of respondents was 31 (range from 17 to 79), 41.4% were male and 58.6% female. Regarding marital status, 38.8% reported being married or declared stable union. In relation to family income, the majority of participants (88.9%) reported making less than 12 minimum wages. A total of 59.6% of participants had completed college, and 16.7% had graduate degrees.

2.3. Study of the Food Technology Neophobia Scale (FTNS)

The Food Technology Neophobia Scale (FTNS) questionnaire translated and validated for Portuguese was applied to assess neophobia among Brazilian consumers. During the interview, participants were asked to answer a questionnaire composed of thirteen statements on the FTNS (Table 1). The thirteen questions were assessed on a scale anchored at the extremes 1 ("strongly disagree") to 7 ("strongly agree").

Familiarity of the participants with regard to foods produced by conventional and non-conventional technologies, such as traditional, pasteurization, enrichment with bioactive proteins, transgenic (genetically modified, GM foods), organic and nanotechnology was evaluated on a non-structured 7-point scale anchored at the extremes 1 ("little familiar") to 7 ("very familiar") (Choe & Cho, 2011).

Later, the definition, advantages and disadvantages of each technology were made available to the volunteers (Table 3). The concepts of the technologies were defined based on an adaptation of Cox and Evans (2008) and Siegrist (2008). After the participants read the information about the technologies, they were asked about their "willingness to try" food using the technologies under study, also in accordance with a non-structured 7 point scale anchored at the extremes 1 ("not at all willing") and 7 ("extremely willing") (Backstrom et al., 2004). Cox and Evans (2008) evaluated the familiarity and willingness to try a set of different technologies to verify how the FTNS is able to correctly predict the consumer judgment about specific technologies. In this work, the same scale was used but applied to food categories, i.e., the participant expressed his/her familiarity and willingness to try foods produced by different technologies. According to Caracciolo, Coppola, and Verneau (2011), consumers are more familiar with the product than the technologies; moreover, a review of the technology only is subject to more negative responses. The final portion of the questionnaire collected general information such as gender, age, marital status, family income and education. The study protocol was

Table 3
Information provided by the participants on the technologies utilized in yogurt production.

Technology	Definition	Advantage	Disadvantage
Traditional	Method of conventional production.	Microbiological safety of food.	Loss of some unstable vitamins.
Pasteurization	Preservation method where food is exposed to mild temperature for a period of time.	Microbiological safety of food.	Loss of some unstable vitamins.
Transgenic (Genetic modification)	Method where an organism receives one or more genes from another species or has modified their genes.	Development of transgenic lactobacilli which stimulate the immune system.	Lack of information about risk to consumer health and the environment.
Enriched with bioactive proteins (Bioactives)	Addition of protein of high nutritional value.	Health benefits.	Additional cost.
Nanotechnology	Method which involves the production of material with sizes less than 1000 nm (10^{-9} m).	Improvement in sensory quality of food and/or health benefits for the consumer.	Lack of information on the safety of nanomaterials for consumers.
Organic	Production method without the addition of pesticides, antibiotics or chemical additives	Health benefits and environmentally friendly.	Additional cost.

approved by Human Research Ethics Committee (HRECs) (n° 526.009).

2.4. Statistical analysis

To confirm the validity of the Portuguese version of the FTNS, responses of the participants to the 13 items were subjected to factorial analysis and calculation of Cronbach's alpha. Data was assessed with regards to normality, collinearity and distribution of outliers. Factorability of the sample was tested by the Kaiser–Meyer–Olkin Index and by Bartlett's sphericity test. Later, the data was subjected to principal components analysis (PCA) with Promax rotation. Reliability of the factors was estimated by calculation of Cronbach's alpha.

Classification of the individuals regarding neophobia in relation to food technology is obtained by summing the individual values for each item, ranging from 13 to 91. The highest value represents the lowest consumer receptivity for new technologies (i.e., greater neophobia) (Cox & Evans, 2008). To perform the statistical analyses, scores of questions 6, 7, 8 and 13 were reversed, so that higher values correspond to greater neophobia. Analysis of variance (ANOVA) was used to determine the main effect of gender, age, marital status and social class. The interviewees were divided into three groups representing low (13.0–35.0), medium (35.0–59.1) and high (59.2–91.0) neophobia in relation to food technology (FTNGs: Neophilicos, Neutral, Neophobic, respectively), to facilitate interpretation of the results. The range corresponding to each group was defined from the average of the FTNS (47.0) plus or minus one standard deviation (12.0). This type of classification was used in earlier studies (Choe & Cho, 2011; Olabi, Najm, Baghdadi, & Morton, 2009; Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001) and was considered a corroborative method. In order to compare gender, age, education and social class between groups of neophobia (FTNGs), the chi-square test was used, defining 0.05 as the level of rejection of the null hypothesis.

Pearson correlation coefficients were calculated to relate the FTNS and familiarity and willingness to try foods produced by technologies under study. Furthermore, the analysis of variance was performed to examine the effects of neophobia groups with respect to food technology (FTNGs) in willingness to try foods produced by conventional and non-conventional technologies. For all analyses we used the program SPSS (Social Package for Statistical Science), version 15.0.

3. Results and discussion

3.1. Revalidation of the FTNS questionnaire

In order to confirm the validity of the Portuguese version of the FTNS, a factorial analysis of the participant responses to the 13 items was performed. All assumptions of the factorial analysis were met. Results of the Kaiser–Meyer–Olkin test (KMO = 0.827) and Bartlett's sphericity test ($\chi^2 = 912.832$, $p < 0.001$) showed adequacy of the sample for factorial analysis.

The principal components analysis with Promax rotation resulted in the formation of three distinct conceptual sets, which explained 55.0% of total variation in the data (Table 1). The first component explained 27.6% of the total variance, being composed of items 2, 3, 4, 5, 6, 9, 10, 11 and 12, and defined as “new technologies are unnecessary”. The second component (15.5% of total variance) is positively correlated with healthy choices and confidence in the role of the media (items 7, 8 and 13). It therefore consists of the perception of benefits for new technologies by consumers regarding control over their food choices and ability to have a balanced diet, besides the role of the media for transmitting information on food technology. The third component (11.9% of total variation) is related to familiarity with new technologies (item 1).

Schnettler, Poblete, et al. (2013), when translating and validating the FTNS questionnaire into Spanish, reported the existence of two factors comprising only 6 items, where 3 were related to the description of “perception of risk” and 3 items for “new technologies are unnecessary”. Cox and Evans (2008) reported the existence of four factors associated with 13 items, six of which are related to the description “new technologies are unnecessary” (items 1, 2, 3, 4, 5 and 12), four items for perception of risk (6, 9, 10 and 11), two items for healthier choices (7 and 8) and one item for information provided by the media (item 13). Therefore, there is a difference in perception of the items between the English and Portuguese versions.

For Brazilian individuals, the definition of “new technologies are unnecessary” also involves the perception of risk. Claims that society should not depend heavily on technology to solve its food problems, or rapidly switch to new technologies, as well as the negative health and environmental effects, are also somehow related to a negative attitude in relation to technology. In the Portuguese version, item 1 did not correlate with the first factor, i.e., familiarity is not associated with “new technologies are unnecessary” and possibly is associated with lack of knowledge of the interviewees on new technologies.

Cronbach's alpha of the 13 items in the Portuguese version of the construct was 0.73, indicating good internal reliability. Because it is a good predictor of acceptance in foods produced by new technologies, such as nanotechnology, the FTNS has been translated and validated in different languages including Spanish (Schnettler, Poblete, et al., 2013) and Italian (Verneau & Coppola, 2011).

3.2. Neophobia in relation to food technology

The average score of neophobia in relation to food technology by Brazilian respondents was 47.0 (±12.0) (Table 1). Sum of the individual values obtained for each item obtained by the participants ranged from 13.0 to 86.4. Cox and Evans (2008) and Evans et al. (2010) reported an average value of 55.00 (range of 21–88) when developing the FNTS and 54.35 (±10.08; range of 25–81) and 53.62 (±11.27; range of 25–81) during revalidation of the questionnaire, both conducted in Australia. Matin et al. (2012) reported that the level of neophobia in relation to Canadian consumers of food technology was 58.5 (±6.21, range 21–91). The largest value of the sum of the items is the lowest receptivity of consumers to new technologies, so the Brazilian respondents are relatively less neophobic that Australians and Canadians.

Neophobia in relation to food technology was not significantly influenced by gender, marital status or number of family members ($p > 0.05$) (Table 2). There was a significant effect of age, education level and income ($p < 0.05$) on scores of the FTNS. The group of individuals older than 36, with low education and those with lower incomes were significantly more neophobic. Generally, more prudent behavior is found in older individuals who seek safer and known foods. Lower receptivity to new technologies among respondents with low purchasing power and schooling may be due to lack of knowledge about new foods and technologies. Evans et al. (2010) reported a significant difference in scores by the FTNS only for the level of education; where participants with lower education levels also presented higher neophobia. According to these authors, people with higher degrees of education seem to be more open to new products and new technologies. Thus, it becomes necessary to increase the knowledge of consumers to reduce neophobia.

3.3. Familiarity and willingness to try foods produced by different technologies

The distribution of groups (FTNGs) representing low, medium and high neophobia in relation to food technology is presented in Fig. 1. Most respondents (70.4%) belonged to the neutral category, 15.2% were classified as neophilic and 14.4% neophobic. Neutral individuals are those with neophobia in some situations, i.e., have an aversion to some technologies but not others. According to Matin et al. (2012), the majority of the Canadian population presents medium to high neophobia.

Familiarity and willingness to try foods produced by different technologies are presented in Table 4. The results showed that foods labeled as traditional and pasteurized are significantly more familiar to Brazilian consumers than those obtained by other technologies ($p < 0.05$). The technologies involving bioactive and organic foods did not differ significantly, to which consumers were more familiar than GM foods and nanotechnology. The lack of familiarity with foods produced by GM foods and nanotechnology may affect the final decision of consumers regarding these foods, since the individual will consume foods considered sufficiently safe. According to Lords of House (2010), fear of new technologies by consumers is often related to lack of information. According to Smiley, Hosgood, Michelson, and Stowe (2008), the lack of information and understanding of the real relationship between risks, perceived benefits and negative perceptions of new technologies can lead to a lack of support from the public, and ultimately to a setback in technological innovation for a significant period of time.

The willingness to try products labeled as transgenic and nanotechnology was significantly lower than other technologies. It is known that technologies involving transgenics, applied to food, often generate high perception of risk and aversion among consumers in some countries (Hansen, Holm, Frewer, Robinson, & Sandoe, 2003). Risk perception and consumer concerns in regards to contact with nanoparticles are considered the main factors that lead to rejection of nanotechnology, and the perceived benefits also influence the acceptance of nanotechnology (Gupta, Fischer, George, & Frewer, 2013). Brazilian consumers are still cautious with regards to GM foods and nanotechnology, possibly due to lack of assurance that these foods are healthy and safe for the environment. Among non-conventional technologies, organic yogurts and those enriched with bioactive proteins were the products that consumers were most willing to try. Information provided on the definition, advantages and disadvantages of these technologies were positive, resulting in increased expectations of Brazilian consumers. According to Rozin et al. (2004) and Rozin (2005), organic products are well defined by consumers according to their attributes of naturalness and safety, while foods with specific health benefits, such as bioactive components, although generally recognized as being unnatural, are regarded as safe and with increased nutritional value. Despite little familiarity, consumer preference for healthier foods may have played a significant role in the willingness to try organic and bioactive foods.

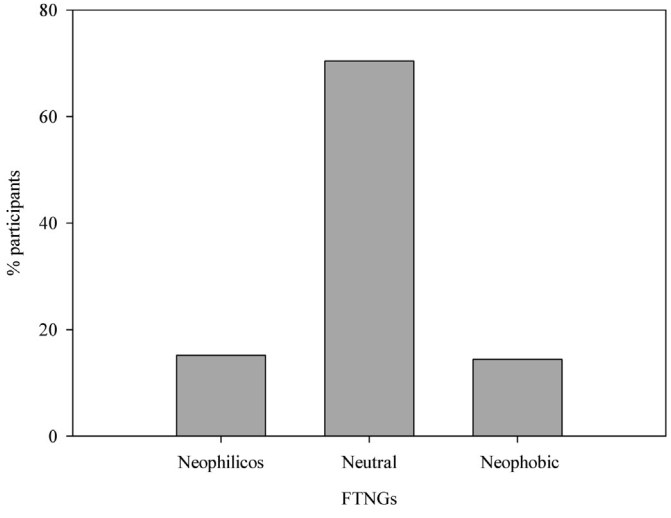

Fig. 1. Distribution of participants in the groups (FTNGs) representing low, medium and high food technology neophobia.

Table 4
Averages values and standard deviation (SD) of familiarity and willingness to try foods produced by different technologies.

Technology	Familiarity	Willingness to try
Traditional	6.2 (1.3)^{a}	5.9 (1.5)^{ab}
Pasteurisation	4.9 (2.1)^{b}	5.4 (1.7)^{b}
Organic	3.0 (2.1)^{c}	6.0 (3.6)^{a}
Genetic modification (GM)	2.0 (1.4)^{d}	3.6 (2.1)^{c}
Bioactives	3.2 (2.2)^{c}	5.7 (1.7)^{ab}
Nanotechnology	1.9 (1.4)^{d}	3.9 (2.1)^{c}

Pairs of means with the same letter in the column do not differ by Tukey's test ($p < 0.05$).

3.4. Study of neofobia groups in relation to food technology (FTNGs)

Familiarity and willingness to try conventional and non-conventional foods were evaluated among the neophobia groups in relation to food technology (Table 5). Regarding familiarity, the technologies of pasteurization, bioactives, organic and GM foods showed significant differences between groups representing low, medium and high neophobia in relation to food technologies (FTNGs). The less neophobic respondents showed greater familiarity with these technologies. There was no difference between the neophobia groups (FTNGs) for yogurt labeled as traditional and with nanocomposites. Traditional foods are already very popular and well known, thus all groups presented high familiarity with the product. In the case of nanotechnology, which is a recent technology, it is still not familiar to Brazilian consumers, with no difference between groups.

Willingness to try the yogurt labeled as enriched with bioactive proteins, organic, transgenic and with nanocomposites varied

Table 5
ANOVA for familiarity and willingness to try unconventional and conventional foods in terms of neophobia groups regarding food technologies (FTNGs).

Food technology		Neophilicos	Neutral	Neophobic	*F*
Traditional	Familiarity	6.5 (1.1)	6.2 (1.3)	6.0 (1.5)	2.167^{ns}
	Willingness to try	6.2 (1.3)	5.7 (1.5)	6.0 (1.5)	3.217^{ns}
Pasteurisation	Familiarity	5.6 (1.8)^{a}	4.9 (2.1)^{a}	4.2 (2.3)^{b}	6.487*
	Willingness to try	5.9 (1.6)	5.3 (1.6)	5.4 (1.8)	3.112^{ns}
Bioactives	Familiarity	3.9 (2.4)^{a}	3.2 (2.1)^{a,b}	2.8 (2.1)^{b}	3.842*
	Willingness to try	6.6 (0.6)^{a}	5.7 (1.6)^{b}	5.0 (2.2)^{c}	15.412*
Organic	Familiarity	3.6 (2.4)^{a}	2.8 (2.0)^{b}	2.7 (2.2)^{b}	3.408*
	Willingness to try	6.5 (1.1)^{a}	5.8 (1.6)^{b}	5.8 (1.9)^{b}	6.385*
Genetic modification (GM)	Familiarity	2.4 (2.0)^{a}	1.9 (1.3)^{b}	1.6 (1.1)^{b}	6.020*
	Willingness to try	5.0 (2.1)^{a}	3.5 (2.1)^{b}	2.8 (2.0)^{b}	17.956*
Nanotechnology	Familiarity	2.2 (1.8)	1.9 (1.3)	1.7 (1.3)	1.730^{ns}
	Willingness to try	5.7 (1.6)^{a}	3.7 (2.0)^{b}	3.1 (2.1)^{b}	31.016*

Pairs of means with the same letter in the line do not differ by Tukey test ($p < 0.05$).
^{ns}Not significant ($p > 0.05$), *$p < 0.05$.

significantly among the FTNGs. The groups formed by neutral and neophobic consumers differed significantly from neophilic group, being less willing to try the new or non-conventional technologies. For conventional, traditional and pasteurization technologies, there was no difference between the groups, since consumers are already accustomed to consuming these products.

Within groups of neutral and neophobic respondents, willingness to try foods labeled as organic and bioactive were significantly superior to those of nanotechnology and genetic modification ($p < 0.05$) (Fig. 2). This is an interesting result since even people who have some reluctance to consume foods obtained by the new technology are more willing to try foods that provide some health benefit. Brazilian consumers not only have low familiarity with nanotechnology and genetic modification, but are not convinced that these technologies are safe and reliable. Behrens et al. (2010), in a study with Brazilian consumers who sought to assess attitudes toward food safety, indicated that trust is one of the most important factors taken into consideration when purchasing, influencing food selections. The authors also reported that participants expressed greater concern about the health risks considered to be of technological origin. According to Napier, Tucker, Henry, and Whaley (2004), most consumers are unable to decide on the choice of foods produced by new technologies associated with possible risks, and appear to be hesitant and afraid to accept and consume food produced by new technologies associated with potential risks without clear benefits. This information may be useful in developing new products and elaborating marketing strategies, when the target audience is composed of consumers belonging to specific FTNGs. Olabi et al. (2009) indicated that it would be a challenge for the food industry to launch "very new and nontraditional" products in markets with high levels of food neophobia. Thus, the food industry and educational institutions should provide more information to consumers about the technology used in production and/or processing of foods in order to increase consumer confidence in the new product.

3.5. Correlation between FTNS and familiarity and willingness to try

Correlations between the FTNS and familiarity and willingness to try foods produced by new and conventional technologies were studied (Table 6). There was no significant correlation between scores of the FTNS and familiarity of respondents with yogurt labeled as traditional, organic, transgenic and with nanocomposites ($p > 0.05$). The FTNS was negatively correlated with familiarity to pasteurized products and those enriched with bioactive proteins, i.e., the greater the familiarity with these technologies, lower was neophobia. Familiarity with new technologies was not a good predictor of neophobia in relation to food technology.

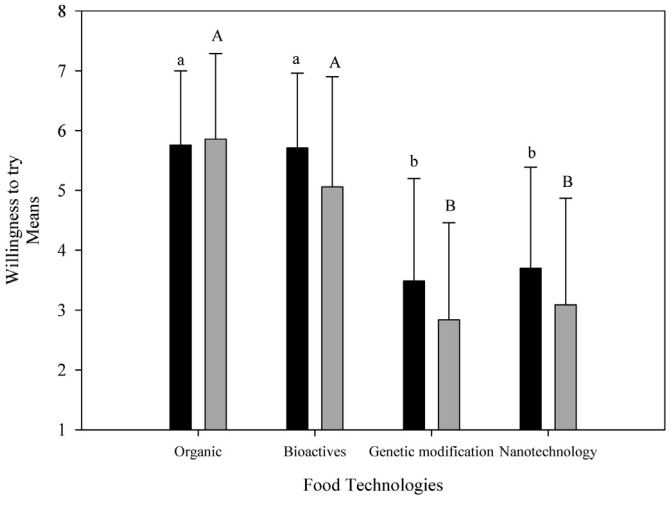

Fig. 2. Willingness to try foods produced by non-conventional technologies of participants in the groups of middle and high neophobia. Scale of 1–7 (Pairs of means with the same lowercase letter do not differ by the Tukey test ($p > 0.05$) for neutral individuals) (Pairs of means with the same uppercase letter do not differ by the Tukey test ($p > 0.05$) for neophobic individuals). Neutral; Neophobic.

The correlation between FTNS and willingness to try the yogurts labeled as traditional and pasteurized was not significant ($p > 0.05$). As was expected, technologies already established in the market were not affected by neophobia in relation to food technologies. Therefore, the neophobia scale is not associated with consumer perceptions in relation to conventional technologies.

Correlations between the FTNS and willingness to try foods produced by new or unconventional technologies were significantly negative, and considered weak to moderate, ranging from −0.15 to −0.35. Evans et al. (2010), during revalidation of the FTNS construct in Australia, evaluated the correlation between the FTNS and willingness to try different technologies, and found significant values equal to −0.29, −0.39 and −0.58 for bioactive components, nanotechnology and genetic modification, respectively. This result was very similar to that encountered in the present study, except for genetic modification, which suggests that Brazilian consumers are less averse to this technology than Australians. This result agrees with that found by Da Costa et al. (2000), who reported that by means of a technical focus group, Brazilian consumers have a more positive attitude towards genetically modified foods.

After receiving the description of the technologies under study, willingness of the participants to try new foods was related to neophobia, indicating that the information is a very important factor which influences consumer behavior. The most neophobic individuals are less likely to try foods produced by unconventional technologies (organic, bioactive, GM foods and nanotechnology) that are considered new or unknown to Brazilian consumers. It was also observed that the willingness to try foods produced by new technologies or those that generate questions, such as bioactive, nanotechnology and genetic modification (for which higher anxiety was expected), showed higher correlation than the less controversial technology (organic). According to Schutz and Cardello (1997), for the acceptance of products obtained by non-conventional technologies, it is necessary to investment in customer education/information programs to reduce the fears of consumers regarding these products. Confidence of consumers is the most important factor for the acceptance of new food technologies (Siegrist, 2008). According to Napier et al. (2004), consumers appreciate receiving information that may facilitate their purchase decision related to foods traditionally produced or new technologies.

4. Conclusion

The FTNS construct may be a good predictor of acceptance of foods produced and/or processed by a new technology by

Table 6
Pearson correlation between mean FTNS and familiarity and willingness to try conventional and unconventional food.

Food technology	FTNS × familiarity	FTNS × willingness to try
Traditional	-0.06^{ns}	-0.01^{ns}
Pasteurisation	-0.17^{**}	-0.06^{ns}
Organic	-0.13^{*}	-0.30^{**}
Genetic modification (GM)	-0.05^{ns}	-0.16^{**}
Bioactives	-0.10^{ns}	-0.27^{**}
Nanotechnology	-0.06^{ns}	-0.35^{**}

^{ns}Not significant ($p > 0.05$), $^{*}p < 0.05$, $^{**}p < 0.01$.

correlation with willingness to try new foods, which although maintain the same appearance as traditional foods. It was expected that familiarity for technologies would be related to food technology neophobia, what was not found.

Food technology neophobia was influenced by socioeconomic factors. The group of individuals older than 36, with low education and those with lower incomes, were significantly more neophobic. Thus, neophobia may be associated with lack of knowledge/information on the technologies. Considering technologies with low familiarity, willingness to try organic and bioactive foods was significantly superior to GM foods and nanotechnology, indicating that the act of providing information on the benefits and disadvantages favored the acceptance of these new products.

One limitation of this study was that it has been conducted in a single Brazilian city. Regional differences in Brazil – considering the cultural and socio-economic characteristics – must be taken into account with a more representative sample of the population. However, it can be considered as a starting point for the study of food technologies neophobia, and its relationship with familiarity and willingness to try new foods.

Understanding food technology neophobia may be a key differentiator for the food industry, especially for those working in the market of non-traditional foods that have some appeal to health. This study also provides important information about the different attitudes of Brazilian consumers regarding the implementation of a new food technology, considering the FTNGs (neophilic, neutral and neophobic). The application of appropriate marketing strategies that consider the neophobic or neophilic characteristics of consumers may permit that the product reach a competitive advantage and be successful. Thus, in order for a food produced by a new technology to enter the market, consumers should be informed about the risks and benefits associated with the new technology by research institutions and the food industry.

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