


# Use of the Kano model and sensory evaluation in the development of an iron supplement for women

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## Funding information

Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Grant/Award Number: 001; Fundação de Amparo à Pesquisa do Estado de São Paulo, Grant/Award Number: 2016/12660-3

## Abstract

The study presents an alternative for the preparation of questions using the Kano model to evaluate the presentation of a powdered, water-soluble supplement. The results were used to develop a formulation containing chelated Fe-peptides for women. The experiment was carried out in two steps: (a) an online survey to determine the satisfaction with the powdered iron supplement in relation to other presentations, and the flavor preference, (b) sensory evaluation of the formulations developed. A total of 364 replies were collected in the online survey, which indicated indifference with respect to satisfaction for the use of a powdered, water-soluble product as compared to pills, drops, and syrups. The flavors preferred were: lemon (46.6%), orange (40.9%), chocolate and red fruits (32%). The sensory test ( $n = 121$ ) of the three formulations (strawberry, tangerine, and chocolate) containing 14 mg Fe<sup>2+</sup> per sachet, validated the tangerine flavor as the most accepted and chocolate as rejected by the consumers.

## Practical Applications

Iron supplements do not have very attractive flavors and have an unpleasant metallic aftertaste. Thus, in order to present a new type of supplement still unavailable on the market, the use of a comprehensive approach making use of methods such as the Kano model and a sensory evaluation, could help elucidate this question. The Kano model is an efficient tool used to evaluate attributes and allows one to obtain other information about consumer desires in both explicit and implicit ways. However, the application of the Kano model for attributes with three or more levels has been little explored. Thus, the present study presents an application of this model with the use of direct questions for an attribute with four levels, and the application of sensory tests that allow one to direct and optimize product development. The analysis of the information obtained contributed to the development of a sensorially acceptable powdered, water soluble iron supplement.

## 1 | INTRODUCTION

Throughout the world iron constitutes the micronutrient showing the greatest deficiency, affecting approximately 2 billion people. Iron

deficiency anemia is responsible for approximately 50% of all types of anemia, being the result of various factors, such as deficient digestion, bad digestion of the nutrient, or even an increase in blood loss (Camaschella, 2015).

Part of the iron deficiency that causes anemia is attributed to factors such as: low intake of this mineral, reduced absorption due to the presence of phytates or phenolic compounds in the food. Some stages of life where iron requirements are especially high (such as growth and pregnancy) low socioeconomic and educational presence of endemic infestations (malaria, ascariasis, helminth infections, intestinal protozoa), and the relationship with various bleeding (as trauma, hematemesis, hemoptysis, menstruation, childbirth) or multiple gestations (Hurrell et al., 2004).

Iron is essential for red blood cell production, the cells which transport oxygen, provide energy and maintain the immune system. They are particularly relevant to women's health due to menstruation, pregnancy, and post childbirth, which result in a decrease in the iron stored in the body. If the losses are not adequately substituted, this can lead to a deficiency of the micronutrient, resulting in iron deficiency anemia (WHO, 2009).

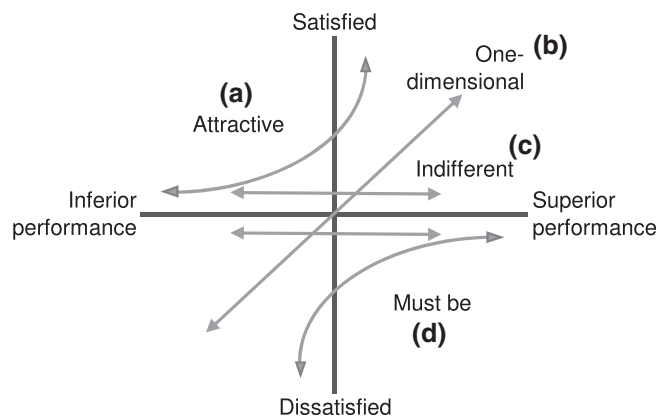
Anemia adversely affects cognitive and motor development, causing fatigue and low productivity, and, when occurring during pregnancy, can be associated with low birth weight of the child and an increase in the risk of maternal and perinatal mortality (Low, Speedy, Styles, De-Regil, & P. S., 2016). Considering the preponderance of anemia in women in their reproductive phase, the health organs have assumed the challenge of reducing these numbers by way of the program "United Nations Decade of Action on Nutrition (2016–2025)" (WHO, 2017). Thus, the global nutrition goal set for 2015 aimed to reduce anemia in women in their fertile phase by 50% (WHO, 2014), a goal endorsed since the Sixty-fifth World Health Assembly, with the participation of Brazil (WHO, 2012).

With respect to iron supplementation therapy, studies have shown a lack of adhesion or abandonment of the treatment by up to 50% of the patients. The impact of the gastrointestinal symptoms on the general wellbeing of the women negatively affects the application of oral iron therapy, resulting in low treatment efficiency (Leonard, Chalmers, Collins, & Patterson, 2014).

It has been observed that some iron fortified foods present a metallic aftertaste, resulting in low acceptance and even rejection by the consumer (Cançado & Chiattonne, 2010). As a technological defect, it may even result in a loss of color of the foods, due to the elevated reactivity of this bivalent metal. Such factors contribute to limited consumer acceptance and are regularly cited as causes for the lack of success of iron fortification programs (Bovell-Benjamin & Guinard, 2003).

Thus, consumer opinion is crucial regarding product development in order to have acceptance and consequently be successfully launched in the market. Hence the information obtained as from sensory analysis is systematized and integrated to the improvement of the sensory characteristics in the development of a product containing iron, thus improving its acceptance (Bovell-Benjamin & Guinard, 2003).

The Kano model is commonly used in the product marketing and development area to classify an attribute as "expected/must be," "proportional/one-dimensional," "attractive" or "indifferent," represented graphically in Figure 1, integrates product performance and consumer satisfaction in a two-dimensional system. The x-axis represents performance, the response is objective and varies from low to



**FIGURE 1** Bidimensional system that integrates product performance and consumer satisfaction. (a) Attractive: they satisfy latent needs, real needs that customers are currently unaware of. (b) One-dimensional: needs those customers express, customer satisfaction is proportional to their degree of service. (c) Indifferent features: when present or absent do not affect consumer satisfaction. (d) Must be features: when they are not present, the consumer will not be interested in the product. Adapted model from Kano (1984)

high meeting expectations and needs, and the y-axis represents consumer satisfaction, the response is subjective and varies from dissatisfaction to satisfaction (Kano, 1984).

MacDonald, Backsell, Gonzalez, and Papalambros (2006) proposed new categorization methodology that uses as the scenario an attribute with three levels: absent, present A and present B, and the classification according to the Kano model was estimated from the combinations of the variables as independent variables followed by a statistical analysis of the data. This was the only paper found that dealt with a characteristic with more than two levels, where the dysfunctional question suggests the absence of this and presence of another characteristic. Ullah and Tamaki (2011) suggested that the functional and dysfunctional responses to the questionnaire of the Kano model are adequate for decision making. However, Grapentine (2015) contests the use of this model, one of his arguments being that the way the questions are expressed impacts on the responses. He suggests the use of Group Analysis and proposes a combination of methods to evaluate the attributes.

Since classification by the Kano model is of interest in decision making concerning product development, the objective of this work was to present an alternative to formulate the questions to evaluate an attribute. Currently, iron supplementation is available in the form of tablets, drops, or syrup. Based on the lack of adhesion on iron treatment, the innovation of the present work consists of developing a powdered supplement to dissolve in water and consume as a drink, not as a medication.

## 2 | MATERIAL AND METHODS

The present work adopted a comprehensive approach with a target consumer group: women in their fertile phase. The experiment was

carried out in two steps: (a) an online survey to determine the perception of the powdered iron supplement in relation to the other presentations, using the Kano model to investigate flavor preference, (b) sensory evaluation of the powder prepared by way of sensory tests. The women who took part in the online survey were different from those who took part in the sensory tests. The project was approved by the Ethics in Research Commission (CEP) under the process number of 2.587.999.

## 2.1 | Product testing

The essential raw material to be presented as a powdered iron supplement was the microparticles containing Fe-peptides prepared according to Filiponi, Gaigher, Caetano-Silva, Alvim, and Pacheco (2019).

### 2.1.1 | Characteristics of the powdered formulation

The objective of the powdered formulation was to offer a new form of iron supplement to women, containing a microencapsulated Fe-peptide complex with elevated bioavailability (De la Hoz, Nunes da Silva, Morgano, & Pacheco, 2014). The concentration of iron in the microparticles ( $\text{Fe}^{2+}$ ) was 14 mg per sachet, based on the daily recommended ingestion (DRI- Institute of Medicine, 2006) for adults. Thus, the ingredients selected were those that did not interfere with absorption of the iron or even presented a synergic effect to improve iron absorption. These microparticles, evaluated in previous studies, showed an increase in iron bioavailability (Caetano-Silva et al., 2017; Cruz-Huerta et al., 2016).

The development of the formulations was accompanied by a team chosen for their sensory acuity in order to carry out a pre-selection with the criterion of the least perception of a metallic taste, according to ISO 13299:2016. Three flavors were chosen for the final test: strawberry, tangerine, and chocolate. The formulations containing approximately 9 g of powder to be dissolved in 100 ml of water at the time of ingestion were packaged in individual sachets and stored in a dry environment at a refrigerated temperature of 5°C and maintained there until preparation for the sensory evaluation. Microbiological analyses were carried in order to guarantee innocuity of the products (American Public Health Association, 2015).

### 2.1.2 | Composition of the powdered formulations

The components used to make up the three formulations have shown below. The ingredients used in the formulations was based on the recommendations of normative instruction N° 28 (2018), according Dal Molin et al. (2019).

#### *Tangerine flavored iron supplement*

Ingredients: polydextrose, maltodextrin, Fe-peptide microparticles, crystal sugar, ascorbic acid, tangerine aroma (Kerry), citric acid,

tangerine aroma (Takasago), tropical yellow dye, orange aroma, masking agent, tangerine aroma (IFF), summer red dye, sucralose, and chelaia.

#### *Strawberry flavored iron supplement*

Ingredients: polydextrose, maltodextrin, Fe-peptide microparticles, crystal sugar, ascorbic acid, strawberry aroma (Döhler), citric acid, masking agent, strawberry aroma (Takasago), red fruits aroma, spring red dye, intense red dye, titanium dioxide, sucralose, chelaia, and summer red dye.

#### *Chocolate flavored iron supplement*

Ingredients: polydextrose, maltodextrin, Fe-peptide microparticles (with vanilla), masking agent, cocoa powder 70, chocolate aroma, cream aroma, summer red dye, xanthan gum, vanilla aroma, titanium dioxide, and sucralose.

## 2.2 | Online survey

### 2.2.1 | Participants

The questionnaire was elaborated on the Google Forms platform ("Google," Mountain View, CA), and placed online via the link <https://goo.gl/forms/PRyw2fpNKKpReued2> and sent via e-mail and social networks, directed at women between 18 and 49 years of age in Brazil and other Latin countries. The objective was to reach at least 50 respondents in Brazil and 50 in other Latin countries, such as Uruguay, Peru, Bolivia, Argentina, Portugal, Mexico, Spain, Ecuador, and Chile.

### 2.2.2 | Questionnaire

The Free and Clarified Term of Consent was presented first. Following this some questions were made to obtain some details concerning the subjects, if they were suffering from anemia or not or had suffered from it at any moment in their lives and if they suffered any side effects or physical discomfort when medicated. The question surveyed was which type of presentation of the iron supplement the individuals preferred. The women were also requested, on considering a water soluble powder as the iron supplement, to make a choice from a list of 18 flavors (Chocolate, Cappuccino, Mate tea, Lemon tea, Jabuticaba, Orange, Red fruits, Lemon, Tangerine, Mulberry, Grape, Vanilla, Banana, Guava, Mango, Peach, Cherimoya, Pineapple, and the option Others). In addition, the central point of the questionnaire was to use the Kano model to investigate the satisfaction of using an iron supplement prepared in the form of a powder. Finally, to measure the degree of satisfaction when informed that the water-soluble powder was more effective with respect to iron absorption and had a pleasant taste.

The Kano model with four levels was used to elaborate the questions with respect to the attribute of supplement presentation, the

form of presenting a water-soluble powder to prepare an instant drink was combined with three other possible presentations: tablet, syrup, or drops. This gave six questions, three functional and three dysfunctional, as follows:

- If, instead of a TABLET (SYRUP or DROPS), your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER as your iron supplement, how would you feel?
- If, instead of a WATER-SOLUBLE POWDER, your doctor or nutritionist indicated the use of a TABLET (SYRUP or DROPS) as your iron supplement, how would you feel?

In parallel, four direct questions were prepared concerning the degree of satisfaction for each of the presentations:

- If your doctor or nutritionist indicated the use of a TABLET (SYRUP or DROPS or WATER-SOLUBLE POWDER) as your iron supplement, how would you feel?

At the end, in order to interpret the data, the six functional and dysfunctional questions were compared with the four direct questions by way of a continuous analysis that evaluates the means data by two-way ANOVA and Fisher's LSD test. A discrete analysis was applied, that considers the predominant category derived from individual attribute data.

## 2.3 | Sensory evaluation

### 2.3.1 | Participants

The sensory tests were applied according to the criteria of the general guide for carrying out hedonic tests in controlled environments (ISO 11136:2014). The 121 women who took part were in the 18 and 49 age range. Before starting the tests, everyone signed a Free and Clarified Term of Consent approved by the Ethics Committee. The criterion considered for inclusion was women who did not reject strawberry, tangerine or chocolate-flavored drinks.

### 2.3.2 | Questionnaire

The drink samples were evaluated in a sensory test carried out in individual booths at controlled environment temperature (24–26°C), with fluorescent lighting and equipped with the Compusense *Cloud* computerized software for data collection and analysis (Compusense Inc., Guelph, Canada). The three formulations were presented in the form of drinks in disposable cups containing approximately 25 ml, at environment temperature. The samples were served in a sequential monadic way based on a random complete block design.

The global acceptance was evaluated considering appearance, color, aroma, consistency (only for the chocolate flavored sample), flavor, sweetness and aftertaste using a nine point hedonic scale

(9 = liked a lot, 5 = neither liked nor disliked and 1 = disliked a lot) according to Meilgaard, Carr, and Civille (2015).

A 5-point Just About Right (JAR) scale was used to evaluate the intensities of the aromas, flavors and sweetness of the strawberry, tangerine, and chocolate drinks. As well as to evaluate the consistency of the chocolate drink and the acidity of the strawberry and tangerine drinks, where 5 = much stronger/more consistent/sweeter/more acid than I like it, 3 = the way I like it, and 1 = much weaker/less consistent/less sweet/less acid than I like it, according to Varela and Ares (2014).

The Check All That Apply (CATA) descriptive method is applied to consumers to describe and discriminate the products (Varela & Ares, 2014). A list of 15 positive and negative descriptors associated with the flavor of the beverage was previously developed using the Repertory Grid Method (Moskowitz, 1983), and presented to the consumers for them to choose those that best described the sample (Varela & Ares, 2014).

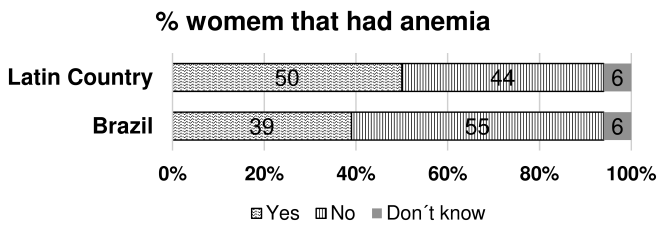
The data obtained from the hedonic scale in the acceptance test were submitted to an analysis of variance. Moreover, Tukey's test, and Cochran's Q test were applied to compare the characteristics of the samples as established by CATA. The penalty analysis was applied to the data relative to the hedonic scale and CATA evaluation, comparing the means given for acceptance in an overall way by the group who perceived a determined attribute as present versus the score given by that group who perceived the attribute as absent. In the preference analysis, the results referring to the sum of the ranking positions were treated based on Friedman's test and Fisher's test in order to compare the samples at 95% confidence level. In addition to the Compusense *Cloud* software (Compusense Inc.) used for data collection and analysis, the program XLSTAT 2016 version 18.03/35937 was used (Addinsoft, Paris, France) for the statistical analysis.

## 3 | RESULTS AND DISCUSSION

### 3.1 | Online survey

A total of 364 replies were obtained from the online survey (312 Brazilian women and 52 women from other Latin countries, such as Uruguay, Peru, Bolivia, Argentina, Portugal, Mexico, Spain, Ecuador, and Chile. About 40% of the Brazilians and 50% of the women from other Latin countries declared they had suffered from anemia at some point in their lives (Figure 2). The results obtained by the online survey indicated a coherent percentage to the report presented in the last WHO (2015) which gave a global anemia estimate of 29% of non-pregnant women and 29% of all women in reproductive age. The difference between the values is probably due to the number detected in this online survey considered the women who had or have anemia whereas the WHO report gives a picture of the moment when the survey was applied. The advantage of using an online survey in this study was to access people in different locations.

Although 60% of the women indicated not having felt side effects from the ingestion of iron supplements, a percentage of 16% reported



**FIGURE 2** Occurrence of anemia in women of Brazil and Latin Countries (Uruguay, Peru, Bolivian, Argentina, Portugal, México, Spain, Ecuador, Chile)

**TABLE 1** Preferred form of presentation of an iron supplement of the Brazilian and Latin woman

Presentation form	Latin countries	Brazil
	(% women)	
Tablet	63	83
Powder to dissolve in water	13	7
Drops	13	7
Syrup	10	3

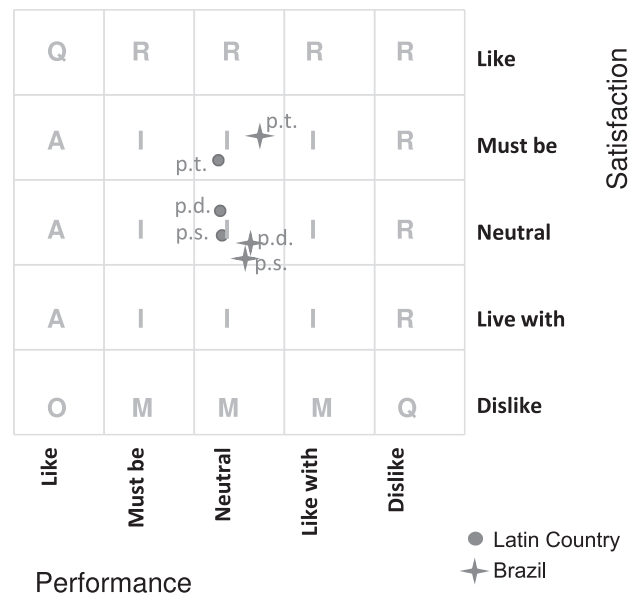
Note: Latin countries = Uruguay, Peru, Bolivia, Argentina, Portugal, Mexico, Spain, Ecuador, Chile.

suffering from headaches, dizziness, nausea, constipation, and vomiting. Similarly, a study carried out by Hyder, Persson, Chowdhury, and Ekström (2002) evaluating the gastrointestinal side effects (heartburn, nausea, vomiting, diarrhea, constipation) indicated that vomiting was the side effect reported with greater frequency, 21% due to weekly supplementation and 11% due to daily supplementation, probably causing a negative impact on adhesion to iron supplementation treatment (Fernández-Gaxiola & De-Regil, 2019; Hyder et al., 2002; O'Brien, 2018).

Table 1 shows the results to the direct questions on preference, where 83% of the Brazilian women and 63% of those from other Latin countries indicated preference for the use of taking tablets as the form of presentation of an iron supplement. However, satisfaction and performance were investigated by the Kano method.

Figure 3 shows the means obtained with respect to the results of the evaluation of satisfaction by the Kano method for the use of a powdered product for iron supplementation. There was indifference for all the proposals between satisfaction with the use of a product prepared in powder form (functional attribute) or in the form of tablets, drops or syrup (dysfunctional attributes). A positioning of the attribute tablet in the area of indifference close to the reverse can be seen, that is, there is a tendency to prefer the use of tablets in relation to the powdered product. In addition, the distance between this reply in relation to the attributes of syrup and drops is greater for Brazilian women than for other Latin women.

Table 2 shows the means of the replies to the six functional and dysfunctional questions and to the four direct questions. Differences were observed between the means for the Brazilians for the questions about the use of a water-soluble powder to prepare a drink instead of



**FIGURE 3** Kano model in the satisfaction in women of Brazil and other Latin countries. A, attractive; I, indifferent; M, must be; O, one-dimensional; p.d, powder beverage × drops; p.s, powder beverage × syrup; p.t, powder beverage × tablet; Q, questionable; R, reverse

drops or syrups, as also for the use of a syrup instead of a water-soluble powder to prepare a drink. These differences were of 0.1 on the scale used, which does not represent an alteration with respect to the category classification. Thus, there is no difference between the replies to the six functional and dysfunctional questions in relation to the four direct questions when one considers the continuous analysis of the data.

Table 3 presents the discreet analysis with the classification resulting from the six functional and dysfunctional questions about the use of a water-soluble powder to prepare a drink instead of taking tablets, drops or syrups, and the permutation of the four direct replies. In addition, the classifications of the most recurring categories were highlighted in first place (above 55%) and in second place (above 10%).

For the two analyses cited above it can be seen that although more than 55% of the women indicated they were indifferent in relation to their satisfaction in using the water-soluble powder (functional attribute) instead of tablets (dysfunctional attribute). More than 33% of the Brazilian women and 19% of the women from other Latin countries indicated the reverse attitude (R), that is, a slight preference for the use of tablets in relation to the water soluble powder. It can also be seen that more than 75% of the women indicated being indifferent in relation to their satisfaction with the use of the water-soluble powder (functional attribute) instead of drops or syrup (dysfunctional attributes). However, there were differences between the women from other Latin countries and the Brazilian women. More than 10% of the Brazilians indicated that the use of the water-soluble powder instead of the syrup is expected (E), that is, a slight preference for the use of the water-soluble powder in relation to the syrup. However, more

**TABLE 2** Continuous analysis of Kano model data versus direct answers

Functional questions	Participants <sup>a</sup>	Performance	Direct questions	Answer	<i>p</i> value
If, instead of a TABLET, your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER	Latin	3.2	If your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER	3.2	1.00
	Brazil	2.8		2.8	.10
If, instead of DROPS, your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER	Latin	3.2	If your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER	3.2	.81
	Brazil	2.9*		2.8	<.01
If, instead of a SYRUP, your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER	Latin	3.2	If your doctor or nutritionist indicated the use of a WATER-SOLUBLE POWDER	3.2	.74
	Brazil	2.9*		2.8	<.01
Dysfunctional questions	Satisfaction				
If, instead of a WATER-SOLUBLE POWDER, your doctor or nutritionist indicated the use of a PILLS	Latin	3.7	If your doctor or nutritionist indicated the use of a PILLS	3.7	.32
	Brazil	4.0		4.0	.22
If, instead of a WATER-SOLUBLE POWDER, your doctor or nutritionist indicated the use of DROPS	Latin	3.1	If your doctor or nutritionist indicated the use of DROPS	3.1	.60
	Brazil	2.8		2.7	.22
If, instead of a WATER-SOLUBLE POWDER, your doctor or nutritionist indicated the use of a SYRUP	Latin	2.8	If your doctor or nutritionist indicated the use of a SYRUP	2.8	.38
	Brazil	2.6*		2.5	.01

Note: In each line, Kano questions mean values followed by asterisks differ significantly to the direct questions at the level of 5%, by the two-way ANOVA and Fisher's LSD test.

<sup>a</sup>Participants: Latin countries (Uruguay, Peru, Bolivia, Argentina, Portugal, Mexico, Spain, Ecuador, Chile) and Brazil.

than 10% of the women from other Latin countries indicated the use of the water-soluble powder as the reverse (R) instead of drops that is a slight preference for the use of drops instead of the water-soluble powder. In addition it was noted that when only analyzing the combinations of the four direct questions and not the analysis of the six questions. Ten percent of the women from Latin countries indicated the use of the water soluble powder as attractive (A) instead of the syrup, that is, a slight preference for the use of the water-soluble powder in relation to the syrup. Despite differences in the percentages the indication of the predominant attribute in first or second place was the same for both the analysis of the six questions and the analysis of the combinations made with the four questions. The exception of the comparison was of the water soluble powder in the place of the syrup by the women from other Latin countries. This difference between the two analyses would possibly not be detected if a greater number of participants from other Latin countries took part. MacDonald et al. (2006), using an attribute with three levels as the scenario, showed dependence of the statistical significance on the size of the sample as a limitation.

The other replies for the combinations between the four direct questions showed indifference above 55% for all the evaluations. With respect to the use of tablets as a functional attribute, the analysis indicated the attraction of the use of tablets instead of the other three presentations in second place. This reverses the substitution of the other presentations by the tablet, confirming the preference of both women from other Latin countries and Brazilian women for tablets. With respect to the use of drops as a functional attribute, 10% of the women from other Latin countries indicated the

water-soluble powder instead of drops as the reverse (R), that is, a slight preference for the use of drops instead of a water soluble powder. With respect to the use of syrups as a functional attribute, more than 10% of both women from other Latin countries and from Brazil indicated the use of a water-soluble powder and drops in the place of syrups as the reverse (R). That is, a slight preference for the use of a water soluble powder or drops in relation to syrups.

It was important to conduct an online survey in order to understand if women would be interested in replacing the tablets, syrups, and drops iron supplements for powdered. The survey with 312 Brazilian women and 52 women from other Latin countries provided evidence of their indifference with respect to the form of the supplement, as well as showing a preference for tablets and rejection of syrups.

Umbreit (2005) stated a preference for the iron tablets, when the consumers were informed of the greater solubility and availability of the iron at the duodenum and jejunum pH value. In our study, similar results were found when women were communicated that the water-soluble powder was more effective in absorption of the iron and had an agreeable flavor. There was an 85 and 93% satisfaction of Brazilian and Latin American women, respectively, and only 5% of the Brazilians showed dissatisfaction. Thus, we observed that experimentation with the use of a powder as an iron supplement could alter the perception and behavior of the consumer with respect to preference.

At the end of the online survey the participants were asked which flavors they preferred when considering a water-soluble powder as an iron supplement. The more preferred flavors were lemon 46.6%, orange 40.9%, chocolate 32%, and red fruits 32%. The Brazilian



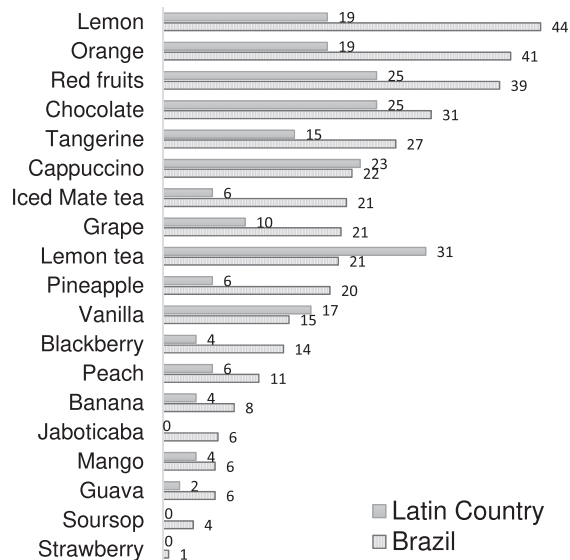
**TABLE 3** Predominant category derived from individual attribute data using the Kano model for iron supplementation in tablet, syrup, and droplet formats

Functional questions	Dysfunctional questions	Participants	Q	R	A	I	O	M	1° place (above 55%)	2° place (above 10%)
If instead of TABLET, your doctor or nutritionist recommends the use of WATER-DISSOLVING POWDER	If instead of water-dissolving powder, your doctor or nutritionist indicates the use of PILL	Latin countries	2	19	4	73	2	0	I	R
		Brazil	3	38	1	56	1	1	I	R
If instead of DROPS, your doctor or nutritionist indicates the use of WATER-DISSOLVING POWDER	If instead of WATER-DISSOLVING POWDER, your doctor or nutritionist indicates the use of DROPS	Latin countries	2	10	6	79	2	2	I	R
		Brazil	4	8	3	77	0	8	I	-
If instead of SYRUP your doctor or nutritionist indicates the use of WATER-DISSOLVING POWDER	If instead of water-dissolving powder your doctor or nutritionist recommends using syrup	Latin countries	4	8	6	75	2	6	I	-
		Brazil	4	6	3	76	1	11	I	M
Questions direct			Q	R	A	I	O	M	1° place (above 55%)	2° place (above 10%)
If your doctor or nutritionist indicates the use of WATER-DISSOLVING POWDER	If your doctor or nutritionist indicates the use of PILLS	Latin countries	2	19	6	71	2	0	I	R
		Brazil	2	33	2	62	0	0	I	R
	If your doctor or nutritionist indicates the use of DROPS	Latin countries	0	12	8	77	2	2	I	R
		Brazil	6	7	3	78	0	6	I	-
	If your dietitian recommends the use of SYRUP	Latin countries	0	8	10	77	0	6	I	A
		Brazil	5	5	2	75	1	12	I	M
If your doctor or nutritionist indicates the use of PILLS	If your doctor or nutritionist indicates the use of WATER-DISSOLVING POWDER	Latin countries	2	8	15	71	2	2	I	A
		Brazil	2	3	25	62	5	3	I	A
	If your doctor or nutritionist indicates the use of DROPS	Latin countries	2	10	15	69	2	2	I	A
		Brazil	3	3	24	59	6	5	I	A
	If your dietitian recommends the use of SYRUP	Latin countries	2	4	17	71	0	6	I	A
		Brazil	2	1	24	56	7	10	I	A
If your doctor or nutritionist indicates the use of DROPS	If your doctor or nutritionist indicates the use of WATER-DISSOLVING POWDER	Latin countries	0	12	8	77	2	2	I	R
		Brazil	6	9	3	78	1	3	I	-
	If your doctor or nutritionist indicates the use of PILLS	Latin countries	2	19	8	69	0	2	I	R
		Brazil	3	35	3	59	0	0	I	R
	If your dietitian recommends the use of SYRUP	Latin countries	0	8	8	79	2	4	I	-
		Brazil	8	6	3	73	1	9	I	-
If your dietitian recommends the use of SYRUP	If your doctor or nutritionist indicates the use of WATER-DISSOLVING POWDER	Latin countries	0	15	4	77	0	4	I	R
		Brazil	5	15	1	75	0	4	I	R
	If your doctor or nutritionist indicates the use of PILLS	Latin countries	2	23	2	71	0	2	I	R
		Brazil	2	40	1	56	0	0	I	R
	If your doctor or nutritionist indicates the use of DROPS	Latin countries	0	13	4	79	0	4	I	R
		Brazil	8	13	1	73	0	4	I	R

Note: Latin countries = Uruguay, Peru, Bolivia, Argentina, Portugal, Mexico, Spain, Ecuador, Chile.

Abbreviations: A, attractive; I, indifferent; M, must be; O, one-dimensional; Q, questionable; R, reverse.

## Favourite Flavor



**FIGURE 4** Preference of flavors (percentage of consumers) in women of Brazil and Latin countries (Uruguay, Peru, Bolivian, Argentina, Portugal, México, Spain, Ecuador, Chile)

women preferred citric flavors (lemon, orange, tangerine), followed by red fruits, chocolate and cappuccino, and finally teas and grape. The women from other Latin countries preferred lemon tea, followed by red fruits, chocolate and cappuccino, and lastly citric fruits (lemon and orange) as shown in Figure 4. These preferences are possibly related to consumption habits where they live and market tendencies for new flavors.

## 3.2 | Product testing

### 3.2.1 | Production of the powdered formulation

One hundred and thirty-two formulations were created considering the information obtained from the online survey concerning flavor preferences, testing various ingredients and additives to contribute to an improvement of the flavor when containing Fe-peptide micro-particles. The selected ingredients were manually weighed and homogenized. Those that best fulfilled the proposed objective continued to the end of process development for further improvement.

Following this logic, polydextrose was added to the iron micro-capsules, this being a special carbohydrate with 90% of soluble fiber, possessing prebiotic action and stimulating iron absorption (Santos et al., 2010). For its part, maltodextrin is a complex carbohydrate, which collaborates with stability of the iron (Pizarro et al., 2015). With respect to the addition of xanthan gum, no adverse evidence was found in relation to iron absorption, and sucrose was added in order to maintain the typical sweet flavor expected by the population. In order to avoid the formulation including sucrose as a major ingredient, but taking the importance of flavor into consideration, a range of sweeteners adequate for consumption by women including during

pregnancy were taken into consideration. Thus, sucralose was selected since it does not cross the placental barrier and presents no side effects or carcinogens, facts duly proven by scientific studies, and presents no aftertaste (Giarola, Pereira, & de Resende, 2015; Kaneva, Chow, Rosenfield, & Kelly, 2017). Ascorbic and citric acids, in addition to providing an acid flavor characteristic of fruits, help avoid oxidation of the iron and collaborate in stabilizing the iron complex (Hurrell et al., 2004; Muñoz-Villa, Sáenz-Galindo, López-López, Cantú-Sifuentes, & Barajas-Bermúdez, 2014). With respect to powdered aromas, those identical to natural aromas were chosen and which presented better performance in covering the metallic flavor of the iron (Baek, 2007; Garg et al., 2018). Similarly, the dyes chosen were of natural origin (Constant, Stringheta, & Sandi, 2002). Due to the potent metallic flavor of iron, a flavor masker had to be added to mitigate the aftertaste. In addition, titanium dioxide was added to the chocolate and strawberry flavored drinks as a blancher, to provide milky and light pink aspects, respectively, using a minimum amount, since it tends to highlight the metallic aftertaste (EFSA, 2016; Jovanović, 2015). Finally, chelaia was added as natural ingredient to form froth (Abdel-Reheim, Messiha, & Abo-Saif, 2017; Hostettmann & Marston, 1995). Different combinations and concentrations of these ingredients were employed, and the selected formulations tested for their iron availability (data still not published). The results of the microbiological tests showed the innocuity of the samples and their aptness for carrying out sensory tests.

## 3.3 | Sensory evaluation

Table 4 shows the mean values scored for global acceptance and, specifically, the scores for appearance, color, aroma, consistency (chocolate flavor), flavor, sweetness and aftertaste of the supplements dissolved in water (1 sachet/100 ml). The tangerine flavor was the best accepted for all the attributes evaluated ( $p$ -value  $\leq .05$ ) in relation to the other samples. It presented means corresponding to “liked

**TABLE 4** Acceptability assessment of samples

Acceptability <sup>a</sup>	Food supplement with Fe-peptide			LSD
	Tangerine	Strawberry	Chocolate	
Overall liking	6.2 (1.8)a	5.4 (2.0)b	4.4 (2.0)c	0.45
Appearance	7.2 (1.2)a	6.3 (1.7)b	5.4 (1.9)c	0.41
Color	7.2 (1.3)a	6.1 (2.0)b	5.6 (1.8)c	0.43
Odor	6.9 (1.5)a	6.4 (1.6)b	6.1 (1.5)b	0.39
Consistency	-	-	5.0 (1.9)	-
Flavor	6.1 (1.8)a	5.0 (2.0)b	3.6 (1.9)c	0.49
Sweetness	6.4 (1.6)a	5.5 (1.8)b	4.8 (1.9)c	0.43
Aftertaste	5.6 (1.9)a	4.4 (2.0)b	3.7 (1.8)c	0.46

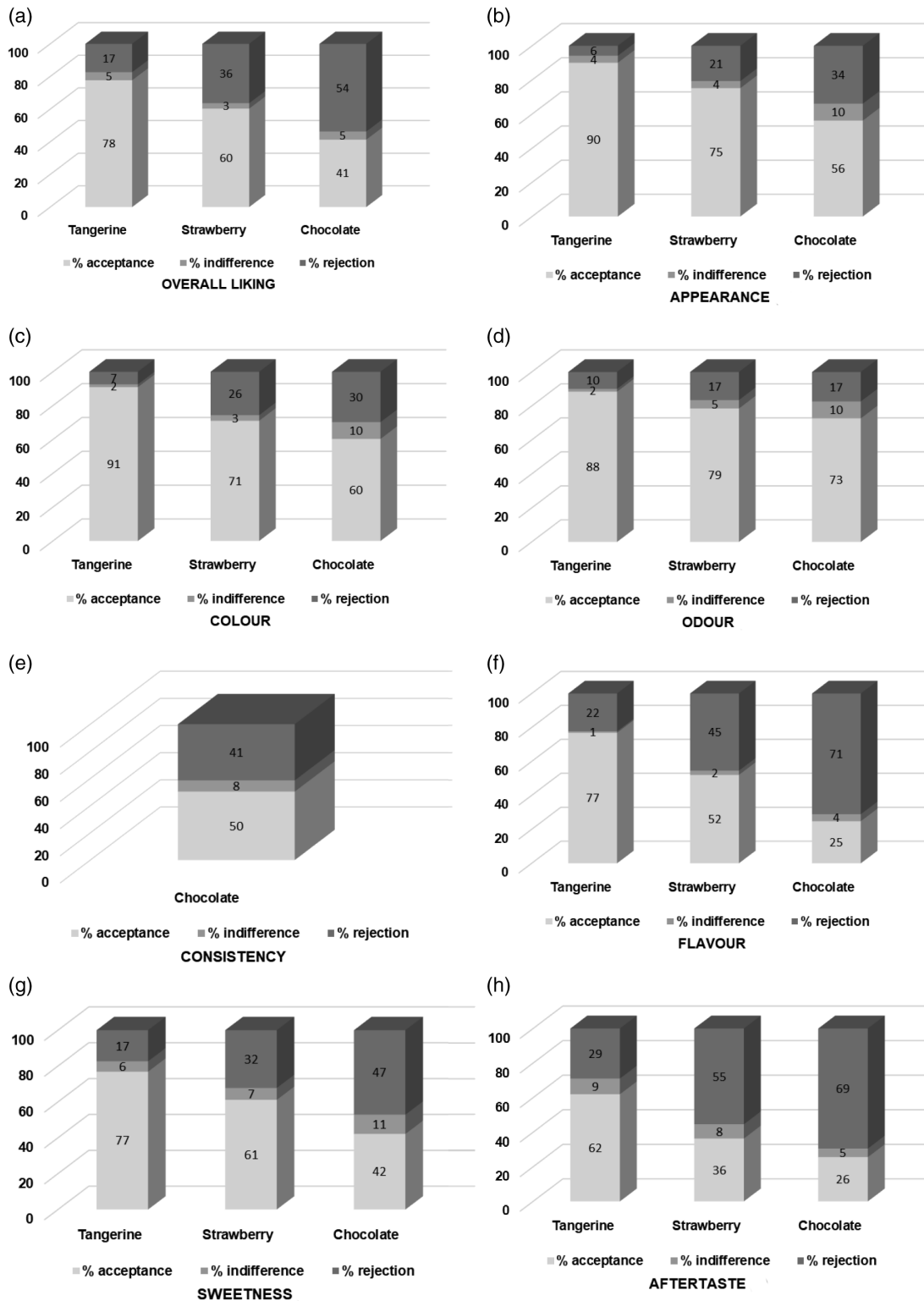
Note: LSD: by the two-way ANOVA and Tukey test, the least significant difference ( $p \leq .05$ ) was calculated and the samples followed by different letters differ significantly from each other.

<sup>a</sup>Results expressed as mean (SD) of 121 evaluations.



moderately” for appearance, color and aroma and means close to “liked a little” for global acceptance, flavor, sweetness, and aftertaste. In a study carried out by Goldenberg et al. (2015), 42 tangerine varieties were evaluated for the acceptance of flavor (nine-point hedonic

scale), and 9 varieties obtained scores greater or equal to that corresponding to “liked moderately,” 19 varieties scores between “liked a little” and “liked moderately” and 14 varieties with scores below “liked a little.”



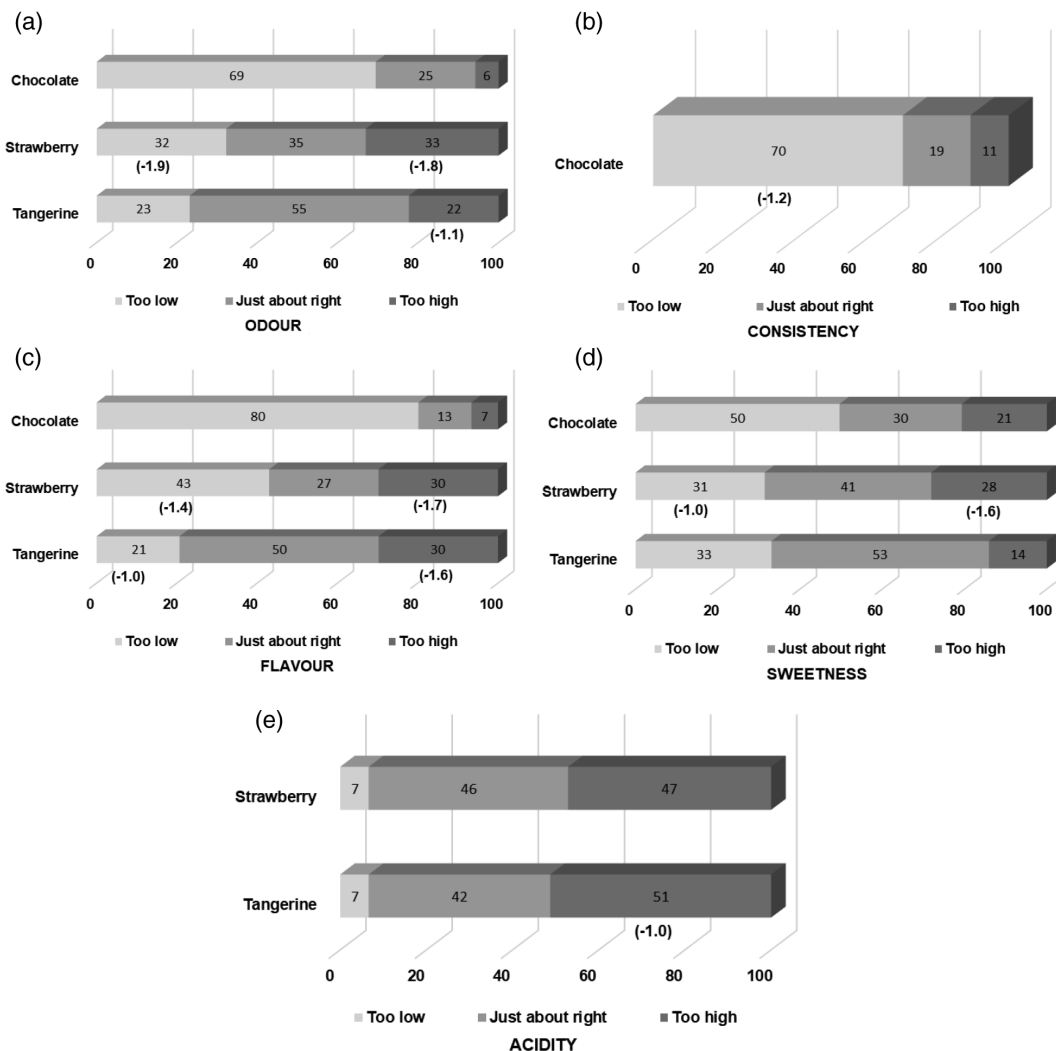
**FIGURE 5** Acceptance, indifference, and rejection percentages of samples: overall (a), appearance (b), color (c), odor (d), consistency (e), flavor (f), sweetness (g), and aftertaste (h) according to the consumers

Excepting aroma, the strawberry flavor was significantly ( $p \leq .05$ ) more accepted than the chocolate flavor.

The chocolate supplement presented means close to “liked a little” for color and aroma, means corresponding to “neither liked nor disliked” for appearance, consistency and sweetness, and means close to “disliked a little” for global acceptance, flavor and aftertaste. These results infer that it was the flavor that resulted in the low acceptability of this formulation, although it also received low scores for appearance and color when compared with the others. The final chocolate formulation had a high pH value and darkened similarly to that reported by Morales, Sánchez-Vargas, García-Zepeda, and Villalpando (2015). The authors reported the development of an undesirable gray color in powdered, chocolate flavored nutritional mixes when fortified with iron, as also with ferrous fumarate and ferrous sulfate. The gray color was solved by including acids such as citric or malic acids in the mixture as buffering agents, such that the pH of the reconstituted product is about 6.5 or less. Another benefit of including these buffering acids is that they tend to stabilize the

chocolate aroma of the reconstituted drink (Mehansho & Irvine, 1997). Since the conception of this chocolate flavored formulation, it was complicated due to the impossibility of adding milk, since milk decreases iron absorption. Thus, the choice of the ingredients was focused on producing a good aspect and flavor, and for this reason, citric acid was added to one of the chocolate pre-formulations, but the acid taste was not characteristic of chocolate and was therefore not applied.

Figure 5 shows the percentages of acceptance (corresponding to scores of 6–9), indifference (score of 5), and rejection (scores of 1–4) associated with the samples by way of the hedonic scale applied. The tangerine flavored food supplement showed an acceptance above 75% for all the attributes evaluated except aftertaste, for which the rejection was 29%. Minim (2018) recommended 70% as the minimum value for the scores to be in an ideal category. The strawberry flavored sample presented rejection of above 30% for the global sensory evaluation and flavor, sweetness and aftertaste characteristics, whereas the chocolate sample presented greater rejection (above



**FIGURE 6** JAR profile comparison and penalty analysis results for odor (a), consistency (b), flavor (c), sweetness (d), and acidity (e) of tangerine, strawberry, and chocolate flavors

50% for global sensory evaluation and flavor and aftertaste characteristics).

For all formulations note that the attributes of flavor and aftertaste showed lower acceptance than aroma, possibly due to perception of the metallic taste, which was greater in the strawberry and chocolate flavored formulations. One of the main reasons for employing microencapsulated ferrous sulfate in some studies was that its potential to improve the sensory quality of the powdered product stood out. According to Arce and Ustunol (2018), the use of microencapsulated iron salts avoids lipid oxidation reactions and disguises the flavors and odors characteristic of iron. On the other hand, in a study of pasteurized milk fortified with microencapsulated ferrous sulfate significant negative sensory changes were observed attributed to the color and flavor of iron (Nkhata, 2013).

Figure 6 shows the percentages of classification above the ideal (scores of 5 and 4), ideal (score of 3), and below the ideal (scores of 2 and 1) for the intensities of aroma, consistency, flavor, sweetness, and acidity, as also the results of the Penalty Analysis (scores in brackets). According to Varela and Ares (2014), if 20% of the scores are above or below the ideal for a determined attribute, with a significant reduction of at least 1.0 point in the mean for global acceptability, this could indicate that the product requires improvement. The attributes, which caused a significant decrease of at least 1.0 point in the global acceptability of the food supplementation samples containing Fe-peptides, were:

- *For the tangerine flavored supplement:* Aroma: considered stronger than ideal by 22% of the women with 1.1 point reduction in the global acceptability mean. Flavor: 21% of the women evaluated this sample with a flavor that was weaker than ideal, with a negative impact of 1 point, whereas 30% of the women declared that the flavor was stronger than ideal, with a 1.6 reduction in the global acceptance. Acidity: 51% of the women considered the sample more acid than the ideal, with a negative impact of 1 point on the global acceptability.
- *For the strawberry flavored supplement:* Aroma and flavor: attributes considered weaker than ideal by 32 and 43% of the women, respectively, with reductions of 1.9 and 1.4 points in the means for global acceptability. On the other hand, 33 and 30% of the women evaluated the sample with aroma and flavor stronger than ideal, with negative impacts on global acceptability of 1.8 and 1.7 points, respectively. Sweetness: evaluated as less sweet than ideal by 31% of the women, with a negative impact of 1.0 point on global acceptability, whereas 28% considered it sweeter than ideal, with a reduction of 1.6 points in global acceptability.
- *For the chocolate flavored supplement:* 70% of the women reported that this sample was less consistent than ideal with a reduction of 1.6 points in the global acceptability.

According to Varela and Ares (2014), some factors could cause polarization of the attributes, since there can be divergence between

**TABLE 5** Contingency table of tangerine, strawberry, and chocolate flavors

Attribute	Tangerine	Strawberry	Chocolate	
	(%)			
Natural flavor	14a	1b	2b	
Artificial flavor	60b	80a	60b	
Odd flavor	14c	28b	60a	
Metallic flavor	33b	44a	50a	
Turvo/opaque	27b	0c	42a	
Transparent/translucent	19b	53a	2c	
Bitter taste	22a	17a	13a	
Astringent (mouth-tightening sensation)	26ab	31a	17b	
Sweetener flavor	17b	29a	28a	
Sweet taste characteristic of sugar	9ab	16a	08b	
Tangerine flavor	87a	0b	0b	
Strawberry flavor	0b	60a	0b	
Chocolate flavor	0b	0b	49a	
Vanilla flavor	0b	1b	19a	
Coconut flavor	0b	0b	13a	
Ranking <sup>a</sup>	Food supplement with Fe-peptides			LSD
	Tangerine	Strawberry	Chocolate	
Sum of ranking positions	163c	243b	320a	30.5

Note: For each attribute, samples followed by different letters differ significantly from each other at  $p \leq .05$  according to Cochran's Q test.

<sup>a</sup>The higher the sum of the ranking positions, the lower the preference for this sample. LSD: Fischer least significant difference ( $p \leq .05$ ).

consumers in relation to the ideal intensity, where one segment prefers a determined attribute with a weak intensity, whereas the other segment prefers a strong intensity. The character of the tangerine and strawberry aromas used (artificial, for example) could have failed to please the women who gave the reply of “stronger than ideal” because they would prefer a less artificial aroma/flavor, whereas those who replied “weaker than ideal” were those who desired an aroma/flavor more characteristic of the natural fruit.

In the acceptability test sequence, the participants were requested to select the attributes of appearance and flavor that characterized the sample evaluated from a list of 15 descriptors, aiming at a better sensory understanding of the formulations containing the Fe-peptide microparticles. Of these 15 descriptors, 11 were used by 20% of the women for the minimal characterization of one of the samples. These results are presented in Table 5 (contingency table), obtained from the CATA data (marked in bold). The results of Cochran's Q test as applied to each attribute can be found in the same table. Samples accompanied by different letters differ significantly at 95% confidence level.

The three flavors were considered artificial by an elevated number of women (strawberry: 80%, tangerine and chocolate: 60%) and to have a metallic taste (more than 30%). Strawberry and chocolate were evaluated with an off flavor (28 and 60%, respectively) and that of a sweetener (28 and 29%), whereas the tangerine flavor was considered to have a bitter taste by 22% of the women. By applying the Penalty Analysis to the CATA data, the attributes used by more than 20% of the women with a significant effect on the global acceptability mean were found to be:

- *Tangerine*: tangerine flavor (+1.4 points), metallic taste (−0.9 points).
- *Strawberry*: strawberry flavor (+1.2 points) and off taste (−2.0 points).
- *Chocolate*: chocolate flavor (+1.2 points) and off taste (−0.8 points).

Table 4 shows the results for the acceptability assessment of samples by the women who took part in the test. The tangerine flavored food supplement with Fe-peptides was the most accepted ( $p$ -value  $\leq 0.05$ ) amongst the other flavors. The strawberry flavor was more accepted than the chocolate flavor.

## 4 | CONCLUSIONS

The online questionnaire was important in order to determine the degree of satisfaction with the use of the powdered iron supplement in relation to the other presentations (tablet, drops, or/syrup) already existent on the market. With the use of direct questions, the attributes could be classified in four levels according to the Kano model. There was an indifferent attitude with respect to the iron supplement as a water-soluble powder, as well as showing a slightly reverse attitude to the syrup and a tendency for the tablet to be attractive. Furthermore, the use of four direct questions has proven to be a faster approach to apply in the place of the several functional and dysfunctional questions practiced in the Kano model. However, the sample size is a limitation and future studies may set this number.

The data composed of 312 respondents proved to be acceptable. Nevertheless, the respondents were open to consuming a powdered water-soluble iron supplement if it presented better absorption characteristics and had a pleasant flavor. Thus, satisfaction could increase with the experimentation once the product has been accepted. The flavors preferred by the women in their fertile phase were citric, chocolate, and red fruits. The sensory evaluation of the three formulations indicated tangerine as the most accepted, and the number of women who perceived a metallic aftertaste in the tangerine formulation was significantly less than for the other formulations. Thus, the results of this study suggest the potential of using citric aromas in a powdered water-soluble iron supplement as a viable alternative to provide iron in an adequate concentration in a little explored format. Thus, a new alternative, which could result in increased adherence to the treatment of iron deficiency in the target group, was born. The results for consumer acceptance showed that the wall material used to microencapsulate the Fe-peptide active agent was not efficient in disguising the metallic aftertaste, since, after reconstitution of the formulation in water, the iron element was freed and the metallic aftertaste perceived. Hence, further studies are required to improve the performance of the microencapsulated material.

## ACKNOWLEDGMENTS

The authors are grateful to the São Paulo Research Foundation (FAPESP) for financial support (grant number 2016/12660-3), and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) through fellowship (n. 001).

## CONFLICT OF INTEREST

All authors declare no conflict of interest.

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**How to cite this article:** Audiverth HLF, de Oliveira Garcia A, Salvucci Celeste Ormenese RdC, Bertoldo Pacheco MT. Use of the Kano model and sensory evaluation in the development of an iron supplement for women. *J Sens Stud*. 2021;36:e12655. <https://doi.org/10.1111/joss.12655>