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CONJOINT CHOICE ANALYSIS FOR THE DEVELOPMENT OF A FUNCTIONAL BEVERAGE

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Summary

The present research proposes the development of a functional beverage based on fruit juice and buttermilk by applying the method of Conjoint Choice Analysis, in order to obtain the utility function of each of the mini-concepts. An orthogonal design of 5 attributes with 2 levels each was elaborated, resulting in 8 miniconcepts. The selected attributes and their levels were: type of beverage (concentrate, liquid), type of fruit (orange, patilla), price ($ 1-3, $ 3-5 per 250 ml), sweetener (sugar, honey) and antioxidant (citric acid yes or no). For the selection of the mini-concept, a Google Forms survey was applied to 251 residents of the metropolitan area of Caracas over 18 years of age, resulting in the selected mini-concept: orange juice/whey milk, honey, $1-3 and with antioxidant. To determine the level of the ingredients, a Taguchi L_4 orthogonal design was applied, the variables being the level of honey and the proportion of orange juice/whey, which resulted in 4 formulations that were prepared and sensorially evaluated by means of an ordering test to determine the definitive formulation. To determine the proximate composition of the selected concept, a physicochemical analysis was carried out. It was determined, by means of a stability test at 5oC for 30 days with weekly measurements of acidity and pH, that the shelf life of the product is around 30 days under these conditions.

Key words: Joint Choice Analysis, functional drinking, Multicriteria Decision Techniques, service life.

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Abstract

This research proposes the development of a functional drink based fruit juices and milk whey applying the Conjoint Based Choice Analysis (CBC) method. An orthogonal design of 5 attributes with 2 levels each was created, which resulted in 8 mini-concepts. The CBC method was used to determine the utility function of each of the mini-concepts. The selected attributes and their levels were: type of drink (concentrated and liquid), type of fruit (orange and watermelon), price ($1-3, and $ 3-5 per 250 ml), sweetener (sugar and honey) and antioxidant (citric acid yes or no). For the selection of the mini-concept, a Google Forms survey was applied to 251 residents of the Caracas Metropolitan area over 18 years of age, resulting in the mini-concept: orange juice/whey, honey, $ 1-3 and with antioxidant. To establish the level of the ingredients, a Taguchi $L4$ orthogonal design was applied, with the variables being the level of honey, and the proportion of orange juice/whey, which resulted in 4 formulations that were prepared and evaluated sensorially by means of an ordering test to establish the final formulation. To determine the proximal composition of the selected concept, physicochemical analysis was conducted. Shelf life was determined, through a stability test at 5oC for 30 days with weekly measurements of acidity and pH, resulting in a shelf life of about 30 days for the product under these conditions.

Keywords: Multicriteria Decision Techniques, functional drink, Conjoint Choice Analysis, useful life

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1. INTRODUCTION

the term "functional food" was first used in Japan in the 1980s, for food products enriched with special constituents that have beneficial physiological effects (ILSI, 2002). The demand in this sector can be explained by the rising cost of healthcare, the steady increase in life expectancy and the desire of people to maintain and improve their quality of life either to improve their health condition or to use as therapeutic medium. The enormous demand of the fruit juice sector as a food category with a healthy perception presents an interesting opportunity to introduce new varieties with novel ingredients that stimulate and support the functionality for nutritional purposes.

Whey is a preferred source of protein beverages due to its excellent nutritional qualities, mild taste, ease of digestion and unique functionality in beverage systems (Chavan et al., 2015). There are numerous types of functional beverages whether dairy-based, dairy-free, natural juice-based, teas, energy drinks, among others. Natural juice-based beverages are rich in vitamins and antioxidants, so it could be confirmed that they provide great health benefits to the consumer. Aron, (2019) developed a review on functional beverages related to health, sports and disease prevention. Ferreira et al. (2020) studied the effects on muscle and oxidative stress in trained individuals of a whey permeate-based beverage with phenolic extract of jabuticaba peel. Islam et al. (2021), who elaborated beverages with whey, pineapple and probiotics, demonstrated that a beverage with these characteristics can have good functional and nutritional qualities for human consumption. Krunic et al. (2022) reviewed the impact on the antioxidant capacity and stability of fermented whey-based beverages by using enriched alginate to encapsulate probiotics with whey concentrate. The demand for fruit-based functional beverages has been increasing as a result of the population's interest in maintaining a healthier lifestyle. Many substances present in fruits, such as vitamin C, vitamin E, beta-carotene and phenolic compounds are excellent antioxidants that are able to stabilize free radicals. According to several authors (Derky et al., 2018; Basantes et al., 2020), the benefits brought by the fruits themselves, especially citrus fruits, increase the vitamin value of the beverage.

Choice-Based Set Analysis (CBC) has been used by many researchers in the area of new food product concept development, (Meyerling et al., 2018; Speight et al., 2019). This method is widely employed for the purpose of gaining insight into consumer preferences. De Peismaker et al. (2017) determined through Conjoint Analysis whether taste is a key driver of consumer preference for chocolate. Velazquez et al. (2021) determined the influence of label information on the snacks parents choose for their children using CBC. At the Metropolitan University, this method has been used in recent years by Khalil, (2021); DaSilva, (2016); Harrar (2010); Garcia, (2009), to evaluate consumer preferences on various types of food. This project proposes the

application of multi-criteria decision methodologies, specifically the CBC to propose concepts of a functional beverage. For this purpose, the necessary ingredients were selected to propose formulations based on whey and fruit juice, and the attributes and levels to be used were determined by means of the CBC to obtain the consumer's preference for this type of beverage. Finally, the selected beverage was prepared, analyzed physically, chemically and sensorially, and its shelf life was determined.

II. RESEARCH METHODOLOGY

Conjoint Choice Analysis (CBC). For the application of CBC, the methodology indicated by Hair et al. (1999) was followed. CBA is a multivariate technique used specifically to understand how respondents develop preferences about products or services. In Conjoint Choice Analysis respondents select from a series of product profiles, this method resembles actual consumer behavior in the marketplace by the choice situation.

Selection of attributes and levels (ingredients). By conducting a market survey similar products were known, which allowed the identification of attributes and levels. With the information obtained from the market survey, bibliographic review and consultation with experts, the attributes and levels that would be used in the Joint Choice Analysis used to develop the functional beverage proposal were selected (Table 1).

Table 1. Attributes and levels selected for the CBC

Attributes	Levels
X1: type of beverage	a1: concentrate a2: liquid
X2: type of fruit	b1: pennyroyal (Citrullus lanatus) b2: orange (Citrus sinensis)
X3: price in USD	c1: 1-3 c2: 3-5
X4: type of sweetener	d1: honey d2: sugar
X5: Antioxidant	e1: added e2: without antioxidant

The properties of the ingredients selected for the development of the nutritional functional beverage are presented below:

Fruits: are an important source of vitamins, minerals and antioxidants present in fruits, especially vitamin C, vitamin E, beta-carotene and phenolic compounds are excellent

antioxidants that are able to stabilize free radicals. The importance of these antioxidants in the maintenance of health and prevention of serious pathologies, including different types of cancer, cardiovascular and neurological diseases, related to aging have been widely reported in research works. Derky et al. (2018). The patilla or watermelon (Citrullus lanatus) is a tropical fruit rich in nutrients, it contains large amounts of vitamin A, B, C and potassium. Its real strength is lycopene, the antioxidant pigment that gives the fruit its deep red color. Some studies suggest that lycopene may have cardiovascular benefits, (Ashurst 1999; Jackson 2003). Orange (Citrus sinensis) is known as a fruit with a high supply of vitamin C (ascorbic acid), vitamins A, B1, B2 and B6 as well as mineral salts such as calcium and potassium which strengthens the body's immune system. It is a source of antioxidants that protect our cells from attacks from the outside (Lujan et al., 2014). Other notable components are organic acids such as citric and malic acid, responsible for its acidity, sugars totaling more than 7%, Davies et al. (2013).

Sugar: sugars are part of the food supply and are used as sweeteners and in some cases as Sugar contains vitamins B1, B2 and A, as well as sucrose, glucose (dextrose), fructose (levulose) and antioxidant. As an antioxidant, it delays cell oxidation and promotes blood circulation. It belongs to the carbohydrate group, the main source of energy for the body, Damoran and Parkin (2019).

Honey: honey is the natural sweet substance produced by the Apis mallifera bee or by different bee species. subspecies, from flower nectar and other extra-floral secretions. Sugars, organic acids (citric, lactic, phosphoric...), vitamins (C, B1, B2, B3, B5), folic acid, minerals (phosphorus, calcium, magnesium, silicon, iron, manganese, iodine, zinc, gold and silver), essential amino acids, sterols, phospholipids, flavonoids, polyphenols and enzymes stand out. (Gonzalez et al., 2017).

Antioxidant: This is a group of vitamins, minerals, natural colorants and other compounds.

Vitamin C is found in plant foods such as fruits, legumes, greens and vegetables, which block the damaging effect of free radicals. Vitamin C has been proposed for many years as an effective antioxidant. Among its chemical properties, its strong reducing power stands out, that is, the ease with which it is reversibly oxidized to dehydroascorbic acid, Domínguez and Ordoñez (2018).

Survey template: The full profile presentation model was selected, in which the

The respondents must choose among several product alternatives. For the application of this model it is necessary to carry out a factorial design, a randomized factorial design was selected. Since 5 attributes with 2 levels each had been defined, the orthogonal arrangement proposed by Taguchi (Gutiérrez-Pulido, H & De la Vara-Salazar, 2008) was used, a s shown in Table 2. To obtain the treatments (screens) to be presented to the evaluators, the procedure recommended by Alcaide-Marzal et al. (2005) should be followed.

a) Based on the combination of attribute levels in Table 2, Profile A, obtain Profile B by modifying one of the columns by adding 1 to all the values in the column; in this project the status column was modified to obtain Profile B.

b) Obtain the Profile C by modifying another of the columns by adding 1 to all the values in the column, the antioxidant column was modified to obtain the Profile C.

c) Obtain Profile D by modifying another of the columns by adding 1 to all the values in the column, the sweetness column was modified to obtain Profile D.

d) Randomly distribute each profile separately

Table 2. Orthogonal array (Profile A)

Treatment	State	Fruit	Price	Sweetener	Antioxidant
A1	a1 (concentrated)	b1 (pin)	c1 (1-3$)	d2 (honey)	e1 (with antioxidant)
A2	a1	b1	c2	d1	e2
A3	a1	b2	c1	d1	e2
A4	a1	b2	c2	d2	e1
A5	a2	b1	c1	d1	e1
A6	a2	b1	c2	d2	e2
A7	a2	b2	c1	d2	e2
A8	a2	b2	c2	d1	e1

Table 3 shows the combination of attribute levels to be used in the survey once the random distribution has been carried out.

Table 3. Results of the random distribution of each of the profiles separately.

Display	Profile A	Profile B	Profile C	Profile D
1	A1	B6	C8	D5
2	A2	B1	C3	D1
3	A3	B5	C2	D6
4	A4	B7	C6	D8
5	A5	B4	C1	D2
6	A6	B3	C4	D4
7	A7	B8	C5	D3
8	A8	B2	C7	D7

Table 4 shows the details of the final combination of attributes and levels to be used in the survey. The aesthetic design of the survey was carried out and, in order to give the respondent greater flexibility, it was decided to add the option “I would choose none”. Figure 1 shows a presentation model of one of the 8 screens presented to the respondent corresponding to the first question (A1, B6, C8 and D5). The survey was developed using the *Google Forms* tool *and* included instructions for filling out the survey and information on the possible ingredients so that the respondents would be aware of the benefits they could bring to the beverage.

Figure 1. Presentation model of one of the CBC screens (Screen 1: A1, B6, C8, D5).

Table 4. Detail of the final combination of attributes and levels to be used in the survey

Screen	Profile A					Profilel B					Profile C					Profile D				
	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5	V1	V2	V3	V4	V5
1 A1, B6, C8, D5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2 A2, B1 C3 ,D1	1	1	1	1	1	1	1	2	1	2	1	2	2	2	2	1	1	1	1	2
3 A3, B5, C2, D6	1	1	2	2	2	2	1	1	1	1	2	2	1	2	1	2	1	1	2	2
4 A4, B7 C6, D8	1	2	2	1	1	1	2	1	1	2	1	1	2	1	1	1	2	2	1	2
5 A5, B4 C1, D2	2	1	1	2	1	2	2	2	1	1	2	1	1	1	2	2	1	2	1	1
6 A6, B3 C4 ,D4	2	1	2	1	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	2
7 A7, B8, C5 ,D3	2	2	1	1	2	1	2	2	2	1	1	1	1	2	2	2	2	1	1	1
8 A8, B2 C7, D7	2	2	2	2	1	2	1	2	2	2	1	2	1	1	1	1	2	1	2	1

Data were requested such as gender (female, male, I prefer not to say), age (ranges between 18-25, 25-35, 35-50 or over 50 years old), municipality where they live (Libertador, Baruta, Chacao, Sucre or Hatillo), if they have lactose intolerance or milk-related allergies and if they would be willing to be part of the sensory analysis of the beverage.

Survey application. The survey was sent via the Web to a sample of 251 people over 18 years of age residing in the Caracas Metropolitan Area.

Data processing. The data were organized into a database classified by age and sex. For data processing, Microsoft Excel and the simple count methodology were used. Equation (1)

was used to calculate the probability of product acceptance at all levels for each sex and age range. Global acceptance was determined, the criterion for selecting the levels was the one with the highest probability, thus obtaining the product profile.

$$P_{Ai} = \frac{Selection\ (A_i)}{Appearance\ (A_i)} \quad (1)$$

Where:

PAi the acceptance probability of attribute Ai

Ai selection refers to the number of times the attribute Ai was selected.

Appearance of Ai - refers to the number of times the attribute Ai appears in the combination of cards shown to the surveyor.

Preparation of the selected beverage

With the result of the consumer preferences for the formulation of the beverage obtained through the CBC, it was possible to elaborate a prototype of the beverage that was analyzed physico-chemically and sensorially. In addition, a shelf-life study was conducted.

Physical-chemical and sensory analysis

The physicochemical analyses performed were: soluble solids (Covenin Standard 1983. Method 924-83), ash (method 923.03 A.O.A.C. 1975), fat (method 922.06. A.O.A.C. 1975) and total solids (method 6.2.1.6, Nielsen, 2003). For sensory analysis, a consumer-oriented test was used where panelists were untrained) (Watts et al., 1992).

Life cycle study

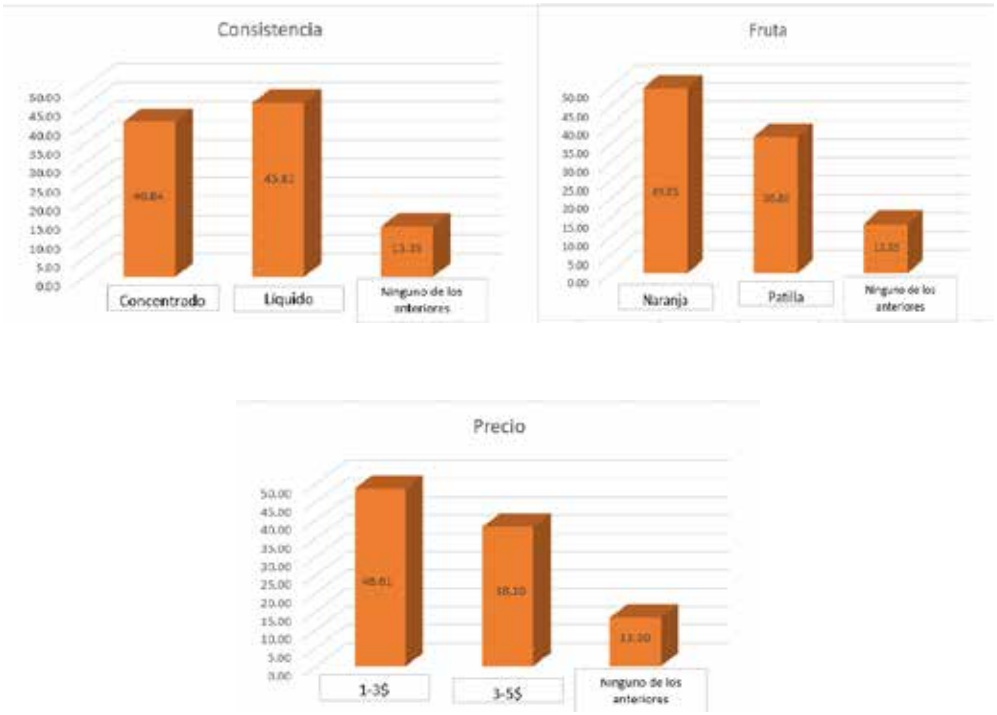
To determine the shelf life of the beverage, it was stored for 28 days at refrigeration temperature (^{5oC}) and weekly measurements of pH (Covenin Standard 1979. Method 1315-79) and acidity (Covenin Standard 1977. Method 1151-77) were performed. This period of 28 $^{days/5oC}$ was selected because it is what is usually used in similar research works (Seyhan et al., 2016); Segura -Badilla et al. (2020).

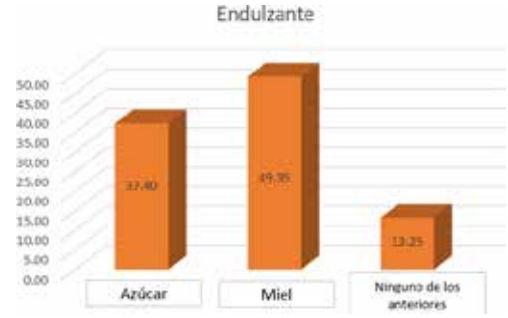
III. RESULTS

Joint Choice Analysis

By processing the data obtained from the surveys, it was possible to obtain the preferences of potential consumers in terms of consistency, type of fruit, price, sweetener and whether or not it would contain antioxidants. Figure 2 shows the results of the partial utility of each of the attributes for the simple tally model.

Figure 2. Overall CBC results for each of the attributes.





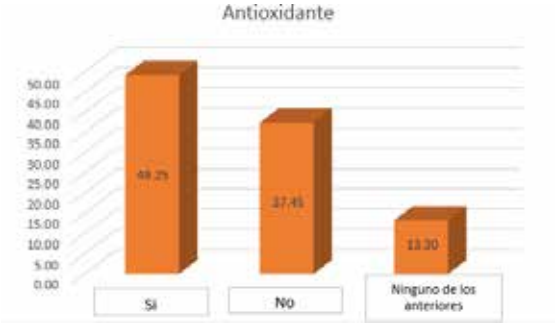


Figure 2 shows that the respondents' preference in terms of consistency was for the liquid beverage (45.82%), which could be because the consumer prefers a beverage that can be consumed without the need to be reconstituted, which is undoubtedly an advantage for housewives. The fruit selected was orange (49.85%), with a markedly higher percentage of acceptance than that of patilla (36.80%). this result agrees with what is indicated by Davies et al. (2013) who in their research work state that orange is one of the citrus fruits preferred by consumers due to its proven benefits. Regarding the percentage of acceptance we can observe that a marked preference for the lower price 1-3 $ (48.61%), however it should be noted that there is a good number of respondents (38.10%) who would be willing to pay more, for a high quality product. As for the sweetener, there is a marked difference for the natural sweetener honey (49.35%), this is probably due to the fact that the consumer is increasingly more aware of the need to eat healthy natural foods and therefore the tendency to prefer a natural product such as honey to a processed product such as refined cane sugar. Finally, it is not surprising that there is a strong preference for the use of antioxidants (49.25%), since the general public is generally aware that this type of compounds are beneficial to health.

According to the overall results shown in Figure 2, the preferences of the respondents for each of the selected attributes, the final product will consist of whey as a base, with orange juice, honey, antioxidant and with a price between $ 1-3.

Figure 3 shows the profile of the combination of attributes selected by the respondents.

Figure 3. Final profile of the selected product

Production of the functional beverage

Once the level of the attributes selected by the respondents (liquid whey beverage, with a price between USD 1 and 3, orange juice, honey and antioxidant) was known through the CBC, it was necessary to determine the amount of each ingredient in the final formulation. Based on the market survey, literature review and interviews with experts, the liquid, price and antioxidant attributes were kept constant; the only variables were the honey content (4-6 g/100 ml), orange juice (40-50 g/100 ml) and whey (30-40 g/100 ml). Following Taguchi's proposal (Gutiérrez-Pulido & De la Vara, 2008), an L4 experimental design was selected where 4 beverages were obtained and sensorially evaluated for the selection of the one preferred by the panelists (Table 5). For all runs (A, B, C and D), 0.018 g/100 ml of ascorbic acid was added.

Table 5. Composition of the formulations for sensory evaluation

Run number	Ingredients		
	Honey (g/100 ml)	Whey (g/100 ml)	Orange juice (g/100 ml)
A	4	30	40
B	4	40	50
C	6	30	50
D	6	40	40

* Drinking water was used to complete the 100 ml of solution.

Sensory evaluation. The sensory test performed to select one of the four beverages elaborated was the acceptability test by ordering where 30 untrained panelists were asked to taste the beverages and are numbered from 1 to 4 with 1 being the most acceptable and 4 the least acceptable. The result of the acceptability of each sample is determined by the summation of each panelist's assignment. The results were:

Beverage A: 85; Beverage B: 98; Beverage C: 56 and Beverage D:61

A significance analysis was performed according to Watts et al. (1992) and significant differences were obtained between beverages B and C and between beverages B and D, and no significant differences were found between beverages D and C.

Physicochemical analysis

Table 6 shows the results of the physicochemical analysis of Drink C and reference value

Table 6. Results of physicochemical analysis of Drink C and reference values

Analysis		Reference values
Total solids (%)	6,250	Chatterjee et al. (2015) report 14,430. Islam et al. (2021) report 8.17 - 16.57
Ash (%)	0,661	Chatterjee et al. (2015) reports 0.670. Portada (2022) reports 0.540
Fat (%)	0,554	Covenin Standard max 1,500 Basantes et al. (2020) report 0.73-0.8 Chatterjee et al. (2015) report 0.73%.
Soluble solids (^{O} Brix)	11,570	Covenin 1994 standard, orange juice ≥ 9^{O} Brix Cedeño et al. (2018) report 11.2 -11.8. Chatterjjee et al. (2015) report 14.43. Derky et al. 2018 (12-13.5). Basantes et al. (2020) report 7,25-7,5

The values of the physicochemical analysis performed on the functional beverage agree with those found in similar works, Islan et al. (2021) elaborated pineapple juice and whey beverages. Cedeño et al. (2018) elaborated a beverage with whey, orange juice, and sugar. Basantes et al. (2020) elaborated a beverage based on whey and white cocoa (Theobroma

grandiflorum) pulp. Chatterjee et al. (2015) elaborated a beverage with whey and orange juice. Portada (2022) elaborated a beverage based on whey, orange juice, carrot, and stevia. Derky et al. (2018) developed a nonalcoholic functional beverage.

Stability analysis

Figure 4 shows the decrease in pH of the selected beverage when stored under refrigeration ($5^{o}C$) for 28 days and Figure 5 shows the increase in acidity.

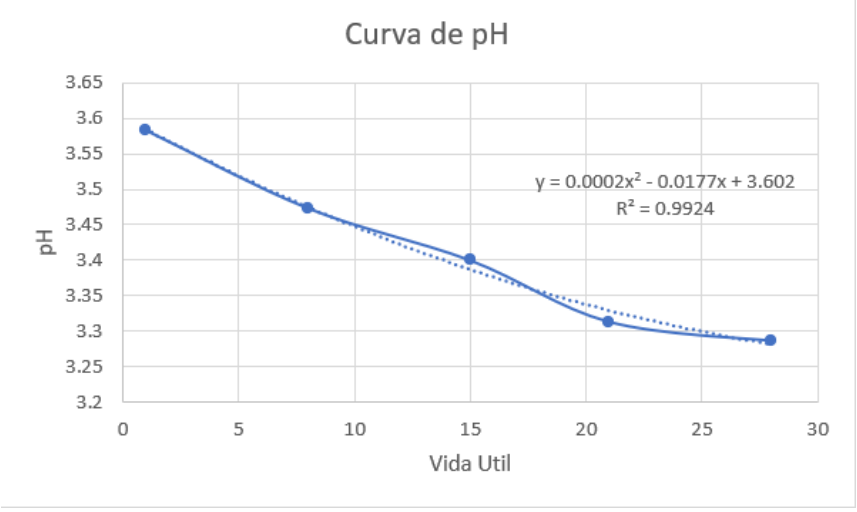


Figure 4. Variation of pH (ionic acidity) in the beverage stored for 28 days at 5 C.^{o}

According to Covenin 1699 (1994), orange juice can be consumed when its pH remains above 3.2. After 28 days of storage, the pH of the beverage was 3.28, so we can affirm that it can still be consumed.

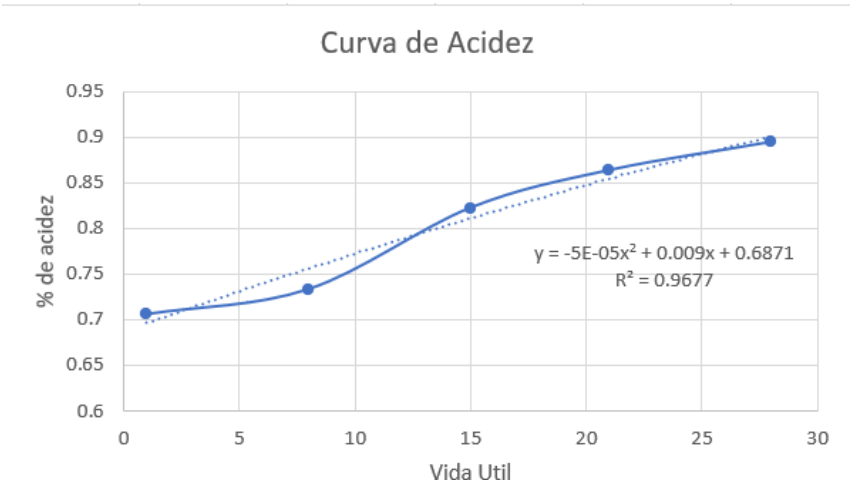


Figure 5. Variation of acidity in the beverage stored for 28 days at 5 C.°

After 28 days of storage of the beverage at 5oC, an acidity of 0.894 was obtained. The acidity obtained by Portada (2022) separately for the ingredients of the beverage they developed was 0.1% for the whey, 0.87% for the orange juice and 0.2% for the carrot juice, which is close to that obtained by this author.

V. CONCLUSIONS

The use of multi-criteria decision making techniques (MCDM) in food science constitutes an important advance in the processes of identification and creation of new segments in the marketing of mass consumption products.

Particularly in the field of functional foods, the use of methods such as conjoint choice analysis greatly facilitates the study and prioritization of multiple variables involved in the formulation processes of new products.

This research demonstrates an example of the application of this methodology to the development of a functional beverage based on orange juice with whey, improving the nutritional quality and protein content of the beverage.

The study demonstrates that at a conceptual level, it is possible to advance the phases of product development through the representation of mini-concepts that can be easily understood, evaluated and prioritized by the respondents and the information gathered efficiently using

processing of publicly available data such as Excel. This, in turn, significantly reduces the number of options that need to be physically produced, speeding up and reducing the cost of the final product design process.

As an extension of this research, we believe that correlation studies of results between concepts presented in graphic form and those that can be physically prepared in the laboratory are still pending.

It remains to be validated whether the graphical representation of a product, which may be biased by the respondent's prior knowledge or experience, correctly simulates the acceptability and order of preference that would result from the physical presentation of these options. In this aspect, issues such as the absence of sensory evaluation in the preliminary stage of the CBC (smell, color, taste, texture) could substantially vary the results of the evaluation and lead to erroneous preference values.

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