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Natural Beverages and Sensory Quality Based on Phenolic Contents

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Abstract

Currently, consumers are demanding natural products, with low sugar content and high nutritional and sensory qualities. Natural beverages have taken an important place due to their mineral, vitamin, and antioxidant contents. Phenolic compounds have great relevance for food industries for their functional properties acting as good antioxidant molecules as well as aging retarders and preventing degenerative diseases. In this connection, design of functional beverages rich in phenolic compounds has been related to the acceptability, quality, and safety for consumers; however, sensory properties regarding influence of these compounds are still poorly investigated. Recent works have been conducted in order to highlight the impact of phenolics on sensory properties of natural beverages. This chapter discusses the relationship between sensory quality and the phenolic compounds in natural beverages. The antioxidant properties, methods, and statistical analysis for sensory evaluation are also reviewed.

Keywords: natural beverages, phenolic compounds, sensory evaluation

1. Introduction

As described in the literature, development of a new product such as natural beverages with functional properties involves technical and market factors. Technical factors include ingredients, formulation, conservation process, and the resistance of functional compounds to thermal treatments as well as their shelf life. As market factors, it is important to consider the needs of the consumer and the acceptance of the new products. This is where the sensory

evaluation of natural drinks with functional properties provides tools in the decision-making for the successful launch to the market of a new product as described below.

In general, market problems faced by natural drinks are:

- High prices currently prevailing in functional products, which limit their frequent consumption and adoption.
- The intensive marketing of sugar-sweetened beverages in contrast with the tiny natural beverage market strategy.
- The problems of industrial production of natural drinks such as: lower shelf life and degradation of functional compounds by light, temperature, and pH changes.
- Safety and consumer confidence in the functional compounds contained in natural drinks.

On the other hand, the development of a natural drink with antioxidant properties must consider the following:

- Development of beverage mix fruits, fruit extracts, herbal teas, and natural origin sweeteners containing functional benefits and lower price to consider in its formulation.
- Sensorially, these drinks should be slightly sweet and of a translucent color, with aromas and broad flavors that captivate consumers.
- Replace the dyes and flavor enhancers used with natural essences of herbs and spices.
- Assess the use of natural sweeteners such as stevia, honey, and agave syrup.
- Preferential presentation to 350 ml glass bottles (with little or no chance of release agents foreign to the drink) to facilitate its transport.
- Also ensure the availability at home of these drinks with presentations of 2–3 l.
- Advertising or marketing of natural beverages should be focused on creating healthy eating habits.

Natural drinks with antioxidant properties are considered functional beverages. According to the International Food Information Council (IFIC), functional foods and beverages are those products, characterized by source of physiologically active components, with beneficial properties for human health. Functional beverages can be made from concentrated juice, from 100% natural juice, from nectars, or teas. They can also be called healthy drinks.

Finally, this section is not intended to fully illustrate the process in which a new drink is developed, rather it is intended to provide the reader with relevant and current information about the ingredients, formulation, packaging, shelf life, and above all, the behavior of functional compounds in the process of conservation or heat treatment as well as through the time of storage, which are important factors in the development of new drinks with functional properties.

2. Antioxidant activity, total content of phenolic compounds in natural drinks

Natural drinks with functional properties include within its production mainly berries, apples, lemons, grapes, in mixtures of milk serum, infusions, or herbal extracts to enhance its beneficial effects to the health, and sweetening matter with substitutes of sucrose and fructose to preserve the image of “good for your health.” These substitutes focused on the use of honey and aspartame among others.

Functional properties usually studied in the development of natural beverages include antioxidant activity, contained phenolic, total phenols and anthocyanins, and vitamin C among others. Studies mainly focus on the study of their behavior during shelf life, after the heat treatments of conservation.

Thermal treatment for the conservation of natural beverages includes pasteurization, where the functional properties can be reduced by the effect of the treatment and the storage time. Cooling tends to preserve these properties during storage time; however, sedimentation of the compounds in the interior of the container may appear.

2.1. Drinks

Rubio-Perez et al. [1] developed an antioxidant drink from apple extract and green tea extract and observed changes in phenolic compounds and antioxidant activity during 8 months at a temperature between 4 and 25°C in a Tetra Brik packaging. They found that the color dropped 10.73%, becoming red-yellowish; drinks also decreased their ascorbic acid by 41.24% in samples stored at 25°C. On the other hand, an apple drink mixed with milk serum was developed by Jaworska et al. [2] and packaged in 330 ml glass bottles. The drink was pasteurized at 80°C for 18 min and was stored at 4°C for 12 months. The changes found after 6 months of storage was the decrease of 64% of phenolic compounds. The content of vitamin C, lactose, sucrose, polyphenols and antioxidant activity decreased between 6 and 93% during the period of storage. It also presented significant changes in the sensory quality of drinks. Color, glucose, and fructose increased during storage. Dominant polyphenols were derived of the cinnamic acid, flavonols, and quercetin.

Aonla juice (*Embllica officinalis*) is used as a mixture with extracts of leaves of custard apple (*Annona squamosa*) in order to enhance its nutraceutical value for the content of quercetin. Drinks are bottled in 750 ml bottles and refrigerated at 4°C. The quercetin was sedimented during the storage of juice at refrigeration temperature. Sensorially, drinks were rated high when they contained 10 g of custard apple leaf extract, and this concludes that you can prepare a juice of aonla containing quercetin with high value nutraceutical [3].

Lemon juice is also used as an ingredient of functional beverages, enhancing their health benefits and improving their sensory properties when sweetened with honey. Sharma et al. [4] prepared a ready to drink beverage in 200 ml glass bottles, used table sugar and honey as a sweetener, the drink was pasteurized at 77°C for 30 min and stored for 6 months at room

temperature (13–27°C) and then cooled (4–7°C). They found no physical-chemical and sensory changes during storage when samples were refrigerated. At room temperature, beverages sweetened with honey can be stored for a period of 6 months without microbial growth. Sensorially, lemon beverages sweetened with honey were rated higher on their sensory attributes than those where table sugar was used.

Blue-black grape juice was used to prepare a fermented beverage in which we studied the time effect and temperature of storage on the color and antioxidant properties [23]. When the drink was stored at 4 and 20°C for 60 days, the pH decreased 10 and 11%, respectively; this change is important to record since it determines the stability of the color of the drink. At the beginning of the test, samples recorded the highest proportion of red and as expected, the brown increased eventually reaching its maximum value at 60 days based on the storage temperature. The phenols total content significantly decreased, 21.4 and 24.1% at the studied temperatures. The anthocyanin content during storage at 4 and 20°C resulted in losses of 60 and 78%, respectively.

2.2. Infusions

Infusions are prepared drinks from very hot or boiling water and substances of vegetable origin like leaves, flowers, fruits, seeds or some barks of plants, in order to dissolve the soluble fraction of its components. The solution made with the leaves of *Camellia sinensis* is called tea infusion. When other plant material is used and properly processed, it is called infusion. **Table 1** summarizes main antioxidants in natural beverages and sources.

The needs of the consumer who seek greater functional properties and sensory attributes are best met with infusions, drinks based on mixtures of leaves, flowers, and roots and sweetened with stevia or sugar substitutes. Beverages containing *Camellia sinensis* are the most used due to the stimulant effect caused primarily by its contained caffeine and their antioxidant properties, however, according to the geographical context, other materials seem suitable for infusions [5].

Tzu-Ying et al. [6] prepared the drink kombucha from black tea leaves of *Camellia sinensis* and juice of germinated wheat (wheatgrass) WGT increasing the content of phenolic compounds and antioxidant capacity. Results showed that the content of phenolics, flavonoids, and antioxidant capacity was greater than in the traditionally prepared kombucha. The kombucha mixed with wheatgrass was characterized by having high contents of gallic acid, catechin, caffeic acid, ferulic acid, rutin, chlorogenic acid. The highest antioxidant capacity was presented at a ratio 1:1 WGT and black tea. They concluded that it is advisable to mix kombucha and WGT for their high and stable antioxidant capacity as a new drink.

Filipendula tea processing (Meadowsweet flower teas) is carried out starting from *Filipendula ulmaria*. Olennikov et al. [7] investigated photochemical profile and nutrition of three possible substitutes (*F. camtschatica*, *F. denudata*, *F. stepposa*) for functional beverages. It was found that *F. stepposa* produces the highest content of phenolic compounds and that the four investigated species in its essential oil contain 28 compounds including simple phenols, monoterpenes,

Plant or fruit	Product	Antioxidant	Reference
Sauco (<i>Sambucus nigra</i> L. subsp. peruviana)	Zumo funcional	Anthocyanins Total phenolics Antioxidant activity	[9]
Date fruit <i>Phoenix dactylifera</i> L.	Jam	Total phenolics Antioxidant activity	[10]
Orange <i>Citrus sinensis</i> L., Osbeck	Minimally processed orange	Total phenolics Antioxidant activity Vitamin C	[11]
Black mulberry <i>Morus nigra</i> L.	Fresh mulberry Dried mulberry Mulberry wine	Total phenolics Flavonoids Anthocyanins Antioxidant activity	[12]
Blueberry <i>Vaccinium corymbosum</i> L. Cranberry <i>Vaccinium macrocarpon</i> Aiton	Fresh fruit at three maturities (white, turning, and fully colored)	Phenolics compounds Anthocyanins Antioxidant capacity	[13]
Date fruit <i>Phoenix dactylifera</i> L.	Jam	Total phenolics	[10]
Yacon <i>Smallanthus sonchifolius</i>	Yacon flour	Phenolic compounds	[14]
Grape <i>Vitis vinifera</i> L.	Table grapes	Total anthocyanins Total polyphenols Total hydroxycinnamic acid	[15]
Kiwifruit <i>Actinidia deliciosa</i> cv.	Wine	Phenolic compounds Total phenolic Antioxidant activity	[16]
Custard apple <i>Annona squamosa</i>	Custard apple leaf mixed with aonla juice	Quercetin	[3]
Chequén <i>Luma chequen</i> Murta Ugni molinae Arrayan <i>Luma apiculata</i> Chilean blueberry <i>Vaccinium corymbosum</i> Meli <i>Amomyrtus meli</i> Calafate <i>Berberis microphylla</i>	Fresh fruits: Chequén, Murta, Arrayan, Chilean blueberry, Meli, Calafate	Anthocyanins Total phenolics Flavonoids	[17]
Grape <i>Vitis labrusca</i>	Purple grape juice	Phenolic compounds Monomeric anthocyanins Antioxidant activity	[18]

Plant or fruit	Product	Antioxidant	Reference
Roselle <i>Hibiscus sabdariffa</i>	Blended with mango, papaya and guava juices	Monomeric anthocyanins Vitamin C Total phenol Antioxidant activity	[19]
Extract Green tea	Antioxidant beverage	Phenolic compounds	[1]
Extract Apple		Antioxidant activity	
Blackberry <i>Rubus fruticosus</i>	Fruits extract	Total phenol	[20]
Mulberry <i>Morus</i> spp.		Anthocyanins	
Blueberry <i>Vaccinium myrtillus</i> L.		Phenolic compounds Antioxidant activity	
<i>Filipendula camtschatica</i>	Meadowsweet floral teas	Flavonoids, tannins, catechins, proanthocyanidins	[7]
<i>Filipendula denudata</i>		WS polysaccharides	
<i>Filipendula stepposa</i>			
<i>Filipendula ulmaria</i>			
Plum fruit <i>Prunus domestica</i> L.	Cloudy juices	Anthocyanins Total phenolics Antioxidant activity	[21]

Table 1. Bioactive compounds in different natural beverages.

sesquiterpenes, and aliphatic components. Anti-diabetic activity and antioxidant properties caused by the presence of highly active ellagitannins were also found. It can be expected from formulations based on *Filipendula* beneficial effects due to its unique nutritional and photochemical profile. Potential applications are suggested as functional health promoting products.

A medicinal drink formulated with arjuna (*Terminalia arjuna*), Ginger (*Zingiber officinale*), safflower (*Carthamus tinctorius*) and stevia (*Stevia rebaudiana*) as an alternative to caffeinated beverages has been made. Verma and Singh [8] optimized and characterized ore and bro-matological herbal mixture, finding that ascorbic acid content fluctuated between 35.66 and 37.64 mg /100 g of formulation. A drink was obtained with sensory characteristics of bright orange brown color and a strong aroma and pleasant taste. The microbial quality allowed a shelf life of 3 months of the herbal mixture packaged in foil pouches.

The preparation of teas from different species of *Artemisia* was studied. Jae et al. [22] included in his study *Artemisia princeps* Pamp. and *Artemis argy*; this last species was studied as a food resource in the preparation of teas. The preparation was performed by adding 5 g of dried leaves per liter of boiling water and was evaluated sensorially and compared between the two-species content of amino-free acids, fatty acids, vitamin C, and total phenolic compounds.

They conclude that *A. argy* is the best species for the production of tea since it exceeded *Artemisa princeps* in all measured variables, in addition to having higher content of volatile compounds when used as tea. As a result, they considered *Artemis argy* has potential for as an ingredient for industrial use.

2.3. Juices

Processing of fruit for juice preparation involves the following operations: grinding, pressing, and enzymatic treatment. When attempting to develop functional juices, it is necessary to extract and preserve most of the functional compounds. Flores [9] evaluated the extraction of antioxidants from elderberries (*Sambucus nigra* l. subsp. *peruviana*) by different techniques in order to obtain juice with these beneficial properties and to develop a functional drink. The author pointed out in his study that the maceration at 70°C for 20 min originated better antioxidant properties with which a juice with good antioxidant and sensorial characteristics was elaborated. Prune juice extraction was achieved with the use of 140 ppm of enzymes at 48°C for 1 to 2 hours. In general, the content of anthocyanins in the juice was increased with the concentration of enzyme, time, and temperature. There was also a growing trend in antioxidant capacity with the concentration of enzyme [21].

The beneficial effects of grape juice as ergogenic and antioxidant were investigated by Tavares et al. [18]; athletes were given 10 ml/kg/day of purple grape juice in two doses provided before and after the training. They found a significant increase in antioxidant capacity (38.7%), vitamin A (11.8%) uric acid (28.2%) and a possible anti-inflammatory effect (20.2%). These results contrast with the control group where whole grape juice was not supplied. Whole-grape grape juice shows an effect ergogenic in brokers to promote the increase in the time to exhaustion, accompanied by an increase in antioxidant activity and a possible anti-inflammatory effect. These results suggest that grape juice is a good component within a functional drink formula and that the antioxidant effect can be enhanced when combined with other functional ingredients such as citrus, pear, cinnamon, ginger, and chocolate among others.

The mixture of Apple juice with grape juice, pear, and peach juice was made by Chiusano et al. [23], who revealed that there are no technological problems for these mixtures. The general acceptance of juices was highly significant and positively correlated with °Brix/acidity relationship, where samples with high percentage of pear juice were preferred.

The mixture of *Hibiscus sabdariffa* flower extract (roselle) with tropical fruit juices such as mango, papaya, and guava was made to provide beverages with high nutritional content and functional activity [19]. The preparation of roselle mixtures with fruit juices was performed in the following proportions: 100:0, 80:20, 60:40, 40:60, 20:80, and 0:100. The beverages thus prepared were packed in sterile 100 ml plastic bottles and pasteurized in a water bath at 82.5°C for 20 min. The mixture turned from red to yellow as the proportion of fruit juices increased. These combinations of extract with fruit juice are rich in essential minerals and vitamin C. The

consumption of anthocyanins in the mixtures studied (493.5–118.2 mg/l) can protect humans from the diseases attributed to the reactions of free radicals.

Juices with pulp or nectar which usually retain the nutritional value of the fruit from which they were made, however, settle during storage. Five types of juices with pulp obtained from apples, pears, carrots and tomatoes, as well as a mixture with ratio 1:1:1 of apples, pears and carrots were studied [24] according to their efficiency for the extraction of juice.

The efficiency of conversion to juice was high for all mixtures studied, the maximum value of 580 ml/kg of apples was recorded, and the minimum value was 25 ml/kg of carrot, which has a high content of vegetable fiber. The acidity, the presence of nitrates and nitrites, and the sugar content in the processed juices were lower than those found in the supermarket. Ascorbic acid was added to all the juices to correct the taste and to prevent deterioration by light oxidation.

3. Quality of natural beverages and their sensory attributes

The development of a new drink requires ensuring its quality in microbiological, physico-chemical, and sensory aspects; the first two relate to the sanitary and nutrimental quality of the drink. The sensory aspects are the reason for this section; the properties and attributes that should be considered to assess and ensure the sensory quality of new natural beverages are presented.

The sensory quality of drinks considered the following properties:

- Organoleptic properties: Visual, olfactory, tactile; auditory properties in beverages do not represent a decision point for the consumer therefore not be addressed in this section.
- Digestive are those that are experienced after ingesting the drink: heaviness, fullness, and/or pleasure.

The parameters that define the quality of a drink are positive attributes such as: color and overall appearance, taste properties: flavor, mouth persistence, aftertaste; olfactory properties: aroma, odor, orthonasal and retronasal; tactile properties: mouth feel, body, and absence of contaminants (odors and strange flavors). Among the negative attributes are: discoloration, foaming, sedimentation, gas, unpleasant smells production (notes ketone or vinegary), bitterness and astringency [25].

Before releasing a drink to the market, its acceptability and availability of purchase by the consumer is valued. Positive and negative attributes are evaluated through hedonic scales; that can be verbal and applied in evaluations carried out with adults; the facial hedonic scale is used preferably with infants, the scales used can be from 5 to 11 points, which vary from the maximum level of displeasure to the maximum level of pleasure. The scales used in the tests of acceptance of a drink are according to their discriminative power, reliability and predictive value correlated with eating habits. The hedonic scale most commonly used in these tests is the

Product evaluated	Sensory evaluation	Sensory panel	Scale	Palate cleansing	Reference
Wine	Aroma, tactile attributes	8	Ten points	Water	[16]
Custard apple leaf extract fortified sweetened aonla juice	Color and appearance, flavor, taste and mouth feel, overall acceptability	Undefined	Nine points	Undefined	[3]
Cloudy plum juices	Color, odor, taste, consistency and overall sensory impression	10–15	Nine points	Undefined	[21]
Arjuna-ginger medicinal mix blended	Appearance, color, taste, flavor, brightness and strength	20	Nine points	Undefined	[8]
Grape juice mixed with apple, pear, and peach juices	Color, odor, aroma, sweet taste, persistence in the mouth, overall pleasantness	50 consumers	Five points	Natural water	[23]
Apple and apple-whey beverages	(a) appearance (color, sediments and suspension); odor desirability, odor intensity and flavor (b) Descriptive flavor analysis	(a) 15 (b) 18	Five points	Undefined	[2]
Drink lemon juice and honey ready to serve	Color/appearance, flavor/aroma, body, taste and overall acceptability	Undefined	Nine points	Undefined	[4]
Plum nectar (<i>Prunus domestica</i>)	Quantitative descriptive analysis (QDA): color, odor, taste, consistency and overall sensory impression	15	Intensity scale 0–10	Salt-free bread and water	[26]
Mugwort tea (<i>Artemisia argyi</i> H. Lev & Vaniot)	Color acceptability, flavor acceptability, saltiness, bitterness, sourness, astringency, sweetness and overall preference	15	Labeled affective magnitude (LAM) scale 15 points	Undefined	[22]
Amarone red wine	Development of sensory descriptors for aroma, taste, flavor and mouthfeel	12	Nine points	Undefined	[27]
Black cherry, concord grape, and pomegranate juices blend	(a) Consumers: overall liking, appearance, Just about right (JAR) attributes (b) Descriptive analysis: development of sensory descriptors for flavor, mouthfeel and strange flavors	(a) 100 consumers (b) 10	JAR scale nine points	Unsalted crackers and water	[28]

Table 2. Attributes commonly evaluated in natural drinks and the sensory tests used.

nine points, also can be three, five, or seven points. Acceptance tests are normally conducted with consumers; the number of participants will be based on the level of confidence that is desired for decision making. **Table 2**, presents a list of attributes commonly evaluated in natural drinks and the sensory tests used. You can call the reader's attention to the use of the attributes taste and taste as well as aroma and smell, for this reason, these qualities are pointed out here:

- Taste refers to those feelings that occur inside our mouth, including the tongue and focuses on sweet, salty, sour and bitter taste; lately umami taste has been included for deliciousness.
- Aroma refers to a perfume or fragrance very nice, usually is a mixture of pleasant olfactory sensations.
- Odor is usually used for unpleasant olfactory sensations and refers to a more specific concept than aroma.
- The oral sensation refers to the viscosity for example, the body of a drink.
- The flavor is the combination of aromatic sensations, taste and viscosity. The flavor is a synthesis that makes the brain express a general feeling of those combinations.

The scientists can also evaluate the persistence in the mouth of a flavor and refers to the time it takes for the stimulus to disappear from the oral cavity. Generally, it is used in wines, although with the new mixtures of juices and teas it is considered one more attribute to evaluate.

The cleansing of the palate aims to eliminate a taste in the mouth to give rise to a new sensory experience. As shown in the following table, the most widely used product is unsalted cookies. This product is used to eliminate sweet, spicy, bitter or fatty tastes. Water is the ideal complement to clean the mouth. To evaluate sweet beverages as natural beverages, it is common to use this combination of products, so common that researchers do not report them in their publications.

4. Tests for sensory evaluation of natural beverages and their statistical analysis

The types of tests that are used in the sensory evaluation of beverages are acceptance tests, discriminative tests, and qualitative tests. In the first two types, can be used the hedonic scale, LAM and JAR, to evaluate attributes. The qualitative tests are used for qualitative descriptive analysis (QDA) as well as to determine the taste profile using the intensity grade scale.

Figure 1 proposes a sequence of sensory tests that are used in the development of beverages (yellow box). In the tests of acceptance, optimization, substitution of ingredients and in the market study, alternative tests are presented; Through the review of literature in this section, the reader will notice that the sensory tests have different strength to accept or discriminate a

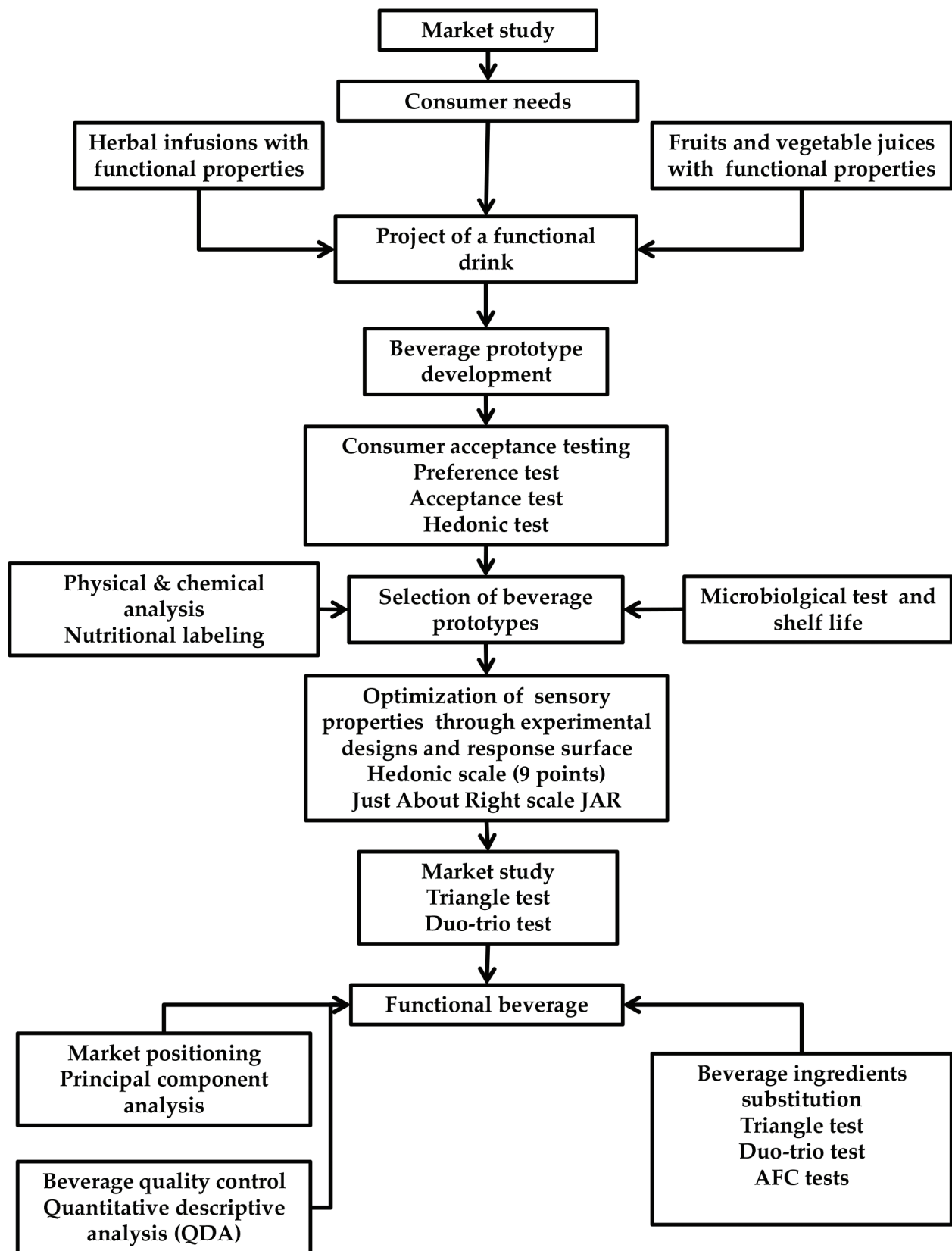


Figure 1. Sequence of sensory tests that are used in the development of natural beverages.

product; therefore, the choice of each of them will be based on the questions that you wish to answer during the process of developing the drink.

In the tests of acceptance with consumers, the hedonic scale is generally used with nine verbal categories, which represent different degrees of taste from “extremely disliked” to “extremely liked.” Then the verbal categories converted to numerical values are subjected to statistical analysis. Nicolas et al. [30], wondered if the words and numbers on the hedonic scale of nine points are interchangeable? The answer found after his research was that most consumers respond differentially to scales that use “only words” or “only numbers.” The percentage of consumers who give different results for “only words” or “only numbers” varied between 79 and 100%. They conclude that the numerical data derived from these two scales are not interchangeable, and if you want to compare results between them, you should be cautious.

Another scale used in consumer acceptance testing is the scale LAM (labeled affective magnitude) due to its higher discriminative power than the scale of nine points and the spacing of anchor words mainly foods or well-liked beverages [29].

A comparison between the hedonic scale of nine points and the LAM scale was made by Lawless et al. [29] in food acceptance tests and mentions that both scales behave well in the discrimination of products according to consumer tastes and reveal a strong relationship between consumption patterns and acceptance ratings. They suggest that there is no strong superiority of the LAM scale over the nine-point scale and that better scales can help to show differences between new products for the consumer preventing the type II error in which the true differences between the products were not detected.

Jae et al. [22] evaluated two species of *Artemis* for the elaboration of teas, through the acceptability of color and taste, salinity, bitterness, acidity, and general preference using the LAM scale. The scale ranged from 0 (greatest imaginable dislike) to 15 (greatest imaginable like). They did not find a significant difference for the evaluated attributes, except for taste acceptability and general preference and attribute the difference to the volatile compounds between the two species studied, particularly in the terpenic compounds.

When you want to optimize the level of an attribute in a product or when you want to identify attributes that need improvement, the JAR (Just About Right) scale is used. This implies that the ideal value of the attribute is equal to or very close to the value of the most liked attribute. Therefore, the products qualified as “just right” must be equivalent to the preferred or most liked products. However, the researches that used the JAR scale repeatedly report optimal values of the attributes very different from those of the products currently on the market.

Epler et al. [31] compared the hedonic scale and two types of JAR scale (boxes or lines) to optimize the degree of sweetness in lemonade. The predicted “optimal” level of sweetness for lemonade was determined, as well as differences in taste for formulations with different sugar content (6–14%). The two types of scales yielded similar results in terms of the predicted optimum value (9.2 and 9.4% sucrose), which was significantly lower than the result obtained by the hedonic scale (10.3% sucrose). In the preference test, consumers prefer lemonade with 10.3% sugar over that which contained 9.3%. These results indicate that the hedonic scale is better for predicting sweetness than the JAR scale.

JAR scale can be used with 3 and 9 points to determine the optimal concentration of sweetness in a drink. Some authors compared these scales by analyzing the data obtained through statistical analysis of survival, followed by a regression analysis. Three different ranges of concentration of sucrose were used in orange juice. Optimum sucrose concentration was 8.2% for the nine-point scale and 13.1% for the three-point scale. A later study showed that 70% of subjects preferred the sample with 13.1% of sucrose on the sample with 8.2%. The three points of JAR scale combined with statistical analysis provided a more real optimal level concentration than the nine-point scale.

Optimization of drinks is made through the methodology of Box and Wilson called response surface, which is a combination of the experimental design and regression analysis. It is an experimental strategy that allows you to find the optimal values of the independent variables (e.g., sugar level) that maximizes or minimizes the response variable (e.g., flavor). They used this methodology to optimize the ideal sweetness of a fermented beverage of extract of soybean to 11 g of sucrose per 100 mL and obtained predictive models of response with respect to the ideal flavor, sweetness, and generally accepted attitude of purchase.

The response surface methodology was applied to differentiate wines from different harvests by their aroma and taste by Pagliarini et al. [27]. There are few publications on this; however, these two publications illustrate the applications of the methodology in the development of beverages. The difference tests referred to in this section are presented in a comparative manner in the **Table 3**.

On the other hand, when you want to substitute ingredients or compare the attributes of the new beverage against a product already on the market, the difference tests are used. There are two types: when the cause of the difference is asked, focusing on a specific attribute (2AFC and 3AFC) and when it is not asked, focusing on others (duo-trio and triangular). These tests

Test	Samples	Presentation sequence	Judge instruction
Triangular	Encoded with three-digit numbers. Two samples are the same and are presented with different code. The third sample is different.	AAB ABA BAA BBA BAB ABB	Which sample is different from the other two?
Duo-trio	A sample is marked as R = reference and the other samples are marked as A or Bs	(a) constant reference: R AB, R BA (b) balanced reference: RA AB, RA BA, RB AB, RB BA	(a) select the sample similar to A (b) select the sample similar to A or B
2AFC	Encoded as A or B	AB and BA	What is the sweetest sample? (for example)
3AFC	Two samples are the same and are marked with three-digit codes. The third sample is the one that has the greatest strength in the attribute and is coded in the same way	ABB, BAB, BBA, BAA, ABA and AAB	What is the saltiest sample? What is the least salty sample?

Table 3. Comparison between different sensorial tests.

can work with trained judges and consumers, where the latter apply simpler tests and require more participants in order to increase the degree of reliability in the results.

These tests are applied with trained judges and with consumers; the statistical method used is Chi-square. Judge fatigue can occur when repeatedly testing the samples and consequently, the adaptation to the stimulus can occur; thus six maximum samples can be evaluated in a session. The interpretation is through the use of statistical tables according to the size of the sample, minimum number of correct answers and the level of significance required. Once the new drink is ready to go on the market, it is necessary to define their sensory properties to establish a flavor profile and define the properties that have to be monitored in the quality control process. Quantitative descriptive analysis (QDA), used for those purposes in this analysis, describes the sensory attributes (no more than seven) of products such as flavor, mouthfeel, aftertaste, and appearances through 10–12 trained judges. The objective of the QDA is to provide a quantitative specification of the sensory attributes of a product as well as to determine the nature and intensity of these.

Beverages are evaluated by the intensity of their attributes crossing the level of intensity found on a vertical line. These distances are converted into numerical values that will be analyzed by means of an ANOVA.

Hruškar et al. [26] evaluated nectars through quantitative descriptive analysis and generated ten descriptive terms related to color, smell, taste, consistency, and overall sensory impression. The analysis of variance showed significant differences in the color intensity, taste sour and sweet intensity, as well as for the overall sensory impression. There were no significant differences in the addition of sugar and acid.

The analysis of main components (PCA) is used to study the positioning of the beverage on the market. It uses the sensory attributes of beverage such as flavor, color, aroma, and body. This descriptive technique allows the study of the sensory attributes quantitatively through the correlation between them and calculates new variables by grouping attributes in such a way that it is possible to observe in a plane the distance between groups of attributes and define which product is better positioned to the consumer and in consequence on the market.

5. Conclusions

- The important factors facing the development of natural beverages with functional compounds are market and technological problems. The current cost of the functional drinks is very high and discourages consumption. A technological challenge is the conservation of the functional properties during conservation treatments and shelf life.
- The mixture of fruit juices and infusions is relevant in terms of the functional properties that contribute to the consumer, as well as provide new sensory experiences.
- Sensory methodologies and current knowledge about the functional properties of fruit and infusions do not constitute a limit for the development of natural drinks with functional properties.

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Conflict of interest

The authors have declared that there is no conflict of interest.

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