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Development of a fortified drink from the mixture of small colombian native fruits

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Abstract
Strawberry (*Fragaria ananassa*), blackberry (*Rubus glaucus*), Peruvian cherry (*Physalis peruviana* L.) and purple passion fruit (*Passiflora edulis Sims*) are important fruit crops in Colombia, due to their organoleptic properties and nutritional qualities, making them attractive for international markets. This study was undertaken to characterize the physicochemical properties of these four fruits and to present an alternative for their use. To achieve this goal, the moisture, pH, soluble solids, acidity, color, iron and vitamin C concentration were determined, and a fortified mixed fruit drink was developed. All of the fruits can be classified as high acidity products due to the acidity results. Purple passion fruit and Peruvian cherry presented the highest content of soluble solids, while blackberry, purple passion fruit and Peruvian cherry did not exhibit statistically significant differences in their iron contents, and strawberry exhibited the highest contribution of vitamin C.

Keywords: fruits; characterization; mixed fruit drink; vitamin C; iron

Desarrollo de un refresco fortificado con hierro a partir de la mezcla de frutas pequeñas nativas colombianas

Resumen
La fresa (*Fragaria ananassa*), la mora (*Rubus glaucus*), la uchuva (*Physalis peruviana L.)* y la gulupa (*Passiflora edulis Sims)* son cultivos frutales importantes en Colombia por sus propiedades organolépticas y nutritivas. Este estudio se realizó para caracterizar las propiedades fisicoquímicas de estos cuatro frutos y presentar una alternativa para su uso. Para lograr este objetivo, se caracterizaron las cuatro frutas determinando humedad, pH, sólidos solubles, acidez, color, contenido de hierro y la concentración de vitamina C. Posteriormente se desarrolló una bebida fortificada de frutas. De acuerdo a los resultados de acidez, todos los frutos se pueden clasificar como productos de alta acidez. La gulupa y la uchuva, presentaron el mayor contenido de sólidos solubles, mientras que la mora, la gulupa y la uchuva, no presentaron diferencias estadísticamente significativas en su contenido de hierro. La fresa presentó la mayor contribución de la vitamina C.

Palabras clave: frutas; caracterización; refresco de frutas; vitamina C; hierro

1. Introduction

Fruits are an important part of human nutrition, and they are widely recommended for their health-promoting properties. They provide vitamins and minerals to the daily diet, coupled with their role as the main source of antioxidants, phytoestrogens, and anti-inflammatory agents [1].

Due to the nutritional properties of fruits, in recent years, the consumption of minimally processed juices, beverages and smoothies has become an alternative for healthy eating habits [2-3] This can be associated with the development of fortified foods, in representing an alternative to the actual market, this new option is characterized by food products that contribute to an increase in the content of micronutrients

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(vitamins and minerals) and antioxidant capacity in the body [4]. This trend can be seen in the increased market of functional products in the United States, which went from US 37 billion in 2011 to US 43.9 billion in 2012, and has an annual growth projection of 8.7 % worldwide [5].

Micronutrients are essential compounds for the proper function of the body; for instance, iron is part of different enzymes and molecular complexes involved in metabolic processes [6], the primary functions of which include the transportation of oxygen by hemoglobin [7], degradation and storage of neurotransmitters [8], and the erythropoietic function and immune response of cells [9]. Conversely, antioxidants are exogenous compounds that contribute to the stabilization of reactive species or free radicals in the body, playing an important role on the reduction of the risk of degenerative diseases such as cardiovascular and neurological illnesses [10].

Given the growing trend for healthy foods and the potential in fruits for their development, a variety of native fruits can be used in order to obtain new products, including fortified/functional beverages, the sales of which are projected to increase based on their importance in the health and wellness industry [11]. In Colombia, small native fruit crops, such as strawberry (Fragaria ananassa), blackberry (Rubus glaucus), Peruvian cherry (Physalis peruviana L.) and purple passion fruit (Passiflora edulis Sims), stand out, especially Peruvian cherry and purple passion fruit, because of their importance for the domestic market associated with their exportation, which reaches values of USD 12.0 million and USD 29.2 million respectively [12]. This behavior derives from the new preferences of the international markets because of their organoleptic properties, their nutritional qualities, and their potential to be transformed by various processes to obtain different food products, including fruit beverages and jams [13], purees [14-15], ice cream [16] and dried fruits [17-19].

According to the importance of these fruits for the Colombian market and the growing interest for healthier products, this research seeks the development of an iron-fortified mixed drink with the inclusion of strawberry, blackberry, Peruvian cherry and purple passion fruit. To this end, the moisture, pH, acidity, color, content of soluble solids, iron and vitamin C contents were determined in the four fruits, and an orthogonal experimental design was presented for a mixed beverage development.

2. Materials and methods

2.1. Material

The four fruits studied, strawberry, blackberry, Peruvian cherry and purple passion fruit, all from the eastern region of the department of Antioquia, were purchased in a wholesale market of Medellin (Colombia). The selection of the fruit was performed by a visual method using color tables according to the last two stages of maturity [20-23]. The iron compound used for beverage fortification was ferrous bisglycinate, due its bioavailability [24-25].

The ferrous bisglycinate for food fortification, reference standard Vitamin C (Supelco) and analytical grade ascorbic acid (Merck), sodium hydroxide (Merck) and metaphosphoric acid (Panreac) were purchased from a local provider.

2.2. Characterization of the four fruits

The selected fruits were characterized in triplicate, determining moisture content, pH, soluble solids, titratable acidity, color, iron and vitamin C content.

2.2.1. Chemical characterization

Moisture, pH and soluble solids

Moisture was verified using the gravimetric official method AOAC 934.01 / 05 [26] The pH was determined using a potentiometric detector (Schott Instruments Lab. 850), according to the standard methods defined for this type of matrix [26] and soluble solids were obtained by refractometric readings using a digital refractometer (Atago pal-1), previously calibrated with water.

Titratable acidity

The titratable acidity of the four fruits was established in terms of citric acid content by a potentiometric titration with a previously standardized 0.1 N NaOH solution, according to the official method, AOAC 942.15 [27].

2.2.2. Nutritional characterization

Iron content

The iron content of the four fruits was measured by atomic absorption spectroscopy with a previous acid digestion of the samples. The absorbance reading was performed in triplicate for each fruit using an atomic absorption spectrophotometer (Thermo Scientific Series 3000) at 248 nm [28-29].

Vitamin C content

The content of vitamin C of the four fruits, was determined by a chromatographic method. The ascorbic acid was extracted from the matrix according to a modification of the method developed by Kubola et al. [30]. Briefly, 10 g of the fruit was mixed with 50 mL of a metaphosphoric acid solution, followed by stirring for 5 min and a centrifugation of the resulting suspension at 9000 rpm for 20 min. The supernatant was filtered by a 0.25 µm disc filter.

The filtrate obtained in the previous step was injected into an Ultra High Pressure Chromatographer (Ultimate 3000 UHPLC, Thermo Fisher scientific) using a C-18 HypersilGold column (Length 250 mm Internal Diameter 4,6 mm; 5 µm particle size) (Thermo Fisher Scientific). The samples were eluted with an acidic phosphate buffer at 0.1 mL min-1. The eluting components were measured with an UV-Vis detector (Ultimate 3000 VWD, Thermo Fisher Scientific) at 245 nm. The calibration curve was made with a standard solution of ascorbic acid diluted at different concentrations in metaphosphoric acid.

2.2.3. Optical characterization

Color

Color was determined by CIELAB coordinates [31], using a sphere X-RITE SP60 spectrophotometer, measuring the parameters (L *), (a*) and (b*) for each fruit at three points of the equator line, and expressed as the arithmetic average. Finally, the angular pitch (hab) was calculated as a qualitative attribute of color; and chroma (Cab*) as a quantitative attribute of colorfulness, following Eq. 1 and Eq. 2 [23].

$$C^{*}_{ab} = [(a^{*})^{2} + (b^{*})^{2}]^{\frac{1}{2}} \quad (1)$$

$$h_{ab} = \arctan\left(\frac{b^{*}}{a^{*}}\right) \quad (2)$$

2.3. Statistical analysis

The statistical analysis was performed by a one-way ANOVA using a Fisher's exact test in statistical software (Statgraphics Centurion XVII, Statpoint Technology).

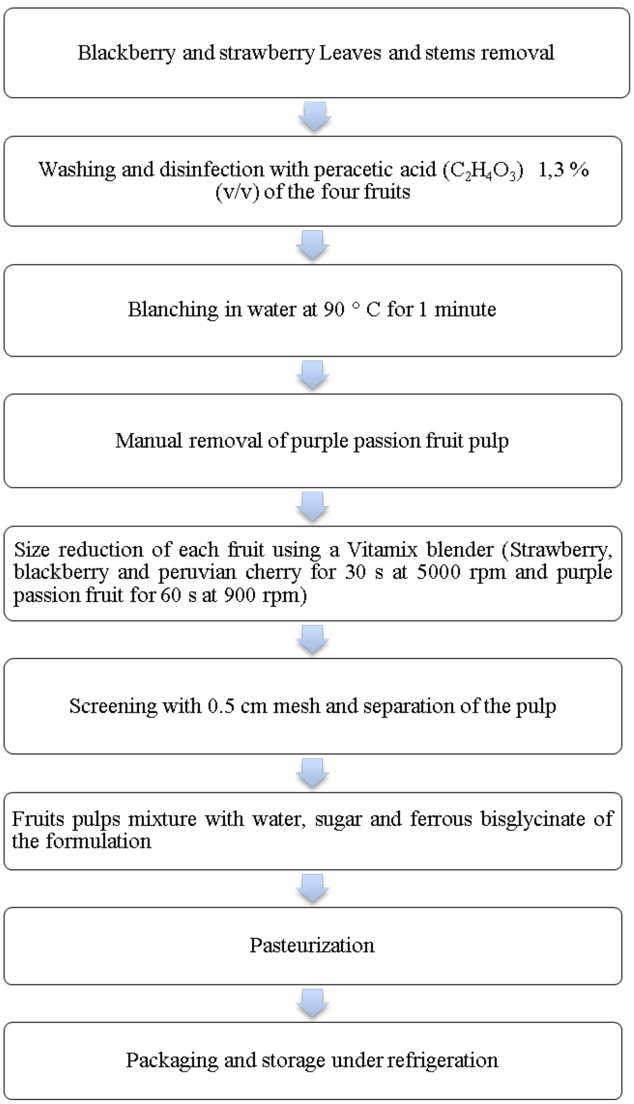

Figure 1. Activities for the fortified mixed drink development
Source: The authors.

Table 1.
Levels and factors of the experimental design for the drink development

Factor	Levels	
	Middle	**Upper**
% Purple passion fruit (A)	6.75	10.00
% Peruvian cherry (B)	6.75	10.00
% Blackberry (C)	6.75	10.00
% Strawberry (D)	6.75	10.00
% Iron daily intake (E)	20.00	30.00

Source: The authors.

2.4. Transformation of the four fruits

After their characterization, the four fruits were processed to obtain an iron-fortified mixed drink, following the process diagram depicted in Fig 1.

To define the levels of the factors A, B, C and D, preliminary tests were conducted, considering the fruit characterization and the Colombian regulation for this type of product, in order to have a minimum of 8 wt% of fruit in the final product [32]. The E levels were established according to the information reported for the recommended daily intake value for iron of 14 mg [33].

2.5. Sensory analysis

The response variable of the experimental design was the mixed drink acceptance, determined by a quantitative descriptive sensory analysis, carried out in triplicate. To perform this analysis a panel of six experts was developed. The panelists selected 11 descriptors: color, characteristic odor/aroma, objectionable odor, acidic flavor, sweet flavor, blackberry flavor, strawberry flavor, Peruvian cherry flavor, purple passion fruit flavor, astringent sensation and spicy sensation. The selected descriptors according to the Colombian legislation [34], were evaluated on a scale of 0 (absent) to 7 (severe), and the acceptance of the mixed drink was established by Karlsruhe test [35], based on the overall quality determination.

The 8 obtained formulations were characterized to determine soluble solids, titratable acidity and pH in order to compare the values with those established in Colombian legislation.

2.6. Characterization of the developed prototype

The final prototype was characterized by the determination of the vitamin C and iron contents, with the same methods shown above, in order to establish the contribution of the fruits and the iron compounds to the nutritional characteristics of the mixed drink.

3. Results

3.1. Chemical characterization

While fruit and vegetable products are characterized by large differences in composition, generally the fruit stand out

Table 2.
Physicochemical analysis results of strawberry, blackberry, peruvian cherry and purple passion fruit

Parameter		Strawberry	Blackberry	Purple Passion Fruit	Peruvian cherry
Moisture	(%)	91.640 ± 0.903 **a**	87.758 ± 0.806 **a**	73.694 ± 1.552 **a**	83.04 ± 1.0919 **a**
Titrable Acidity	(g citric acid/100ml)	0.723 ± 0.069 **d**	2.343 ± 0.055 **b**	3.528 ± 0.178 **a**	1.361 ± 0.011 **c**
Soluble solids	(°Brix)	7.554 ± 0.722 **c**	8.118 ± 1.319 **b**	15.013 ± 0.873 **a**	14.575 ± 0.524 **a**
pH		3.403 ± 0.097 **a**	2.823 ± 0.063 **b**	2.869 ± 0.091 **b**	3.364 ± 0.315 **a**
Vitamin C	(mg/100g pulp)	27.996 ± 7.122 **a**	10.385 ± 1.712 **c**	22.919 ± 3.629 **a, b**	19.593 ± 3.453 **b**
Iron	(mg/100 g pulp)	0.2605 ± 0.0825 **b**	0.5088 ± 0.1555 **a**	0.6467 ±0.0752 **a**	0.5412 ± 0.0290 **a**

For each row there is no statistically significant difference between the values that share the same letter (Fisher test with 95% confidence).
Source: The authors.

Table 3.
Color analysis results of strawberry, blackberry, peruvian cherry and purple passion fruit

Parameter		Strawberry	Blackberry	Purple Passion Fruit	Peruvian cherry
	L	32.344 ± 1.5411 **b**	18.421 ± 0.982 **c**	31.717 ± 1.792 **b**	62.411 ± 1.692 **a**
	a	27.113 ± 1.9597 **a**	5.558 ± 1.145 **c**	6.246 ± 1.530 **c**	22.843 ± 1.463 **b**
Color	b	15.719 ± 2.1275 **b**	1.003 ± 0.303 **d**	3.338 ± 0.825 **c**	50.824 ± 0.790 **a**
	h_{ab}	30.037 ± 3.239 **b**	10.079 ± 1.101 **c**	28.553 ± 6.320 **b**	65.925 ± 0.954 **a**
	C^{ab}	31.386 ± 2.276 **b**	5.649 ± 1.179 **c**	7.121 ± 1.548 **c**	55.731 ± 1.232 **a**

For each row there is no statistically significant difference between the values that share the same letter (Fisher test with 95% confidence).
Source: The authors.

by their high water content. This is verified in Table 2 where the results of the fruit characterization are shown. The obtained values show that the moisture content of the four fruits does not exhibit a statistically significant difference, with values between 82 % and 92 %. In contrast, the titratable acid content shows that the purple passion fruit has the highest titratable acidity, followed by the blackberry; consequently, these samples presented the lowest pH values.

3.2. Nutritional characterization

The strawberry showed the lowest iron content; the other fruits did not exhibit a statistically significant difference (Table 2). For the vitamin C content, the strawberry and purple passion fruit presented the highest values, without a statistically significant difference, followed by Peruvian cherry and blackberry. According to these results, the purple passion fruit is the smallest fruit with the highest nutritional intake of vitamin C and iron.

3.3. Optical characterization

The color analysis indicated positive values of a and b coordinates (Table 3), which established that the four fruits presented shades between red and yellow.

Although statistically significant differences were present in the L coordinate, all the values are related to clear luminosities (white), while those obtained for the chroma or Cab, allows the association of the strawberry and Peruvian cherry with higher color intensities (higher values of Cab), than those obtained for purple passion fruit and blackberry, which presented statistically similar results. However, all the fruits are related to medium-high intensities of color, characteristics of yellow, orange and red colors [36]. Moreover, the value obtained for the angular pitch or hab, locates the four fruits within the range set for the orange color [36].

3.4. Transformation of the four fruits

The formulation for the 8 prototypes evaluated for the transformation of the four fruits are reported in Table 4. In this case, the sugar content added in the formulation was initially determined as a relation between the fruit content (strawberry, blackberry, purple passion fruit and Peruvian cherry), therefore it is not included in the design.

The prototypes were characterized and the results are presented with their respective statistical analyses and shown in Table 5.

The 8 formulations meet the values for acidity levels (minimum 0.2), soluble solids (maximum 13) and pH (maximum 4), as described in Colombian legislation [32].

Table 4.
Formulations of the fortified drink prototypes

Prototype	Purple passion fruit (%)	Peruvian cherry (%)	Blackberry (%)	Strawberry (%)	Sugar (%)	% Ferrous bisglicinate	Water (%)
517	6.70	6.70	6.70	6.70	4.00	0.02	68.90
264	6.70	6.70	6.70	10.00	4.90	0.03	64.80
844	6.70	10.00	10.00	6.50	5.90	0.02	60.60
527	6.70	10.00	10.00	10.00	6.90	0.03	56.30
190	10.00	6.70	10.00	6.50	5.90	0.03	60.60
273	10.00	6.70	10.00	10.00	6.90	0.02	56.30
944	10.00	10.00	6.70	6.50	5.90	0.03	60.60
593	10.00	10.00	6.70	10.00	6.90	0.02	56.30

Source: The authors.

Table 5.
Results of the chemical characterization of the fortified drink prototypes

Prototype	Titrable acidity (g citric acid/100ml)	Soluble solids	pH
517	0.5 ± 0.006 ***a***	7.0 ± 0.052 ***e***	3.2 ± 0.006 ***a***
264	0.6 ± 0.079 ***a, b***	8.3 ± 0.122 ***d***	3.2 ± 0.006 ***b***
844	0.6 ± 0.006 ***a, b***	10.0 ± 0.052 ***c***	3.2 ± 0.006 ***c***
527	0.6 ± 0.012 ***a***	11.6 ± 0.842 ***a***	3.2 ± 0.001 ***a, c***
190	0.6 ± 0.027 ***c***	10.0 ± 0.075 ***c***	3.1 ± 0.006 ***d***
273	0.6 ± 0.009 ***b***	10.9 ± 0.472 ***b***	3.1 ± 0.006 ***d***
944	0.6 ± 0.033 ***a, b***	9.8 ± 0.207 ***c***	3.1 ± 0.006 ***e***
593	0.6 ± 0.017 ***a***	11.0 ± 0.082 ***b***	3.3 ± 0.006 ***a***

For each column there is no statistically significant difference between the values that share the same letter (Fisher test with 95% confidence).
Source: The authors.

The results show some homogeneous groups, such as those observed during the determination of soluble solids, which clearly reflects the dependence of this variable on the fruit content and the sugar added during the development; the higher values of soluble solids were achieved by the formulations with greater sugar and fruit content: 36.7 wt% (527, 273 and 593), followed by the prototypes with 33.5 wt% (944, 190, 844) and 30.2 wt% fruit (264). Finally, the 517 prototype showed the lowest content of soluble solids, which is concordant with its fruit content (27 wt%). Additionally, this result can be also related to the sugar added during the formulation, being this prototype the one with the less amount of this additive. The previous behavior stablish the direct relation between fruit and sugar content of the product and its soluble solids. However, the fruit percentage evaluated had an impact on the measured variables. Despite this, it is possible to use four fruits for the development of iron-fortified mixed drinks. This is confirmed by the results obtained during the sensory characterization (Table 6).

Table 6.
Results of the sensory characterization of the fortified drink prototypes

Prototype	High overall quality %	Acceptance %
517	81.0	100
264	86.7	100
844	100.0	100
527	100.0	100
190	100.0	100
273	100.0	100
944	76.7	100
593	86.7	100

Source: The authors.

The prototypes showed variations in the 12 descriptors selected during their sensory analysis that included the evaluation of the color, the characteristic aroma, the sweet taste, the astringent sensation and the spicy sensation. This behavior can be observed through the variations evidenced in the high overall quality of each sample. However, all prototypes achieved 100 % acceptance; this is associated with the overall quality, which was higher than 3.5 (the low value of the average quality category). These results did not allow the realization of the Taguchi method, "more is better", of statistical analysis [37], considering that the response variable "sensory acceptance" presented the same numerical score (100 %) for all the prototypes, making its optimization impossible. In this way, the selection of the final prototype (527) was done by taking into account the one that allowed a greater incorporation of fruits and iron.

Table 7.
Results of the nutritional characterization of the developed fortified drink

Parameter	Value
Iron (mg/250 ml)	4.1875 ± 0.042
Vitamin C por HPLC (mg/250 ml)	23.071 ± 2.707

Source: The authors.

3.5. Characterization of the developed prototype

For the iron and vitamin C content in the 527 prototype, the results that are shown in Table 7 confirm that the developed iron-fortified mixed drink contributes 30 % of the recommended daily value of iron established in Colombian regulations [33].

4. Discussion

4.1. Chemical characterization

The results obtained for the moisture content of the fruits are similar to those reported in the literature of 90.00 % and 90.95 % for strawberry [38-39], between 84.57 % and 87.33 % for blackberry [40-41], and between 84.09 % and 86.65 % for Peruvian cherry [31]. In the case of purple passion fruit, the reported values for the moisture content, between 82.1 % and 88.9 % [23,42] are higher than those obtained experimentally; this behavior can be associated with the high susceptibility of dehydration of the pasifloras, related to the transport and post-harvest processes, which generates wrinkling of the shell and a mass loss [42].

The variation observed for the titratable acidity and pH values of the fruits is associated with the fruit selection process, since in the latter stages of development the ripening process results in a reduction of the organic acids [43] and an increase in soluble solids due to the transformation of starch reserves in sugars [44]. Nevertheless, the four fruits can be classified as high acid foods, since they present pH values lower than 3.7 [45], unlike low-acid foods such as banana, which have pH values between 5.3 and 5.7 [46], or mango, which is classified as a medium-acidity food with a pH value of 5.3 [47].

In general, the results obtained during the chemical characterization of the four small Colombian fruits are in the ranges reported in the literature and show the potential of these fruits for the development of food products as an alternative for their use. However, it is important to note that the variations found are explained by the influence of agronomic conditions and postharvest management. Climatic conditions such as temperature and light intensity have a strong effect on the nutritional quality of fruits [48]. Additionally, soil type, rootstock, mulching, irrigation, fertilization and other cultural practices influence the water and nutrient supply of the plant, which can affect the composition of the fruit [49].

4.2. Nutritional characterization

Fruits are recognized worldwide as an excellent source of nutrients [50] which include vitamins, minerals and other biologically active compounds such as anthocyanins and carotenoids associated with decreased a risk of disease [51]. This study emphasized two nutrients: iron and vitamin C. The first was chosen for its importance for the proper behavior of the human body, and the second because of its importance as an exogenous antioxidant [52] in the human diet and as a marker of quality in the food industry.

Variations of iron content between the fruits are associated with changes during their primary production; this mineral acts as a micronutrient and is important for the development of plants, being involved in processes such as photosynthesis and electron transport [53], but due to differences in farming practices [54], its concentration may vary. This is corroborated by comparing experimental results with those presented in the USDA database, which reported values for the strawberry (0.41 mg / 100 g), and purple passion fruit (1.6 mg / 100 g) (USDA, 2014), that are greater than those established in this investigation, similar to the behavior presented with Peruvian cherry (1.2 mg / 100 g) [55].

As for the results of the quantification of vitamin C in the four small Colombian fruits, some variations are observed from the values reported by the USDA. Strawberry (27.996 mg / 100 g) and blackberry (10.385 mg / 100 g) showed lower values than those reported, namely, 58 mg / 100 g and 21 mg / 100 g, respectively [56], while the vitamin C contents for Peruvian cherry (19.593 mg / 100 g) and purple passion fruit (22.419 mg / 100 g) are close to the reported values of 20 mg / 100 g for Peruvian cherry [57] and between 18 and 30.00 mg / 100 g for purple passion fruit [58-59]. The previous behavior is mainly because the vitamin C content in fruits and vegetables is highly influenced by different factors, including preharvest climatic conditions, maturity, harvesting methods and postharvest handling procedures [48].

According to the results obtained for the four fruits it can be established that none of them represents a high source of vitamin C, especially when given the values reported for fruits with a high intake of this vitamin, such as guava with 228 mg / 100 g [56] and acerola with 1341 mg / 100 g [60]. These measurements highlight the importance of the fortification of any products developed using these fruits, in order to improve the nutritional value of the final products. After assessing the nutritional properties of the small Colombian fruits it is important to assess their optical properties as they could affect the resulting mixed drink and could aid in the understanding of the previous results.

4.3. Optical characterization

Positive values of a and b coordinates obtained for the four fruits are characteristic of fruits with a high content of carotenoids, substances responsible for red and yellow colors [61], and the four small native Colombian fruits have representative values of this type of compound [13,23,40,62].

Finally, the color coordinates established experimentally are similar to those reported for purple passion fruit [23], strawberry and blackberry [15], while the values for the Peruvian cherry differ from those reported in the literature [31]. This is likely due to variation in the maturity stage, considering that during ripening, the degradation of chlorophyll and the synthesis of other compounds responsible for color occurs [63], including the development of anthocyanins, compounds associated with red, blue and purple colors [41].

The results obtained during the determination of color are a clear example of the heterogeneity of fruits [23], where the pigment distribution depends on the maturity stage and is indicated in the significant variation of the obtained values; for this reason the food industry relies on pigments to standardize the color of products. However, the current development seeks to obtain a product without added colorants and stabilizers, given the growing interest of consumers for more natural products.

4.4. Characterization of the developed prototype

The developed product presents higher contents of vitamin C than a portion of blackberry, purple passion fruit or Peruvian cherry contributing with the 38.3 % of the recommended daily value of vitamin C [64]. In addition, this contribution, allows the classification of the product as a “High Source” of Vitamin C, according to the FDA nutrition content claims [65], making a mixed drink from strawberry, blackberry, Peruvian cherry and purple passion fruit a good source for incorporating vitamin C in the human diet. However, it is important to note that during the storage process, there can be degradation of this vitamin in the product, so the above expression should be adjusted according to the final value in the product.

The sugar content is another important characteristic of the developed product, since this corresponds to a prototype with higher content of added sugar. Due to the effect of sugar consumption on human health and the growing interest of consumers for healthier foods [66], this aspect can be reviewed in further investigations, in order to evaluate the effect of other types of sweeteners in this product.

The results obtained during the transformation of the four small Colombian fruits show that they can be used for food development, including in mixed fruit drinks that meet the parameters set for these products and that is sensorily attractive for the consumers, especially given the current market requirements for more healthy nutritional products that contribute to the maintenance of the human organism.

In addition, this fortified mixed drink shows the potential of these four fruits, which are highly important to the Colombian market, for developing new processed foods, allowing not only the generation of new alternatives for their use, but it also represents an attractive opportunity for producers to increase their incomes and improve their profits.

5. Conclusions

The results demonstrated that the four fruits stand out for their high water content and can be classified as high acidity products. Purple passion fruit and Peruvian cherry were highlighted for presenting the highest content of soluble solids. Strawberry showed the lowest iron content but the highest value of vitamin C. According to the color analysis, the four fruits are associated with yellow, orange and red colors. Consequently, they can be used toward the development of an attractive iron-fortified mixed drink. Finally, a further study on the nutritional components may be important to complement the results on the characterization of strawberry, blackberry and purple passion fruit grown in the eastern region of Antioquia, Colombia.

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