Low-Calorie Beverages Made from Medicinal Plants, Flowers and Fruits: Characteristics and Liking of a Population with Overweight and Obesity

Elizabeth Contreras-López 1, Juan Ramírez-Godínez 2*, Miguel Maximiliano García-Martínez 3*, Ana Luisa Gutiérrez-Salomón 4*, Luis Guillermo González-Olivares 1* and Judith Jaimez-Ordaz 1,*

Abstract: Nowadays, there are few options of low or no added sugar drinks offering health benefits and oriented to consumers with a special health condition, such as overweight and obesity. The objective of this work was to develop and characterize a low-calorie antioxidant beverage made from aqueous extracts of medicinal plants (Melissa and lemon verbena), flowers (chamomile and bougainvillea), and fruits (guava, pineapple, strawberry, orange, and tangerine) as an alternative for people with overweight and obesity. Four formulations were developed from medicinal plants, flowers, and fruits. For this, a solid-liquid conventional extraction was carried out (at 90 °C during 5 min) followed by a cold shock in ice. The developed beverages were characterized in a microbiological and physicochemical way according to official analysis methods. The sensory evaluation was carried out through liking and buying intention tests. The population under study was integrated by 400 adults divided into two groups (with and without overweight or obesity). The beverages developed were low-calorie (<40 kcal per portion), very low in sodium (<34 mg per portion), rich in antioxidants (>1.6 g GAE portion), and with an attractive color. The results indicate that these beverages could be an alternative to the consumption of common industrialized drinks conferring additional benefits for the prevention of chronic diseases.

Keywords: beverages; antioxidant capacity; Melissa; lemon verbena; medicinal plants

1. Introduction

In 2015, the WHO (World Health Organization) recommended the consumption of sugar to be no more than 10% of the total daily energy intake [1]. However, in Mexico, in the last decades, sugar consumption has increased due to processed food, particularly sweetened beverages. Results of the National Health and Nutrition Survey of Medio Camino...
revealed that 85.3% of the Mexican population regularly consumes non-dairy sweetened beverages. This survey also exposed that 81.6% of adults like the taste of sweetened beverages, although the majority (92.3%) do not consider them healthy. The high intake of sweetened non-alcoholic drinks is a risk factor to suffer from non-communicable chronic diseases (NCCD) such as overweight, obesity, diabetes and cardiovascular diseases [3]. Mexico has one of the highest prevalence of NCCD [4,5], 72.5% adult population (>19 years old) present overweight and obesity [2]. This is due, in part, to the fact that sweetened drinks do not promote satiety, leading to their excessive consumption [6]. Mexican intake level of flavored non-alcoholic beverages is one of the highest worldwide, reaching 45.3 billion liters in 2016, and it is expected to increase to 52 billion in 2021 [7]. No meaningful impact has so far been observed on Mexicans’ sugar consumption by applying strategies such as the taxation of food with more than 275 kcal, such as sodas and other non-alcoholic flavored beverages [3].

As a response to the described issue, in the last years, the development of healthy products, including functional beverages, "health and wellness drinks" and flavored water; has increased worldwide [8,9], as well as the consumption of those high qualities and easy to drink new products [10,11]. Recently, the demand for alternative beverages to replace sweetened drinks has been increasing [12,13]. Consumers’ need for healthy and functional beverages along with simple hydration has led to the growth of the market for functional beverages and flavored water [12].

Healthy and functional beverages include dairy-based, energy and sports, weight management and, plant-based drinks [14]. Despite the natural composition of these drinks, most of them contain a high proportion of added sugars in their formulation. There are a few low-calorie presentations produced by using artificial sweeteners as saccharin, cyclamate, aspartame, and acesulfame-k [15]. However, the consumption of this type of additives is not recommended due to its association with some health problems.

Plant-based beverages generally are made from fruits, vegetables, and herbs, alone or combined with other ingredients such as fiber, vitamins and minerals. Besides their nutritional properties, these beverages also contain bioactive compounds [16] such as antioxidants (polyphenols, flavonoids, terpenes among others). Several epidemiological, experimental and clinical studies have demonstrated the biological efficiency of antioxidant compounds in decreasing and preventing the negative effect of diseases related to oxidative stress [17,18]. Tea and herbal infusions can be major sources of bioactive compounds such as polyphenolics and flavonoids which possess strong antioxidant activity and metal chelating properties [19,20]. Melissa and lemon verbena are two plants commonly used in Mexican traditional medicine. They are consumed as herbal infusions to relieve a wide variety of diseases. Several studies have revealed their antioxidant properties [21,22]. Some flowers, such as chamomile and bougainvillea, are also used as part of infusions against several health disorders [23–25].

Fruits are a source of nutrients (vitamins, minerals, fiber, carbohydrates, water) and phytochemicals (terpenoids, sulfur derivatives and phenolic compounds) that present antioxidant, immunological and anti-inflammatory properties [26,27]. In Mexico, there is a large variety of fruits including berries, exotic and citric. Some of them are affordable and widely consumed, for example, guava, pineapple, orange, and tangerine. These fruits are a source of vitamin C, carotenoids, anthocyanins and terpenes. Strawberry has a remarkable nutritional composition due to its high content of vitamin C, folates, and phenolic constituents [28].

Infusions prepared from plants or parts of them (flowers, fruits) are matrices easy to obtain. Besides, they can be used as a base to develop beverages with bioactive properties and adequate organoleptic characteristics for the consumer with no need to add ingredients like sweeteners, artificial flavors or colors. This paper focused on the development and characterization of low-calorie antioxidant beverages using aqueous extracts of medicinal plants (Melissa and lemon verbena), flowers (chamomile and bougainvillea), and fruits.
(guava, pineapple, strawberry, tangerine and orange) as an alternative to non-alcoholic sweetened beverages consumption, mainly for people with overweight and obesity.

2. Materials and Methods

2.1. Samples

To develop the beverages, two plants, lemon verbena and Melissa (Aloysia triphylla and Melissa officinalis, respectively) widely used in Mexico for medicinal purposes, were selected, as well as bougainvillea and chamomile flowers (Bougainvillea glabra and Matricaria chamomilla) and five fruits (guava, strawberry, pineapple, tangerine, and orange). Regarding the citrus fruits, only their peels were used. The samples were purchased in local markets of Hidalgo, Mexico.

2.2. Sample Conditioning

The medicinal plants, flowers, and fruits were washed with abundant water and disinfected by immersion into a commercial disinfecting solution. Afterward, the plants and flowers were dried in the shade with ventilation for 4–8 days depending on the sample. In the case of fruits, they were cut into pieces of 1–3 cm³, depending on the fruit and they were deep-frozen in hermetic plastic bags at −75 °C (Thermo Electron Corporation® ULT Freezer Forma −86C, Model 8607) until they got lyophilized at −40 °C and 133 × 10⁻³ mBar (LABCONCO® Freeze dry system/Freezone 4.5).

2.3. Development of the Beverages’ Formulations

The initial formulations were prepared based on an herbal aqueous extract of Melissa and lemon verbena, adding combinations of flowers and fruits in different proportions (Table 1). Next, a solid-liquid conventional extraction was made in 240 mL of purified water at 90 °C for 5 min ending with a cold shock in ice.

Table 1. Proportion of each ingredient (grams dw/240 mL) used in the formulation of the developed beverages.

| Plants and Flowers | Grams | Fruits      | Grams |
|--------------------|-------|-------------|-------|
| Melissa            | 0.5–2 | Orange      | 1–5   |
| Lemon verbena      | 0.5–2 | Guava       | 1–5   |
| Bougainvillea      | 0.25–1| Tangerine   | 1–5   |
| Chamomile          | 0.1–1 | Strawberry  | 1–5   |
|                    |       | Pineapple   | 1–5   |

The selection of the final formulations was conducted by a panel of six judges with experience in evaluation of beverages and familiar with sensory procedures. Eight preliminary formulations were analyzed. The panel classified the beverages from a non-verbal approach consisting of a sorting task [29]. From this, four final formulations were selected and codified as BR, BB, BM, and BC. BR contains Melissa, bougainvillea, guava, strawberry, and pineapple; BB has Melissa, chamomile, orange, strawberry and pineapple; BM incorporates lemon verbena, bougainvillea, guava, and tangerine while BC contains only Melissa, bougainvillea, and guava. Fifteen liters of each beverage were prepared in the same batch and kept in refrigeration until analysis (24 h after preparation).

2.4. Microbiological Quality of the Developed Beverages

It was evaluated the presence of three groups of indicator microorganisms by using the methods described in the Mexican standards [30]: Mesophilic aerobic bacteria (NOM-092-SSA1-1994), molds and yeasts (NOM-111-SSA1-1994) and total coliform microorganisms (NOM-113-SSA1-1994). The samples were prepared according to the established by NOM-110-SSA1-1994.
2.5. Physicochemical Characterization of the Developed Beverages

2.5.1. Color

The determination of color was carried out according to the methodology suggested by Padrón et al. [31] and Llerena et al. [32]. For that, the values of CIE L* (luminosity), a* (red-green coordinate), and b* (yellow-blue coordinate) were measured through digital images analyzed with the Photoshop® CS3 Extended software.

2.5.2. Physicochemical Composition

The proximate composition was determined by using the AOAC official methods [33]: moisture AOAC 925.19, protein AOAC 920.165 and ashes AOAC 941.12. Carbohydrate content was calculated by subtraction. Concerning the calorie content, this value was obtained by multiplying the carbohydrate content by the factor 4 g per kcal. The analysis of the sodium content was performed by ICP OES according to the AOAC 984.27. The soluble solids (°Brix) were measured by using a manual refractometer (Atago® 0–30 °Brix). Titratable acidity was determined by titrating the diluted sample with a solution of sodium hydroxide 0.1 N and a digital potentiometer (Hanna® HI 300) previously calibrated with buffers of pH 4, 7 and 10. The results were reported as the most abundant organic acid in each sample according to literature. The pH was measured by using the same potentiometer used to measure acidity.

2.6. Content of Total Phenolic and Antioxidant Capacity of the Developed Beverages

2.6.1. DPPH Method

For this determination, the method suggested by Brand-Williams et al. [34] with some modifications [35] was used. A calibration curve was prepared, (0 a 33 µM) from a pattern solution of Trolox 1 mM in MeOH (methanol). The absorbance was measured at 515 nm.

2.6.2. Determination of Ferric Reducing Antioxidant Power (FRAP)

This analysis was carried out through the Benzie and Strain technique [36]. A calibration curve was prepared [0 a 100 mM] through a pattern solution of iron chloride tetrahydrate (FeCl₂·4H₂O) in HCl 40 mM. The absorbance was measured at 593 nm.

2.6.3. Determination of Total Phenolic Content by the Folin-Ciocalteu Method

The quantification of total phenolic was made by using the Folin-Ciocalteu method [37]. A calibration curve was built in a concentration interval of 0–15 mg/L, from a standard solution of gallic acid (GA) 1000 mg/L. The absorbance readings were made at 760 nm. The determination for all the analyzed parameters was made by triplicate.

2.7. Body Mass Index Calculation of the Participants

The body mass index (BMI) of each participant in the study, was calculated to know their nutritional state and to classify them according to the criteria of NOM-008-SSA3-2017 [30] in one of the following groups: normal (18.50–24.99 kg/m²), overweight (25.00–29.99 kg/m²) and obesity (>30.00 kg/m²). Once they were classified, the participants took the sensory tests of the developed beverages.

2.8. Sensory Analysis of the Developed Formulations

The sensory analysis was carried out in a population of 400 individuals (237 females and 163 males; aged 19–25 years old) belonging to the academic community of the Universidad Autónoma del Estado de Hidalgo. The groups of individuals are from the Schools of Basic Sciences and Engineering (ICBI), Commerce and Business Administration (ICEA), and Health Sciences (ICSa). The total number of participants was calculated through a probability sampling based on the total population of the three schools.

The 400 participants carried out a liking and a buying intention test. The samples (30 mL of each beverage) were presented in 50 mL plastic cups, identified with three-digit codes randomly selected. The beverages were served randomly, in a different order. The
liking test was the first applied. The group of consumers tried the beverages evaluating the degree of liking or disliking according to the attributes of flavor, odor and color of each beverage, using a 9-point scale (1 = “I extremely dislike it”, 5 = “I don’t like it nor dislike it”, 9 = “I extremely like it”). Then, the buying intention test was performed using a 7-point scale (1 = “I would not buy it at all”, 4 = “Maybe I would buy it, maybe not”, 7 = “Definitely, I would buy it”).

2.9. Statistical Analysis

Standard deviation was performed as well as ANOVA test, with Duncan post hoc tests for the physicochemical determinations and total phenols and antioxidant capacity analysis. For the sensory evaluation, in order to find significant differences among populations, the Student’s t-test was applied.

3. Results and Discussion

3.1. Final Formulations

According to the results of the sorting test (data not shown), the flavor of the preliminary formulations was not a differentiation criterion, unlike color and smell. Considering these last attributes as the main selection criteria, four final formulations were chosen to be analyzed (BR, BB, BM, and BC).

3.2. Microbiological Quality

No growth was observed in any of the indicator microorganisms analyzed in the developed beverages. This reflects the application of Good Manufacturing Practices during their elaboration, as well as the use of raw material that meets the quality parameters for their use as ingredients in this type of products.

3.3. Physic and Chemical Characteristics

3.3.1. Color

In general, the developed beverages presented intense and attractive colors. The formulations that include bougainvillea (BM, BR and BC) presented red and intense pink shades, while the BB drink (without bougainvillea) presented yellow-shining brown shades. The bougainvillea flower is responsible for the red and pink shades due to their high content of a complex of more than 30 betanins [38] which besides providing color, are responsible for some of its medicinal properties [39]. The values of L (brightness), a (red shades) and b (yellow shades) of each developed beverage are presented in Figure 1. The obtained results were consistent with the ingredients and proportions used for each formulation being significantly different between them ($p < 0.05$). Among the current trends of functional drinks, people are looking for attractive natural colors associated with beneficial properties, additives free and made with natural products [40]. The developed beverages presented similar shades to those of the trendy drinks available in the market.
Figure 1. Color values (L* a* and b*) of the developed beverages. Mean ± Standard deviation, n = 3. Different lowercase letters within rows indicate significant difference (p ≤ 0.05) according Duncan’s test.

3.3.2. Physicochemical Composition

Table 2 presents the results of the physicochemical composition of the developed beverages. The ANOVA of the data obtained indicated that the composition of the four beverages was significantly different (p < 0.05) except for BB and BM which presented the same °Brix value. Due to the nature of the samples, moisture was the main component (>99%). Regarding carbohydrates, which represents the mineral content in a sample, the values determined in the elaborated drinks were <0.1%. The ingredients that were used in the formulations did not contribute to the mineral content maybe because of the extraction method used. The mineral extraction could have been limited by using water as the extractant solvent, a temperature of 90 °C, and a short time of extraction [41].

Table 2. Chemical characterization of the developed beverages.

| Sample Code | Moisture (%) | Ash (%)       | Sodium (mg/L) | pH     | Titratable Acidity (%) | °Brix  | CHO (%) | kcal/p (240 mL) |
|-------------|--------------|---------------|---------------|--------|------------------------|--------|---------|----------------|
| BR          | 99.01 ± 0.01 | 0.077 ± 0.0092 | 138.74 ± 1.04 | 4.83 ± 0.007 | <0.01 | 0.9 ± 0.0 | 0.913 ± 0.0 | 7.20 ± 0.0 |
| BB          | 99.25 ± 0.00 | 0.079 ± 0.0074 | 87.57 ± 2.00  | 4.86 ± 0.007 | <0.01 | 0.6 ± 0.0 | 0.671 ± 0.0 | 5.36 ± 0.0 |
| BM          | 99.31 ± 0.00 | 0.079 ± 0.0048 | 95.37 ± 1.88  | 6.26 ± 0.007 | <0.01 | 0.6 ± 0.0 | 0.611 ± 0.0 | 4.88 ± 0.0 |
| BC          | 99.41 ± 0.01 | 0.097 ± 0.0058 | 78.89 ± 2.30  | 5.50 ± 0.000 | <0.01 | 0.4 ± 0.0 | 0.493 ± 0.0 | 3.94 ± 0.0 |

CHOs: Carbohydrates. Mean ± Standard deviation; n = 3, different lowercase letters (a, b, c, d) within columns indicate significant difference (p < 0.05).

Regarding carbohydrates and °Brix, all the samples presented low values (<1%) attributable to the ingredients that were used and to the fact that they do not contain added sugars. Regarding the calorie content, the Mexican standard, NOM-086-SSA1-1994 [30] establishes that the beverages containing ≤40 kcal/portion are classified as “Low-calorie”
while those with \( \leq 5 \text{ kcal/portion} \) are “No-calorie”. The World Health Organization and the Food and Drug Administration (FDA) recommend consuming less than 10% of calories per day from added sugars. Mexican sugar intake is higher than that recommendation, the main source of added sugars are sweetened beverages contributing with 69% [42]. In Mexico, most popular soft drinks contain on average, 78 g of sugar and provide more than 300 kcal, per each 300 mL. Some commercial beverages with tea extracts marketed as healthy products contain 75 g of sugar and provide 300 kcal in a 600 mL portion. A study published in 2016, revealed that sugar-sweetened beverages (especially regular soda) are the main sources of added sugar intake in the Mexican population [42]. The developed beverages reported in our research are a healthier alternative to sweetened beverage considering that, according to the standard NOM-086-SSA1-1994 mentioned above, they are classified as zero-calorie drinks (BM and BC) and low-calorie drinks (BR and BB).

Concerning sodium, in México, this is the only mineral that must be mandatorily declared according to the labelling law for food (NOM-051-SCFI/SSA1-2020) [30]. The developed beverages presented sodium values from 78 to 138 mg/L, which classify them as very low-sodium products according to the established by Mexican standard NOM-086-SSA1-1994 [30]. The sodium content determined in the drinks was higher to that reported for green tea marketed in Portugal (35–69 mg/L) [43] and they are lower than the one reported by Flores-Martínez et al. [44] for commercial flavored and colored teas ready to drink (180.70–271.74 mg/L). It has been reported that the consumption of sweetened beverages contributes to increase sodium intake in teenagers [45]. For Mexican population the main source of sodium are bread products and processed meat (i.e., ham, sausages, bacon), although some street food like tacos also contributes in sodium intake [46]. Street and fast food are usually consumed with sweetened beverages, mainly sodas or aguas frescas (Mexican handmade sweetened beverages prepared with fruits).

3.3.3. Titratable Acidity and pH

Titratable acidity values of the samples were <0.01% (Table 2). These results are lower than those reported for beverages developed using medicinal plants, fruits and flowers alone or combined, which ranged from 0.13% to 0.88% [47–50]. The values for titratable acidity observed in our research are also different from those reported by Flores-Martínez et al. [44] for ready-to-drink flavored-colored commercial teas (0.092–0.174%) containing citric acid as acidifier agent. For pH, the values were found between 4.83 and 6.26 (Table 2) which were similar to those reported by Badejo et al. [47] (4.46–5.56) but higher than the values informed by Sharma et al. [48] (2.03–2.7) and Lakshan, et al. [49] (3.14). The pH declared (3.7–4.5) for some commercial non-alcoholic carbonated and non-carbonated drinks [51] and some ready-to-drink commercial flavored-colored teas (3.7–4.1) [44] is also lower than our results. The beverages developed in our research do not contain additives, unlike the commercial products which are added with acidulants and stabilizers (mainly citric and phosphoric acid and sodium citrate). Apparently, in our research, despite the content of ascorbic, citric, fumaric, and malic acids of the fruits used for the elaboration of the developed beverages, the amount used was not enough to contribute neither to titratable acidity or pH parameter.

3.4. Total Phenolics and Antioxidant Capacity

The results of total phenolics, as well as the antioxidant capacity of the developed beverages were significantly different (Table 3). Total phenolic values were from 810.50 to 943.38 mg GAE/100 mL. In descending order, the content of total phenolics was BC > BR > BM > BB. The highest values corresponded to the drinks containing Melissa, bougainvillea and guava while the lowest ones were observed in formulations with Melissa, apple, orange, strawberry, and, pineapple.
Table 3. Total phenolics and antioxidant capacity of the developed beverages.

| Formulation | Content of Total Phenolics | DPPH Method | FRAP Method |
|-------------|----------------------------|-------------|-------------|
|              | [mg GAE/100 mL]           | [mg TE/100 mL] | [mg EFe^{2+}/100 mL] |
| BR          | 844.74 ± 3.29             | 464.64 ± 3.96 | 426.12 ± 1.04 |
| BB          | 810.50 ± 3.29             | 375.38 ± 3.67 | 414.08 ± 0.52 |
| BM          | 831.43 ± 5.70             | 547.49 ± 3.98 | 434.86 ± 2.57 |
| BC          | 943.38 ± 4.74             | 776.94 ± 3.35 | 379.59 ± 1.50 |

BR, BC, BB, BM indicate the developed beverages. Mean ± Standard deviation; n = 3; different lowercase letters (a, b, c, d) within columns indicate significant difference (p < 0.05).

The total phenolic content of the beverages developed was remarkably superior to those reported for several functional beverages prepared with a mixture of flowers, fruits, and medicinal plants. For example, a drink prepared with a combination of tigernut (*Cyperus esculentus*), moringa (*Moringa oleifera*), hibiscus (*Hibiscus sajdarifia*), and spiced with ginger presented total phenolic contents from 21.67 to 45.67 mg GAE/100 mL [47]. Other beverages prepared from *Aloe vera* combinations (sweetened juice, squash and ready-to-serve) presented total phenolic contents from 8.20 to 62.65 mg/100 mL [48]. In the same way, a functional beverage containing blue pea flower (*Clitoria ternatea*), lime juice and stevia syrup presented a total phenolic value of 0.85 mg GAE/100 mL [49] and infusions prepared with some edible flowers presented contents from 375 to 433 mg GAE/100 mL [50], which are also lower than those obtained in our research.

The total phenolics results agree with the antioxidant capacity observed, which was measured by DPPH. However, when the antioxidant capacity was measured by the FRAP method, the beverage BC presented the lowest value and BM the highest. This could be explained because of the type of antioxidant determined in each method [52,53]. The results obtained for antioxidant capacity by FRAP were higher than those reported for 70 medicinal plant infusions including chamomile and Melissa [54].

In our research, the main source of phenolic and antioxidant compounds are the plants used. Several studies have demonstrated high amounts of these kinds of compounds in Melissa [53,55,56] and lemon verbena [57,58]. Katalinik et al. [54] mention that consuming a cup of Melissa infusion could be a dietary source of phenolic and antioxidant compounds comparable to beverages like red wine and tea. In the case of the bougainvillea, the presence of more than 30 compounds that include betanins, their conjugates, betaxanthins and flavonoids has been confirmed [25,59–61]. Guo et al. [62] reported that some fruits peel and pulp including guava, pineapple, tangerine, orange, and strawberry have a strong antioxidant capacity and could be a rich source of antioxidants. It has also been observed that the combination of several plants and fruits for the preparation of beverages favors the antioxidant content [63–66].

3.5. Classification of Population according to BMI

According to the diagnostic from BMI, the participants were classified in two groups: normal weight (N) and with overweight and obesity (OO). Within the population who participated, 58% presented normal weight while 42% was classified with OO. The highest prevalence of overweight and obesity was observed in the School of Commerce and Business Administration ICEA (52%), while the lowest prevalence was observed for the population of the School of Health Sciences ICSA (29%). The participants of ICEA belong to the highest socioeconomic stratification (data not shown) allowing them to have a higher access to food, besides studying careers like Culinary Arts and Tourism. Since the population of ICSA is related with undergraduate programs of the health field (medicine, nursing, nutrition), it might be more aware of health care by eating healthier food. The observed results regarding the BMI are close to the data reported by the National Survey of Health and Nutrition [2] which showed a national prevalence of 72.5% of overweight and obesity for Mexican adults up to 20 years old.
3.6. Results of the Sensory Analysis of the Developed Formulations

3.6.1. Liking and Buying Intention of the Developed Beverages per School

The results of liking and buying intention of the developed beverages obtained per school are shown in Figure 2. According to the ANOVA, there were significant differences \( p < 0.001 \) among the four variables analyzed (liking of color, smell, and flavor as well as buying intention) in the developed beverages. The color of the BM beverage obtained the highest scores in the three schools (Figure 2A). These values are close to those reported by Nabaniita et al. [67] for the liking of the color of a citrus-based beverage developed with a medicinal herb \( (\text{Asteracantha longifolia}) \), sugar syrup and spices (cardamom and cinnamon) and for a blue pea \( (\text{Clitoria ternatea L.}) \) flower extract, lime juice and stevia beverages developed by Lakshan et al. [49]. The color of BM beverage, can be attributed to the natural pigments of the bougainvillea which gave an attractive pink color to the product. The beverage BB which does not include bougainvillea obtained the lowest scores for this attribute. Other ingredients as chamomile and Melissa were the main responsible for the dull yellow color of this beverage. The color of a food product is a relevant criterion for its selection, consumption, and preference, influencing consumer acceptance [67]. In this case, the color of the beverages developed was attractive and positively related to products based on fruits and herbal extracts.

Concerning the flavor (Figure 2B), ICBI participants showed the same degree of liking for the 4 developed beverages. In contrast, for ICSA and ICEA participants, significant differences \( p < 0.01 \) were found. In these schools, the flavor of BM and BB was the most liked. The beverage BR includes Melissa among its ingredients, so it is probable, that this plant provided an unpleasant or no recognizable smell and flavor. In the case of the beverage codified as BB, this one also contains Melissa, but other ingredients like orange and chamomile could have masked Melissa’s smell and flavor, contributing to the liking degree showed toward it. In relation to the smell of the developed beverages, no

![Figure 2](image-url)
significant differences were found for ICEA and ICBI participants. On the contrary, at ICSA school, the smell of BC beverage was significantly the most disliked (Figure 2C). This formulation contained only three ingredients (Melissa, bougainvillea, and guava) in the lowest proportion compared to BM, BB and BR. This fact may have contributed to the low impact of smell and flavor of BC beverage. The results observed for the liking of flavor are lower than those reported for Nabanita et al. [68] and Lakshan et al. [49] although the formulations developed for those authors include sugar and stevia, respectively, which could have influenced positively the liking degree of flavor.

The smell and flavor of herbal infusions may be unpleasant for some consumers due to their association with medicinal uses which is not desirable when developing a healthy drink. So, it would be recommendable to mask these attributes using ingredients with a high smell and flavor impact. In our case, the amount of all ingredients incorporated in the formulations was low in general; using a higher quantity of pulp and peel fruits could increase the liking of smell and flavor of these beverages.

Regarding the buying intention, the participants did not show a clear intention to purchase or not the developed beverages, except for the BC formulation (the participants commented that “probably would not buy it”). Apparently, its low impact of smell and flavor affected negatively the buying intention for this formulation. Significant differences for buying intention variable were found only for ICSA school (Figure 2D). The participants in the sensory tests belong to the age range between 19–25 years old, so their beverage consumption habits could have influenced their responses since several studies [69] state that the most consumed beverages by Mexicans between 19 and 29 years old are sodas (carbonated and non-carbonated), beverages based on fruit juices (with and without added sugar), aguas frescas, and natural fruit juices (prepared with 100% fruit without added sugar). Nutritional labels and health warnings in sweetened beverages can help to discourage their consumption [70].

3.6.2. Liking and Buying Intention of the Developed Beverages Per Population with Normal Weight (N) and with Overweight and Obesity (OO)

Results of the degree of liking and buying intention for the developed beverages according to the weight condition are presented in Figure 3. The Student’s t-test showed significant differences between the color (t = 2.33; \( p = 0.020 \)) and flavor (t = 2.14; \( p = 0.032 \)) only for BB formulation (Figure 2A,B, respectively). Participants with overweight or obesity (OO) expressed a higher degree of liking for BB flavor, while participants with normal weight (N), liked most the color of this formulation. The evaluation of liking data reflected that both populations (N and OO) showed the same responses for the smell of the four developed beverages and, except for BB formulation, also for the flavor and color. Regarding this last attribute, Gouss et al. [71] observed that the color has a significant effect on some attributes related to aroma and flavor intensity for grapefruit-like beverages. In their research, the red color liked more than the yellow and a low over high aroma. Similarly, in our research, pink or reddish beverages were preferred over the yellow-brownish ones.

These results indicate that the bougainvillea could be an excellent source of natural color for the development of beverages of this type. This flower, besides the color, provides compounds with antioxidant capacity that will confer bioactive properties to the final product [61].
Regarding the buying intention, it was observed that there were no significant differences nor by institute nor by populations with normal weight and with overweight or obesity (means between 4.1 and 4.5). In general, no clear intention neither to buy or not the developed beverages was observed. The lack of sugar in the formulations may explain the low buying intention values observed. Our results are in agreement with Pineli et al. [72]. These authors suggested the lack of sugar as the cause for the low acceptance means observed for unsweetened Brazilian wild Passiflora infusions, mentioning that people who consume unsweetened beverages like tea are a small and specific group of consumers. The beverages developed in our research were intended as healthy alternatives to soft drinks, hence the addition of sweeteners has not been considered. Cox et al. [73] stated that providing information about the health properties of products can be an effective mechanism to increase the liking and the purchase intention. In this regard, Sabbe et al. [74] observed a positive effect of providing health information about acai (Euterpe oleracea) juices on hedonic measures as well as on purchase intention.

Mexico is among the top ten countries in the world including Chile, United States, Argentina, Saudi Arabia, Germany, the Netherlands, Slovakia, Austria, and Brazil with the highest intakes of sugary drinks [75], exceeding the WHO recommended calorie intake. It has been demonstrated that the consumption of this kind of beverages contributes to the increase in obesity of the Mexican population. The consumption of beverages made from plants, flowers and fruits turns to be a healthy alternative within the market as it will contribute to cover the recommended daily intake of antioxidants without elevating the calorie intake in Mexican population.

4. Conclusions

The use of medicinal plants widely used in traditional Mexican medicine (Melissa and lemon verbena) combined with flowers and fruits proved to be effective to produce healthy drinks with antioxidant capacity and low-calory. The overweight or obesity condition of participants did not affect significantly the liking and the buying intention towards the developed beverages. However, the absence of sugars in their formulations, as well as the

**Figure 3.** Mean (n = 400) of scores for liking (A: color, B: flavor, C: smell) and buying intention (D) of the developed beverages according to the weight condition (normal weight -N- and overweight and obesity -OO-). Different lowercase letters between bars indicate significant difference (* p < 0.05).
habits of sugary drinks consumption, may have affected the results of the sensory tests. The acceptance of the healthy developed beverages can be increased by providing information about their beneficial health properties. The high consumption of sugary drinks in Mexico and around the world is an important factor in the development of overweight, obesity, and related diseases. The reduction of its consumption is urgent and necessary. One way to do this is to have healthy alternatives on the market. The beverages based on plants, fruits, and flower extracts show potential for maintaining health due to their antioxidant and physicochemical properties.

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Informed Consent Statement: Before the tests, all the participants were verbally informed about the objective of the study and the individuals that manifested their agreement participated.

Data Availability Statement: All data obtained from this research are presented in this article except beverage formulations due to trade secrets.

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