CROSS-CULTURAL DEVELOPMENT OF HIBISCUS TEA SENSORY LEXICONS FOR TRAINED PANELISTS AND CONSUMERS

Running title

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ABSTRACT

Given the growing worldwide interest in high quality hibiscus teas and the scarcity of information regarding their sensory profile, sensory lexicons were developed in English, French and Portuguese. Twenty-one samples, including freshly prepared and ready-to-drink infusions, syrups, concentrates and an instant tea, were evaluated by trained panelists, resulting in a set of 21 defined and referenced attributes (e.g., aroma reminiscent of hibiscus flowers, with fresh and dried fruit, herbaceous and sweet aromatic notes). The attributes used by untrained panelists to describe hibiscus teas were then investigated in Senegal, France and Portugal. To this end, exploratory focus groups and consumer studies using CATA questions were held (n=370). A consumer lexicon with 17 sensory and 12 overall impression attributes was developed.

Trained panelists used a more precise vocabulary to describe hibiscus teas' aromatic characteristics, whereas consumers were more prolific in the use of overall impression descriptors. Culture and familiarity influenced the selection of attributes by trained and untrained subjects.

PRACTICAL APPLICATIONS

This work provides a foundation for sensory research on hibiscus teas and practical support for product optimization processes, whether through hibiscus calyx selection and breeding or tea processing methods. Moreover, new lexicons will facilitate communication between the actors involved in the development, production and marketing of hibiscus extracts and products thereof across Africa, Europe and North/South America. Finally, by relating descriptive analysis results to the sensory evaluations of familiar as well as unfamiliar consumers, potential drivers of hibiscus tea acceptance in both traditional and new markets could also be identified.

INTRODUCTION

Dried calyces *Hibiscus sabdariffa* var. *sabdariffa ruber* flowers (hereinafter referred to as *hibiscus calyces*) are commonly used for artisanal or industrial preparation of teas and extracts in many countries of tropical and subtropical areas of Africa, Asia and North-America (Fasoyiro *et al.* 2005; Pérez-Ramírez *et al.* 2015). Hibiscus extracts are a rich dietary source of polyphenols and have been demonstrated to possess important nephro- and hepato-protective, renal/diuretic, anti-cholesterol, anti-hypertensive, anti-diabetic, hypolipidemic and anti-tumoral effects (Da-Costa-Rocha *et al.* 2014; Patel 2014; Pérez-Jiménez *et al.* 2010; Pérez-Ramírez, et al. 2015).

Penetration of hibiscus teas in Western markets has already occurred, with dilute-to-taste extracts in liquid or powder form (targeting the African diaspora in Europe), herbal teas and infusions (aiming at Hispanics and health-conscious, all-natural, ethnic food consumers in the US) and specialty flavored syrups (for foodservice professionals and end-customers seeking novel, exotic and exciting drink mixers and baking ingredients) being the main examples (Bennett *et al.* 2014; Ramirez *et al.* 2010). Bulk hibiscus concentrates are also commonly employed in the European and North-American food, beverage and pharma industries as natural coloring and flavoring ingredients (Cid-Ortega and Guerrero-Beltrán 2015; Cisse *et al.* 2009).

The ever-growing number of health conscious consumers, together with the recent interest of Europeans and North Americans in plant-based beverages made from exotic ingredients are creating additional, mainstream market opportunities for the development of high quality hibiscus products. In spite of such developments, research on the descriptive sensory attributes of hibiscus teas remains quite scarce (Bechoff *et al.* 2014; Wong *et al.* 2003). Minimum quality requirements for the export of hibiscus calyces to Europe and the US have been established, which do take into account some

of the desirable sensory characteristics of their extracts (Plotto *et al.* 2004). However, due to their limited number and scope, as well as lack of empirical validation, these sensory descriptors are of very limited use for the sensory characterization of hibiscus teas.

Sensory lexicons provide accurate and reproducible results for descriptive sensory analysis (Cherdchu *et al.* 2013) and constitute a tool for communication within panels and across diverse audiences (Hayakawa *et al.* 2010; Lawless and Civille 2013). Its application to describe and compare the quality of hibiscus teas should, therefore, lead to a better understanding of the quality of existing products and suggest avenues for the development of new ones. Moreover, it should facilitate communication between the actors involved in research, production and regional/international trading, particularly in what respects the steering of the breeding of new hibiscus cultivars of high commercial value.

When developing lexicons for cross-cultural application, the involvement of researchers from all relevant cultures is desirable (Lawless and Civille 2013). Furthermore, comparison of results between different cultures/countries/languages can provide additional lexicon validation (Chambers *et al.* 2012; Cherdchu, et al. 2013; Chung and Chung 2007). On the other hand, food producing and trading companies do not always have the possibility to train or get access to trained panelist. Comparisons between the sensory lexicon used by trained panelists and untrained subjects can help determine how reliable the latter are (Worch *et al.* 2010). Consumer lexicons can also provide relevant product description for marketing research, sales and customer support (Hayakawa, et al. 2010; Kim and Lee 2016).

The main aim of this paper is to establish a valid, cross-cultural sensory lexicon for hibiscus tea, which not only contains the descriptive terms, definitions and reference standards to be used by trained panelists, but also assembles them in a simple and

convenient format for all the actors involved in the hibiscus beverage industry, i.e., in a sensory wheel. Additionally, we investigate the sensory vocabulary of consumers in three countries – Senegal, France and Portugal -, to describe hibiscus teas using CATA questions, and highlight differences and similarities relative to the lexicon developed by trained subjects, as well as those attributable to their relative level of familiarity with this type of drink.

MATERIALS AND METHODS

Ethical Approval

Studies were conducted in accordance with the Declaration of Helsinki, and the protocol was approved by project AFTER's Ethics Committee (project code 245025). Prior to the study, participants were informed about the aim of the study and procedures for handling personal data. In addition, they signed an informed consent, in which their voluntary participation was explicitly stated and also that they could withdraw from the study at any time. All tested samples were produced and prepared according to good hygiene and manufacturing practices.

Samples and Preparation

Twenty-one hibiscus teas were evaluated: eight freshly brewed infusions, five ready-to-drink infusions, five diluted-to-taste syrups, two diluted-to-taste concentrates and one prepared instant drink (Table 1). These products were selected to represent the most important product market segments at present, as well as to ensure sufficient diversity in sensory characteristics, as they differ considerably in origin and production process.

Lexicon Development for Trained Panelists: Stage 1

Participants. A panel of 17 Senegalese subjects with no relevant experience in sensory descriptive analysis (university technical staff and students, technical staff of local food companies) was used. These were recruited based on their interest and availably to participate in the study and pre-screened for high levels of familiarity with hibiscus teas.

Procedure. Sessions were held in at the Cheikh Anta Diop University of Dakar in French (Senegal's official language). Eight teas were evaluated (RInf1-3, FInf1-3 and Syr1-2). Tastings were conducted in an air-conditioned room (22-25ºC) with controlled lighting. Sensory attributes were generated during orientation sessions guided by an experienced panel leader. Eleven descriptors were subsequently developed by consensus and the corresponding definitions were established (Bechoff, et al. 2014). After a period of training in attribute recognition and intensity scoring, panelists evaluated the eight teas. Approximately 50 ml samples were served in clear plastic cups coded with three digit numbers. Samples were tested in triplicate and presented in randomized order. Mineral water was used to clean the palate.

Lexicon Development for Trained Panelists: Stage 2

Participants. Seven senior panelists with over ten years of experience in sensory descriptive evaluation and attributes' intensity rating, belonging to the sensory evaluation panel of Escola Superior de Biotecnologia - Universidade Católica Portuguesa (ESB-UCP), participated in the lexicon development. Panelists had neither prior experience in the evaluation of hibiscus teas nor familiarization with hibiscus products.

Procedure. Sessions were conducted in Portuguese and were held at the ISO 8589:2007 compliant sensory evaluation laboratory of ESB-UCP.

During orientation sessions panelists were exposed to six hibiscus teas (FInf4-7, Syr3 and Inst), asked to analyze each one, compare it with others and list the terms that characterized the samples and described their differences. To this end, the list sensory descriptors previously obtained along with sensory descriptors referenced in literature were provided (Plotto, et al. 2004; Wong, et al. 2003). Odor was defined to panelists as the fragrance perceived through orthonasal analysis, while retronasal perception of odorants during tasting was designated by aroma or flavor (ISO 5492:2008). For each sample, appearance was evaluated, followed by odor, then flavor and finally aftertaste.

After orientation, terms and references generated by panelists were refined by consensus. To increase familiarization with berry odors and flavors, reference samples of berry fruits and/or its juices were provided. The elimination of some of these terms was then performed taking into account the frequency of quoting, intensity ratings and the contribution to the differentiation of samples (ISO 11035:1994). In the following sessions, definitions were proposed and discussed, reference standards were established and tested, and the sequence of evaluation of each attribute defined. As a result, a score sheet was developed, with attributes intensity being quantified using an unstructured line scale. This was accomplished in twelve 1½ hours sessions.

Panelists were trained and their performance evaluated according to ISO 11132:2012. They were subsequently requested to rate the intensity of each of the selected attributes in the beverages as part of the lexicon validation process (Chambers *et al.* 2016; Lawless and Civille 2013). Tasting was performed in triplicate with a maximum of four samples per session. Samples were labelled with three digit codes and presented to panelists in randomized order. Tasting was held in tasting booths under white light (6500 K) and controlled temperature (20-22 ºC).

Lexicon Development and Sensory Wheel for Trained Panelists: Stage 3

Participants. Six new panelists participated in this study, along with the seven involved in the second stage. New panelists included one senior panelist and five others selected, screened and assessed (health status, ability to discriminate and match basic tastes and odors, attribute intensity perception and descriptive ability) according to ISO 8565:2012 out of 26 volunteers (PhD students and university staff members). Six 90-minute training sessions were then conducted, during which new panelists received sensory and practical descriptive sensory analysis instruction. They were also introduced to the terminology, references and rating procedures used in the subsequent descriptive analysis.

Procedure. With the aim of expanding the lexicon seven new hibiscus teas were evaluated (RInf14-5, FInf8, Syr4-5, and Conc1-2). Lexicon development and validation were carried out using the procedure described in the previous stage. Descriptors resulting from the second and third stage were finally translated from Portuguese into French and English. Translations were validated by bilingual trained panelists and by native speaking French and English subjects. ISO standard for vocabulary (5492:2008) was used as reference.

Hibiscus Tea Sensory Wheel. English lexicon descriptors were assembled by sensory modalities [appearance, odor and aroma, (basic) taste and mouthfeel] in a two-tiered wheel (Koch *et al.* 2012). The inner tier comprised classes of descriptors which group together the more specific ones found in the outer tier (Noble *et al.* 1984; Theron *et al.* 2014).

Lexicon Development for Untrained Panelists in: Stage 1

Participants. Researchers and food processors participated in exploratory meetings held in Senegal, Senegalese consumers self-reported to be highly familiarized with

hibiscus teas (N=20; 50% men; 19-50 years old) participated in focus group sessions. Researchers and consumers of cold tisanes and/or fruit beverages participated in exploratory meetings held in Portugal and France and in focus groups held in Portugal (N=22; 54% men; 18-71 years old). Most of these participants were not familiarized with hibiscus teas.

Procedure. Participants were asked to taste 3 to 4 blind samples of hibiscus teas, selected to present very different sensory profiles, and to describe their attributes. Additionally, participants familiarized with hibiscus teas were asked to provide descriptors for hibiscus teas in general. During the discussion participants were allowed to drink and taste the beverages as much as they wanted.

Lexicon Development for Untrained Panelists: Stage 2

Participants. Subjects were non-probabilistically recruited in Senegal (N=150), France (N=120) and Portugal (N=100). Subjects in Senegal were screened for consumption of hibiscus teas. Subjects in France and Portugal were screened for consumption of cold tisanes and fruit beverages. Tasting sessions were conducted at recruiting sites under central location test conditions.

Procedure. Questionnaires written in French (France and Senegal) and Portuguese (Portugal) were administered to participants. Thirty milliliters samples (identified by 3-digit codes) were served in randomized order to participants in clear plastic glasses. In Europe samples were presented as non-alcoholic beverages without information on origin or ingredients. Water was supplied to clean the palate between tastings. Participants were asked to taste each sample and selected from a list of terms (presented in randomized order) the ones that described the samples (CATA questions). Four samples (RInf 4-5, Syr4 and Conc1) and fifteen terms were used in Senegal: light red,

dark red, acid, bitter, sweet, astringent, syrup like, natural, artificial, watery, refreshing, sharp odour, light in hibiscus, strong in hibiscus and appealing. Six samples (FInf 4-5, Syr3-4, Conc1 and Inst) and 22 terms were used in Europe: clear, red, pink, floral, acid, bitter, sweet, astringent, fruity, red fruit, syrup like, tisane like, instant tea like, natural, artificial, watery, simple, strong, fresh, full bodied, viscous, and fluid.

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Statistical Analysis

XLSTAT software V. 2015 (Addinsoft, Paris) was used to carry out all statistical analyses. Assessment of panel performance was performed according to ISO 11132:2012 using analysis of variance (ANOVA). Significant differences between intensities of sensory descriptive attributes were performed using ANOVA with Fisher post-hoc test and ANOVA Welch test with Games-Howell post-hoc test (in case of unequal variances). Principal components analysis (PCA) was used to investigate relations and represent sensory variables and samples and Pearson's correlation tests were used to investigate relationships among variables. To analyze CATA question results, frequency of use of each descriptor was determined by counting the number of consumers that used that term to describe each sample. Multiple Factor Analysis (MFA) was performed to explore the relationships between data sets resulting from consumer profiling results using CATA questions and sensory descriptive analysis obtained from trained assessors (Abdi *et al.* 2013; Escofier and Pagès 2008). Spearman correlation tests were used to investigate relationships among sensory descriptive variables and CATA terms. The significance of statistical tests was evaluated at $p<0.05$, unless otherwise stated.

RESULTS AND DISCUSSION

Lexicon Development for Trained Panelists: Stage 1

Eleven sensory descriptors were obtained: three for appearance (red color intensity, clarity and concentration), two for both aroma and flavor (hibiscus and fermented) and four for taste/mouthfeel (sweet, acidic, bitter and irritant). Attributes fermented and irritant were related to deviations in the quality of the samples. According to Lawless and Civille (2013), the set of samples used to develop a sensory lexicon should provide a fair representation of the whole product category, including products with defects. Hence, these attributes, along with previously reported off odors and flavors resulting from the contamination of hibiscus calyces with extraneous botanical materials and spices (Plotto, et al. 2004), were included in the lexicon.

A descriptive analysis of eight hibiscus teas yielded significant differences across samples for all attributes, with the exception of fermented odor (Bechoff, et al. 2014). This could due to panelists' difficulty to discriminate low intensity odors. Attributes concentration and red color intensity presented a very high correlation (r=0.99) and were thus considered to assess the same appearance attribute. In view of this, only red color intensity was retained in the lexicon.

Lexicon Development for Trained Panelists: Stage 2

Sixty-one terms were initially elicited by panelists: 6 for appearance, 29 for odor and 26 for flavor, taste and mouthfeel. After reduction, descriptors visual and mouthfeel viscosity, astringency, as well as six new odor and aroma descriptors (fresh fruit: aronia/cranberry, raspberry and sour cherry; dried fruit: raisins; sweet associated aromatics: honey and cold black tea; and herbaceous: hay) were added to the lexicon. Descriptors visual and mouthfeel viscosity appeared to be strongly affected by hibiscus calyx cultivar, being selected by panelists to describe only the samples made of 100%

Koor or Vimto calyces. Previous studies have uncovered that blends of similar proportions of Koor and Vimto calyces lead to extracts with improved sensory quality, particularly in terms of appearance and taste/mouthfeel (Babajide et al., 2005; Bechoff et al., 2014; Cisse, Vaillant, et al., 2009). Regarding odor and aroma attributes, the descriptor raspberry was considered the most suitable to describe fresh fruit odor of the instant tea, whereas for the remaining samples the descriptors aronia/cranberry and sour cherry were considered more representative. The rather different selection of odor and aroma descriptors by Portuguese panelists when compared to Senegalese (Stage 1) is likely to derive chiefly from cultural differences rooted on attribute familiarity (Chung and Chung 2007; Hersleth *et al.* 2013; Tu *et al.* 2010).

Significant differences across tea samples were found in all descriptors (Table 2). The impact of calyx cultivar and extraction conditions on red color perceived intensity was notorious. Higher values of red color intensity were obtained for samples prepared from Vimto calyces, compared to Koor, as well as for those extracted with boiling water rather than at ambient temperature. Vimto cultivar is known for its intense red colour and exceptionally rich content in anthocyanins when compared to Koor (Cisse, et al. 2009). The use of hot water leads to higher extraction rates of anthocyanins (responsible for the red color of hibiscus calyces and their extracts) (Cisse *et al.* 2012; Ramírez-Rodrigues *et al.* 2011; Wong, et al. 2003) particularly when whole calyces are used. Red color intensity was also higher for the infusions than for the syrup and the instant tea, likely due to calyx-to-water ratio used in their production together with the dilution employed in beverages preparation prior to testing in the later (table 1). Also reflecting the amount of hibiscus calyces used, sample dilution and sugar addition, hibiscus odor and flavor intensities, acid taste, bitter taste and astringency were generally higher for infusions than for the syrup and the instant tea, whereas sweetness was considerably lower. These findings are in good agreement with those earlier reported for hibiscus

teas, which described hibiscus odor and flavor of infusions as stronger and sour and that of syrups as predominantly sweet (Bechoff, et al. 2014). Raspberry odor was much more intense in the instant tea than in other samples, whereas hay, honey, cold black tea and raisins odors were much less intense.

Highly significant associations were also found between acid taste and bitter taste with astringency (positive, $p<0.01$) and with sweet taste (negative, $p<0.01$). Strong acid taste in juices and other plant-based beverages usually co-occur with perceptions of bitterness and astringency sensations, while moderate and high sweetness intensities are known to be generally suppressive of acid and bitter tastes (Bett-Garber *et al.* 2015; Keast and Breslin 2002; Koppel and Chambers Iv 2010; Laaksonen *et al.* 2014).

Lexicon Development and Sensory Wheel for Trained Panelists: Stage 3

Twelve attributes were evaluated: red color intensity, hibiscus, aronia/cranberry, raisin, honey, hay and cold black tea odor, hibiscus flavor, sweet, acid and bitter taste and astringent mouthfeel. Significant differences across tea samples were found for all attributes except raisin odor. The widest variations were observed in descriptors red color intensity, hibiscus odor, hibiscus flavor, acid taste and sweet taste. Narrower variations and moderate or low intensities of honey, hay, cold black tea and aronia/cranberry odors, bitter taste and astringency were observed.

Figure 1 depicts the projection of samples and descriptors in the first two principal components (PC), which together explained 85% of variance. Basic tastes and astringent mouthfeel, along with honey, cold black tea and raisins odors, were mainly correlated with PC1, while red color intensity, aronia/cranberry odor and hibiscus odor and flavor were mainly correlated with PC2. A good discrimination between samples was observed. Situated on the first quadrant, FInf8 was characterized by strong red color and aromatic character (hibiscus odor and flavor, aronia/cranberry and hay odors),

acidity and sweetness, and weak bitterness and astringency. Located on the second quadrant, Syr4 and Syr5 were described as having a strong sweetness, moderate red color intensity, moderate floral and fruity aromatic character and weak acidity, bitterness and astringency. Conversely, RInf4 and RInf5, located in the third and fourth quadrant, respectively , exhibited higher acidity, bitterness and astringency. Like FInf8, RInf4 exhibited strong red color and hibiscus odor, yet only moderate hibiscus flavor and sweetness, as well as moderate to weak aronia/cranberry odor. RInf5 was perceived to had weakest red color, aromatic character and sweetness of all samples, but high acidity. Finally, Conc1 and Conc2 were located close to RInf4, hence being equally characterized by strong red color intensity and acidity, as well as moderate to weak aronia/cranberry odor. However, they exhibited more pronounced hibiscus odor and flavor, a moderate to strong sweetness, a weak hay odor and more moderate intensities of bitterness and astringency.

Higher intensities of red color, hibiscus odor and flavor and aronia/cranberry odor were observed for teas prepared from ground calyces than from whole ones. Earlier studies on hibiscus anthocyanins extraction and degradation kinetics, showed that for ambient temperature and moderate soaking times the use of crushed (rather than whole) calyces resulted in an important increase in anthocyanin (and hence color) extraction and preservation (Cisse, et al. 2012). Present results seemed to indicate that besides improving color these processing conditions also contributed to the highly appreciated fragrant fresh fruit and floral aroma and flavor of the beverages.

Overall, these results showed that the set of descriptors obtained enabled trained panelists to describe and discriminate well the sensory properties of a broad range of hibiscus teas. Based on them, a sensory lexicon developed for trained panelists in English, French and Portuguese, including descriptors, definitions and references, was

hence compiled, as depicted in Table 3. English lexicon descriptors were then assembled by sensory modalities in a two-tiered wheel (Koch, et al. 2012) (Figure 2).

To simplify the display and use of the sensory lexicon and wheel, odor and aroma descriptors were grouped together as were descriptors related to off-odors/flavors which were compiled in the class "extraneous".

Lexicon Development for Untrained Panelists: Comparison across Countries and with Trained Panelists

Figure 3 compiles the vocabulary used to describe hibiscus teas by trained panelists, by Senegalese hibiscus teas' consumers and by French and Portuguese consumers, who were mostly unfamiliar with these beverages.

Seventeen sensory terms were used by subjects to describe hibiscus teas during interviews and focus groups sessions. Three were used to describe color: light red, dark red and pink. The latter, however, was only mentioned by European subjects, as well as the terms clear and fluid/viscous to describe appearance. Regarding aroma and flavor, Senegalese subjects used terms hibiscus, fermented, irritant and sharp odor, whereas Europeans mentioned fruity, floral and red fruits. This is explained both by the characteristics of the samples evaluated in each location and cultural differences in the recognition of hibiscus odor (by Europeans) and red fruits (by Senegalese), attributable to lack of familiarity with the stimuli. Tu, et al. (2010) for of soy yogurts evaluated by French and Vietnamese and Yang *et al.* (2012) for description of perilla oil by American, Chinese and Korean panels, reported similar finding. In both cross-cultural studies panelists used different familiar descriptors that related to their individual experiences, consumption habits and cultural background to characterize the samples.

Finally, taste/mouthfeel attributes sweet, acid, bitter and astringency were elicited by subjects in all three countries.

All terms used by untrained subjects to describe the sensory characteristics of hibiscus teas were also elicited by trained panelists during lexicon development. However, some of these were not included in the trained panelist lexicon when more precise or specific terms were favored. In line with previous studies comparing sensory lexicon used by untrained and trained panelists (Chollet and Valentin 2001; Hayakawa, et al. 2010) untrained subjects used fewer terms and choice of descriptors related to aromatic characteristics was more precise and specific than untrained assessors.

Twelve terms were additionally used by untrained subjects to describe overall impressions. Most of these were common to participants for the three countries, with the exceptions being full bodied, simple, tisane like and instant drink like used only by Portuguese/French subjects and strong/light in hibiscus used only by Senegalese participants. Trained panelists conversely to untrained subjects did not use overall impression descriptors.

Cross-Cultural Lexicon Application: Consumer CATA Descriptions of Hibiscus Teas and Comparison with Trained Panelists' Evaluations

Fig. 4 depicts the first two dimensions of the Multiple Factor Analysis (MFA) plot of sensory evaluations by trained panelists and CATA results from consumers in A) France and Portugal (78.7% of variance explained), and B) Senegal (92.5% of variance explained).

Visual comparison of the relative position of CATA terms indicates high similarities between the two European countries regarding term elicitation. This is confirmed by the high RV coefficients relating the corresponding sensory spaces (0.965, $p<0.01$). Terms natural/artificial were an exception, indicating that Portuguese and French participants

used different cues to infer about the natural/artificial nature of hibiscus teas. High RV coefficients were also found for the sensory spaces defined by trained panelists evaluations and consumers in France and Portugal (0.961 and 0.951, respectively, $p<0.01$). Moreover, significant or marginally significant, positive correlations were found between trained panelists' evaluations and Portuguese and French consumers' elicitations of the terms red color ($p<0.05$), acid ($p<0.10$), sweet ($p<0.05$), bitter ($p<0.10$) and astringent ($p<0.05$) attributes, and between evaluations of aronia/cranberry odor and the term red fruit ($p<0.10$). Meanwhile, non-significant correlations were found between evaluations of aronia/cranberry odor and the term fruity, as well as between hibiscus odor and flavor evaluations and terms floral, fruity and red fruit. CATA terms full bodied and strong (overall impression) were marginally associated to sensory evaluations of red color, hibiscus odor and flavor and acid taste ($p<0.10$), with the exception of the association between acid taste and full bodied for Portuguese consumers.

Similarly to what was obtained for European consumers, a high RV coefficient was found between the sensory spaces relating trained panelists and Senegalese consumer evaluations (0.927, $p<0.01$). Moreover, a strong positive relationship between trained panelists and consumers' term elicitations was also observed for attributes acid, sweet, bitter and astringent ($p<0.01$). However, elicitation of the hibiscus term was more closely associated to evaluations of acid taste ($p<0.01$) than those of actual hibiscus odor and flavor ($p>0.10$). A possible reason for this may be the traditional use of hibiscus calyces from the Koor cultivar in the preparation of hibiscus teas in Senegal, yielding infusions with a pronounced sourness, a sensory characteristic that is very much appreciated by local consumers (Bechoff, et al. 2014). Regarding overall impression, the term appealing was strongly associated to evaluations of sensory descriptors red color, hibiscus odor, hibiscus flavor ($p<0.01$). Meanwhile, the term

natural was significantly positively correlated to evaluations of aronia/cranberry odor, while artificial was related with terms light red, light in hibiscus and watery (p<0.01). Finally, the term syrup like was positively associated (p<0.10) to evaluations of sweet associated aromatics raisin and cold black tea.

CONCLUSIONS

A trilingual sensory lexicon for trained panelists of 21 attributes was defined and referenced. Attributes were assembled in a sensory to facilitate use. The lexicon was successfully used to evaluate hibiscus teas with differences in the sensory characteristics between and within product types being shown. Future studies carried out to validate or adapt the lexicon and wheel to other hibiscus cultivars and production regions of the world are however recommended.

Vocabulary used by untrained familiar subjects to describe and characterize hibiscus teas was investigated in a cross-cultural study. A consumer lexicon of 17 sensory and 12 overall impression terms was developed. Major differences between trained and untrained subjects were found as well as differences in the use of lexicon rooted on culture and product familiarity.

This work provides a foundation for practical sensory research on hibiscus teas and supports optimization whether through hibiscus calyx selection and breeding, extraction and processing methods. Moreover it should facilitate communication between the actors involved in research, production and regional/international commerce.

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