F T E R

African food tradition revisited by research

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Executive summary

The work presented in this deliverable had as main objective the sensory profiling of products resulting from process reengineering of traditional products from group 3 − plant based extracts. The new processing expected to improve food safety and product quality to facilitate their promotion and introduction to EU markets.

The products belonging to this group were Bissap - *Hibiscus sabdariffa L.*, Baobab - *Adansonia digitata L.* and Jaabi - *Ziziphus mauritiana* Lam. However, due to restrictions of Jabbi product only Bissap and Babobab was studied in Europe. In previous study in Europe sensory evaluation of the cake samples was carried out by 5 semi-trained panellists from CIRAD Montpellier (paper under submission), and sensory aspect of jaabi was not well accepted by the European consumer. For that reason, and because the reengineered product was only improved in terms of nutritional value ith no sensory improvement, we did not reached conditions to test this product in Europe.

In the case Baobab samples, four different samples were included: two syrups obtained from Baobab powder by two different processes: hot dissolution and cold dissolution; two syrups one produced from Baobab fruit and one from Baobab fruit pulp and control: a commercial pear nectar selected for comparison as standard sample recognised by Portuguese consumers and resembling similar sensory attributes. The samples were assessed by a Portuguese trained panel (n=18).

The results of sensory profiling showed similar results between the four samples, however samples produced from similar raw material, Baobab powder or fruit showed to be closer in particular concerning color hue and turbidity. The attribute that was highlighted in all samples was sweetness and all samples were considered very swee. The Baobab fruit pulp syrup was the most appreciated sample in consumer testing (see Deliverable 5.4.2.3), possibly by its sensory profile, since higher values in the attributes, namely fruit odor intensity and color hue were obtained.

Concerning Bissap descriptive analysis was performed on three hibiscus drinks, an hibiscus infusion prepared freshly from dried calyces according to Senegalese recipe for baseline comparison and two new hibiscus drinks developed under as reengineered products – an ultra-vacuum concentrate and improved syrup. The samples were assessed by a Portuguese trained panel (n=16).

Results showed a greater proximity between UVc and FTi, than with REs. REs was characterized for its strong sweetness, low acidity and weak colour intensity, while FTi showed the stronger hibiscus character. FTi and UVc had similar colour intensity, acidity and bitterness. These results are in line with the ones obtained using the consumer profiling technique, Check-all-that-apply, according to which REs was perceived to have a highly distinct sensory profile when compared with FTi and UVc, being attributed with mild descriptors (sweet, watery, syrupy and light red), and UVc and FTi were related to more aggressive ones (strong taste, acidic, bitter, astringent, dark red).

So these studies make evidence that reengineered products presented similar profiles, in particular for baobab drinks, while for baobab a very clear difference in some drinks were observed mainly in terms of Intensity. These results of Groups 3 will support the introduction of the new products in Europe and will allow selecting the best strategy to do it.

General approach

The work encompassed in this deliverable had as main objective the evaluation of sensory properties of products resulting from process reengineering of traditional functional foods that expected to overcome food safety and product quality issues to facilitate their promotion and introduction to EU markets from group 3 − plant based extracts for functional foods.
The products belonging to this group were Bissap - *Hibiscus sabdariffa L.*, Baobab - *Adansonia digitata L.* and Jaabi - *Ziziphus mauritiana* Lam.

Bissap or Karkadé is obtained from the flower of Red Sorrel (*Hibiscus sabdariffa* L.*)*. Dry calyx of the flower is used in Senegal and other Western African countries for the preparation of beverages and other products with high anthocyanins content.

Baobab or Bouye is a juice obtained from the fruit of the baobab (*Adansonia digitata L.*). The baobab is a tree that grows wild in all semi-arid and dry sub-humid areas throughout Africa and Madagascar. The fruit of the baobab or *monkey bread*, called *Bouye* in Senegal (*Buy* in wolof), is widely consumed in various forms.

Jaabi also called *Jujube (Ziziphus mauritiana* Lam.) is the fruit of the jujube tree, widely spread in the Soudano-Sahelian savannas of Africa, particularly in North-Cameroon. The fruit is locally used fresh or dried for food purpose. It is consumed as snack food or processed into flour for the preparation of pancakes, or also associated with pastry or drinks. The dried and processed fruit has a pleasant biscuit taste and a plain aromatic flavour.

The products selected for European studies of reengineered products at this stage were Bissap - *Hibiscus sabdariffa L*. and Baobab - *Adansonia digitata L.*. drinks. The sensory testing of the reengineering of product from Jaabi - *Ziziphus mauritiana*, a tree of *Rhamnacea* family locally called *Jaabi* in northern Cameroon, that is also part of this group of products could not be tested in Europe since it is a very local product, with reduced processing expression, with reduced acceptability in Europe (previous studies conducted in CIRAD, Montpelier) and with high seasonality, constraining commercial transference to Europe, and consequently from all the products from group 3, *Jabbi* was that with minor chances and interest in Europe, and for that no study was performed at this stage in Europe. Additionally, the reengineered product was tested by consumers in Cameron, but due to a storage problem with the new flour product it was not possible to do sensory study of the product, and the new production and new flours were not available till middle of January 15, constraining the sensory study in Africa or even in Europe.

The sensory profiling using trained panellists were used to provide important information regarding specific attributes of the developed products. This quantitative descriptive analysis was helpful to validate product development, validate, in some cases, the expected sensory quality improvement, and the knowledge gained was providing support to marketing and promotion studies to commercialise the new food products in the EU. In sensory analysis, one of the most important tools is the quantitative characterization of the perceivable product attributes. In the literature, this tool is referred to as ‘‘descriptive analysis”, or‘‘profiling”. The two frequently used profiling methods are quantitative descriptive analysis (QDA, developed by Stone, Sidel, Oliver, Woosley, & Singleton, 1974) and SpectrumTM (developed by Meilgaard, Civille, & Carr, 2006)), which require trained or expert panels. Considering the routinely use of the type of products in question, and because of dedicated training sessions, these panels seem to be more able to characterize products in an accurate way than naïve consumers (Worch et al, 2010). In this deliverable (D 5.4.2.3) only sensory analysis by trained panel was included, and for both products Bissap and Baobab descriptive and quantitative analysis was performed in Portugal, by a trained panel in ESB. So, these results will be also used in deliverable of sensory analysis of African countries or group 3.

So, in **Bissap and Baobab reengineered products,** the Sensory studies included the same products used in consumer preference studies performed in Portugal.

In order to efficiently assess the sensory properties of the products, the study will be described one product at a time, in order to be easier to perceive the main differences.

1. Sensory evaluation of Baobab reengineered products in Europe

1.1 Baobab Summary

The Baobab tree has an Arabic history, and belongs to the Bombacaceae family and Adansonia gender and the most common name of baobab fruit pulp in Senegal is “Monkey bread” or "Bouy".

Baobab samples used for sensory test were new Baobab syrups developed under the AFTER project scope according different protocols of a Senegalese recipe and included four different samples: two syrups were obtained from Baobab powder by two different processes: hot dissolution and cold dissolution. The other two samples were syrups produced from Baobab fruit (Esteval) and syrup from Baobab fruit pulp. All samples were diluted with potable water prior to tasting in order standardize the Brix in the range of the sample control used for comparison in sensory tests (commercial Portuguese pear nectar) corresponding to 11.1 ºB.

The sensory panel was constituted by eighteen selected and trained assessors and the samples were evaluated using Descriptive Analysis.

The main results of sensory tests showed similar results between the four Baobab samples, however samples produced from similar raw material, such as Baobab powder or fruit showed to be closer in particular concerning color hue and turbidity. The attribute that was highlighted in all samples was sweetness, since all samples were considered very sweet. The Baobab fruit pulp syrup was the most appreciated sample, and which obtained a positive value on the probability consumption.

1.2 Introduction

The Baobab tree has an Arabic history, and belongs to the Bombacaceae family and Adansonia gender.

There are eight species in the world including *Adansonia digitata L.*which is found in Senegal. This species is encountered in many African zones and has along life. In many parts of Africa tubers, fruits, seeds, leaves and flowers of this plant are identified as common ingredients in traditional dishes in rural and urban areas. African baobab is a very long-living tree. It normally lives for about 500 years, but it is believed that some trees are up to 5000 years old (Gruenwald and Galizia, 2005)

The flowering of the plant begins in June and ends in January when the fruit is fully ripened in its capsule. The fruit can be harvested all year round. The most common name of baobab fruit pulp in Senegal is “Monkey bread” or "Bouy". The baobab pulp is economically the most important food stuff, and is recognized by the EU commission as an additive and exported in many countries.

The quality characteristics are linked to some intrinsic and extrinsic parameters that govern the food products. The pulp is very nutritious. Arnold et al. (1985) reported that with an average of 8.7% moisture, the pulp contains about 74% carbohydrates, 3% proteins, 9% fibers, 6% ash and only 0.2% fat. The content of pectin is approximately 56% (Nour et al., 1980), which is why the pulp is traditionally used as a base for jam making. It is also characterized by a high vitamin C (ascorbic acid), calcium, phosphorus and potassium content. The acidulous taste is attributed to the presence of organic acids, such as citric acid, tartaric acid, malic acid and succinic acids.

Baobab fruit pulp has a particularly high antioxidant capability mainly because of its high natural vitamin C content, which is equivalent to 6 oranges per 100 g. Antioxidants protect the cells of organisms from damage by free radicals. A deficiency of vitamin C weakens the immune system and promotes the susceptibility to disease. Deficiency of vitamin C also results in scurvy. The recommended daily allowance (RDA) for ascorbic acid is 75 mg for women and 90 mg for men. If we consider that baobab has an ascorbic acid content of 300 mg per 100 g pulp, the oral intake of 25 and 30 g, respectively is able to provide the daily vitamin C allowance required by humans. Additionally, vitamin C aids the bodily uptake of iron and calcium, of which the fruit pulp contains more than double than the same amount of milk. Therefore, in some areas, it is used as a milk substitute for babies.

Baobab fruit pulp, due to the combination of health claims (such as prebiotic and antioxidant functions, the high calcium content, and the anti-inflammatory properties) and food technological functions (because of its high pectin and fiber content, baobab fruit pulp gives beverages a thicker consistency and can be also used as filler), is a very interesting candidate for a new generation of functional foods and drinks. Baobab fruit pulp can be particularly interesting as an ingredient for smoothies, which are a kind of thick fruit juice with a high content of fruit pulp. From July 2008, "An exotic fruit with six times the vitamin C of an orange can be sold in Britain after an EU ruling.

In studies carried out under the project were applied reengineering technologies for optimization of a dried powder from Baobab pulp, which can be reconstituted when necessary for the production of Baobab drinks. Drying contributes to the shelf stability for the export market. From dried powder and using new technology new improved Baobab syrups were produced.

The aim of the present work was to gather information about sensory profile by a trained panel using QDA approach. Four samples (n=4) were tested, two syrups were obtained from Baobab improved powder by two different processes: hot dissolution and cold dissolution. The other two samples included syrup produced from Baobab fruit and pulp fruit. Sensory profiles of selected drinks were determined using a trained panel (n=18) and an established Baobab drink sensory language.

Consumers' profiling and acceptance was also studied for these drinks as part of project AFTER and has been reported in deliverable 5.4.2.3.

1.3 Material and methods

1.3.1 Baobab samples and sample preparation

Baobab samples for sensory tests were new Baobab syrups developed under the AFTER project scope according different protocols of Senegalese recipe.

The Baobab samples included four different samples: two syrups obtained from Baobab powder by two different processes: hot dissolution and cold dissolution; two syrups one produced from Baobab fruit and one from Baobab fruit pulp.

Given the results of the different training and preliminary testing sessions with the panel a commercial pear nectar was selected for comparison with a standard sample recognised by Portuguese consumers and resembling similar sensory attributes.

All samples were diluted with potable water prior to tasting in order to obtain a Brix in the range of the control sample used for comparison (commercial pear nectar) corresponding to 11.1 ºB.

Five different samples were coded and presented to the panellists as following (Figure 1):

1. Syrup from Baobab power cold dissolution (BSCD)
2. Syrup from Baobab power hot dissolution(BSHD)
3. Syrup from Baobab fruit pulp (BSFP)
4. Syrup from Baobab fruit (Esteval) (BSFE)
5. Commercial pear nectar (Standard) (CPN)

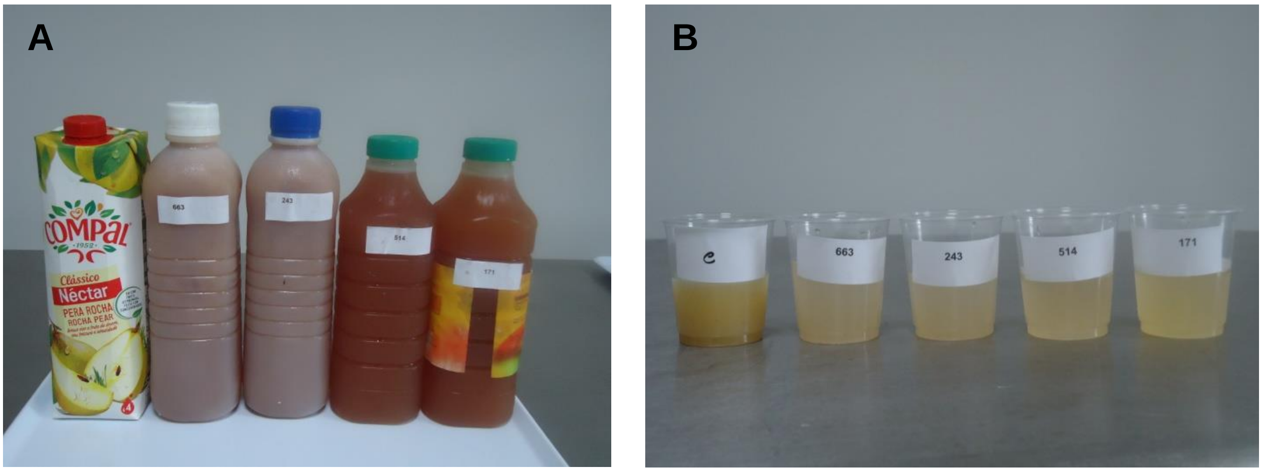

Figure 1 – A - Baobab syrups and commercial pear nectar. **B -** Baobab syrups samples diluted to obtain a standard Brix and commercial pear nectar used for comparison in sensory testing.

The samples were presented to the panelists at room temperature, however they were taken from the refrigerator in advance (see Figure 2).

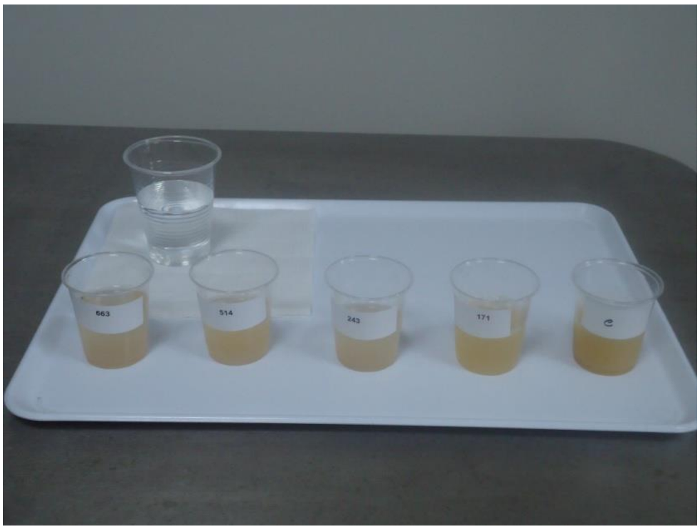

Figure 2 - Baobab syrups and commercial pear nectar as presented to the assesors.

1.3.2. Ethical assessment and consent

The study was reviewed by project AFTER’s Ethics Committee. Participants were informed about the study’s general aim and procedures for handling personal data, and gave written informed consent prior to participating in the tasting sessions. All tested samples were produced and prepared according to good hygiene and manufacturing practices. The new drinks tested resulted mainly from incremental changes in the traditional manufacturing processes, with the aim of better extracting and preserving its nutritional value while increasing its eco-efficiency. No safety or health concerns were hence introduced by such changes.

1.3.3. Test facilities

Sensory sessions took place in the laboratory of sensory evaluation with controlled room/air temperature and lightning, laboratory of the Escola Superior de Biotecnologia – Universidade Católica Portuguesa, Porto in Portugal. These facilities comply with the requirements of ISO 8589 (ISO, 2007) and comprise a training room, dedicated kitchen and sensory booths with computerized data collection. The language used for the sensory testing was Portuguese.

1.3.4. Sensory evaluation

A Descriptive Analysis was performed based on the procedure described by Stone, Sidel, Oliver, Woolsey, & Singleton, 1974, 2008.

1.3.5 Panelists

The panelists (Figure 3) were recruited and selected in compliance with ISO Standard 8586:2012 (ISO, 2012a). The sensory panel was constituted by eighteen selected assessors who completed a 3-month training period on sensory evaluation. This training focussed on language development, improvement of discriminating ability, memorization and rating intensities of selected attributes. Panel performance was evaluated in compliance with ISO 11132:2012 (ISO, 2012b).

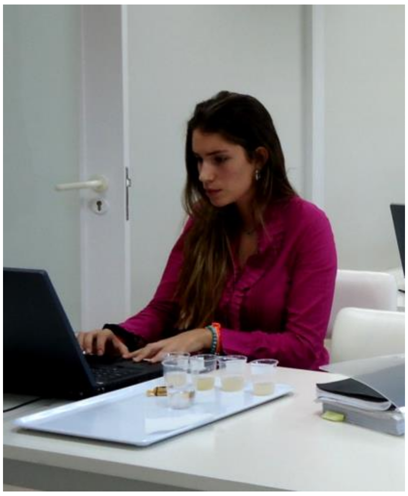

Figure 3 - Panelist participating in the sensory test.

1.3.6 Sensory attributes and tasting sessions

The Baobab samples were evaluated and rated by a trained sensory panel (as described on ISO 11035:1994 Sensory analysis — Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach based on Standard Operation Procedure 2 (SOP 2) (Figure 4).

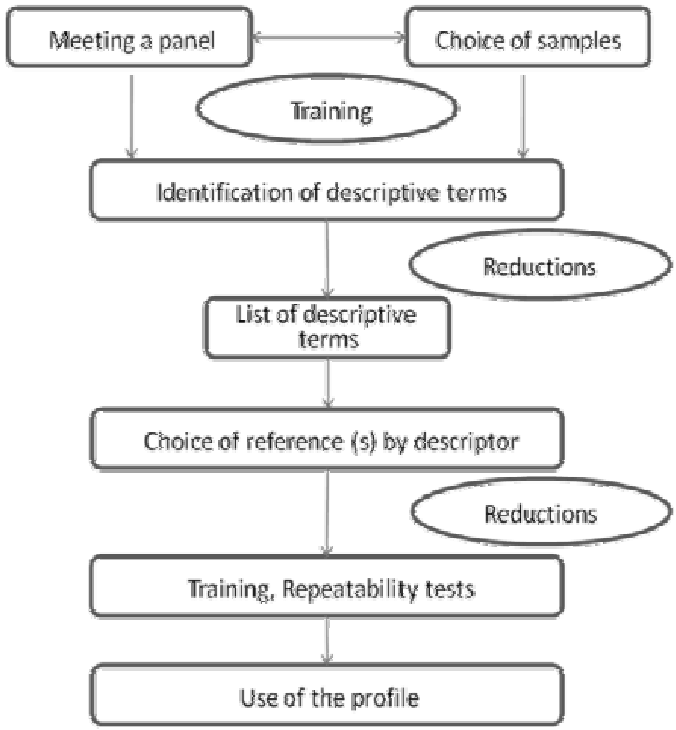

Figure 4 – Stages in identification and selection of descriptors for establishing a sensory profile.

During consecutive training sessions, the panelists were exposed to the 4 Baobab samples and to the Control (commercial pear nectar) and tried to identify all (or part of) the aforementioned attributes.

A first reduction of descriptors was performed by consensus between panellists and was followed by a second reduction using statistical techniques. Subsequently, definitions for remaining attributes were generated, reference standards defined and the standard procedure of sensory evaluation developed.

After specific training, the products were evaluated in repeated trials In each sensory session, panellists received blind coded samples randomized in order to minimize carry over and order effects. Filtered water was used as palate cleanser between the samples.

1.3.7 Statistical analysis

XLSTAT software (Addinsoft SARL, France) was used to carry out the statistical analyses. The significance of statistical tests was evaluated at $p<0.05$, unless otherwise mentioned.

To perform the second reduction of descriptors, relevance was estimated by simultaneously taking into account the frequency of mention and the perceived.

A Generalised Procrustes Analysis (GPA) on beverages the discriminating attributes was used to obtain the product's and attributes' configurations (Gower, 1975). GPA reduces the scale usage effects by detecting and minimizing individual differences (Næs et al., 2010) (Hernández-Carrión, Varela, Hernando, Fiszman, & Quiles).

1.4 Results

Eight sensory attributes were considered, being grouped by appearance (turbidity and colour hue), odour (overall intensity, fruity and herbaceous (straw)), viscosity in the mouth and flavour (fruity and sweetness). The panelist rated the beverages for every attribute, the rated the product on a 10-cm, unstructured, linear scale with anchors. The minimal value of this scale corresponded to "no sensation". The eight descriptors and related standards are described in tables 1 and 2.

Table 1 – Attributes form used for Baobab sensory descriptors

Sensory evaluation of Baobab drinks

	Panelist name			Date
	Attribute		**+ Weak**	**+Strong**
Appearance	Turbidity		Absent	Strong
	Color hue		Absent	Thick
	Other		Absent	Strong
Odour	Fruity Odour	Cooked pear	Absent	Strong
	Herbaceous	Straw / hay	Absent	Strong
	Intensity		Absent	Strong
	Other		Absent	Strong
Texture	Viscosity	In the mouth	Absent	Thick
	Other		Absent	Strong
			Absent	Strong
Flavour	Fruity flavour	Cooked pear	Absent	Strong
	Sweetness		Absent	Strong
	Other		Absent	Strong

Table 2- Baobab sensory descriptors and definitions and the references/anchors.

	Attribute		References*/Anchors	Definition
	Turbidity		Low;high	is the "optical property that causes light to be scattered scattered and absorbed rather than transmitted in straight and absorbed rather than transmitted in straight lines through the sample.
	Color hue		Absent;Strong	the color tone
Odour	Fruity Odour	Cooked pear	Absent;Strong	aromas and taste associated with cooked fruit
	Herbaceous	Straw	Absent;Strong	the aroma associated with straw
	Intensity		Absent;Strong	Intensity of the odour
Texture	Viscosity	In the mouth	Low;high	in everyday terms (and for fluids only), viscosity is "thickness". Thus, water is "thin", having a lower viscosity, while honey is "thick", having a higher viscosity
Flavor	Fruity flavour	Cooked pear	Absent;Strong	the taste associated with cooked fruit
	Sweetness		Absent;high	the taste stimulated by sucrose and other sugars, such as fructose, glucose, etc.

* The water and an commercial pear nectar were choice standard references.

The graphical representation of the final panel's mean ratings obtained in the Descriptive Analysis performed on the four studied Baobab drinks is presented in Figure 5.

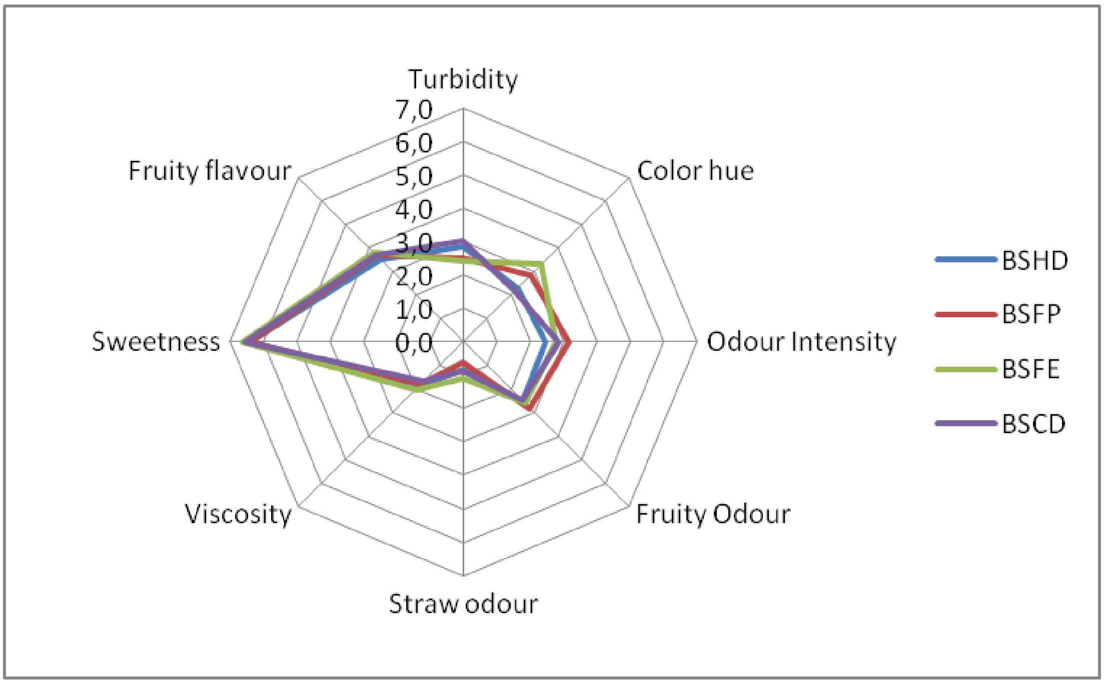

Figure 5 – QDA graphical representation of intensity of Baobab drinks descriptors (n=8). BSCD=Syrup from Baobab power cold dissolution; BSHD= Syrup from Baobab power hot dissolution; BSFP= Baobab fruit pulp (syrup); BSFE = Syrup from Baobab fruit (Esteval).

Results in figures 5 showed a high proximity between the four Baobab samples, except for the pair of samples BSHD and BSCD (similar among them) and the pair of samples BSFE and BSFP (similar among them), which showed some differences concerning attributes turbidity and color hue, comprehensive due to the similar origin of raw material.

All samples were characterized by their high sweetness and being nearly imperceptible straw odour.

Principal component analysis (PCA) was performed to establish the relationship between the sensory attributes and the Baobab drinks (BSHD, BSCD, BSFE and BSFP). The first two principal components (PCs) accounted for by 52,5 % and 34.0 % of the variance of the experimental data, respectively. As shown in Figure 6, the first PC was positively related to BSFE (syrup from Baobab fruit (Esteval) with sweetness, viscosity and straw odour, fruit flavour and colour hue attributes. On the other hand, the second PC was related to turbidity sensory attributes being associated with BSCD (syrup from Baobab power cold dissolution) and BSHD (syrup from Baobab power hot dissolution) and to BSFP (syrup Baobab fruit pulp) with fruit odour and odour intensity descriptors.

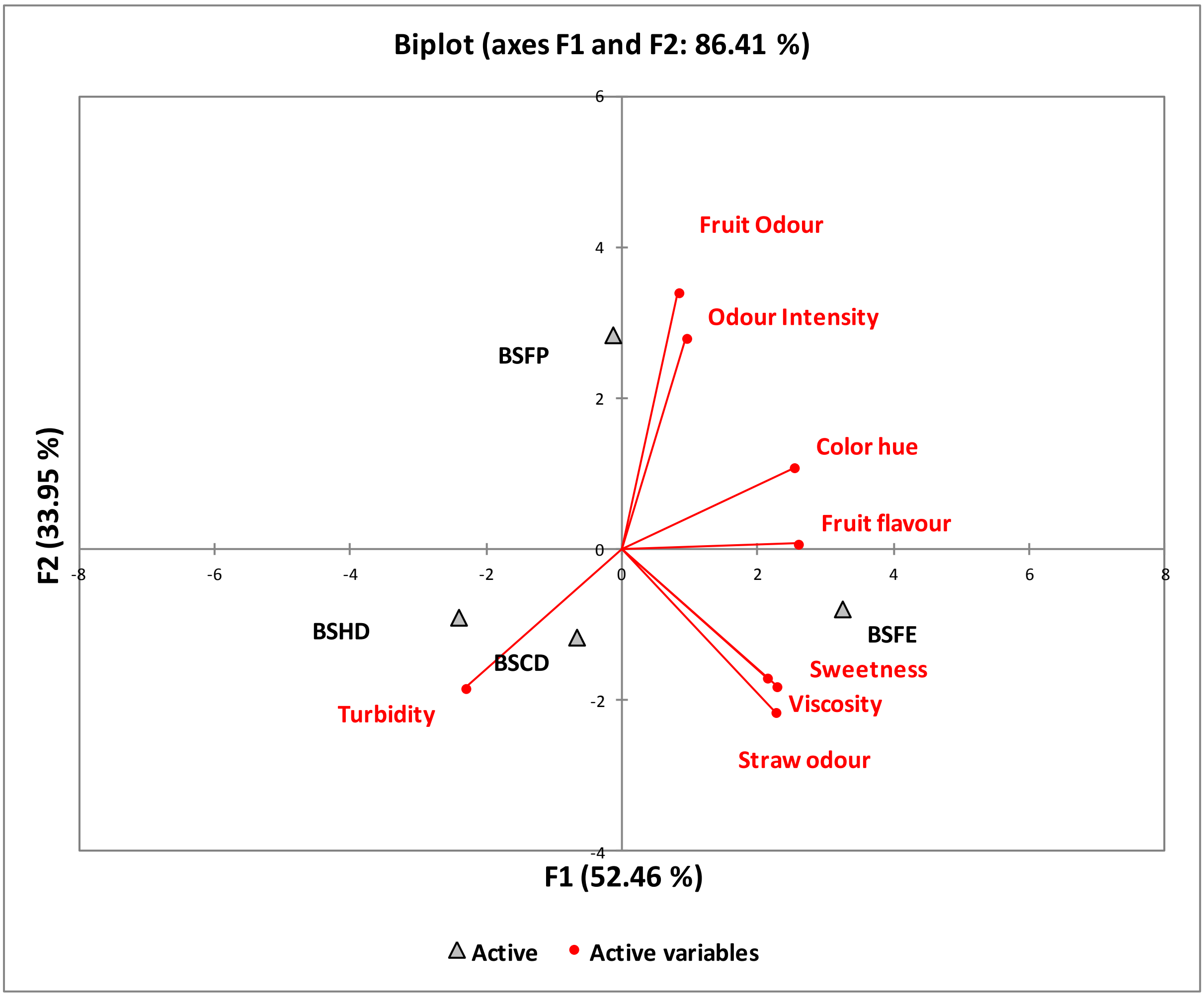

Figure 6 - Representation of the Baobab drinks and sensory attributes evaluated in the two dimensions of a GPA analysis, performed on discriminating attributes. **BSCD** = Syrup from Baobab power cold dissolution; **BSHD** = Syrup from Baobab power hot dissolution; **BSFP** = Syrup from Baobab fruit pulp; **BSFE** = Syrup from Baobab fruit (Esteval).

1.5 Conclusions

The results showed a high proximity between the four Baobab samples, however the sample BSHD= Syrup from Baobab power hot dissolution and sample BSCD=Syrup from Baobab power cold dissolution showed to be closer instead the sample BSFE = Syrup from Baobab fruit (Esteval) and sample BSFP= Baobab fruit pulp (syrup) showed also to be closer between them. This evidence was already highlighted in Figure 5, and manly justified for the closer proximity of the raw materials from where they were produced.

The attribute that was more distinguished for all samples it was sweetness and all samples were found to be very sweet. Probably, because by the lack of acidity of all drinks, this attribute has not been evaluated because the panelists not consider this attribute in any of the assessed samples, thus by this fact the sweetness of the drink appears to be more pronounced.

2. Sensory evaluation of Bissap reengineered products in Europe

2.1 Bissap summary

Three hibiscus drinks were tested, a hibiscus infusion prepared freshly from dried calyces according to Senegalese recipe for baseline comparison (FTi) and two new hibiscus drinks developed under the AFTER project scope – an ultra-vacuum concentrate (UVc) and improved syrup. Quantitative Descriptive Analysis was applied to assess sensory profiling, using a trained panel of 16 assessors. The main selected descriptors (13) for descriptive analysis of the three hibiscus beverages tested were: appearance (colour intensity), odour (overall intensity, hibiscus, herbaceous (hay), cold black tea, raisins and honey) and flavour (hibiscus, fruity cranberry/ aronia, acid, sweet, bitter and astringent). REs was characterized for its strong sweetness, low acidity and weak colour intensity, while FTi exhibited the stronger hibiscus character. Howhever, FTi and UVc had similar colour intensity, acidity and bitterness distinguishable from Res samples.

2.2 Introduction

Bissap is a non-alcoholic drink commonly consumed in African countries, particularly in Senegal. It is made from *Hibiscus sabdariffa* L. - an herbaceous plant belonging to the Malvaceae, most often from its Ordinary/Kor (Senegal) and/or Vimto (Sudan) varieties. Past research has shown that Hibiscus drinks are generally rich in vitamins, minerals and bioactive compounds.). Although there is different recipes to prepare the drink, typically in Africa is made from an extract obtained by aqueous extraction from solid to solvent ratio, at temperatures between 25 and 100 ºC. After filtration, sugar and others ingredients may be added depending of the region where it is consumed (Cissan, 2010, Rodrigues et al, 2011). It is consumed as cold or hot beverage (Sáyago-Ayerdi et al, 2007, Rodrigues et al, 2011) and different aroma compounds were found according to the preparation (Rodrigues et al, 2011).

The consumption of this drink is widespread in Africa and Asia, as far as we know little appears to have been published about European consumers' acceptance, once the drink is quite unknown in Europe. In order to achieve product acceptance followed by successful market introduction, it is prime importance to gain insight in the factors determining consumers' food choice. Understanding how consumers perceive food products is critical for food companies. This information is essential for the development and marketing of new products, the reformulation of existing ones, the optimization of manufacturing processes and the establishment of specifications in quality control programs. So based on traditional drinks assessment (sensory and quality) the traditional drinks where submitted to reengineering processing and analysed in terms of sensory profiling and consumer aceptence.

The present report describes the procedure and results of descriptive analysis performed on three hibiscus drinks, an hibiscus infusion prepared freshly from dried calyces according to Senegalese recipe for baseline comparison and two new hibiscus drinks developed under the AFTER project scope – an ultra-vacuum concentrate and improved syrup. Consumers' profiling and acceptance of these samples were also studied for these drinks as part of project AFTER and has been reported in deliverable 5.4.2.3.

2.3 Material and Methods

2.3.1 Bissap samples and preparation

Three hibiscus drinks were tested, a hibiscus infusion prepared freshly from dried calyces according to Senegalese recipe for baseline comparison (FTi) and two new hibiscus drinks developed under the AFTER project scope – an ultra-vacuum concentrate (UVc) and improved syrup (REs). All drinks were produced from ground dried calyces of the local 'Koor' and the Sudanese 'Vimto' H. var. sabdariffa cultivars (50:50), purchased at Latmingue – Kaolack.

The hibiscus infusion (FTi) was freshly prepared with 30 g of calyces soaked in 1 liter of boiling water. After 20 minutes the resulting extract was filtered, sweetened with sucrose (130 gL^{-1} and kept refrigerated until used.

The new syrup (REs) was obtained using a ratio of 1/10 dried hibiscus calices/water and 30 min extraction time at ambient temperature. The resulting infusion was filtered at 0.45 µm and pasteurized at 75ºC during 20 minutes. Sucrose was added (1.2 kg/L, until approximately 65 °Brix), the syrup was cooled down immediately, it was bottled as the product reached a temperature of 70°C and stored at room temperature.

The Under-vacuum concentrate (UVc) was obtained employing a similar process of REs, using a ratio of ground calices/water of 1/5 (w/v) and 30 minutes extraction time at ambient temperature. The filtered extract (0.45 µm) was pasteurized at 75ºC for 20 minutes, subsequently evaporated under-vacuum at 75 °C and remained unsweetened. Upon cooling to ambient temperature, the concentrate was stored at 4 to 8°C.

The REs sample was diluted 4 times with potable water prior to tasting. The UVc concentrate was diluted 40 times with potable water and sweetened with sucrose (130 gL^{-1}).

2.3.2 Ethical assessment and consent

The study was reviewed by project AFTER's Ethics Committee. Participants were informed about the study's general aim and procedures for handling personal data, and gave written informed consent prior to participating in the tasting sessions. All tested samples were produced and prepared according to good hygiene and manufacturing practices. The new drinks tested resulted mainly from incremental changes in the traditional manufacturing processes, with the aim of better extracting and preserving its nutritional value while increasing its eco-efficiency. No safety or health concerns were hence introduced by such changes.

2.3.3 Test facilities

Sensory sessions took place in the laboratory of sensory evaluation laboratory of the Escola Superior de Biotecnologia – Universidade Católica Portuguesa. These facilities comply with the requirements of ISO 8589 (ISO, 2007) and comprise a training room, dedicated kitchen and sensory booths with computerized data collection.

2.3.4 Sensory evaluation

A Quantitative Descriptive Analysis (QDA®) was performed (Stone, Sidel, Oliver, Woolsey, & Singleton, 1974, 2008).

2.3.5 Panelists

Twenty eight panellists were recruited and selected in compliance with ISO Standard 8586:2012 (ISO, 2012a). The sensory panel was constituted by sixteen selected assessors who completed a 3-month training period on sensory evaluation. This training focussed on language development, improvement of discriminating ability, memorization and rating intensities of selected attributes. Panel performance was evaluated in compliance with ISO 11132:2012 (ISO, 2012b).

2.3.6 Sensory attributes and tasting sessions

The methodology employed followed ISO standard 11035 (ISO, 1994), as presented in Figure 1.

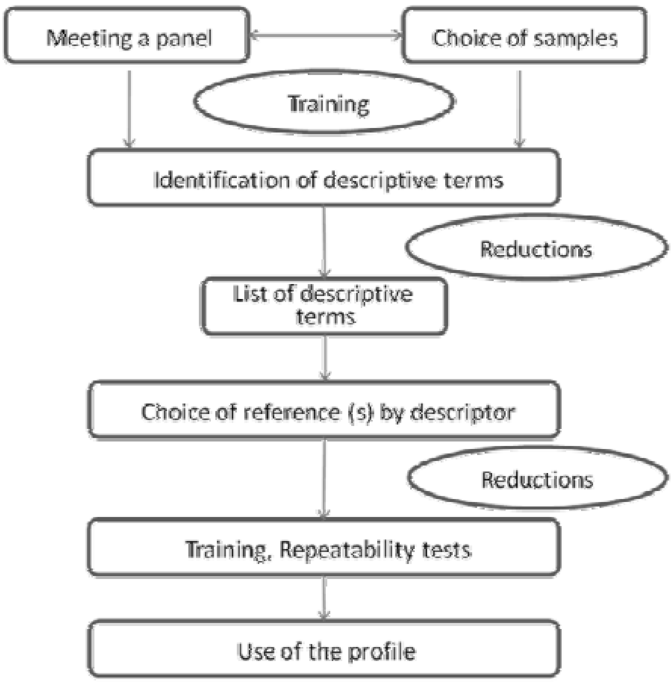

Figure 1 – Stages in identification and selection of descriptors for establishing a sensory profile

Preliminary selection of sensory descriptors was based on previous descriptive analysis of Bissap drinks held within the project After (Franco et al.; Tomlins et al.), as well as 3 on focus group sessions guided by the panel leader. In these sessions, panellists were exposed to fruits and fruit beverages, hibiscus beverages and herbal infusions. To this end, five hibiscus samples were used - an hibiscus infusion prepared from dried calyces Koor:Vimto varieties (50:50), two beverages prepared from hibiscus concentrates, one ultra-vacuum concentrate and one concentrate produced by reversed osmosis and two syrups.

A first reduction of descriptors was performed by consensus between panellists and was followed by a second reduction using statistical techniques, to estimate relevance and evaluate discriminating ability. Subsequently, definitions for remaining attributes were generated, reference standards defined and the standard procedure of sensory evaluation developed.

After specific training, the products were evaluated in repeated trials, 3 to 5 trials per panellist and sample. In each sensory session, panellists received blind coded samples randomized in order to minimize carry over and order effects. Each panellist was required to undertake the tests in an individual booth. Filtered water was used as palate cleanser between the samples.

2.3 7 Statistical analysis

XLSTAT software (Addinsoft SARL, France) was used to carry out the statistical analyses. The significance of statistical tests was evaluated at $p<0.05$, unless otherwise mentioned.

To perform the second reduction of descriptors, relevance was estimated by simultaneously taking into account the frequency of mention and the perceived intensity and using geometric means (ISO, 1994). The discriminating ability of descriptors was evaluated using non-parametric tests (Mann–Whitney *U* test, Wilcoxon signed-rank test, Kruskal–Wallis one-way analysis of variance by ranks).

The assessment of panel performance and attribute importance was performed using a mixed model ANOVA for all attributes, followed by multivariate analysis of all panellist and attributes simultaneously and using Tucker-1 method (Næs, Brockhoff, & Tomic, 2010).

A Generalised Procrustes Analysis (GPA) on beverages the discriminating attributes was used to obtain the product's and attributes' configurations (Gower, 1975). GPA reduces the scale usage effects by detecting and minimization individual differences (Næs et al., 2010) (Hernández-Carrión, Varela, Hernando, Fiszman, & Quiles).

2.3. Results

Twenty sensory attributes were initially considered, being grouped by appearance (colour intensity, viscosity, hue), odour (overall intensity, hibiscus, herbaceous (hay), cold black tea, raisins and honey) and flavour (hibiscus, cranberry, aronia, sour cherry, cherry, strawberry, raspberry, acid, sweet, bitter and astringent). After reduction, 13 descriptors were kept for descriptive analysis of the three hibiscus beverages tested: appearance (colour intensity), odour (overall intensity, hibiscus, herbaceous (hay), cold black tea, raisins and honey) and flavour (hibiscus, fruity cranberry/ aronia, acid, sweet, bitter and astringent). The panellist rated the beverages for every attribute, the panel rated the product on a 10-cm, unstructured, linear scale with anchors. The minimal value of this scale corresponded to "no sensation". The thirteen descriptors and related standards are described in tables 1 and 2.

Table 1 – Hibiscus sensory descriptors and standards

	Descriptor	Definition	Standards [(a)]
Appearance			
	Colour intensity	Intensity or strength of the colour	Standard hibiscus infusion
Odour			
	Odour intensity	Global intensity of the odour	Dried hibiscus calyces
	Hibiscus	Aromatics associated with hibiscus calyces	Dried hibiscus calyces
	Fruity (cranberry/ aronia)	Aromatics associated with cranberry and aronia fruits	Cranberry and aronia juice
	Herbaceous (hay)	Hay like odour	Air dried hay
	Honey	Aromatics associated with honey	Honey
	Cold black tea	Aromatics associated with old tea infusion	Old tea infusion
	Raisins	Raisins like aroma	Raisins
Flavour			
	Hibiscus	Aromatics of hibiscus infusion	Standard hibiscus infusion
	Acid	--	Standard hibiscus infusion
	Sweet	--	Standard hibiscus infusion
	Bitter	--	Coffee infusion
	Astringent	--	Unripe banana

[a] standard corresponding to an intensity rating of 9

Table 2 – Preparation of standards

Standard	Preparation
Standard hibiscus infusion	40g grinded (Sieve 2.8 mm-1mm) calyces Vinto : Koor (1:1). Addition of 1 litre boiling water. Extraction 30 minutes with periodic agitation. Filtration. Addition 190g sugar.
Dried hibiscus calyces	Commercial dried hibiscus calyces Vinto : Koor (1:1).
Honey	Commercial honey
Cranberry and aronia juice	Mixture of cranberry and aronia juices (50:50)
Herbaceous (hay)	Air dried hay
Cold black tea	Black tea infusion (2 tea bags lipton yellow label infusion 5 min 350ml, prepared the day

	before).
Coffee infusion	Commercial expresso coffee made from Arabica and Robusta
Raisins	Commercial raisins

Following the QDA based descriptive evaluation of the three samples, the assessment of panel performance led to the elimination of three of the sixteen panellists, due to insufficient discriminating ability or poor repeatability.

The graphical representation of the final panel's mean ratings for the three studied hibiscus drinks is presented in Figure 2.

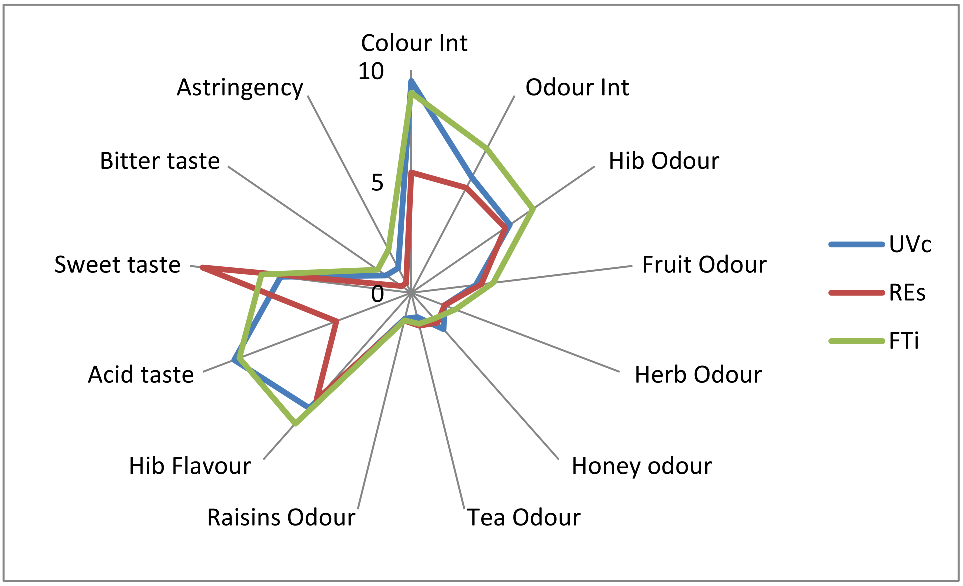

Figure 2 – QDA graphical representation of intensity of hibiscus drinks descriptors (n=13). UVc=under-vacuum concentrate; RES=improved syrup; FTi= infusion prepared from calyces; Int =overall intensity; Hib = hibiscus; Fruit = fruity cranberry/ aronia; Herb =herbaceous (hay).

The results of mixed model ANOVA analysis revealed that four of the thirteen attributes did not discriminate among beverages. The nine remaining attributes were submitted to a GPA analysis, and the results are depicted in Figure 3.

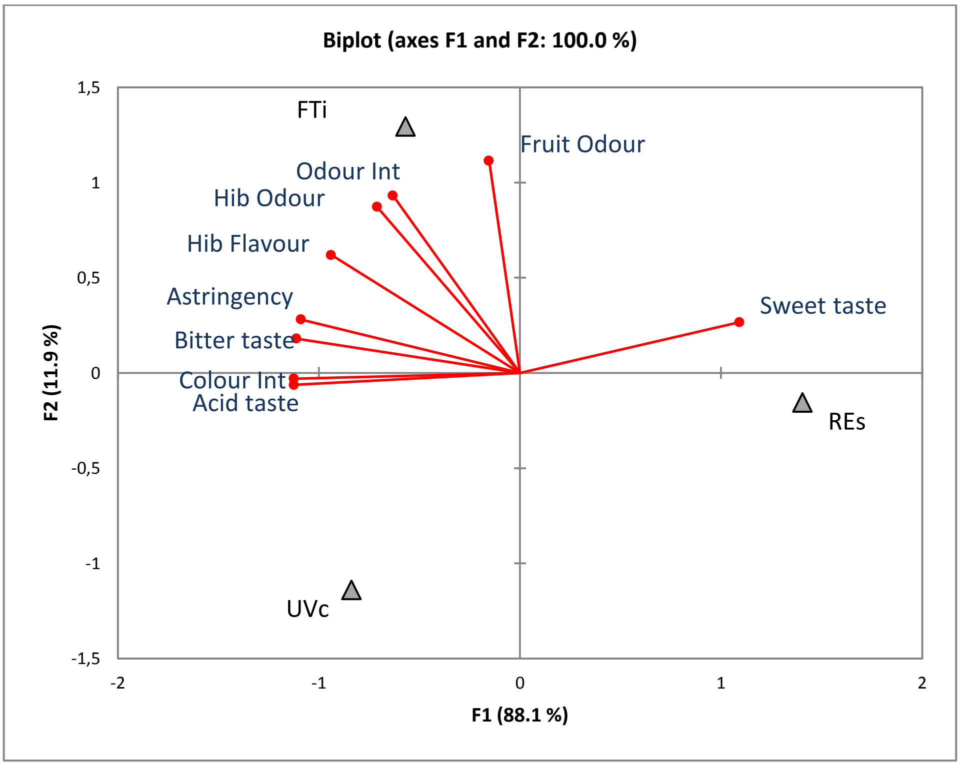

Figure 3 - Representation of the hibiscus drinks and sensory attributes evaluated in the two dimensions of a GPA analysis, performed on discriminating attributes. UVc=under-vacuum concentrate; RES=improved syrup; REi=improved infusion; CTi=traditional infusion; Int=overall intensity; Hib=hibiscus.

2.4 Conclusions

Results showed a greater proximity between UVc and FTi, than with REs. REs is characterized for its strong sweetness, low acidity and weak colour intensity, while FTi exhibited the stronger hibiscus character. FTi and UVc had similar colour intensity, acidity and bitterness. These results are in line with the ones obtained using the consumer profiling technique, Check-all-that-apply, according to witch REs was perceived to have a highly distinct sensory profile when compared with FTi and UVc, being attributed with mild descriptors (sweet, watery, syrupy and light red), UVc and FTi were related to more aggressive ones (strong taste, acidic, bitter, astringent, dark red).

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