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Nutritional Composition And Sensory Profile Of Moroccan Orange Juices.

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ABSTRACT

The aim of the present work is to compare biochemical properties of 24 industrial and natural orange juices and analyse the performance and acceptability of a group of assessors. The biochemicals tests were performed using analytical methods and the sensory analysis was also assessed by principal component analysis (PCA). Result showed that juice of bloody orange (68.10 mg/100 ml) was found to be rich in vitamin C and presented higher amount of TSS (31.4g/100ml), *Citrus sinensis*. (Berkane) contains highest content of carotenoid (0.61 mg /100 ml), while lowest content of protein and lipid was noticed in natural and industrial juices, on the other hand higher content of reducing sugar was observed in the same samples. The correlation between the scores given by the panelists and the results of biochemical parameters shows a good correlation between nutritional parameters and most attributes, besides mandarin *(citrus reticulata)* was the most preferred among the natural juices.

Keywords: citrus, juice, vitamin C, sensory analysis, PCA.

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INTRODUCTION

Orange juice (OJ) is the most important fruit juice consumed worldwide, either fresh fruit or as juices, with an estimated consumption of 1.8 billion liters a year globally [1]. Morocco is known as being one of the leaders of citrus fruits production, while consumption for 2015/16 reached 777,000 MT with annual individual consumption estimated at 19 kg per year for oranges, 11kg per year for small citrus, and 1.3 kg per year of lemon/limes.

This widespread success is due to orange juice's particularly appreciated organoleptic properties, but consumers' interest is also based on a general trend towards healthier eating and lifestyle in which fruit and vegetables play a major role, as they are natural rich sources of vitamin C, dietary fiber, and health-promoting bioactive compounds. Indeed, from the nutritional viewpoint, a serving of orange juice (240 ml) would cover the reference daily intake (RDI) amount of vitamin C. Moreover, it's very rich in natural antioxidants, mainly phenolic compounds, being an important source of flavanones, especially hesperidin and naringenin, as well as hydroxycinnamic acids (particularly in the bloody varieties) that can play a significant role as anticancer, cardiovascular and anti-inflammatory agents [2] -[3].

Orange juice is also very rich in carotenoids, being an important dietary source of vitamin A, carotenoids (β-carotene, α-carotene and β-cryptoxanthin) and antioxidant carotenoids (β-carotene, β-cryptoxanthin, zeaxanthin, and lutein). In the bloody varieties, the red color is due to the presence of anthocyanins [4]. Organoleptic properties are linked of rich and fresh flavor, on account of the sweet and acid taste and of the rich volatile profile mainly characterized by terpenes, alcohols, aldehydes and esters [5].

Sensorial characteristics of orange juice, especially its natural flavor and aroma are important attributes that affect the consumer demands. Among citrus juices, orange juice is the most appreciated and consumed because of its pleasant taste and its high content of vitamin C [6]. The objective of this study is the investigation of biochemical composition and sensory profile of natural and industrial orange juices. Moreover, we try to assess the presence of correlating biochemical analysis with the sensory profile through multivariate analyses (PCA).

MATERIALS AND METHODS

Orange juice preparation

24 samples of orange juices were purchased from different sites of production in Morocco (Figure 1) between January and March 2017, 4 natural varieties of orange from different origin: *C. sinensis* (Berkane), *C. reticulata* (Berkane), *C. sinensis* (bloody orange) (Sidi slimane), *C. sinensis* (Sidi kacem) were extracted by cutting the fruit in half and careful hand-squeezing in a kitchen juicer, and 20 industrial orange juices (11 juices and 8 nectars).

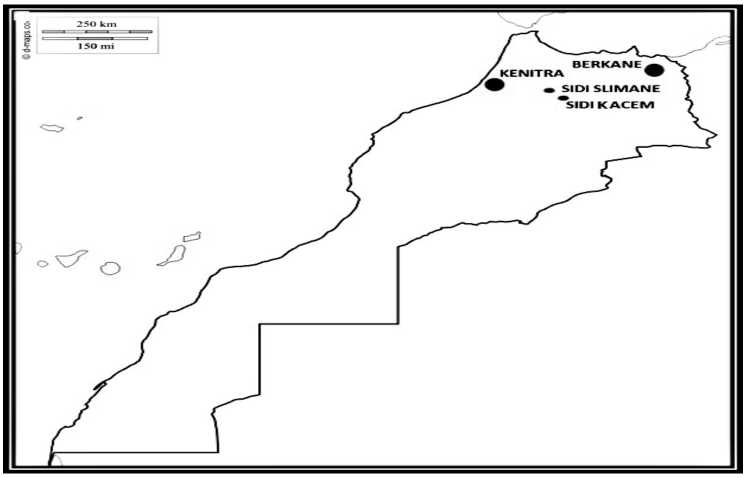

Figure 1: Geographical map of studied area

Biochemical analysis

The nutritive components of orange juice of the 24 samples were determined according to validated analytical methods. Vitamin C content was determined following a method described by [7] with DCPIP (2,6-Dichlorophenolindophenol), carotenoids content was determined by a colorimetric assay, based on procedure described by [8], protein was estimated with the method of [9], lipid content was measured using the method of Soxhlet [10] with some modifications, reducing sugar content of the varieties was determined according to the method of [11], and the level of total soluble solids (TSS), as ºBrix and % salinity were assessed using a digital handheld refractometer (DR 301-95, Germany).

Descriptive sensory analysis

A trained sensory descriptive panel was used for the descriptive sensory profile of 24 orange juices. The sensory panel was composed of 20 assessors (15 women and 5 men), ranging in age from 24 to over 50 years. To evaluate panel performance, a conventional profile was carried out with 24 juice samples served in plastic cups (25ml), orange juice was extracted before sensory tests in order to keep its freshness characteristics. Assessors evaluate the attributes (appearance, aroma, flavor, texture and overall acceptance) of the list by scoring their intensity in an unstructured line scale (0–10), 0 was the lowest and 10 were the highest score.

Table 1: Vocabulary developed to describe Moroccan orange juice.

attribute	definition
color	Intensity of orange color judged by looking into the cups.
Clearness	The state of being clear.
Brightness	The quality of being bright.
Odor intensity	It is the perceived strength of orange odour.
Pleasant odor	Odor that makes person feel comfortable.
Orange taste intensity	Perceived intensity of orange.
Acid/sugar	Balanced acidity with a sweet taste.
Pulpy	Containing pulp.
Appreciation of aroma	Overall intensity of the orange essence and aroma.
Pleasant flavor	Obviously full of flavor associated with fresh orange juice.
Acidity	A tangy acidity at the back of the mouth. the opposite of sweet, sugary.
Bitterness	Bitter sensation, lack of sweetness. It is a characteristic taste of bile, quinine and other alkaloids that produces a disagreeable and lasting sensation.
Astringency	Astringent taste causing the contraction of tongue cells.
Pleasant after taste	The length of time that the overall orange aftertaste remains up to 1 min after swallowing.

Statistical analyses

To assess the difference between samples in term of nutritive components and scores given by panellists, one-way ANOVA was performed and values were considered significant at $P \leq 0.05$. Experimental data was statistically analysed using PCA (Past Software) which allow to distinguish between different types of orange juices. All tests were done in triplicate.

RESULTS AND DISCUSSION

The values of vitamin C, carotenoids, proteins, lipids, sugars, total soluble solids (ºBrix) and % salinity of all samples analysed are summarized in Table 1. Using kruskal-wallis test there is singinficant difference between orange juices (p=0,0081).

Table 2: Biochemical characterization of different orange juices

		Samples	Vitamin C mg/100ml	Carotenoid mg/100ml	Protein g/100ml	Reducing Sugar g/100ml	Lipid g/100ml	ºBrix	%Salinity
Industrial juices	juices	1	28.76	0.15	0.00	7.00	0.10	8.30	7.10
		2	40.18	0.11	0.00	0.04	0.00	10.70	9.20
		3	13.11	0.15	0.00	12.00	0.00	11.80	10.20
		4	9.37	0.08	0.00	12.30	0.00	13.00	11.20
		5	40.60	0.08	0.70	11.20	0.10	11.40	9.80
		6	13.11	0.15	0.00	12.00	0.00	11.00	9.50
		7	38.49	0.11	0.10	11.10	0.00	11.90	10.20
		8	25.8	0.14	0.40	8.66	0.05	8.50	7.30
		9	29.60	0.18	0.70	11.00	0.10	9.50	8.20
		10	37.65	0.12	0.60	10.90	0.20	10.80	9.30
		11	38.91	0.16	0.00	12.00	0.00	11.60	10.00
		Average	28.69	0.13	0.23	9.84	0.05	10.77	9.27
	Nectars	12	38.49	0.12	0.30	12.00	0.00	12.00	10.30
		13	40.18	0.14	0.30	11.90	0.00	11.90	10.20
		14	13.11	0.15	0.30	8.70	0.10	9.40	8.50
		15	26.18	0.23	0.30	4.00	0.10	5.10	4.40
		16	13.53	0.09	0.30	12.00	0.00	11.60	9.90
		17	13.53	0.13	0.49	7.28	0.09	7.50	6.40
		18	37.65	0.22	0.40	6.44	0.05	7.50	6.10
		19	26.18	0.22	0.40	4.70	0.10	5.80	5.00
		20	39.34	0.13	0.30	9.10	0.20	11.80	10.20
		Average	27.58	0.16	0.34	8.46	0.07	9.18	7.89
Natural juices	Fresh juices	21	64.29	0.53	0.05	9.63	1.8	13.70	11.90
		22	68.10	0.60	0.01	7.8	0.00	31.40	29.10
		23	64.29	0.61	0.06	5.62	0.13	21.40	18.90
		24	63.79	0.60	0.02	11.47	0.22	13.00	11.30
	Average		65.12	0.59	0.04	8.63	0.54	19.88	17.80

(1,2,3,4,5,6,7,8,9,10,11) juices ; (12,13,14,15,16,17,18,19,20) nectars ; (21) *C. reticulata*, (22) *C. sinensis* (bloody orange): sidi slimane (23) *C. sinensis*: berkane, (24) *C. sinensis*: sidi kacem.

In orange juice, the concentration of vitamin C is the most important indicator of nutritional quality. Ascorbic acid contents of orange juices studied ranged from 9.37 to 68.10 mg/100 ml. The average value of ascorbic acid found in fruit juices was higher than that determined in industrial juices. The results of the study presented in Table 1 reflect that highest amount of vitamin C in bloody orange (68.10 mg/100 ml) followed by *C. sinensis* (berkane) and *C. reticulata* (64.29mg/100 ml), Our results were concording to those reported by [9] showing higher concentration for orange varieties (64mg/100g) but significantly higher than those reported by [12] finding (50 mg /100 ml) for orange juice.

The vitamin C may vary largely due to climatic conditions, topographical variation nature of soil and maturity of fruit [9]. In this context, it is well-known that thermal processing of orange juice in the industry has a negative effect, not only on the levels of ascorbic acid, but also it may cause changes in functional molecules, vitamins and other nutrients [9]-[13]. The levels of vitamin C in industrial juices were slightly lower than the fresh juices which may be due in part to the different industrial processing, to the storage conditions and dilutions.

Carotenoids are qualitive indicators of orange juice as they contribute to color and nutritional value. The different varieties investigated showed variations in their carotenoid contents. The industrial juices presented the lowest total carotenoids content less than 0,23 mg /100 ml, while *C. sinensis* (Berkane) showed the highest levels (0.61 mg /100 ml), followed by *C. sinensis* (Sidi Kacem) and bloody orange (0.60 mg /100 ml), which is relatively similar to the results found by [14].

As mentioned for vitamin C, the carotenoid contents of the different juices are different, due to the numerous factors affecting carotenoid composition, like climate, soil and season harvested [15].
From the Table 1, lowest amount of proteins was observed in industrial juices and citrus juices ranged from 0 to 0.7 g/100ml, the results obtained by [9]. were in disagreement with those found by our study, they established a higher content of total soluble proteins for citrus fruits.

This study showed that lipid contents of the citrus juices and industrial juices are negligible at a percentage of about 0.22% except *C. reticulata* which represent 1.8%. These results are in accordance with the values reported by [16].

Sugar constitutes the largest quantity of the total soluble solids in orange juice [17]. The results (Table 1) reflect that highest amount of reducing sugar content in industrial juices and fresh juices. The levels of reducing sugars detected were similar to those reported by [18].

Concerning TSS the highest value was found in fruit juices varied between (31.4g/100ml) in bloody orange and (13g/100ml) in *C. sinensis* (Sidi kacem), while the lowest value was found in industrial juices ranged from 5.10 to 13 g/100ml. This result is in agreement with the values normally reported for oranges and *C. reticulata* by [19].

Salinity percentage ranged from 4.4% to 29.1%, with a higher salinity value of 29.1% in bloody orange. These lower correlation values imply the possible independent genetic mechanisms controlling the biochemical properties of fruit juice in citrus.

As one basic principle in developing sensory techniques, multivariate analysis plays a fundamental part. A main objective of sensory profiling is to determine differences in attributes'intensity among samples, also studied the correlation between groups of samples and their main nutritional and biochemical characteristics.

Dimensional analysis (PCA) of Biochemical assay

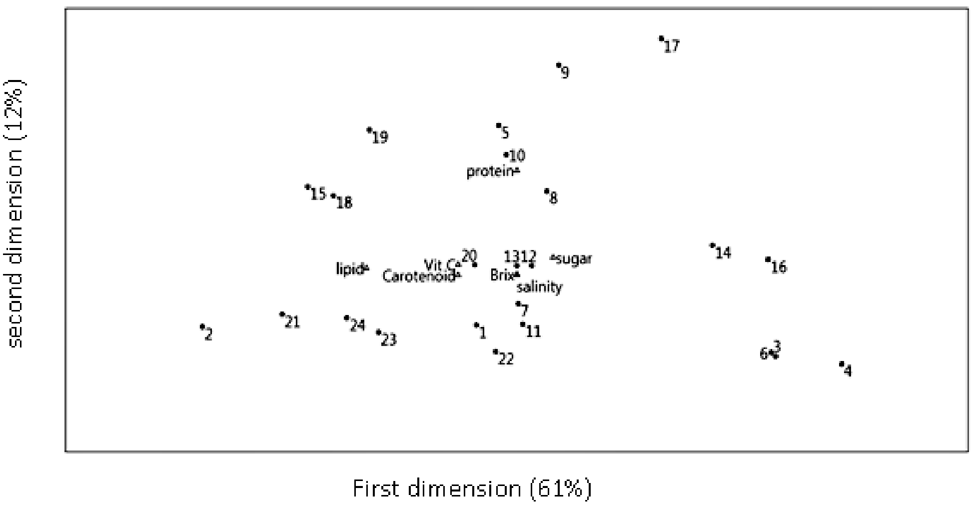

Figure 2: Principal component analysis of biochemical variable of different orange juices varieties. (1,2,3,4,5,6,7,8,9,10,11) juices ; (12,13,14,15,16,17,18,19,20) nectars ; (21) *C. reticulata*, (22) *C. sinensis* (bloody orange): sidi slimane (23) *C. sinensis*: berkane, (24) *C. sinensis*: sidi kacem.

To better understand the relationships among the variables studied for the different samples, a principal component analysis (PCA) were used to the results obtained. The later (PCA) showed separated the oranges groups into two groups with PC1 in 61% and PC2 in 12% (Figure 2). Sugar, Brix and salinity are correlated with some nectars and one industrial juice (7) and contributed positively to PC1, protein is correlated with some industrial juice and contributed positively to PC1, besides vitamin C, carotenoid and lipid are correlated with fresh juices and contributed positively to PC1. Most industrial orange juices are negatively correlated to PC1 and PC2.

Although consumers usually do not know the difference between juice and nectar, fruit juice concentration differentiates them. Nectars are diluted in water thus containing less fruit content, presents added sugar, colors and preservatives [20], that are generally cheaper than fruit that's why its presented an extremely high Brix and reducing sugar correlation. On the other side, the levels of vitamin C and carotenoids in the natural juices studied were clearly higher than the industrial juices and nectar which may be due in part to the different industrial processing, with a complete absence of concentration processes, and to the storage conditions of industrial juices. In relation to this, it has been demonstrated, in frozen orange juices, that the content of ascorbic acid declined noticeably in both pasteurized and unpasteurized orange juices stored at a temperature of -18C or lower over a long term [21]. Concerning carotenoid content, in a recent study [22], a significant decrease in the total amount of carotenoids has been reported after pasteurization at 90 °C for 30 s. Important losses of violaxanthin and antheraxanthin were observed, although the content of provitamin A carotenoids did not change considerably.

PCA of tasting analysis

The total variability was explained by 13 principal components, the first principal components explained 55.87% of the total variation. Nearly 30.60% of the variability observed was explained by the second components.

Figure 3 illustrate the attributes of freshly squeezed and industrial orange juices according to the first and the second dimension obtained by PCA. the 24 juices were found in different locations of the PCA plot, thus reflecting the distinctive sensorial and flavor differences among the samples. Since most attributes were highly closer in PC1 (the exceptions was Bitterness and Astringency), As could be expected attributes of pleasant odor, acid/sugar, orange taste intensity, flavor, appreciation of aroma and pleasant aftertaste were highly positively correlated with natural juices in the map and distinguished as one groups. The exception was acidity, pulpy, astringency and bitterness represented far from each other.

The most sensory characteristic associated with industrial juices and nectars were acidity, acid/sugar and odor intensity which were positively correlated to PC1 and PC2.

As a result of the industrial processing, storage and other factors changes in the composition take place and colour changes can occur, sometimes visually noticed, besides increased storage time lead to a decrease in sweet odor and strength of the orange odor [23]. Also, flavor, aftertaste and appreciation of aroma of natural orange juice is due to the volatile compounds. According to a study by [24] in freshly squeezed orange juice more than 300 aroma compounds have been identified by gas chromatography–mass spectrometry (GC-MS) analytical methods, of which less than 25 appear to have significant odour activity at levels found in fresh orange juice, but the number and composition of aroma-active compounds required to reproduce the orange odour still has not been generally accepted. It must also be taken into account that the volatile composition changes with agricultural factors (variety, maturity, soil) and technological process (pasteurization, concentration) [25].

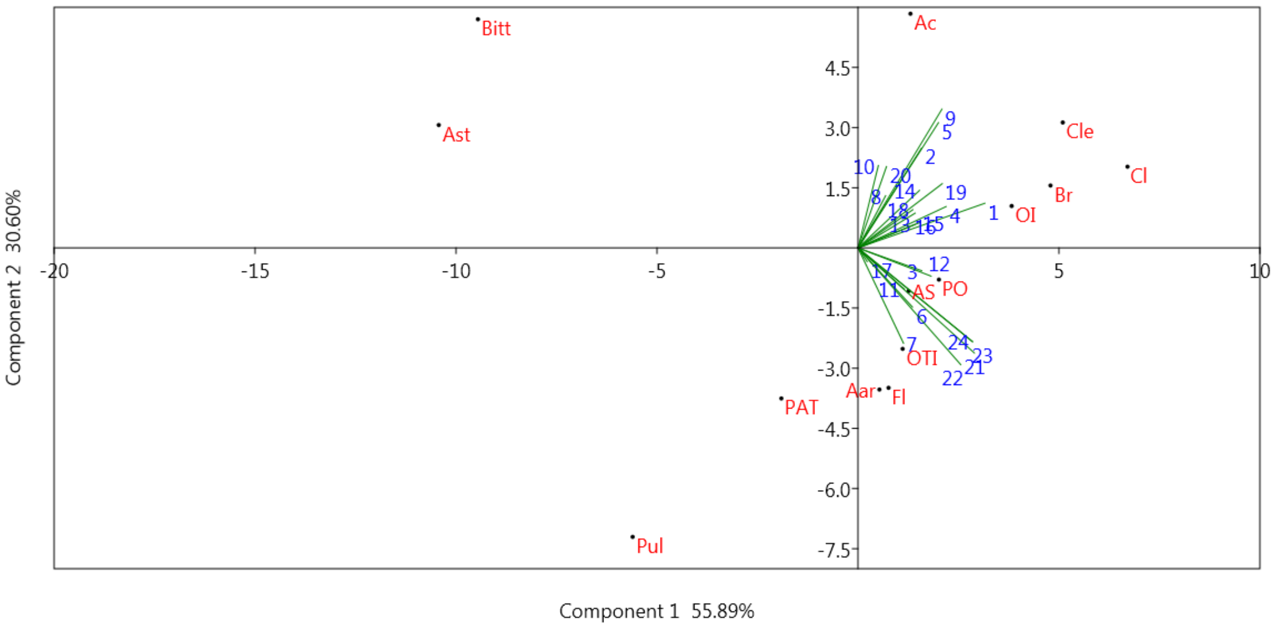

Figure 3: Principal component analysis (PC1and PC2) of sensory attributes of orange juice

(Cl: Color. Clr: Clearness. Br: Brightness. OI: Odor intensity. PO: Pleasant Odor. OTI: Orange taste intensity. AS: acid/sugar. Pul: Pulpy. Aar: Appreciation of aroma. Fl:flavor. Ac: Acidity. Bittr: Bitterness. Ast: Astringency. PAT: Pleasant aftertaste.

Analysis of sensory quality of orange juices

The results of the consumer acceptability study are shown in figure 4. significant differences (*P*≤0.05) were detected by the panellists between natural juices, industrial juices and nectars. For freshly orange juice, seven attributes were selected, namely color, clearness, brightness, odor intensity, pleasant odor, orange taste intensity, acid/sugar, pulpy, appreciation of aroma, flavor and pleasant aftertaste. On the other sides industrial juices and nectar were characterized by acidity, bitterness and astringency and not appreciated by consumers.

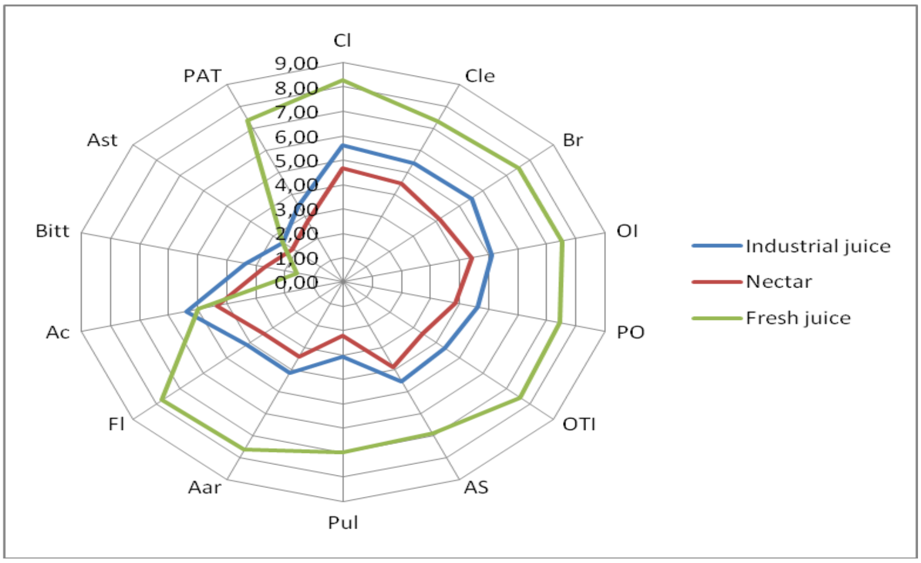

Figure 4: Graphical plot of sensory analysis of specific attributes of different orange juices.

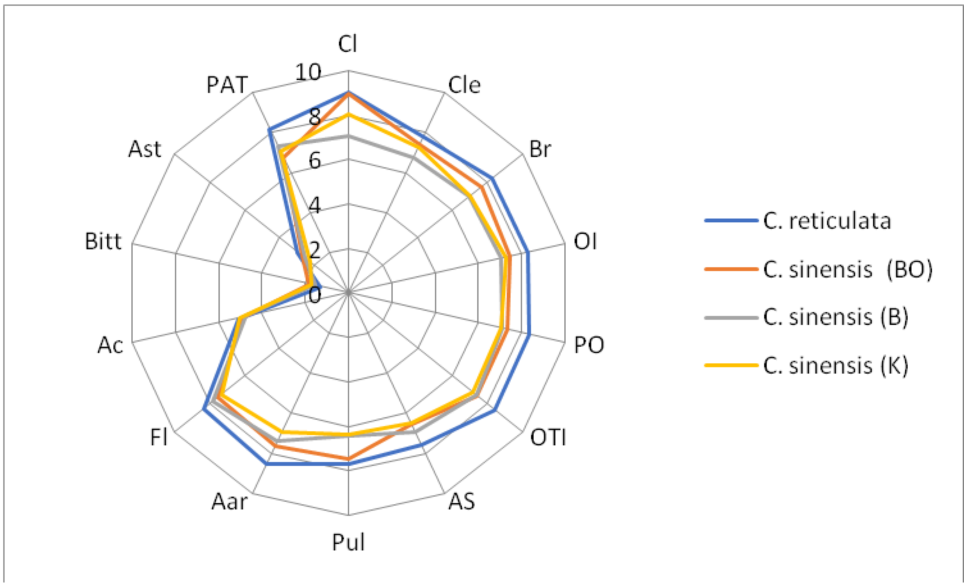

Figure 5: Graphical plot of sensory analysis of specific attributes of natural orange juices.

Figure 5 showed the results of the evaluation of sensory properties of the four natural juices. There is no significant differences (*P*≥0.05) between samples. It can be concluded that most juices gave maximum acceptability scores, but mandarin (*C. reticulata*) is the best prefered by consumers because of its flavor, aroma and pleasant taste. These results are in agreement with the findings by [26]. Thus, these results confirm that the mandarin which is the most abundant in morocco, is also the variety suitable for producing high quality juices and preparing commercial juices.

CONCLUSION

In Conclusions 24 samples of orange juices were characterised through measuring their physicochemical properties and a list of 14 descriptors suitable to profile fresh and industrial orange juices used to evaluate performance of a group of panellists with experience in sensory analysis. The result of our study showed that bloody orange is a good source of vitamin C (68.10 mg/100 ml) followed by *C. sinensis* (berkane) and *C. reticulata* (64.29mg/100 ml), while *C. sinensis* (Berkane) contains highest amount of carotenoid (0.61 mg /100 ml), followed by *C.sinensis* (Sidi Kacem) and bloody orange (0.60 mg /100 ml), lowest content of protein and lipid was observed in natural and industrial juices. Furthermore, industrial and fresh juices contained the highest amount of reducing sugar; it was found that highest value of TSS was detected in fruit juices (31.4g/100ml) in bloody orange, while the lowest value was found on industrial juices.

Good correlations were found between sensory profiles and chemical composition with the aid of multivariate analysis. Regarding acceptability test, most industrial juices were rejected by the panellist, but all freshly juices were accepted, mandarin (C. reticulata) was the best prefered.These results are of great importance for the moroccan citrus industry, since it is the most abundant variety and will constitute the main source of raw material for processing plants. Hence, this finding may benefit future work correlating sensory perception with a larger number of orange juices.

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