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RESEARCH ARTICLE

POMOLOGICAL AND NUTRITIONAL CHARACTERIZATION OF SOME VARIETIES OF GRAPEFRUIT (CITRUS PARADISI MACF)

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ABSTRACT

The aim of this work was to determine some fruit quality parameters of grapefruit "Citrus Paradisi Macf" including, weight, diameter, peel, seed number, juice content, titratable acidity, soluble solids, maturity index, as well as its antioxidant content. Fruits ''Mac carty'', ''Natsu mikan'', ''Triumphe'', ''Marsh'', ''Thompson", ''Java'', ''Ruby'' and ''Foster'' Collection of citrus INRA Morocco were used. In this study, we have only found that the three varieties: ''Marsh'', ''Triumphe'' and ''Java'' have respectively significant juice content (40.13 ± 0.090%, 39.36% and 38.57 ± 0.010 ± 0.020%) and sugar (9.47% ± 0.057, 8.70 ± 0.010% and 7, 20 ± 0.10%) but a relatively low acidity (1.56 ± 0.010%, 1.45% and 1.15 ± 0.000 ± 0.010%). In addition, ''Marsh'' had a rich in caroténoïds (0.0967 ± 0.07506 mg / L) compared to ''Triumph''e and ''Java''. Moreover, in the variety ''Natsu mikan'' and ''Foster'' the concentration of ascorbic acid was much higher (592.2 mg / L and 516,53mg / L), but the caroténoïds content and sugar was low. On the other hand, the ''Mac Carty'' proved very rich in caroténoïds (0.1800 ± 0.01000 mg / L), acidity (1.85 ± 0.040%) and sugar (10.33 ± 0.058%). According to our results, Grapefruit ''Marsh'', ''Natsu mikan'', ''Foster'' and ''Mac carty'' have proved to be good sources of natural antioxidants among the varieties studied.

INTRODUCTION

Grape fruit (*Citrus Paradisi Macfadyen*) Swingle, (1943). Is regarded as a natural hybrid of grapefruit (C.grandis L.BSF), and sweet orange (C. Sinensis L. OSB) (Scora *et al*, 1982; Kumamoto *et al*, 1987; Yamamoto *et al*, 1993). It is considered as unique, because it is the only type of citrus known to be from Barbados islands, the Caribbean (the New World) compared to grapefruits and other citrus species which originate from tropical and subtropical areas (Asian regions) (J.forsyth, 2003). Grapefruit has become of great economical value when it was introduced in Florida, where most of commercial varieties come from (Hodgson, 1967).Grapefruits are highly polyembryonic varieties, all clones are nucellar embryo. Genetic variability within the group are associated to natural mutations (Hodgson, 1967; Gmitter Jr., 1993). The grapefruits are generally classified on the basis of their skin color: yellow, pink and red. Yellow grapefruit include: Duncan, Marsh, Oroblanco, Sweetie, Jaffa Sweetie and Melogold. Pink varieties include: Henderson, Ruby, Ray Ruby, Red Blush, Thompson and Foster. Red ones are: Star Ruby, Rio Star, Rio Red and Sunrise.

Nowadays, grapefruit has become a key commercial agriculture in The United States, namely, in Texas, Arizona, California and Florida. In Florida, more than 2.5 million tonnes of grapefruit are harvested each year. The USA produces 60% of grapefruit in the world. Grapefruits are also grown and marketed in Spain, Morocco, Israel, Jordan, South Africa, Brazil, Mexico, Jamaica, and in Asia. The main caroténoïds of grapefruit were identified as lycopene and β-carotene by searchers at the beginning of 1930 till 1950 (Matlack, 1935; Curl, *et al* 1957). Caroténoïds are the main pigments in the peels of fruit walls of most citrus cultivars which contribute in different fruit colours ranging from yellow, gold to red. Their presence in the vesicles of juice makes the citrus as an important nutrtional source (Xu, Chang-Jie *et al* 2006). Citrus fruit caroténoïds composition is one of the first factors of the fresh fruit and fruit juice quality; they are micronutrients of several biological functions. (Olsen, 1989; Van Vliet and al 1996; Parker, 1996. Some caroténoïds (essentially β-carotène, α-carotene et β cryptoxanthine) are

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provitamins A. in fact, B carotene during cleavage reaction leads to the formation of two molecules of vitamin A or ritenol whereas other caroténoïds as α-carotene or β- cryptoxanthine allows for the formation of only one molecule of vitamin A. caroténoïds are also antioxydants (Garner *et al*. 2000; Sanchezmoreno *et al*. 2003). It is thanks to this feature that caroténoïds are related to the prevention from certain cancers and cardiovascular diseases (Krinsky, 1993; Yano, 1999; Murakami, 2000; Mayne, 2003; Nishino, 2009).

Quantitatively rather than qualitatively speaking, vitamin C or salicylic acid is the major organic antioxydant of citrus (Rock E and Fardet A, 2014), vitamin C provides other functions depending on it reducing property, namely in maintaining the ion of the iron at the level of the active sites of the enzyme in the ferrous form and conferring maximum activity in these enzymes. Furthermore, a study published by the same authors showed that the relative risk of cardiovascular risk factors is significantly decreased by intakes of antioxidants (Rock E and Fardet A, 2014). Another study done by Knekt *et al* (2002) on the effect of citrus fruit shows the relative risk associated with the consumption of oranges or grapefruit is respectively of 0,79 (IC : 0,64–0,98) and of 0,63 (IC : 0,57–0,99), consumption of grapefruit could better reduce the cardiovascular risk than consumption of oranges.

Sugars and organic acids are soluble solids in fruit juice. In addition, content sugar and organic acids determine largely sensory properties of fruit juices. Organic acids are the second component of the most abundant soluble solids in fruit juice, and are typically present in approximately 1% of the total weight of a juice (Huang *et al*, 2009). Concerning the total soluble solids, acids and report Brix and acidity are the main indicators of quality for fruit juices (Huang *et al*, 2009). The objective of this work is the valorisation of our germplasme of grapefruit from the collection of the INRA in terms of richness in antioxidants, including vitamin C and caroténoïds. This will also introduce these genetic resources of citrus in the program of the creation of variety of antioxidant-rich citrus.

MATERIALS AND METHODS

Plant materials

The fruits of Mac carty, Natsu Mikan, Triumphe, Marsh, Thompson, Java Foster and Ruby grapefruit (Citrus Paradisi Macf) derived from the collection of citrus planted in the experimental field of the INRA Morocco next to Kenitra , were collected during the 2012-2013 season. Fruits were collected from adult trees, and were subject to the same agricultural conditions (water, fertilizers and pesticides). For each genotype, 10 fruits were harvested on 3 commercial mature trees. In the laboratory, their weights and their diameters were measured, the stage of the fruit maturity was determined using, the recommended indicators: the juice content, titratable acidity (using a solution of NaOH 0, 1 m), the soluble solids (°Brix) using a réfractomèter and maturity index (Sanson, 1986; Davies *et Al*brigo, 1994). Juices were pressed the same day, filtered with 1 mm mesh sieve and placed in ambered bottles and stored at -18°C for later analysis.

Table 1 Distribution of weight, diameter, bark, number of seed per fruit, juice percentage, titratable acidity, Brix degree and maturity index of eight varieties Grapefruit study.

Varieties	Weight (g) Moy±σ [IC à95%]	Diamètre (mm) Moy±σ [IC à95%]	Bark (mm) Moy±σ [IC à95%]	NSF Moy±σ [IC à95%]
Mac carty	596,99 ± 31,70d [574,32- 619,67]	105 ± 9,70ab [98,01 - 111,90]	8,05 ± 1,28a [7,13 - 8,96]	15,40 ± 2,22c [13,81 - 16,99]
Natsu mikan	384 ± 60,61a [340,35 - 427,07]	98 ± 4,72a [94,34 - 101,09]	9,20 ± 1,56ab [8,08 -10,32]	1,00 ±1,05a [0,25 - 1,759]
Triumphe	464 ± 74,23bc [410,83 - 517,03]	101 ± 5,72a [97,22 - 105,41]	9,15 ± 2,21ab [7,57-10,72]	0,90 ± 0,99a [0,19 - 1,61]
Marsh	413 ± 55,39ab [373,28 - 452,53]	98 ± 3,72a [95,52 - 100,84]	8,26 ±1,58a [7,13 - 9,39]	2,90 ± 1,37b [1,92 - 3,88]
Thompson	482 ± 37,78bc [454,53 - 508,58]	97 ± 8,04a [91,38 - 102,88]	9,19 ±1,65ab [8,01-10,37]	0,20 ± 0,42a [-0,10 - 0,50]
Java	663 ± 70,95de [612,24 - 713,75]	112 ± 4,69b [108,80 -115,51]	9,04 ± 1,84ab [7,72 - 10,36]	0,90 ± 0,99a [0,19 - 1,61]
Foster	495 ± 67,72c [446,49 - 543,37]	103 ± 5,11a [99,67 - 106,98]	9,19 ±1,39ab [8,19 - 10,18]	0,90 ± 0,88a [0,27- 1,53]
Ruby	688 ± 45,71e [655,08 -720,47]	113 ± 4,07b [110,32 -116,14]	10,97 ±0,96b [10,29 -11,66]	0,30 ± 0,48a [-0,05 - 0,65]
Signification	0,000	0,008	0 ,000	0,000
Variétés	**Juice (%) Moy±σ [IC à 95 %]**	**AT (%) Moy±σ [IC à 95%]**	**ESS (°Brix) Moy±σ [IC à 95%]**	**IM (ESS/AT) Moy±σ [IC à 95%]**
Mac carty	34,92±0,28a [34,23 - 35,60]	1,85±0,04d [1,75 - 1,95]	10,33±0,06f [10,19 -10,48]	5,58±0,10abc [5,34 - 5,82]
Natsu mikan	36,93±0,19cde [36,46 - 37,40]	1,45±0,01ab [1,43 - 1,47]	7,80±0,00ab [7,80 - 7,80]	5,38±0,04ab [5,28 - 5,48]
Triumphe	38,57±0,02def [38,52 - 38,62]	1,15±0,01a [1,13 -1,17]	7,20±0,10a [6,95 - 7,45]	6,26±0,14cd [5,91 - 6,61]
Marsh	40,13±0,09f [39,91 - 40,35]	1,56±0,01bcd [1,54 -1,58]	9,47±0,06ef [9,32 - 9,61]	6,07±0,05cd [5,94 - 6,20]
Thompson	35,54±0,07ab [35,37 - 35,71]	1,26 ± 0,02a [1,21 - 1,31]	8,10±0,00bc [8,10 - 8,10]	6,43±0,10d [6,18 - 6,68]
Java	39,36±0,01ef [39,34 - 39,38]	1,45 ± 0,00bc [1,45 -1,45]	8,70±0,01cde [8,45 - 8,95]	6,00±0,07bcd [5,83 - 6,17]
Foster	36,67±0,01bcd [36,65 - 36,69]	1,70±0,05cd [1,58 - 1,82]	9,03±0,06de [8,89 - 9,18]	5,31±0,13a [5,00 - 5,63]
Ruby	36,26±0,01abc [36,24 - 36,28]	1,29 ± 0,06ab [1,14 - 1,44]	8,33±0,06cd [8,19 - 8,48]	6,47±0,27d [5,80 - 7,13]
Signification	0,000	0,000	0,000	0,000

Different letters in the same column show significant differences in the level ofsignificance of 5% by Tukey test:AT= titratable acidity:NSF= number of seeds per fruit:ESS= soluble solids:IM= maturity index

Table 2 Analyses of vitamin C means between varieties of grapefruit.

Test			p-value		
Kruskal-Wallis			0,002		
Sample (I)-Sample (J)	**Test Statistics**	**Standard Error**	**Test Std. statistic**	**p**	**Adjusted p**
Mac carty-Natsu Mikan	-12,000	5,774	-2,078	0,038	1,000
Mac carty - Triumphe	-15,000	5,774	-2,598	0,009	0,262
Mac carty - Java	-18,000	5,774	-3,118	0,002	0,051
Mac carty - Marsh	-21,000	5,774	-3,637	0,000	0,008
Thompson - Triumphe	12,000	5,774	2,078	0,038	1,000
Thompson - Java	-15,000	5,774	-2,598	0,009	0,262
Thompson - Marsh	18,000	5,774	3,118	0,002	0,051
Ruby - Java	12,000	5,774	2,078	0,038	1,000
Ruby -Marsh	15,000	5,774	2,598	0,009	0,262
Foster - Marsh	12,000	5,774	2,078	0,038	1,000

Fruit quality parameters

The sugar content (°Brix)

The sugar content is determined by using a hand réfractomèter

(PR-1.Atago Co. Ltd., Japan), by putting a drop of juice on the prism and the reading is done directly, the value is expressed in (°Brix).

Table 3 analysis of the mass β-Caroténoïds in grapefruit varieties

	β-Caroténoïds in mg/L		
	Moy± σ	**E.S**	**IC at 95% per average**
P.Mac carty	[0,1800 ±0,01000]	0,00577	[0,1552; 0,2048]
P.Natsu Mikan	[0,0333±0,02887]	0,01667	[-0,0384; 0,1050]
P.Triumphe	nd	-	-
P. Marsh	[0,0967±0,07506]	0,04333	[-0,0898; 0,2831]
P.Thompson	[0,0033±0,00577]	0,00333	[-0,0110; 0,0177]
P. Java	nd	-	-
P.foster	nd	-	-
P.Ruby	[0,0300±0,02646]	0,01528	[-0,0357; 0,0957]
Total	[0,0429±0,06649]	0,01357	[0,0148; 0,0710]

Table 4 Analysis of mean difference of the β-Caroténoïds in mg/L.

Dependent variable: average of the β-Caroténoïds in mg /L			
Sample (I)-Sample (J)	**Mean différences**	**Standard**	**Signification**
	(I-J)	error	
Mac carty -Natsu mikan	0,14667*	0,02466	0,000
Mac carty -Triumphe	0,18000*	0,02466	0,000
Mac carty -Thompson	0,17667*	0,02466	0,000
Mac carty -Java	0,18000*	0,02466	0,000
Mac carty -foster	0,18000*	0,02466	0,000
Mac carty -Ruby	0,15000*	0,02466	0,000
Marsh -Triumphe	0,09667*	0,02466	0,000
Marsh -Thompson	0,09333*	0,02466	0,021
Marsh -Java	0,09667*	0,02466	0,027
Marsh -foster	0,09667*	0,02466	0,021
Marsh -Ruby	0,06667*	0,02466	0,021

Described by Lee & Castle, in (2001). 2 ml of fruit juice of each variety has been mixed with 5 ml of extraction solvent (hexane, acetone, ethanol, 50: 25:25, v/v/v), Shaked and centrifuged for 5 min 6500 rpm. The top layer of hexane containing caroténoïds was recovered and transferred to a 25 ml flask. The volume of hexane recovered is then adjusted to 25 ml with hexane. White is represented by hexane. The absorbance reading is done at 450 mm using a spectrophotometer (SP-8001.Metertech Inc. 1.09), levels of caroténoïds were calculated in mg β-carotene per liter by referring to the obtained calibration curve, using β-carotene as a calibration standard.

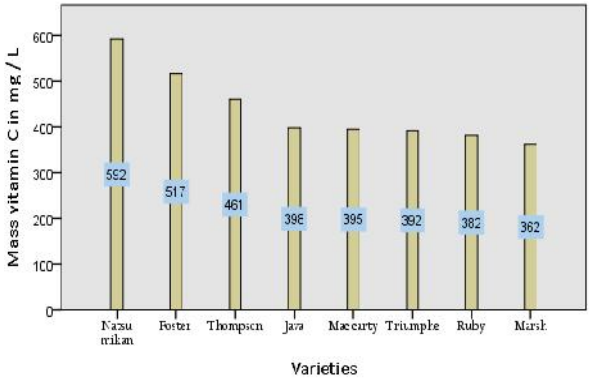

Figure 2 Content of vitamin C at the level of the juice of eight Varieties of grapefruit in mg/L

Determination of ascorbic acid

The vitamin C content is carried out by the method described

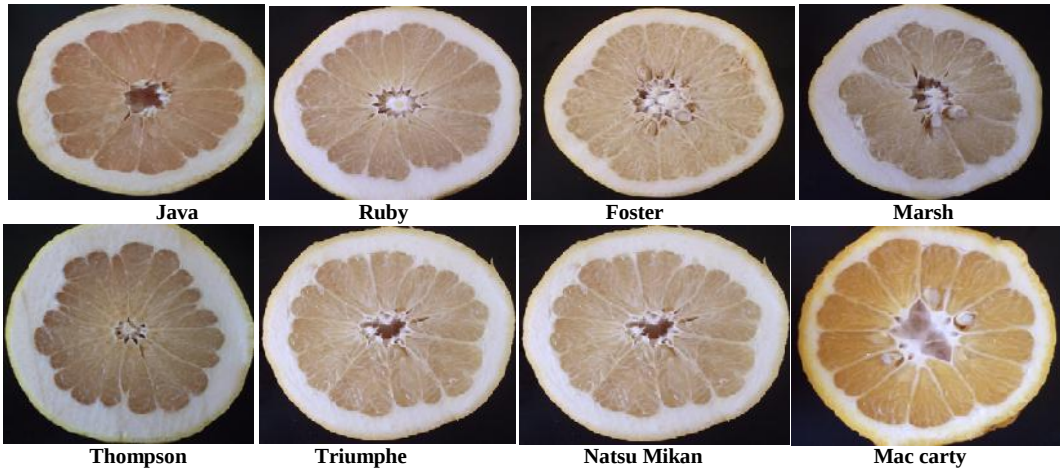

Figure 1 cross section of eight varieties of grapefruit study.

Determination of acidity (titratable acidity)

We put a soda alkaline liquor in a Mohr burette at 6, 25 g/l. We take 10 cm3 of juice decanted with a few drops of colored indicator phenolphthalein at 1%, and then we leave the soda liquor gently by shaking the beaker till the beginning of the turn. The reading of the number of cm3 elapsed soda liquor is divided by 10cm3 (volume of juice) to get the exact value of citric acidity which is expressed in % (Davies and Alberigo, 1994).

Determination of total Caroténoïds of juice

Determining total caroténoïds is performed by the method By Izuagie. A, and Izuagie F. O, in (2007). We dissolve 0, 2 g of KIO3 and 1, 6 KI in a bottle of 500 containing distilled water. The solution was acidified by adding 1 ml of concentrated acid of tetraoxosulphate (VI) (H3SO4). The mixture was swirled and the volume of solution raised to 500 ml with distilled water. The bottle was clogged and stirred to ensure homogeneity of content. Thus, the concentration of the iodine solution 5, 6076 x 10-3 M. 20 ml of juice for each sample was titrated against standard iodine solution 5, 6076 10-3 mol.L-1. The starch solution is used as indicator.

Stastical Analysis

For the comparison of averages, we conducted a unvaried

Variance analysis and non-parametric Kruskal-Wallis ANOVA tests to one factor. The statistical significance level adopted was defined p < 0, 05. In order to assess the accuracy of the estimates, we have indicated the 95% confidence interval (IC to 95%) of the average data.

RESULTS

Fruit Quality Parameters

The parameters of in eight varieties were detailed in table 1. Apparently, the values vary widely within these varieties, on the other hand, weight, diameter, bark and number of seed analysis shows that Java and Ruby had a weight and diameter respectively (663 ± 70,952 ; 112 ± 4,687), (113 ± 4,071 ; 688 ± 45,706) higher. However, in Marsh (413 ± 55,393; 98 ± 3,719), Natsu mikan (384 ± 60,613; 98 ± 4,717), Triumph (464 ± 74,230; 101 ± 5,719) and Thompson (482 ± 37,780; 97 ± 8,039) . These parameters were much lower. Yet, the lowest bark was observed in Marsh (8, 26 ±1, 58) and Mac carty (8, 05 ± 1,277) compared to that observed in Ruby (10, 97 ± 0, 96) . the minimum number of seeds were found respectively, at Thompson Ruby, Foster, Java, Triumphe and Natsu mikan (0,20 ± 0,42 ; 0,30 ± 0,48 ; 0,90 ± 0,88 ; 0,90 ± 0,99 ; 0,90 ± 0,99 ; 1,00 ±1,05) contrary to that found at Mac carty (15,40 ± 2,22). While in other varieties these parameters were moderately higher.

A multiple comparison of proportions among these varieties in juice, AT, ESS and IM shows that the three varieties, Marsh, Java and Triumph reach higher juice content (between 38, 57±0,020% and 40, 13±0, 09 %) followed by Foster, Ruby and Natsu mikan (between 36, 26±0,010% and 36, 93±0,190%). however, the Mac carty and Thompson recorded the lowest performance (34, 92±0,277 %35, 54±0,070%). Yet, the rate of acidity varies inversely relative to the rate of the juice. This is well illustrated in table (1), where they are significantly increased in Mac Carty and Foster (1, 85±0,040% and 1, 70±0,050%). On the other hand, Triumph, Java and Marsh have rates in acidity significantly low (1,15±0,010% ; 1,45±0,000% and 1, 56±0,010%). However, taking into account the rate in soluble solids, the two varieties Marsh and Ruby respectively recorded the highest sugar content in terms of low acidity (9, 47±0,057% and 8, 33±0,058%). But the content of soluble solids and titratable acidity composition was respectively low in Thompson and Triumph(8,10±0,00% and 7,20±0,10) while Ruby and Thompson had a higher maturity index(6,47±0,267 and 6,43±0,10). And Foster low (5, 31±0,127 %).

Ascorbic Acid

Figure (2) shows the distribution of the average of vitamin C in mg/l in eight varieties. Vitamin C is greater in the group of Natsu mikan, Foster (592,2mg/l and 516,53 mg/l) compared to that found in the group of Mac carty, triumph, Marsh, Thompson, Java and Ruby (361,9 and 460,6 mg/l) which presents a rather similar average mass if we expect Thompson variety (Figure 2)The non-parametric Kruskal-Wallis test demonstrates that the composition by mass of vitamin C is not equivalent (p=0,002) among these varieties. Table (1). To locate this difference, we made multiple analyses of averages. Indeed, a statistically significant difference was found between the variety of Mac Carty and Java (adjusted p = 0,051), and Marsh (adjusted p = 0,008) table (2), and also between Thompson and Marsh (adjusted p = 0,051). So, it seems that
The two varieties Natsu mikan and Foster bring the highest mass in vitamin C and Ruby and Marsh bring the lowest compared to other varieties of our series of study. The variation of the average mass of vitamin C confirms the main effect of the variety on the mass in vitamin C.

B-Caroténoïds

First stage of the analysis of the mass β-Caroténoïds in these varieties showed that they have a significantly mass (F= 13, 63; p=0,000) table (3). Multiple analysis of averages according to the Tucky test shows that in eight varieties, the average mass difference is significant between the two varieties Marsh and Mac Carty. However, a highly significant difference was respectively observed between Mac Carty on the one hand and Marsh on the other hand compared to the varieties (Natsu Mikan, triumph, Thompson, Java, Foster and Ruby). Indeed, Mac Carty and Marsh have the highest average masses (0,180±0,010 mg/L and 0,097±0,075 mg/L) compared to other varieties .table 3. This mass is lower in Ruby (0, 0300±0,026 mg/L) and Natsu mikan (0,030±0,029 mg/L) but much poorly represented at Thompson.

The variation of the average mass of the β-Caroténoïds confirms the main effect of the variety on the average mass β-Caroténoïds. Furthermore, Pearson correlation analysis showed that the weight of the fruit has no effect on the significant variation in β-Caroténoïds (r = 0,323; p=0,124) but a highly significant effect on the content of vitamin C (r =-0, 555; p=0,005) in the different varieties studied. However, the amount synthesized in vitamin C is independent of variation in mass β-Carotene (r=-0,293; p=0,164).

DISCUSSION

In the present study, the lower juice content was observed in ''Mac carty'' (34, 92±0, 28%), but higher than ''Marsh'' (40, 13±0, 09%). These same results were found by J. Forsyth (2003) in ''Marsh '' 39% and by Elmass Ozeker (2000) in ''Marsh seeds'' 42.9%, and above those found in the same variety (31,6±1,4%) by Fanciullino and al, (2006). In another series of study in Pakistan in eight varieties of grapefruit, by Nabil Ghulam and Jan Tasleem (2004), a content lower than '' White II'' 26, 78 % and higher than ''Marsh'' in ''Red Blush'' 57, 25% (Nabil Ghulam and Jan Tasleem 2004), was reported. But in the United States, this contribution varies from 35 to 47 % among this group of grapefruit (Forsyth, J., 2003).

Ascorbic acid composition analysis showed that ''Natsu mikan'' brought a higher ascorbic acid mean (592, 2 mg/L) content followed by ''Foster'' with a mean of 516, 3 mg/L compared to '' Marsh'' and '' Ruby'' with only a content mean 362 and 382 mg/L respectively. In other works, are even closer than those reported for eight varieties of grapefruit (Citrus Paradisi Macf) by Nabil Ghulam and Jan Tasleem (2004) between 123,8 and 581,7 mg/L, by Gorinstein *et al* (2004)

between 340 and 500 mg/L [32], and by Kelebek Hasim, (2010) between 330 and 430 mg/L. Our results in β-caroténoïds in the'' Mac carty''(0,180 ±0,010mg/L) variety and'' Marsh'' (0,097±0,075mg/L) were the highest, but compared to other work, these intakes are lower than those found in ''Star Ruby'' (0,22±0,03 mg/L) by Rafaella Guimaraes, *et al* (2010) and'' Changshanhuyou'' (0,22±0,03 mg/L) by Xu, Guihua, *et al* (2008).

Among these varieties which have been the subject of our study , we were able to highlight the two varieties ''Mac carty'' and ''Marsh '' as most rich in soluble solids (ESS) (10,33±0,06%) and (9,47±0,06%) respectively unlike ''Triumph'' and ''Natsu mikan'' at a lower grade, with only (7,20±0,10%) and (7,80±0,00) respectively. All remaining cultivars were having a quite moderately high intake. The same results were obtained by Gulam Nabil and Jan Tasleem (2004) between 7, 66 and 10, 30 % and less than those reported in China between (9,68± 0,05%) and (11,89±0,09%) (Wanpeng Xi, *et al* 2014). But a similar soluble solids composition like ''Mac carty'' was observed in ''Changshanhuyou'' 10,58 % by Xu, Guihua, *et al* (2008) and in ''Star Ruby'' 10,3 % (Olivier Pailly, *et al* 2004) and the same results as '' Ruby '' were mentioned in ''Star Ruby'' 8,1 % by Forsyth, J. (2003).

Critical acid content found in the juice in these studied varieties varies from (1, 15± 0, 01%) in "Triumphe" for (1,85±0,04%) in ''Mac carty''. What is in concordance with results previously reported by Davies and Alberigo, in (1994) the critical acid in the grapefruit of 0, 8 % to 2, 5 %, between (0, 73±0,004%) and (1, 56±0,06%) (Wanpeng Xi, *et al* 2014), between 0, 6 and 1, 9 % by Forsyth, J. (2003) between 0, 85 and 2, 32% by Nabil Gulam and Jan Tasleem (2004). In another work published by Karadeniz in (2004) a content considerably high in critical acid between 1, 70 and 2, 43 %.

The analysis of the maturity index (soluble solids / titratable acid) in our varieties showed that ''Ruby'' and ''Thompson'' brought average grades (6, 47±0, 27) and (6, 43±0, 10) highest respectively. These results were lower than those found in Mexico (Salvador Becerra-Rodriguez, *et al* 2008). On the other hand, the other cultivars had a moderately low index except ''Foster'' and ''Natsu mikan'' having the lowest average maturity index (5, 31±0, 13) and (5, 38±0, 04) respectively. Similar results were obtained in France by Fanciullino and al, (2006) but higher to our results obtained in Cyprus by V. Goulas, and G. A. Manganaris, (2012).

Furthermore, the study of the average weight of the grapefruit allowed us to identify the highest weight (687, 78 ± 45,706g), (663, 00 ± 70,952g) and (596, 99 ± 31,70g) respectively in''Ruby'',''Java'' and ''Mac Carty''. These results have been already found in ''Oroblanco'' 626, 20 g (Salvador Becerra-Rodriguez, *et al* 2008). But ''Triumphe'', ''Thompson'' and ''Foster'' had a moderately higher weight of (464±74,23g), (482±37,78g) and (495±67,72g) respectively. Which significantly higher than those reported in Pakistan, where the eight varieties of grapefruit have produced fruits with an average weight between 302,4 and 506,5 g (Gulam Nabil and Jan Tasleem 2004). However, almost the same results were observed in Mexico (455.3 and 926,5 g) (Salvador Becerra-Rodriguez, *et al* 2008) .On the other hand, ''Natsu mikan'' and''Marsh'' had respectively lower average weight (384 ± 60,61g) and (413 ± 55,39g) but higher than that found in''Marsh''378, 00 g (Gulam Nabil and al 2004) and slightly different from those found in ''Marsh seedless'' 385, 00 g (Elmass Ozeker, 2000), and lower, as reported in ''Gardner Marsh'' 537,50 g and ''Reed Marsh'' 556,20 g (Salvador Becerra-Rodriguez, *et al* 2008).

The largest size and the thickest bark of the fruits studied in our varieties were respectively in ''Ruby'' (113± 5,13mm) and (10, 97± 0,96mm). On the other hand, ''Marsh '' was a result of a smaller average (113± 5,13mm) and (10, 97± 0,96mm). According to Geang *et al* (1983)''white marsh'' had a slimmer bark 7,1 mm, and according to Rafaela Guimaras, *et al* (2010) ,''Star Ruby'' bark average 6,00 mm. But a moderately thick bark has been found in ''Star Ruby'' of (8,922±0,156mm) (Jian Xian Shi, *et al* 2007).

Finally, the study of the number of seeds among the cultivars tested shows that only ''Mac Carty'' had the largest number of seeds, with an average of 15, 40 seeds per fruit over other varieties comprising between (0, 20± 0, 42) and (2, 90±1, 37) seeds per fruit with the exception of ''Marsh'' and ''Natsu mikan''. However, other varieties produce fruits with a low number. These results are significantly lower than those reported in Pakistan by Nabil Gulam and Jan Tasleem (2004) between 3, 66 and 54, 67 seeds per fruit. Our result was almost similar to those obtained in Mexico between 1, 4 and 3, 9 seeds per fruit (Salvador Becerra-Rodriguez, *et al* 2008) and higher than those obtained in the United States with an average of 1 to 6 seeds per fruit (Forsyth, J.2003).

CONCLUSION

The highest weight and diameter of the fruit was found in the ''Java '' and ''Ruby '' variety and quite weak in ''Marsh'', ''Natsu mikan'', ''Triumphe'' and ''Thompson''. The thickness of the lower bark was discovered in ''Marsh'' and the thickest at ''Ruby''. The minimum number of seeds has been found in ''Thompson'' and ''Ruby'' and the maximum number was recorded in ''Mac Carty''. ''Marsh'' reached the highest yield in juice and ''Mac Carty'' the lowest. The maximum amount of soluble solids and β-caroténoïds was found in ''Mac Carty'' and the lowest in ''Triumphe''. On the other hand, concerning titratable acidity, the highest sum of titratable acidity was found in ''Mac Carty'' and lowest at ''Triumphe''. But high vitamin C levels have been detected in ''Natsu mikan'' followed by ''Foster'' and ''Thompson''. Finally, it must be noted that there are significant differences in physicochemical parameters such as the pomological characteristics, chemical and antioxidant compositions. These results could be useful for other well in-depth subsequent studies on these varieties in grapefruit in Morocco with the aim of better externalizing its qualitative parformances.

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DISCLOSURE

The authors reported no conflict of interest related to this article. None of the authors has a financial or corporate relationship.

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