Phenotypic polymorphism, pomological and chemical characteristics of some local varieties of fig trees (*Ficus carica* L.) grown in Eastern Morocco

Aziz Tikent^{1*}, Ahmed Marhri¹, Atika Mihamou¹, Nargis Sahib¹, Hana Serghini-Caid¹, Ahmed Elamrani¹, Malika Abid¹, and Mohamed Addi¹

¹Laboratoire d'Amélioration des Productions agricoles, Biotechnologie & Environnement (LAPABE), Faculté des Sciences, Université Mohammed Premier, BP : 717, 60000, Oujda, Morocco

Abstract. The fig tree (*Ficus carica* L.) is one of the earliest fruit trees cultivated in Morocco, especially in the north-eastern region; which is growing inextricably linked to our social and cultural heritage. This study concerns morpho-pomological and chemical parameters of five local fig varieties, namely: Aouank Hmam "AH", Chetoui "CH", Bounacer "BN", Ghoudane "GH", and Malha "MA". Significant differences were observed among the studied fig cultivars for some of the parameters investigated. In particular, the average fruit weight that ranged from 29.72 g to 58g for MA and AH respectively. At the ripening stage, fruits "MA" show the best skin cracks, while fruits "AH" are distinguished by their ease of peeling. In terms of titratable acidity, "AH" has the lowest value, while "CH" has the highest level. For the sweetest and tastiest variety of figs, Brix readings (expressed as total soluble solids content) registered range between 27 - 35% respectively for the MA and GH. According to the results of the parameters evaluated, particularly the acidity and the Brix index, the best varieties worthy of consideration from an agricultural and industrial point of view are "AH" and "CH" cultivars.

1 Introduction

The common fig (*Ficus carica* L., $2n = 26$) belongs to the family Moraceae with more than 800 species [1], native to western Asia and the eastern part of the Mediterranean regions [2, 3]. It was one of the first Mediterranean fruit species to be domesticated [4, 5]. The fig and olive trees are among the oldest domesticated trees in Morocco's northern region (Rif) [6]. Several studies on the fig tree's characterization have been conducted in Morocco. In the northern region of Morocco (Rif), Hmimsa et al [7] conducted a vernacular classification of fig varieties based on biological, agronomic, and use characteristics. The research revealed a high level of diversity among local fig varieties. The high level of intraspecific diversity, as well as the complexity of the naming system and classification system for fig varieties, is associated with high sociocultural and economic values. El Hajjami's [8] inventory of Moroccan local varieties of fig (*Ficus carica* L.) in four main production sites, (Chefchaouen, El Jadida, Ouezzane, and Taounate provinces) revealed the presence of 43 varieties. The principal component analysis (PCA) and agglomerative hierarchical clustering (AHC) have revealed similarities between some varieties. Hssaini et al [9] collected and analyzed phenotypic variation in fig accessions grown in three northern Moroccan regions (Taounate, Ouazzane, and Meknes). Based on pomological traits, they discovered three distinct groups with a total inertia of 90.92 %. In Morocco, Figs are also a valuable social resource. Figs are popular as gifts (fresh or dried) for family and friends, especially during religious events. The Ministry of Agriculture, Maritime Fisheries, Rural Development, Water and Forests has launched a project to plant 100 hectares of fig trees and build a drying unit in the rural municipality of Aghbal in the province of Berkane over the period 2019-2020 as part of the Green Morocco Plan. The project's objectives include the enhancement and development of the fig sector, as well as the improvement of the fig sector's productivity. The farmers involved in this project led by the cooperative "Gharmawne" will benefit from support equipment, training and supervision. In partnership with the municipality and other agricultural creators, this cooperative organizes each year the Aghbal festival of figs, a socio-economic event that aims to bring together consumers and producers of figs in eastern Morocco. This event is held every year during the last weekend of August. The festival is an opportunity to promote the commercialization of figs and fig's derivative products, to encourage the innovation of small producers in this sector, and to show the natural and cultural assets of this region. The local fig

*Corresponding author: tikent.aziz@ump.ac.ma

germplasm has not been subjected to intensive plant selection programs; as a result many fig populations and ecosystems had a great genetic diversity, which must to be fully exploited by its identification and classification[9].The fig has a wide geographical distribution in the country and is well-known for its high commercial value and best fruit flavor for fresh consumption. When compared to many other fig cultivars, the local fruits are known to be very high in sugars, the most important criterion of quality in figs. The purpose of this study is to assess the impact of different agro-ecological zones on the fruit quality of local fig varieties. Besides, this work aims to identify the morphological characteristics of local fig varieties and estimate the quality of their fruit, respectively, according to the morpho-pomological traits based on the IPGRI and CIHEAM descriptors [10, 11] and to the Aksoy's fig fruits quality descriptors[12], in order to conserve the fig germplasm and preserve this species from genetic erosion.

2 Materials and methods

2.1 Materials sampling

The sampling region (made up of 7 provinces and a prefecture) located in the northeast of the country (fig1), it covers an area of 90.130 km², accounting for or 12.7% of the country's total land area [13].

Fig1. Geographical location of the study in eastern Morocco. The area is delimited, to the north by the Mediterranean Sea, and to the south by the arid region of Daraa-Tafilalet. The climate of this region is Mediterranean in the north, with rare precipitation, often in the form of strong thunderstorms and continental in the south, sensitive to Saharan factors, with cold in winter and heat in summer, low rainfall generally poorly distributed in time and space[13].

Table1. Short name (Code) with important features of the five fig cultivars studied

N	Fig cultivars	Code	Figs category	Autumn fig skin color	utilisation
1	Aouk Hmam	AH	unifer figs	Purple spotted in green	Fresh
2	Bounacer	BN	bifer figs	Black more than purple	Fresh
3	Chetoui	CH	unifer figs	Green spotted in purple	Fresh/Dried
4	Ghoudane	GH	bifer figs	Black	Fresh/Dried
5	Malha	MA	unifer figs	Green	Fresh

The identification of trees (Table 1) was made with the local vernacular name given by farmer to crop and cultivar, and they were selected for their widespread distribution and their commercial value in this region. Prospection and sampling were carried out on traditional orchards of farmers (adult trees of roughly the same age "ten years") at different locations in eastern Morocco (fig 1), in the early of February for the apical buds and during the period (June, July ,August and September) for the fruits and leaves. At the level of three different zones in each site, samples of 150 fresh fruits (ten fruits per plant and three plants per cultivars in each zone for two successive years 2019-2020) ripe and disease free were chosen, selected (the most basal on shoot) and harvested. According to the description instructions, the same sampling approach was used for leaves and apical buds.

2.2 Phenotypic and pomological Study

A digital scale was used to take the fruit weight measurements. (KERN PCB 2000-1 Max 2000 g d = 0.1 g), the length and width of the fruit, the neck and the fruit stalk, the ostiole width, the internal fruit pulp thickness carried out with a digital caliper PAQUIMETRO DIGITAL INOX 0-150MM), the index = fig width/fig length (Oblong < 0.9; globose 0.9–1.1; Oblate > 1.1) and the ease of peeling (easy, medium, difficult) and lack of skin cracks (without cracks, longitudinal, Cracked skin) are determined. The leaf dimensions (length and width) were measured with a graduated ruler, while the thickness of the leaf stalk carried out with a digital caliper (in mm). As well as the terminal bud length and width were carried out with a digital caliper (in mm).

2.3 Chemical analysis

The chemical analyzes were carried out in triplicate and focused on the acidity and the Brix as a metric of fruit maturity parameters. The titratable acidity (expressed in % of citric acid) by titrating fig juice with 0.1 M NaOH to pH 8.1 in the presence of a colored indicator according to the AFNOR method (NF V 05–101, 1970). The Brix index indicates the total content of all sugars as the soluble solids in the fruit. Brix readings were done using digital refractometer (HANNA NUMERIQUE HI 96801 - ECHELLE 0-85% BRUX).

2.4 Statistical analysis

The data obtained was subjected to statistical analysis using IBM SPSS Statistics V21.0 software for descriptive statistics and also for analysis of variance by comparing average of characteristics studied using post hoc testing (Tukey's test) at the 5% threshold, graphs produced by the GraphPad Prism 8 software. The quality of the figs was assessed using the weighted ranked method by Aksoy [12], based on nine pomological characters.

3 Results and discussions

The morphological characterization of the figs was carried out on plant material available at the sampling site and therefore does not take into account the environmental component. Thus, the ease of peeling as well as the presence of skin cracks seems to be positive quality factors for figs intended for consumption in the fresh state. On the other hand, the absence of cracks would be a positive parameter allowing better preservation of dried figs. In addition, we note that this type of figs without skin cracks is intended both for consumption in the fresh state as for the production of dried figs. According to this study, AH had the best quality in terms of peelability while MA had the best quality in terms of skin cracking (Table 2).

Table2. Study results of two important parameter used to determine figs quality by Aksoy ranked method [12]

Cultivar	Ease of peeling	Skin cracks
Aounk Hmam (AH)	Easy	longitudinal
Bounacer (BN)	Medium	longitudinal
Chetoui (CH)	Medium	cracked skin
Ghoudane (GH)	Medium	longitudinal
Malha (MA)	Medium	without cracks

The susceptibility for skin cracks is favored by low temperatures associated with high humidity during the fig ripening and especially common in genotypes with a thin epidermis [14]. Varieties that have a too long maturity are more vulnerable to the problem of skin cracks; they should not be grown in early and rainy autumn areas. When the fruits are ripening, fig cracking begins at the ostiole and is exacerbated by low temperatures and/or an increase in relative humidity [15].

Fig2. Figs weight average

Fig3. Figs width average

Fig4. Figs length average

The results show that fig weight (Fig 2) is high in AH (58.09 ± 9.129 g) and CH (50.12 ± 7.209 g) varieties and medium for GH (42.94 ± 1.627 g) and BN (40.09 ± 2.182 g), while MA recorded the lowest weight (29.72 ± 1.767 g). The figs weight gives extremely attractive pricing for producers and traders in the market, for this purpose AH; CH and GH will certainly have the best chances of being appreciated by consumers. According to the results obtained concerning fig width (Fig 3), fig length (Fig 4) and their comparisons with those of the descriptor, we found that the width oscillates between small [28-38 mm] or medium [38-49 mm] at MA (39.88 ± 1.278 mm), GH (39.56 ± 3.073 mm) and BN (41.16 ± 3.202 mm), for CH (47.03 ± 3.140 mm) and AH (47.63 ± 3.575 mm) it's between medium or large [50-60 mm]. The length is long [54-75 mm] for AH (64.07 ± 5.033 mm), and between medium [29-54 mm] and long for GH (57.44 ± 5.106 mm), and medium for CH (49.86 ± 2.728 mm), BN (44.32 ± 2.856 mm) and MA (42.88 ± 1.151 mm).

The Shape fruit changes depending to the stage of maturity and cultural maintenance [16], or because of environmental conditions and genotypic effect [17]. In the fresh fig sector, shape or index is particularly important. According to the findings of this study (Fig 5), the oblong form ($I < 0.9$) is represented in GH (0.694 ± 0.080) and AH (0.745 ± 0.049), whereas the globose shape ($I = 0.9-1.1$) characterizes BN (0.928 ± 0.031) and MA (0.930 ± 0.022) and CH (0.943 ± 0.044) varieties, which is suitable for commerce domain due to its appealing appearance and convenience of presentation.

Fig5. Figs Index = width/ length fig average

Fig6. Neck length average

Fig7. Neck thickness average

Furthermore, AH (12.81 ± 2.121 mm) variety has the longest neck followed by CH, BN, MA and GH (5.218 ± 0.456 mm) in that order (Fig 6). The same results have been observed in terms of fruit's neck thickness. The thickest neck (Fig 7) belongs to the AH (12.18 ± 1.244 mm) variety, followed by CH, BN, MA, and GH (5.408 ± 0.252 mm). It should be noted that for the neck length and the neck thickness BN, GH and MA are very similar. The fig farmers also considered that increasing these two characteristics would improve the freshness of the fig. Moreover, results show that AH (7.344 ± 3.287 mm), MA (8.407 ± 0.489 mm) and CH varieties have the longest fruit stalk (Fig 8) compared to BN and GH (4.905 ± 0.407 mm). In addition, AH (6.557 ± 0.728 mm), BN, and CH cultivars have thicker fruit stalks than GH and MA (5.106 ± 0.363 mm) varieties (Fig 9).

Fig8. Fruit stalk length average

Fig9. Fruit stalk thickness average

Short necks, unlike long stalks, are considered as an undesirable characteristic by arborists because they make harvesting difficult and destructive to the fruit. Varieties with short necks, such as MA, may not be of interest to growers because they are difficult to harvest, whereas varieties with a long neck and stalk, such as AH, are preferable for their ease of harvest.

Results have shown that AH (6.887 ± 1.10 mm) figs have the greatest ostiole width (Fig 10) followed by CH, GH, BN and MA (3.788 ± 0.24 mm) in that order. The largest pulp width (Fig 11) is seen in AH figs (43.59 ± 3.528 mm), followed by CH, GH, BN, and MA figs (36.84 ± 1.293 mm). A large ostiole will facilitate the entry and flight of blastophagous as well as pesticides and pathogens, which make varieties with this character unsuitable for the fig industry and storage [18]. The thickness of the internal pulp is a determining pomological character in the fruit quality and their use.

Fig10.Ostiole width average

Fig11.Pulp thickness average

There was a lot of heterogeneity amongst the cultivars based on the fruit fig pomological qualities evaluation (Table3), with few exceptions in the following characteristics : width between AH/CH and GH/MA, Fig width/fig length regarding BN;CH and MA between them, Ostiole width between BN/GH and CH/GH, Neck length regarding BN;GH and MA between them, Neck thickness regarding BN;GH and MA between them, Stalk length between BN/GH, Stalk thickness between GH/ MA, Pulp thickness between AH/ CH and BN/MA also between GH/ MA.

Table3. Ordinary one-way ANOVA of pomological fig characters (n=150) averages

Tukey's multiple comparisons test	F.W (g)	F.Wi (mm)	F.L (mm)	Wi/L Index	O.W (mm)	N.L (mm)	N.T (mm)	S.L (mm)	S.T (mm)	P.T (mm)
AH vs BN Mean Diff	**** 18.00	**** 6.472	**** 19.75	**** -0.1831	**** 1.678	**** 7.414	**** 6.485	**** 2.092	**** 1.036	**** 5.803
AH vs CH Mean Diff	**** 7.977	Ns 0.5983	**** 14.21	**** -0.1985	**** 1.314	**** 5.426	**** 1.097	**** 1.341	**** 0.7029	Ns -0.178
AH vs GH Mean Diff	**** 15.15	**** 8.067	**** 6.639	**** 0.05096	**** 1.577	**** 7.596	**** 6.880	**** 2.439	**** 1.278	**** 7.382
AH vs MA Mean Diff	**** 28.38	**** 7.745	**** 21.19	**** -0.1851	**** 3.099	**** 7.590	**** 6.769	**** -1.063	**** 1.451	**** 6.751
BN vs CH Mean Diff	**** -10.03	**** -5.873	**** -5.540	Ns -0.01535	** -0.363	**** -1.988	**** -5.388	*	** -0.332	**** -5.981
BN vs GH Mean Diff	** -2.849	** 1.595	**** -13.11	**** 0.2341	Ns -0.101	Ns 0.1818	Ns 0.3956	Ns 0.3476	Ns 0.2422	** 1.579
BN vs MA Mean Diff	**** 10.37	* 1.274	Ns 1.441	Ns -0.001978	**** 1.421	Ns 0.1756	Ns 0.2839	**** -3.155	**** 0.4152	Ns 0.9481
CH vs GH Mean Diff	**** 7.176	**** 7.468	**** -7.572	**** 0.2494	Ns 0.2622	**** 2.170	**** 5.784	**** 1.098	**** 0.5751	**** 7.560
CH vs MA Mean Diff	**** 20.40	**** 7.147	**** 6.981	Ns 0.01337	**** 1.785	**** 2.164	**** 5.672	**** -2.404	**** 0.7481	**** 6.929
GH vs MA Mean Diff	**** 13.22	Ns -0.3216	**** 14.55	**** -0.2361	**** 1.522	Ns -0.006	Ns -0.111	**** -3.502	Ns 0.1730	Ns -0.631

* Weakly significant, ** Moderately significant, *** Highly significant, ****Very highly significant, Ns non-significant
F.W Fig weight, F.Wi Fig width, F.L Fig length, Wi/L Fig width /Fig length, O.W Ostiole width, N.L Neck length , N.T Neck thickness, S.L Stalk length , S.T Stalk thickness, P.T Pulp thickness.

This investigation has shown that the number of lobes per leaf (Fig 12) varies between 3 and 5 for AH (3.6 ± 0.9), MA (3.66 ± 0.94), CH (3.71 ± 0.96) and BN (4.2 ± 0.98) but for GH (5.22 ± 1.38 mm) it is between 3 and 7. The great majority of the studied leaves have three lobes in AH, CH and MA in contrast to BN and GH they have five lobes.

Fig12.Number of lobe per leaf average

Fig13.Leaf length average

Moreover, AH (20.89 ± 2.26 cm) fig tree has the longest leaves followed by MA, CH, BN and GH (17.72 ± 2.009 cm) in that order (Fig13). AH (18.56 ± 2.75 cm) and CH fig trees has the greatest leaf width (Fig14) followed by GH, MA and BN (17.04 ± 1.46 cm). The average leaf area of AH (392.9 ± 97.98 cm²) followed by CH, MA, GH, and BN (319.7 ± 51.60 cm²) in that order. These values show that their areas are Medium [$250\text{--}400$ cm²], while the data demonstrate that all of these cultivars have large leaf areas [$400\text{--}500$ cm²], with only AH and CH having a very large area [> 550 cm²] and GH having a tiny area [250 cm²] (Fig 15).

Fig14. Leaf width average

Fig15. Leaf area average

Fig16. Leaf stalk length average

Regarding leaf stalks length CH (91.92 ± 15.11 mm) and GH (90.11 ± 15.42 mm) have a long leaf stalks [> 80 mm] while AH (75.93 ± 17.92 mm); MA (65.05 ± 6.152 mm) and BN (63.90 ± 5.858 mm) have a medium leaf stalks [$50\text{--}80$ mm] (Fig 16). The highest average for leaf stalk length/leaf length ratio was recorded by GH (0.508 ± 0.072), followed by CH, AH, BN, and MA (0.322 ± 0.019) varieties (Fig17).

Fig17. Leaf stalk length/leaf length average

Fig18. Leaf stalk thickness average

Fig19. Leaf lobe central length average

The leaf stalks length is not proportional to the leaves length. When it comes to leaf stalk thickness, MA (4.912 ± 0.177 mm) is the thickest, followed by AH, GH, CH, and BN (4.043 ± 0.141 mm) in that order (Fig18). We noticed that the leaf stalks length is not proportional to the leaf stalks thickness.

Concerning the leaf central lobe length (Fig 19), GH (11.13 ± 1.415 cm) is the longest then CH followed by AH; BN and MA (8.472 ± 0.896 cm) in that order. According to the results of degree of leaf lobation [= Length of central lobe/ length of leaf] (Fig 20) GH (0.629 ± 0.055); CH (0.519 ± 0.058) and BN (0.504 ± 0.018) have a marked lobation [$0.51\text{--}0.75$], while AH (0.47 ± 0.045) and MA (0.41 ± 0.016) are on average lobation [$0.26\text{--}0.50$]. As for the number of leaves per shoot (Fig 21) BN (14.63 ± 1.55) and MA have the biggest number, then AH followed by CH and GH (6.467 ± 1.10) at last.

Fig20. Degree of leaf lobation average

Fig21. Number of leaves per shoot average

Foliar analyzes show that the variability associated with the leaf area, leaf stalk size and the number of leaves per shoot, may be influenced by genetic characteristics. The leaf areas vary according to the varieties [19], this variation is independent of the number of leaves per shoot, of the number of lobes per leaf and their shape.

Morphological characteristics such as leaf size; number of leaves per shoot and pulp thickness; are important to selector and can be highly distinguishing variables. Nevertheless, differentiating fig tree varieties using their leaves is difficult because they are polymorphic within the same individual, particularly in terms of the number of lobes and the leaf stalk thickness[20].

The results of multiple comparisons of leaf character averages (Table 4) demonstrate a high degree of diversity among genotypes, with some exceptions in the characteristics listed below: Number of lobe regarding AH;CH and MA between them, Leaf length between AH/MA and CH/MA, Leaf width regarding AH;CH and GH between them also between BN/MA and GH/MA, Leaf area between AH/CH and CH/MA, leaf stalk length/Leaf length between AH/BN and BN/MA, leaf stalk length between BN/MA and CH/GH ,leaf stalk thickness regarding CH;GH and BN or MA between them also between AH/GH and AH/MA , Lobe central length between AH/CH, Degree of lobation leaf between BN/CH , Number of leaves per shoot between BN/MA.

Table4. Ordinary one-way ANOVA of leaves characters (n=150) averages

Tukey's multiple comparisons test	N.L	L.L (cm)	L.W (cm)	L.A (cm ²)	LS.L/L.L	LS.L (mm)	LS.T (mm)	LC.L (cm)	DL.L (mm)	N.L/S (mm)
AH vs BN	**	****	****	****	Ns	****	****	*	****	****
Mean Diff	-0.6000	2.225	1.515	73.21	0.01879	12.03	1.120	0.5027	-0.0302	-2.633
AH vs CH	Ns	****	Ns	Ns	****	****	*	Ns	****	*
Mean Diff	-0.1111	1.357	-0.07667	26.38	-0.1081	-15.99	0.6734	-0.1829	-0.0457	1.067
AH vs GH	****	****	Ns	****	****	****	Ns	****	****	****
Mean Diff	-1.622	3.168	0.6097	71.54	-0.1473	-14.17	0.5304	-1.212	-0.1555	5.767
AH vs MA	Ns	Ns	*	*	****	****	Ns	****	****	****
Mean Diff	-0.06667	0.6842	0.9566	34.48	0.03896	10.89	0.2516	1.445	0.05462	-2.392
BN vs CH	*	*	****	****	****	****	Ns	**	Ns	****
Mean Diff	0.4889	-0.8678	-1.592	-46.82	-0.1269	-28.02	-0.4466	-0.6856	-0.0154	3.700
BN vs GH	****	**	*	Ns	****	****	Ns	****	****	****
Mean Diff	-1.022	0.9428	-0.9053	-1.669	-0.1660	-26.20	-0.5896	-1.715	-0.1252	8.400
BN vs MA	**	****	Ns	**	Ns	Ns	**	****	****	Ns
Mean Diff	0.5333	-1.541	-0.5584	-38.73	0.02018	-1.147	-0.8684	0.9426	0.0848	0.2417
CH vs GH	****	****	Ns	****	****	Ns	Ns	****	****	****
Mean Diff	-1.511	1.811	0.6863	45.15	-0.03914	1.817	-0.1430	-1.029	-0.1098	4.700
CH vs MA	Ns	Ns	**	Ns	****	****	Ns	****	****	****
Mean Diff	0.04444	-0.6731	1.033	8.099	0.1471	26.87	-0.4219	1.628	0.1004	-3.458
GH vs MA	****	****	Ns	**	****	****	Ns	****	****	****
Mean Diff	1.556	-2.484	0.3469	-37.06	0.1862	25.06	-0.2789	2.657	0.2101	-8.158

* Weakly significant, ** Moderately significant, *** Highly significant, ****Very highly significant, Ns non-significant
 N.L Number of lobe, L.L Leaf length, L.W Leaf width, L.A Leaf area , LS.L/L.L Leaf stalk length/Leaf length, LS.L Leaf stalk length , LS.T Leaf stalk thickness, LC.L Lobe central length , DL.L Degree of lobation leaf, N.L/S Number of leaves per shoot.

The tendency to form suckers is low [less than three] for AH; BN; CH and MA, medium [three to seven] for GH (Fig 22). The harvest period average is medium [21-40 days] for BN and GH; it coincides with that observed in Turkey varieties [21], Long [41-60 days] for AH and MA, Very long [>60 days] for CH (Fig 23). The beginning of fruit maturation for BN and GH is early [20-31 July], mid-season [1-15 August] for MA, and late [15-31 August] for AH and CH. The fig sector in eastern Morocco has the major advantages of fruit cultivation, early harvests (extended beginning of maturity from early to late) and great availability of fresh fruits on the market prolonged harvest period from medium to very long, allowing the market for fresh figs to be satisfied for an extended period of time.

Furthermore, the terminals buds (Fig 24) of CH (11.53 ± 1.93 mm) and AH are the longest, followed by BN, GH, and MA (9.172 ± 0.96 mm). In terms of terminal bud width (Fig 25), AH (7.196 ± 0.96 mm) is the largest, followed by CH and BN, then GH and MA (5.319 ± 0.56 mm). Regarding to the terminal bud length/width ratio (Fig 26) the biggest one is for CH (1.820 ± 0.20 mm) then BN and GH followed by MA and AH (1.524 ± 0.15 mm) in that order.

Fig24. Terminal bud length average

Fig25. Terminal bud width average

Fig26. Terminal bud length/width average

The terminal bud color is green for AH, BN, CH and MA, Pinkish brown for GH. The dominant terminal bud shape is conical for them at all (Fig27).

AH terminal bud

BN terminal bud

CH terminal bud

GH terminal bud

MA terminal bud

Fig27. Terminal bud shape and color of the studied fig cultivars

From the multiple comparisons (table 5), we notice a great variability in tree and terminal bud characters averages with some exceptions in the following variables: Bud terminal length between GH/MA, Bud terminal width between BN/GH and GH/MA, Bud terminal length/Bud terminal width regarding BN; CH and GH between them, tendency suckers between AH/CH and BN/MA, Harvest period between AH/MA and BN/GH.

Table5. Ordinary one-way ANOVA of tree characters (n=45); terminal bud (n=150); total soluble solids and titratable acidity averages

Tukey's multiple comparisons test	T.S	H.P (days)	Bt.L (mm)	Bt.W (mm)	L/W Bt	T.S.S %	T.A %
AH vs BN	*	****	*	****	****	****	****
Mean Diff	-0.407	4.667	0.6146	1.443	-0.266	1.575	-0.028
AH vs CH	Ns	****	*	****	****	****	****
Mean Diff	0.225	-16.13	-0.619	0.8487	-0.295	4.883	-0.040
AH vs GH	****	****	****	****	****	Ns	Ns
Mean Diff	-2.641	5.600	1.163	1.718	-0.255	-0.023	-0.004
AH vs MA	*	Ns	****	****	****	****	**
Mean Diff	-0.407	1.033	1.738	1.876	-0.200	8.19	-0.013
BN vs CH	****	****	****	****	Ns	****	**
Mean Diff	0.633	-20.80	-1.234	-0.594	-0.028	3.327	-0.011
BN vs GH	****	Ns	Ns	Ns	Ns	****	****
Mean Diff	-2.233	0.9333	0.5483	0.2751	0.0110	-1.580	0.024
BN vs MA	Ns	****	****	**	**	****	**
Mean Diff	0.000	-3.633	1.124	0.4332	0.0661	6.633	0.014
CH vs GH	****	****	****	****	Ns	****	****
Mean Diff	-2.867	21.73	1.783	0.8694	0.0399	-4.907	0.036
CH vs MA	****	****	****	****	****	****	****
Mean Diff	-0.633	17.17	2.358	1.028	0.0949	3.307	0.026
GH vs MA	****	****	Ns	Ns	*	****	*
Mean Diff	2.233	-4.567	0.5754	0.1581	0.0550	8.213	-0.009

* Weakly significant, ** Moderately significant, *** Highly significant, ****Very highly significant, Ns non-significant
T.S tendency suckers ,H.P harvest period , Bt.L Bud terminal length,Bt.W Bud terminal width, L/W Bud terminal length/Bud terminal width, T.S.S Total Soluble Solids, T.A Titratable Acidity

Regarding to the total soluble solids (Fig 28) GH (24.16 ± 0.04 %) and AH (24.13 ± 0.01 %) have the highest percentages, followed by BN; CH and MA (15.94 ± 0.08 %). As for titratable acidity (Fig 29) CH (0.272 ± 0.03 % C.A= Citric. Acid) has the highest percentage, followed by BN, MA; GH and AH (0.231 ± 0.004 % C.A) in that orders. The chemical fruits characteristics are important in the pomological quality determination and can also be used for varietal discrimination [22]. Fig fruit with a good quality should have a soluble solid content between 13.0% and 25.1%, and an acidity levels between 0.226 and 0.300 % [23]; these two criteria are met by our cultivars studied. Also significant differences of total soluble solids and titratable acidity averages in figs cultivar are noted except between AH and GH for these two traits (table5).

Fig28.Figs total soluble solids average

Fig29.Figs titratable acidity average

In order to determine the quality of figs; we use the weighted ranked method of Aksoy, based on nine characteristics which are with their weighting: the weight of the fruit (g) 20; beginning of maturation 20; shape of the fruit (index) 9; neck length (mm) 6; fruit skin cracks 10; ease of peeling 10; ostiole width (mm) 5; total soluble solids (%) 10 and titratable acidity (%) 10. The lowest score is obtained by MA (570), followed by BN (680) then GH (702), while the highest are recorded in particular at CH (720) and AH (738), these scores reflect a very good pomological fig quality in the eastern Morocco (Fig 30). The fig quality is influenced by the genotypic effect, environmental conditions (temperature, humidity, wind...), the maturity stage and cultural maintenance [18]. Certain pomological characteristics of apple, such as size and dry matter content, are more affected by the increase of the tree fruit load due to poor tree development. Thus, a weak tree development increases the effect of tree fruit load on fruit quality [24].

Fig30.Quality of figs by the weighted ranked method of Aksoy

4 Conclusion

The overall analysis of our results shows that morphological markers reveal phenotypic variability among the fig tree grown in eastern Morocco. In the studied area, this plant exhibits a wide range of morphological characteristics. Thus, the fig cultivars investigated appear to be well suited to the pedoclimatic conditions, requiring less water and phytosanitary treatment. In order to preserve and maintain the biological diversity of fig trees in this region, this research needs to be completed through the development of illustrated varietal sheets with useful recommendations. (e.g. A fig cultivars list with useful suggestions developed by nursery workers and arborists to help farmers choose varieties and use. Furthermore, from an agricultural point of view, the studied cultivars are popular and recommended by local farmers because of their high fruit yields. Moreover, from an agri-food standpoint, as a summer fruit, these fresh figs produced in this region have an excellent taste, they are sought after and appreciated by consumers, in particular the fruits of the cultivar AH, CH. Finally, the cultivars AH, GH deserve to be candidates for IGP labeling as fresh fruits, not only because of their outstanding quality, but also because of their good pomological parameters and high Aksoy weighted method scores.

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