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DIVERGENCE AND SELECTION OF PEACH TREES AND NECTARINE TREES BASED ON COLD DAMAGE OF ITS FRUIT

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ABSTRACT - The knowledge of the post-harvest physiology of the fruit is of great importance in order to have technical subsidies aimed at extending the storage time without, however, altering its physical, organoleptic and nutritional characteristics, and, especially, in the case of the peach, due to its fragility. The objective was to evaluate the genetic divergence among 40 peach trees and nectarine trees genotypes based on the susceptibility fruit to cold damage. The study was carried out at EEAD-CSIC, Zaragoza - Spain. The susceptibility to cold damage was assessed after 14 and 28 days of cold storage using temperatures of 0º and 5ºC for symptoms of the presence of physiological disorders as wooliness mealy, grainy, leathery, changes in the color of the mesocarp, browning, bleeding and absence of flavor. As a selection criterion, 20% of the genotypes with the highest frequency of superiority were adopted in terms of quality characteristics, that is, the least damage presented. Divergent groups were formed, demonstrating that the accessions showed different behaviors among the tests. The 'Queen Giant' access showed less susceptibility to damage and differed genetically, according to the applied methods. In this way, it can be introduced as a genitor in breeding programs.
Keywords: *Prunus persica* L., fruit breeding, germplasm collection, physiological disorder.

DIVERGÊNCIA E SELEÇÃO DE PESSEGUEIROS E NECTARINEIRAS COM BASE NO DANO DE SEUS FRUTOS PELO FRIO

RESUMO - O conhecimento da fisiologia pós-colheita do fruto é de grande importância para que se tenha subsídios técnicos que visem prolongar o tempo de armazenamento sem, no entanto, alterar suas características físicas, organolépticas e nutricionais, e, principalmente, no caso do pêssego, devido à sua fragilidade. O objetivo foi avaliar a divergência genética entre 40 genótipos de pessegueiros e nectarineiras com base na suscetibilidade dos frutos aos danos causados pelo frio. O estudo foi realizado na EEAD-CSIC, Zaragoza - Espanha. A suscetibilidade aos danos causados pelo frio foi avaliada após 14 e 28 dias de armazenamento refrigerado utilizando temperaturas de 0º e 5ºC para sintomas de presença de distúrbios fisiológicos como lanosidade farinhenta, granulada, coriácea, alterações na cor do mesocarpo, escurecimento, sangramento e ausência de sabor. Como critério de seleção, foram adotados 20% dos genótipos com maior frequência de superioridade em termos de características de qualidade, ou seja, os menores danos apresentados. O genótipo 'Queen Giant' demonstrou menor susceptibilidade aos danos por frio, diferindo geneticamente dos demais de acordo com os métodos aplicados, podendo ser introduzido como possível genitor em programas de melhoramento.
Palavras-chave: *Prunus persica* L., coleta de germoplasma, distúrbio fisiológico, melhoramento de frutas.

INTRODUCTION

One of the techniques widely used in the post-harvest conservation of peaches and nectarines is refrigerated storage at low temperatures (MOSTAFIDI et al., 2020; SHIN et al., 2023), since it decreases their metabolism, delaying the senescence process and automatically extending their marketing time. However, the peaches and nectarines subjected to cold storage can develop physiological disorders if prolonged exposure to low temperatures (FABIANE et al., 2019; BARRETO et al., 2019), negatively affect fruit quality.

The search for resistant and/or tolerant cultivars is an important strategy that can prevent the onset of damage caused by cold in stored fruits (YAHAYA; MARDIYYA, 2019). In this context, genetic divergence studies are essential to identify divergent parents (TAVARES et al., 2018), which can be used in controlled hybridizations, increasing the probability of obtain cultivars without physiological disorders caused by storage at low temperatures. Thus, the variability of accessions in terms of susceptibility to cold damage is valuable for breeding programs (CARVALHO et al., 2023).

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According to Barbieri et al. (2005), the higher the divergence between parents is, the higher the resulting variability in the segregating population and the higher the probability of regrouping all of them into new favorable combinations. Different multivariate analysis techniques have been used to estimate genetic divergence (BENIN et al., 2003; HUSSAIN et al., 2022), including principal component analysis, canonical variables and agglomerative methods (CRUZ et al., 2012; SOUZA et al., 2023). As it is necessary to evaluate the genetic divergence among accessions of peach trees and nectarine trees based on the characteristics of susceptibility to cold damage and to select genotypes with potential for using as genitors, the present study was carried out with this objective.

MATERIAL AND METHODS

The study was carried out at the Experimental Station of Aula Dei (EEAD-CSIC), Zaragoza - Spain. Fruits of Adriatica (1), Alejandro Dumas (2), Andross (3), Baby Gold 6 (4), Baby Gold 7 (5), Baby Gold 8 (6), Baladin (7), Big Top (8), Bonet I (9), Bonet II (10), Borracho de Jarque (11), Brasileño (12), Campiel (13), Campiel Rojo (14), Carson (15), Catherina (16), Del Gorro (17), Fantasía (18), Flavortop (19), Fortuna (20), GF3 (21), Keimoes (22), Miraflores 2844 AD (23), Miraflores 3521 AD (24), Mountaingold (25), NJC 97 (26), Queen Giant (27), Redhaven (28), San Jaime (29), San Lorenzo (30), Sarell (31), Shasta (32), Stanford (33), Sudanell 1 (34), Sudanell 3 (35), Sudanell Blanco (36), Sudanell GF (37), Tempranillo de Aytona (38), Vesuvio (39), Zaragozano (40) varieties were evaluated in one productive cycle.

All varieties were grafted on the Adesoto plum rootstock (MORENO et al., 1995) and established in an experimental orchard, including three plants per genotype, in the winter of 2004/2005. Most of the accessions have fruits with yellow pulp and non-melting, with adherent stone. Among them, only four of the 40 accessions were nectarine trees, only two had white pulp, five melting pulp and two non-adherent stones. The experiment was conducted in a completely randomized design, with three replications, consisting of 20 fruits by experimental unit, considering each plant as a repetition. Susceptibility to cold damage was assessed after 14 and 28 days of cold storage using temperatures of 0º and 5ºC, with an average relative humidity of 95%, according to the Crisosto methodology (CRISOSTO et al., 1999).

Two days after being taken out from the cold, fruits exposed to room temperature (approximately 25ºC) were observed as for the damage of the presence of symptoms such as lack of succulence (Lanosity) evaluated by the presence of mealy, grainy, as well as, alterations of mesocarp staining (CM) by means of browning and bleeding. Complementing the mesocarp staining, the coloring variations consisting of L* (brightness or luminosity), a* (-a = greenish +a*= reddish), b* (-b = bluish +b= yellowish), C* (chromaticity) and h* (angle brightness) were measured with the aid of the colorimeter (Chroma Meter, CR-400 Konica Minolta, Japan).

Color observations were made in the mesocarp and in the area around the core immediately after the fruit was cut in equal parts on the suture plane. The browning was visually classified on a scale from 1 (without darkening) to 6 (severe darkening). The bleeding was visually scored on a scale from 1 (without reddening) to 3 (more than 50% of the reddish pulp), and readings were immediately performed with a colorimeter. The genetic diversity of the populations was evaluated by the methods of grouping the nearest neighbor and main component, using the Mahalanobis distance as a measure of dissimilarity. All analysis were performed by using the computer application in genetics and statistics, Genes® (CRUZ, 2006).

For the 20% selection of accessions regarding susceptibility to cold damage, scores from one to 40 were assigned to all genotypes in all response's variables corresponding to symptoms, one for the best average and 40 for the worst obtained. Subsequently, the overall average of the scores was calculated and the eight accesses with the lowest values were selected.

RESULTS AND DISCUSSIONS

The divergence evaluation by the principal component method demonstrated that the first four variables (L*, a*, b* and C*) were necessary to explain about 80% of the variation obtained by the 40 accessions studied. The importance of a variable is assessed through the percentage of total variance that it explains (CRUZ et al., 2012). According to Table 1, the L* parameter explains between 31.35 to 39.61% of the total variation, thus being the most important component.

Based on the graphical dispersion of the scores in this study, the first four main components were used, these are L* (CP1), a* (CP2), b* (CP3) and C* (CP4). In the graphs of the genetic divergence studies, the accessions were represented by the same identification numbers described in the Materials and Methods. In order to explore the maximum heterotic effect in controlled crossings amid the most divergent, it is possible to observe Figures 1 to 16 where different groups were formatted, which are more genetically distant based on the phenotypic characteristics of susceptibility to damage by cold.

TABLE 1 - Proportion of variance explained by the main components obtained by analyzing 11 variables of cold damage symptoms evaluated in 40 accessions of the peach tree from the germplasm collection of the Experimental Station of Class Dei-CSIC, Zaragoza - Spain, in the one production cycle.

	Variance (%)			
Components	14 days		28 days	
	0°C	5°C	0°C	5°C
L*	31.35	33.76	35.28	39.61
a*	25.28	21.52	19.75	17.76

Continuation os Table 1- Proportion of variance…

b*	14.50	15.77	16.41	14.81
C*	9.75	9.65	13.20	11.59
h*	7.60	7.21	4.94	6.13
Flavor alteration	5.72	4.89	4.05	4.66
Browning	3.78	3.49	3.12	2.93
Grainy	1.13	1.80	2.16	1.31
Leathery	0.70	1.68	1.04	1.09
Mealy	0.14	0.16	0.04	0.11
Bleeding	0.04	0.07	0.01	0.01

For the test where the accessions were submitted for 14 days exposed to 0ºC (Figures 1, 2 and 3), six, five and three groups were formed, respectively. Among Figures 1, 2 and 3 there was a coincident group formed by the accessions ‘Campiel’ (13) and ‘Campiel Rojo’ (14). It is noteworthy that the same accessions presented great severity of damage by cold in this test, and were highly affected by browning. Both accesses have their origin through open pollination, their genealogy is unknown, so they cannot affirm their relationship. However, both are from the same region (Huesca-Spain). The Figures 1 and 2 showed a coincident access group isolated ‘Queen Giant’ (27), the same is an American nectarine with white pulp.

In the Figures 2 and 3 there were a coincident group formed by the accessions ‘San Lorenzo’ (30), ‘Sudanell 1’ (34) and ‘Sudanell GF’ (37). These same accessions were grouped separately in Figure 1, in which the first two cited formed a group and the last was grouped isolated. These accessions are yellow-fleshed peach trees, the first two being Spanish and the last French. It is also inferred that the three showed susceptibility to cold damage during 14 days at 0ºC in relation to other accessions, specially presenting browning and mealy.

Also partially coincidentally, the large group formed for all the main components of this test was observed (Figures 1, 2 and 3). There were 31 accessions [‘Alejandro Dumas’ (2), ‘Andross’ (3), ‘Baby Gold 6’ (4), ‘Baby Gold 7’ (5), ‘Baby Gold 8’ (6), ‘Baladin (7), ‘Big Top’ (8), ‘Bonet I’ (9), ‘Bonet II’ (10), ‘Borracho de Jarque’ (11), ‘Brasileño’ (12), ‘Carson’ (15), ‘Catherina’ (16), ‘Del Gorro’ (17), ‘Fantasia’ (18), ‘Flavortop’ (19), ‘Fortuna’ (20), ‘GF3’ (21), ‘Keimoes’ (22), ‘Miraflores 2844’ (23), ‘Miraflores 3521’ (24), ‘Mountaingold’ (25), ‘Redhaven’ (28), ‘San Jaime’ (29), ‘Sarell’ (31), ‘Shasta’ (32), ‘Stanford’ (33), ‘Sudanell 3’ (35), ‘Tempranillo de Aytona’ (38), ‘Vesuvio’ (39) and ‘Zaragozano’ (40)] common to all groups. Completing the large group in Figure 1, the accessions ‘Adriatica’ (1) and ‘NJC 97’ (26). Forming the large group of Figure 9, still ‘Sudanell Blanco’ (36). And closing the group in Figure 2 were ‘Adriatica’ (1) ‘NJC 97’ (26), ‘Queen Giant’ (27) e ‘Sudanell Blanco’ (36).

In Figure 1, the sixth group was formed with the isolated access ‘Sudanell Blanco’ (36), a Spanish peach with white pulp. The Figure 2 completed its five groups with the accessions ‘Adriatica’ (1) and ‘NJC 97’ (26), which are Italian and American, respectively. These also did not show damage by cold in this test.

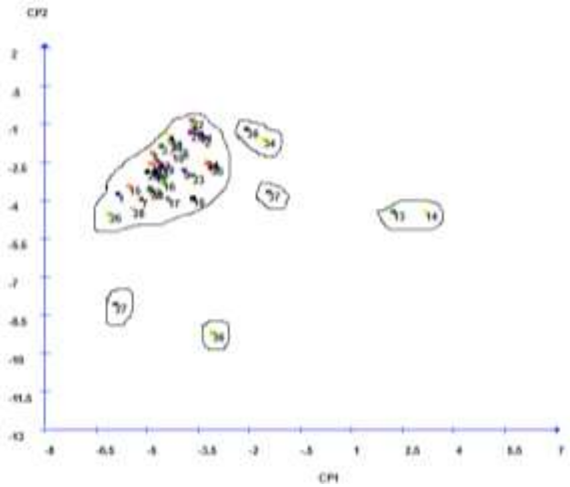

FIGURE 1 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza- Spain, in relation to the main components L* (CP1) and a* (CP2) stored for 14 days at 0ºC, in the one production cycle.

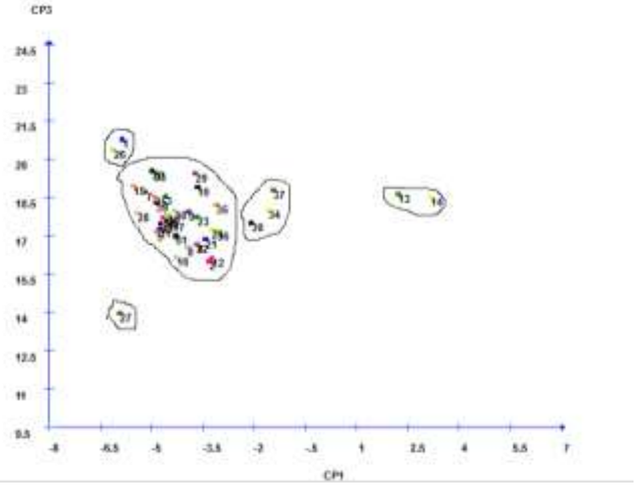

FIGURE 2 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza- Spain, in relation to the main components L* (CP1) and b* (CP3) stored for 14 days at 0ºC, in the one production cycle.

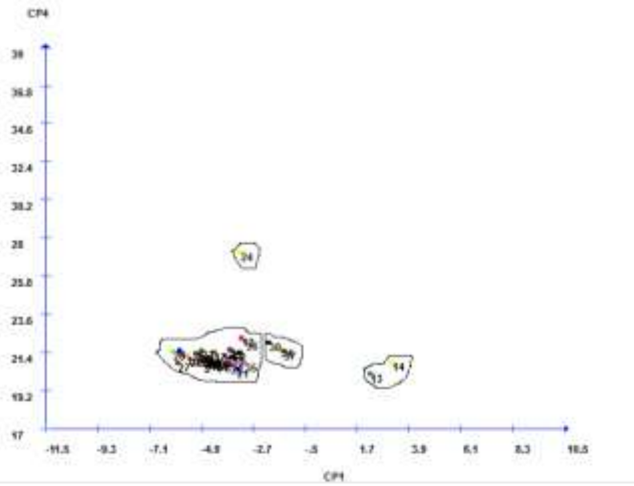

FIGURE 3 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza- Spain, in relation to the main components L* (CP1) and C* (CP4) stored for 14 days at 0ºC, in the one production cycle.

For the test where the accessions were submitted for 14 days at 5ºC (Figures 4, 5 and 6), the formation of eight, eight, and seven groups was observed, respectively. 'San Lorenzo' access (30) has remained isolated for all major components. This is a native Spanish peach, yellow/orange pulp, non-melting and adherent stone, obtained by open pollination.

The Figures 4, 5 and 6 showed the largest group with 23 accessions, with 19 coinciding in both ['Baby Gold 6' (4), 'Baby Gold 7' (5), 'Baby Gold 8' (6), 'Baladin' (7), 'Big Top' (8), 'Bonet I' (9), 'Carson' (15), 'Catherina' (16), 'Flavortop' (19), 'Fortuna' (20), 'Keimoes' (22)', 'Mountaingold' (25), 'Redhaven' (28), 'Sarell' (31), 'Shasta' (32), 'Stanford' (33), 'Tempranillo de Aytona' (38), 'Vesuvio' (39) and 'Zaragozano' (40)]. In addition to these, Figure 4 included 'Alejandro Dumas' (2), 'Andross' (3), 'Del Gorro' (17), e 'Sudanell 3' (35). For Figure 5, the group 'Alejandro Dumas' (2), 'Borracho de Jarque' (11), 'Del Gorro' (17), and 'Sudanell Blanco' (36) were completed. In Figure 6, the accesses 'Andross' (3), 'Bonet II' (10), 'Sudanell 3' (35) and 'Sudanell Blanco' (36) closed the 23 accessions of the large group.

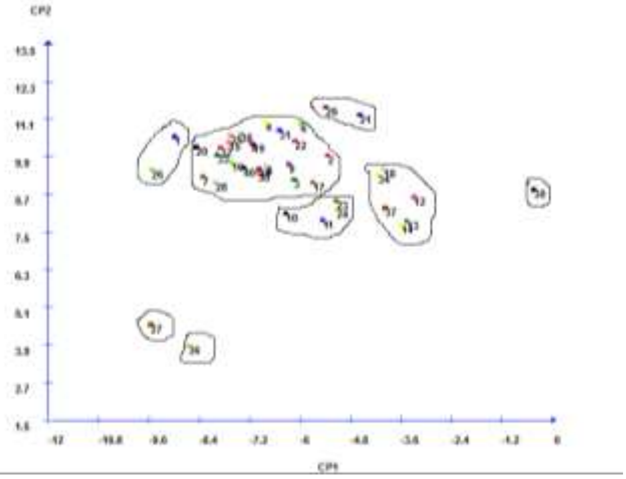

FIGURE 4 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components a* (CP1) and b* (CP2) stored for 14 days at 5ºC, in the one production cycle.

The Figures 4 and 5 showed two coincident groups. The accessions 'Adriatica' (1) and 'NJC 97' (26) were grouped in the same group, both being yellow-fleshed peaches, non-melting and with adherent stone, but with different origins. The american white-fleshed nectarine 'Queen Giant' (27) remained isolated. The Figures 4 and 6 also coincided with a group formed with six quite different accessions ['Fantasia' (18), 'Brasileño' (12), 'Campiel' (13), 'Campiel Rojo' (14), 'Sudanell 1' e 'Sudanell GF' (37)]. This group was composed of peach trees and a nectarine tree, whose origin was from France, USA and Spain.

In Figure 4, in addition to the five groups already mentioned, a sixth group formed by a single access could be seen, consisting of 'Sudanell Blanco' (36) which is a Spanish peach, white-pulped, non-melting and adherent stone. Forming the seventh group, there are 'GF3' and 'San Jaime' (29), which have different origins. However, both produce yellow and non-melting peaches. The eighth group was composed of 'Bonet II' (10), 'Borracho de Jarque' (11), 'Miraflores 2844' (23) and 'Miraflores 3521' (24), which are native Spanish peaches, obtained by open pollination.

In Figure 5, in addition to the four groups mentioned above, isolated is 'San Jaime' (29), which is a Spanish peach tree with yellow pulp, non-melting and adherent stone. Three accessions comprised the sixth group ['Andross' (3), 'Bonte II' (10) and 'Sudanel 3' (35)], with the characteristic of producing yellow-fleshed peaches, but which nevertheless has divergence as to the origin, since 'Andross' comes from the USA and the others are Spanish. Also formed with three accessions, there was the group composed of 'Brasileño' (12), 'Fantasia' (18) and 'GF3' (21), whose characteristics are peach trees from Spain, nectarines from the USA and peach trees from France, forming the seventh group, respectively. The eighth group was formed by the accessions 'Campiel Rojo' (14), 'Campiel' (13), 'Miraflores 2844' (23), 'Miraflores 3521' (24), 'Sudanell 1' (34) and 'Sudanell GF' (37) (Figure 5), with almost all of them producing yellow, non-melting and adherent stone peaches, native to Spain, except 'Sudanell GF', which is French.

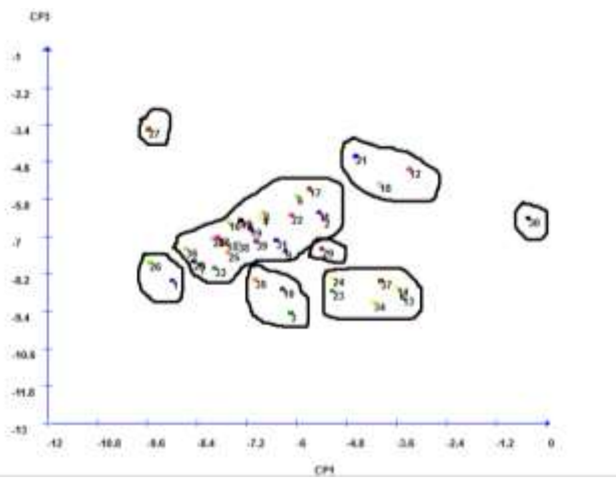

FIGURE 5 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L * (CP1) and b * (CP3) stored for 14 days at 5ºC, in the one production cycle.

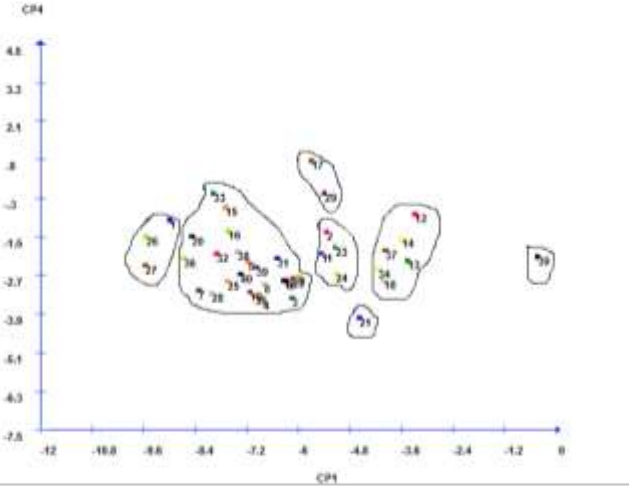

FIGURE 6 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and C* (CP4) stored for 14 days at 5ºC, in the one production cycle.

It was observed in Figure 6, that in addition to the three groups mentioned, there was the isolated group with ‘GF3’ (21), which produces yellow, non-melting peach and adherent stone from France. Forming the fifth group there are the accessions ‘San Jaime’ (29) and ‘Del Gorro’ (17), whose peaches are Spanish and yellow. Three accessions comprised the sixth group, these by the nectarine tree ‘Queen Giant’ (27) and the peach trees ‘Adriatica’ (1) and ‘NJC 97’ (26). The seventh group was formed with four accessions [‘Alejandro Dumas’ (2), ‘Borracho de Jarque’ (11), ‘Miraflores 2844’ (23) and ‘Miraflores 3521’ (24)], all Spanish with yellow pulp, obtained by open pollination.

For the test where the accessions were submitted for 28 days at 0ºC (Figures 7, 8 and 9), the formation of sixteen, eight and twelve groups were observed, respectively. The ‘Adriatica’ access (1) remained isolated for all main components, according to Figures 7, 8 and 9. This is an Italian peach, yellow pulp, non-melting and adherent stone. The Figures 7 and 8 showed three isolated coincident accessions. ‘Sudanell 1’ and ‘San Lorenzo’ Spanish peaches with yellow pulp, non-melting and adherent stone. And, the white-fleshed peach ‘Sudanell Blanco’.

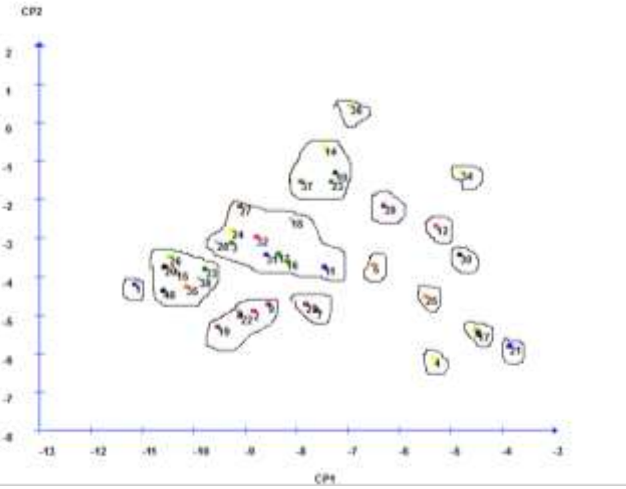

FIGURE 7 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and a* (CP2) stored for 28 days at 0ºC, in the one production cycle.

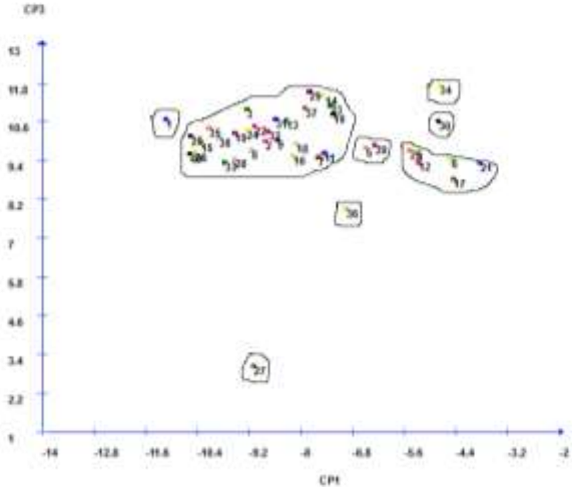

FIGURE 8 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and b* (CP3) stored for 28 days at 0ºC, in the one production cycle.

In Figures 7 and 9, four isolated accesses coincided. 'Baby Gold 6' and 'Baby Gold 7', which come from US breeding programs, both of which are yellow peaches. These, even if they are separated, have in common the parental 'NJ196'. And also the French access 'GF3' and the Italian 'Vesuvio', both yellow peaches.

In the Figures 8 and 9, there was a correspondence among 20 accessions ['Alejandro Dumas' (2), 'Andross' (3), 'Baladin' (7), 'Big Top' (8), 'Bonet I' (9), 'Bonet II' (10), 'Borracho de Jarque' (11), 'Campiel' (13), 'Catherina' (16), 'Flavortop' (19), 'Keimoes' (22)', 'Miraflores 2844' (23), 'Miraflores 3521' (24), 'Redhaven' (28), 'San Jaime' (29), 'Sarell' (31), 'Shasta' (32), 'Stanford' (33), 'Sudanell 3' (35), 'Sudanell Blanco' (36), 'Sudanell GF'(37)] within the largest group of these Figures, with 27 and 22 accessions in this group, respectively. Thus, they completed the large group of Figure 8, the accessions 'Campiel Rojo' (14), 'Carson' (15), 'Fantasia' (18), 'Fortuna' (20), 'NJC 97' (26), 'Tempranillo de Aytona' (38) and 'Zaragozano' (40). Completing the large group in Figure 9, the white pulp accessions 'Queen Giant' (27) and 'Sudanell Blanco' (36).

As for the grouping of Figure 7, in addition to the eight groups aforementioned, two other accessions were also formed with the Spanish 'Brasileño' (12) e o American 'Mountaingold' (25), which have yellow pulp. Forming the eleventh group, there are two distinct accesses, 'Baby Gold 8' (6) and 'Del Gorro' (17), from the USA and Spain, respectively. Consecutive to this group, another one emerged with two accessions 'Baladin' (7) and 'San Jaime' (29), the first French and the second Spanish, both with yellow pulp. The accessions 'Bonet II' (10), 'Campiel Rojo' (14), 'Miraflores 2844' (23) and 'Sudanell GF' (37) were grouped to form the thirteenth group.

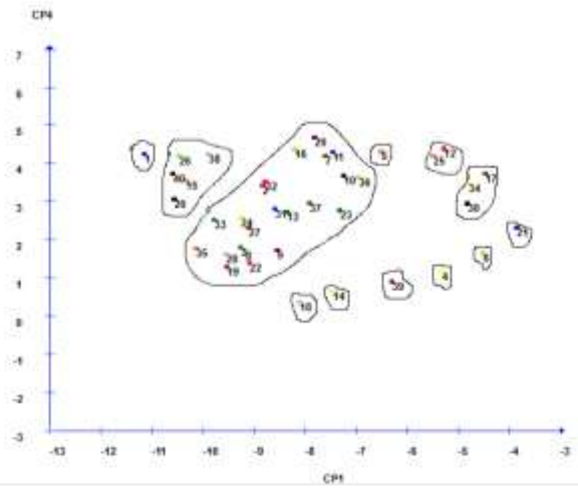

FIGURE 9 - Distribution of 40 peach accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and C* (CP2) stored for 28 days at 0ºC, in the one production cycle.

The five accessions, 'Bonet I' (9), 'Alejandro Dumas' (2), 'Big Top' (8), 'Flavortop' (19) and 'Keimoes' (22) made up the fourteenth group. Common to all, the color of yellow pulp. However, the first two mentioned are

Spanish peaches and the last one comes from South Africa. ‘Big Top’ and ‘Flavortop’ are nectarine trees, coming from the USA.

Based on the combination of components CP1 and CP2, seen in Figure 7, the fifteenth group is still observed, with seven accesses [‘Carson’ (15), ‘Fortuna’ (20), ‘NJC 97’ (26), ‘Stanford’ (33), ‘Sudanell 3’ (35), ‘Tempranillo de Aytona’ (38) e ‘Zaragozano’ (40)], and the sixteenth with the remaining 10 accessions [‘Andross’ (3), ‘Borracho de Jarque’ (11), ‘Campiel’ (13), ‘Catherina’ (16), ‘Fantasia’ (18), ‘Miraflores 3521’ (24), ‘Queen Giant’ (27), ‘Redhaven’ (28), ‘Sarell’ (31) and ‘Shasta’ (32)].

For Figure 8, in addition to the five groups mentioned above, there was still an isolated formation of the group with the nectarine tree ‘Queen Giant’ (27). Two accessions, ‘Baby Gold 7’ (5) and ‘Vesuvio’ (39), formed the seventh group. The eighth group consisted of the accessions ‘Baby Gold 6’ (4), ‘Baby Gold 8’ (6), ‘Brasileño’ (12), ‘Del Gorro’ (17), ‘GF3’ (21) and ‘Mountaingold’ (25), that it are producers of yellow pulp peaches. However, three of these are from the USA, one from France and two from Spain.

In Figure 9, in addition to the six groups previously placed, another three accessions were isolated, these being ‘Baby Gold 8’ (6), ‘Campiel Rojo’ (14) and ‘Fantasia’ (18). The tenth group was formed with ‘Brasileño’ (12) and ‘Mountaingold’ (25). Three accessions [‘Del Gorro’ (17), ‘San Lorenzo’ (30) and ‘Sudanell 1’ (34)] made up the eleventh group, all of which are Spanish native peach trees. Succeeding this, there was the group formed by ‘Carson’ (15), ‘Fortuna’ (20), ‘NJC 97’ (26), ‘Tempranillo de Aytona’ (38) and ‘Zaragozano’ (40), being the first three mentioned from the USA and the last two from Spain.

For the test where the accessions were submitted for 28 days at 5 ºC, shown in Figures 10, 11 and 12, the formation of thirteen, ten and eleven groups observed, respectively. The ‘Campiel Rojo’ (14) accession remained isolated from all main components, which stood out as the one with the greatest severity of cold damage in this trial, suffering from wooliness to changes in the color of the mesocarp, which may justify such a divergence. Also isolated for all components, there was access to 'San Jaime' (29), which is a Spanish peach tree with yellow pulp.

The third coincident group for both main components was composed of the accessions ‘Carson’ (15), ‘NJC 97’ (26), ‘Tempranillo de Aytona’ (38), ‘Adriatica’ (1) and ‘Flavortop’ (19). The latter was grouped only in Figure 10. However, it is isolated in Figures 11 and 12. Although partially coincident, among Figures 10, 11 and 12, it can see the largest group formed in these with 10, 16 and 15 accesses, respectively. Forming the large group of Figure 10, the accessions ‘Keimoes’ (22), ‘Miraflores 2844’ (23), ‘Miraflores 3521’ (24), ‘Fantasia’ (18), ‘Alejandro Dumas’ (2), ‘Vesuvio’ (39), ‘Baby Gold 7’ (5), ‘Baby Gold 8’ (6), ‘San Lorenzo’ (30) and ‘Borracho de Jarque’ (11). Completing the large group of Figures 11 and 12, in addition to those mentioned above, the accessions ‘Del Gorro’ (17), ‘GF3’ (21), ‘Baby Gold 6’ (4), ‘Bonet I’ (9), ‘Sudanell GF’ (37). Closing the 16 accessions of the large group, in Figure 11 appears ‘Sudanell Blanco’ (36).

In the Figures 10 and 11 coincidentally occurred the isolated grouping of the nectarine tree 'Queen Giant' (27), which has white pulp. In the Figures 11 and 12, there were two equal groups, with three [‘Zaragozano’ (40), ‘Baldin’ (7) and ‘Catherina’ (16)] and five [‘Sudanell 1’ (34), ‘Brasileño’ (12), ‘Campiel’ (13), ‘Bonet II’ (10), and ‘Andross’ (3)] accesses. For Figure 10, in addition to the five groups mentioned in the coincident groups, there was a formation with three isolated accesses, 'Brasileño' (12), 'Del Gorro' (17) and ‘Bonet I’ (9), all Spanish with yellow flesh. The ninth group was formed with two accessions ‘Baby Gold 6’ (4), ‘GF3’ (21), being American and French, respectively. The tenth group also had two accessions, with white ‘Sudanell Blanco’ (36) and yellow ‘Sudanell GF’ (37).

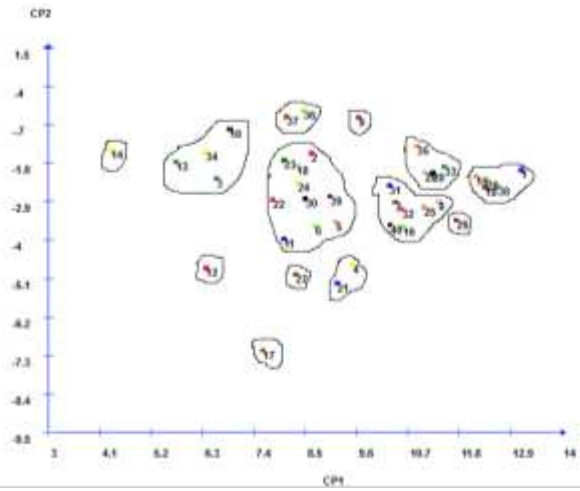

FIGURE 10 - Distribution of 40 peach tree accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and a* (CP2) stored for 28 days at 5ºC, in the one production cycle.

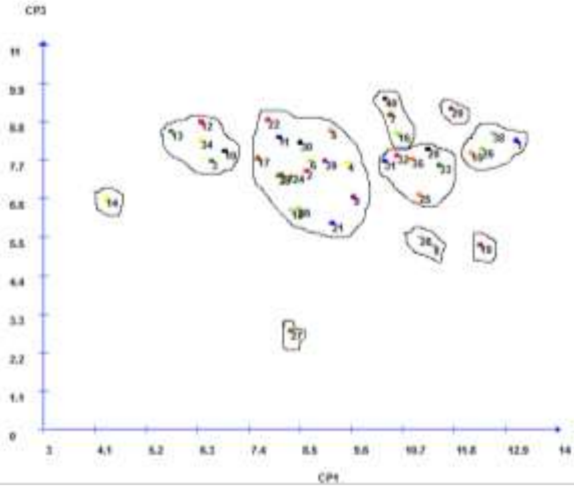

FIGURE 11 - Distribution of 40 peach tree accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and b* (CP3) stored for 28 days at 5ºC, in the one production cycle.

The four accessions ‘Bonet II’ (10), ‘Campiel’ (13), ‘Sudanell 1’ (34) and ‘Andross’ (3) formed the eleventh, it being the same, except for the last of Spanish origin. Consecutive to this, another four accessions were grouped, which consisted of ‘Sudanell 3’ (35), ‘Stanford’ (33), ‘Fortuna’ (20) and ‘Redhaven’ (27), whose origin is the USA, except to the first one that is Spanish. The accessions ‘Sarell’ (31), ‘Baladin’ (7), ‘Shasta’ (32), ‘Mountaingold’ (25), ‘Big Top’ (8), ‘Zaragozano’ (40) and ‘Catherina’ (16), formed the thirteenth group. They were all formed by genotypes of yellow-fleshed peaches, except for ‘Big Top’ which is nectarine tree.

As for the grouping of Figure 11, in addition to the eight groups previously mentioned, there were two accessions [‘Redhaven’ (28) and ‘Big Top’ (8)] in the same group, whose origin is the USA. The tenth group consisted of the accessions ‘Fortuna’ (20), ‘Shasta’ (32), ‘Stanford’ (33), ‘Mouintaingold’ (25) ‘Sarell’ (31) and ‘Sudanell 3’ (35), of which, only the last two are Spanish and the rest are from the USA, the first being yellow nectarine.

For Figure 12, in addition to the seven groups previously mentioned, one with ‘Sarell’ (31) appeared isolated. The accessions of white pulp ‘Queen Giant’ (27) and ‘Sudanell Blanco’ (36) were grouped in the same group. Forming the tenth group, there were two accessions from the US improvement programs, ‘Fortuna’ (20) and ‘Stanford’ (33), being nectarine tree and peach tree, respectively. ‘Big Top’ (8), ‘Mountaingold’ (25), ‘Redhaven’ (28), ‘Sudanel 3’ (35) and ‘Shasta’ (32), formed the eleventh group, of which the first three are Americans and the last two Spanish.

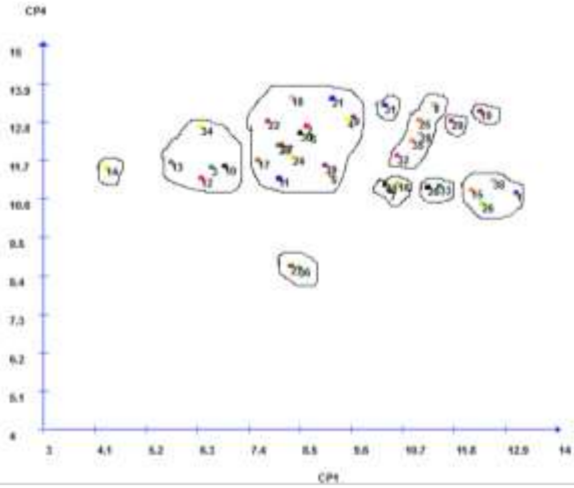

FIGURE 12 - Distribution of 40 peach tree accessions (identified by numbers) from the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, in relation to the main components L* (CP1) and C* (CP4) stored for 8 days at 5ºC, in the one production cycle.

In the dendrograms formation by the nearest neighbor method, the formation of three groups was observed for the 14-day trials at both temperatures (Figures 13 and 14). At 28 days, two groups occurred for the two temperatures tested (Figures 14 and 15).

The Group I coincided in all trials, it being formed by the ‘Queen Giant’ access with 100 % distance, except for the 14-day trial at 0ºC (Figure 13). In this, the accessions of white pulp ‘Queen Giant’ (Group I) and ‘Sudanel Blanco’ (Group II) were 100% distant from the others (Group III), all of which were yellow pulp fruits and more than 65% apart each other, since the first is nectarine tree and the second peach tree. These distances shown are mainly due to the color of the pulp, since, the divergence shown in Figure 13, considered all the variables studied, in which five are related to the color of the pulp.

For the 14-day trial at 5ºC (Figure 14), the access ‘Sudanell Blanco’ showed 100% distance from Group I and more than 70% from Group III (formed by the other accesses). Regarding Group III, three accessions ‘Baby Gold 6’, ‘GF3’ and ‘Baby Gold showed more than 35% of distance from the others at 14 days at 0ºC (Figure 13) and approximately 25% in the trial 14 days at 5ºC (Figure 14).

Among these three accesses, at 0ºC, the distance was less than 5%. However, at 5ºC, the ‘GF3’ access presented more than 10% of the other two. This can be explained, since ‘Baby Gold 6’ and ‘Baby Gold 8’ belong to the US breeding program, while the origin of ‘GF3’ is France. Still in Group III, at 14 days at 0ºC (Figure 13) the accesses ‘Campiel’ e ‘Campiel Rojo’ were approximately 15% apart from the others. It is noteworthy that in this trial, they presented severity of damage caused by cold, showing greater susceptibility than the others.

Within Group III, at 14 days in a condition of 5ºC (Figure 14), the access ‘Borracho de Jarque’ was around 15% away from the others. Also, in a similar distance, ‘San Lorenzo’, coincided with the graphic presentation of all the main components of this test, in which it was isolated, showing greater heterotic potential in relation to the large group of yellow pulp accessions.

Observing the Figure 15 (trial 28 days in a condition of 0ºC), in Group II, the peach with white pulped fruits showed more than 30% of distance from the other accessions. This was possibly due to the color of the pulp. The other accesses have less than 10% of distance.

As for the 28-day trial at 5ºC (Figure 16), within group II, with approximately 15% of distance, three accessions occurred, ‘Big Top’, ‘Flavortop’ and Redhaven’. This subgroup formed by two nectarine trees and a peach tree had in common, in addition to all being from the USA, the fact that they were less susceptible to the symptoms of cold damage. It should also be noted that in the grouping between ‘CP1 e CP3’, e ‘CP1 e CP4’, in this essay, ‘Flavortop’ was isolated, and ‘Big Top’ and ‘Redhaven’ forming a single group for ‘CP1 e CP3’. The other accessions showed less than 10% of distance, including the accession of fruit with white flesh ‘Sudanell Blanco’, which due to the incidence and severity of the symptoms presented, joined the others.

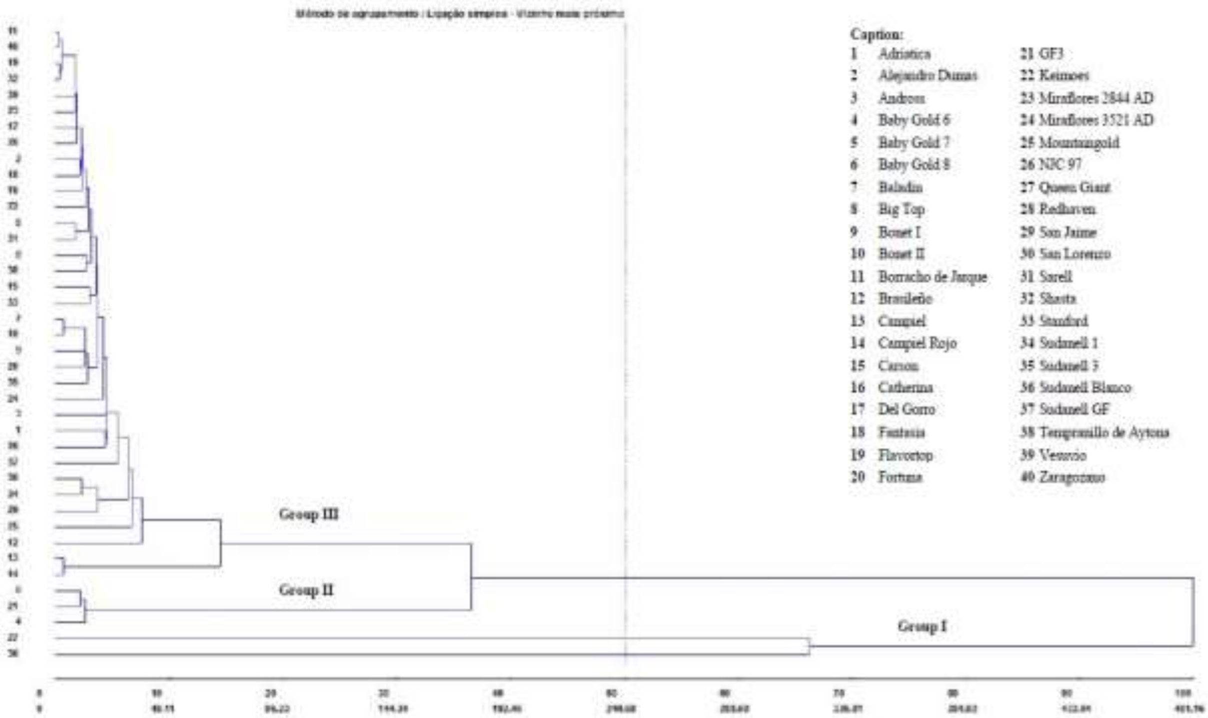

FIGURE 13 - Dendrogram of genetic dissimilarities between 40 accessions of peach from the germplasm collection of the Experimental Station Aula Dei-CSIC, Zaragoza - Spain, submitted for 14 days at a temperature of 0ºC, obtained by the 'neighbor more' method next 'based on the variables (PF, PC, PG, EI, AI, AS, L*, a*, b*, C*, h*), using the generalized Mahalanobis distance. On the X axis, the percentages of the distances between the populations were represented and on the Y axis, the 40 accesses were represented.

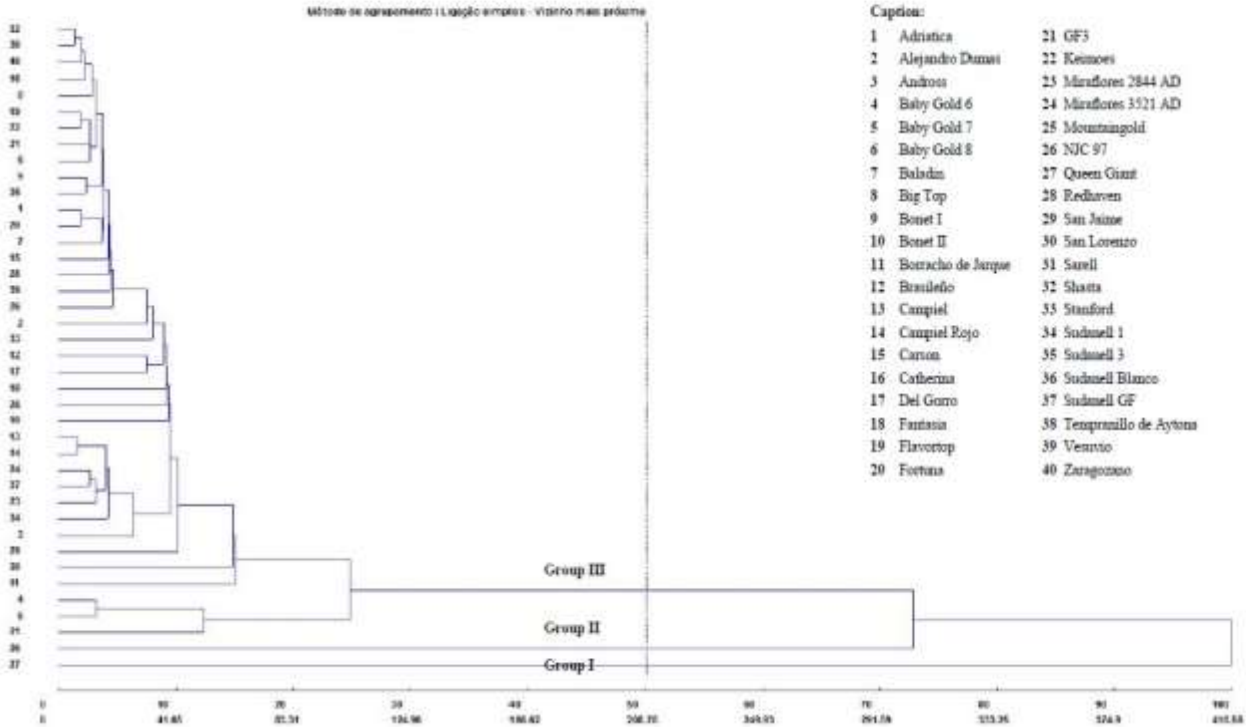

FIGURE 14 - Dendrogram of genetic dissimilarities between 40 accessions of peach tree from the germplasm collection of the Experimental Station Aula Dei-CSIC, Zaragoza - Spain, submitted for 14 days at a temperature of 5ºC, obtained by the 'nearest neighbor' method based on the variables (PF, PC, PG, EI, AI, AS, L*, a*, b*, C*, h*), using the generalized Mahalanobis distance. On the X axis, the percentages of the distances between the populations were represented and on the Y axis, the 40 accesses were represented.

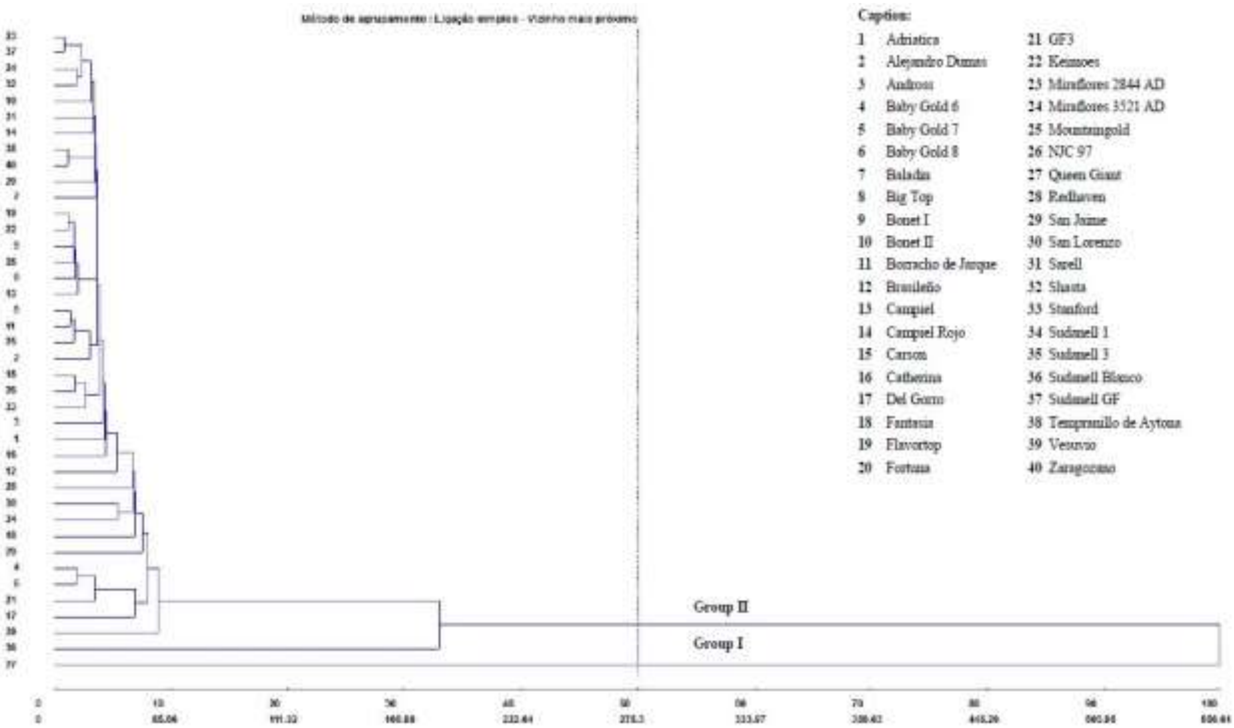

FIGURE 15 - Dendrogram of genetic dissimilarities between 40 accessions of peach from the germplasm collection of the Experimental Station Aula Dei-CSIC, Zaragoza - Spain, submitted for 28 days at a temperature of 0ºC, obtained by the 'nearest neighbor' method with based on the variables (PF, PC, PG, EI, AI, AS, L*, a*, b*, C*, h*), using the generalized Mahalanobis distance. On the X axis, the percentages of the distances between the populations were represented and on the Y axis, the 40 accesses were represented.

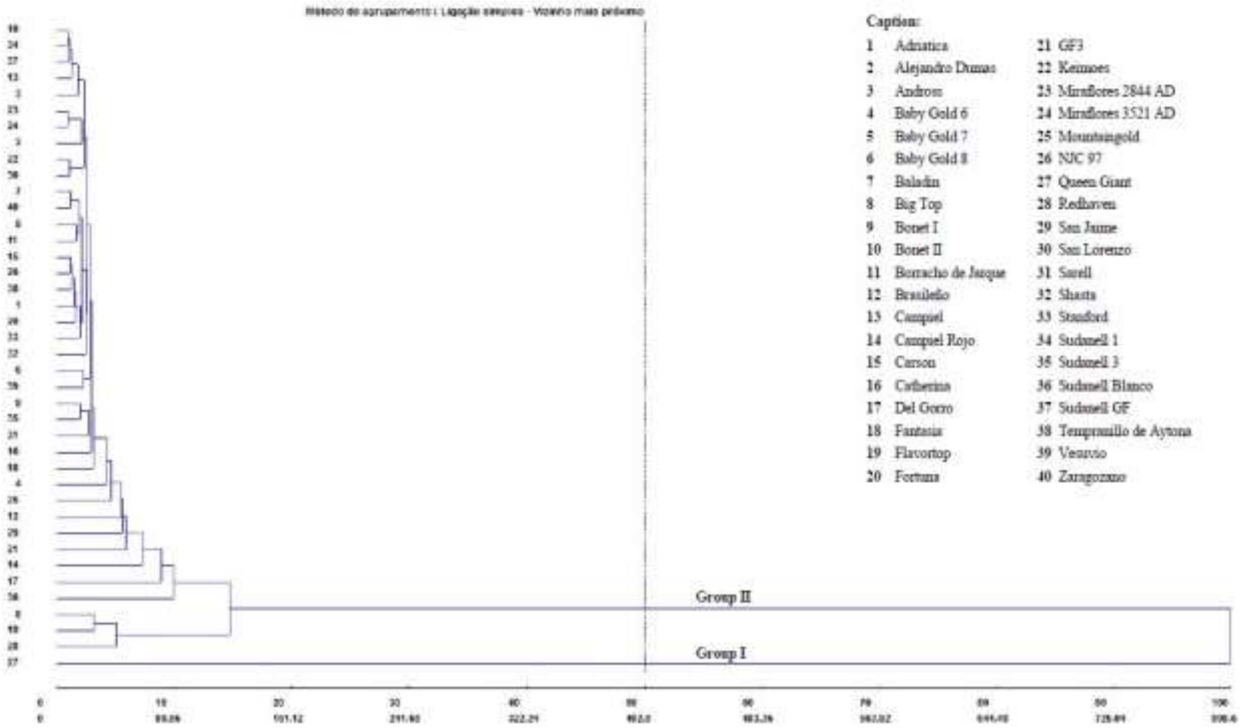

FIGURE 16 - Dendrogram of genetic dissimilarities between 40 accessions of peach from the germplasm collection of the Experimental Station Aula Dei-CSIC, Zaragoza - Spain, submitted for 28 days at a temperature of 5ºC, obtained by the method 'nearest neighbor' with based on the variables (PF, PC, PG, EI, AI, AS, L*, a*, b*, C*, h*), using the generalized Mahalanobis distance. On the X axis, the percentages of the distances between the populations were represented and on the Y axis, the 40 accesses were represented.

Formation of divergent groups was observed among the tests for graphic presentation of the CP, as well as, in the dendograms demonstrating that the accessions presented different behaviors among the tests. There was partial similarity among the methods for the accessions of white pulp (‘Queen Giant’ and ‘Sudanell Blanco’), which were grouped separately in some main components and in the dendrograms, of which greater emphasis can be given to ‘Queen Giant’ nectarine. It was observed that accessions that suffered more severe damage due to cold, mainly browning, tended to group or present greater distance from the others, for example, ‘Campiel’ and ‘Campiel Rojo’. The selection of 20% of the studied genotypes that presented a higher frequency of superiority, according to the incidence and severity of cold damage (mealy, grainy, lathery, Browning, bleeding and lack of flavor) was carried out for both tests at 0ºC, and in the combination of all tests.

Due to the lower incidence and severity of damage observed at a temperature of 0ºC, ‘Queen Giant’, ‘Keimoes’, ‘Flavortop’, ‘Big Top’, ‘Redhaven’, ‘Sudanell 3’, ‘Bonet I’ e ‘Carson’ were selected. When selected based on the damage suffered in all tests, it is possible to observe the replacement of the accessions ‘Bonet I’ and ‘Keimoes’ by ‘Fortuna’ and ‘Sarell’ (Table 2). However, even with six coinciding accessions for both selections made, it is noteworthy that they showed greater damage in the temperature of 5ºC. Therefore, it is indicated that the accessions less susceptible to cold damage, with greater potential for use as genitors in breeding programs were selected in refrigeration at 0ºC.

TABLE 2 - Classification of peach tree accessions in the germplasm collection Experimental Station of Aula Dei-CSIC, Zaragoza - Spain, selected according to the 20% criterion with higher frequency of superiority according to the incidence and severity of cold damage, in the one production cycle.

Classification	0ºC tests	0 and 5ºC tests
1º	Queen Giant	Flavortop
2º	Keimoes	Big Top
3º	Flavortop	Queen Giant
4º	Big Top	Redhaven
5º	Redhaven	Carson
6º	Sudanell 3	Sudanell 3
7º	Bonet I	Fortuna
8º	Carson	Sarell

It was observed that among the selected accessions were found the four studied accessions that present melting pulp: ‘Redhaven’, ‘Flavortop’, ‘Big Top’ and ‘Queen Giant’, indicating that these tend to be less susceptible, it being the three last nectarine trees. Among the eight accessions, five are from the US breeding programs, two are native Spanish and one is from South Africa.

CONCLUSIONS

Divergent groups were formed, demonstrating that the accessions showed different behaviors among the tests. The ‘Queen Giant’ access showed less susceptibility to damage and differed genetically, according to the applied methods. In this way, it can be introduced as a genitor in breeding programs.

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