# Physicochemical description of traditional *Ceratonia siliqua* L. cultivars

**Miquel Barceló[1*], Jeroni Pou[1], Miquel Llompart[1], Joana Maria Luna[2], Isabel Gálvez[2], Ismael Mateu[2], and M. Carme Garau[2]**

[1] Empresa de Transformación Agraria S.A. Passatge Cala Figuera, 6, 07009, Palma, Spain.
[2] Institut de Recerca i Formació Agroalimentària i Pesquera de les Illes Balears (IRFAP). C/ Eusebi Estada, 145, 07009, Palma, Spain.
[*]mbarcelo@tragsa.es

## Introduction

*Ceratonia siliqua* L. is a native plant of the Mediterranean region, where it usually grows on nutrient poor soils and under harsh climatic conditions (Winer, 1980; Batlle & Tous, 1997; Gubbuk et al., 2009). The Mediterranean region has important plant genetic resources and genetic conservation is essential to safeguard the potential for adaptation to environmental changes (Maxted & Bennett, 2001). Thus, ex-situ conservation system makes it possible to measure the ability to adapt to the climate change (Ipinza Carmona, 2018). The aim of the present study was to carry out the physicochemical characterization of different cultivars of *Ceratonia siliqua* L. from the Balearic Islands.

## Material and methods

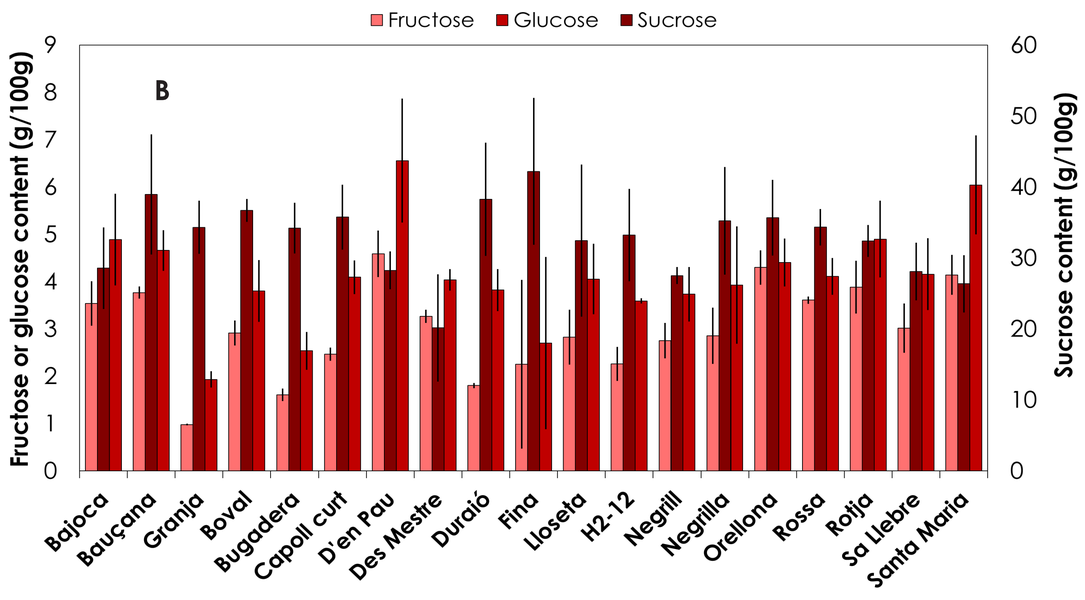
The characterization was carried out in the germplasm bank, located in Son Real, in the northeast area of Mallorca (39º 44' 15'' N, 3º 10' 40'' E). In particular, thirteen traditional cultivars from Majorca (Bajoca, Bauçana, Bugadera, Capoll curt, D'en Pau, Des Mestre, Duraió, Lloseta, Negrill, Negrilla, Sa Llebre, Santa Maria and Rossa), four traditional cultivars from Eivissa (Boval, Fina, Orellona and Rotja) and two open-pollinated cultivars (Granja and H-2-12 (E 13P)), were characterized in this study during 2021 and 2022. Four individuals, selecting randomly twenty pods, were studied for each cultivar. The physical parameters evaluated for every pod were length (cm), width (cm), weight (g), pedicel length (mm), thickness (mm), valley thickness (mm), seed quantity, total seed weigth (g) and seed yield (%). On the other hand, the chemical parameters evaluated were sugar content (%), pH and tritatable acidity. The sugars content were obtained using ion chromatography by the company AGROLAB Iberica S.L.U., Tarragona, Spain, and the pH values were measured using a pH-Meter BASIC 20+ (Crison Instruments, S. A., Alella, Barcelona, Spain). Tritatable acidity (citric acid g/100 g sample) was measured by neutralizing the acid present in the sample using NaOH 0.1N until 8.1 pH (Lobit et al., 2002). Data obtained were evaluated by means of an analysis of variance (ANOVA) and a Duncan test when the distribution was normal, otherwise the non-parametric Kruskall Wallis test was used. IBM SPSS Statistics 29 software package (IBM Corp., 2013) was used for statistical analysis.

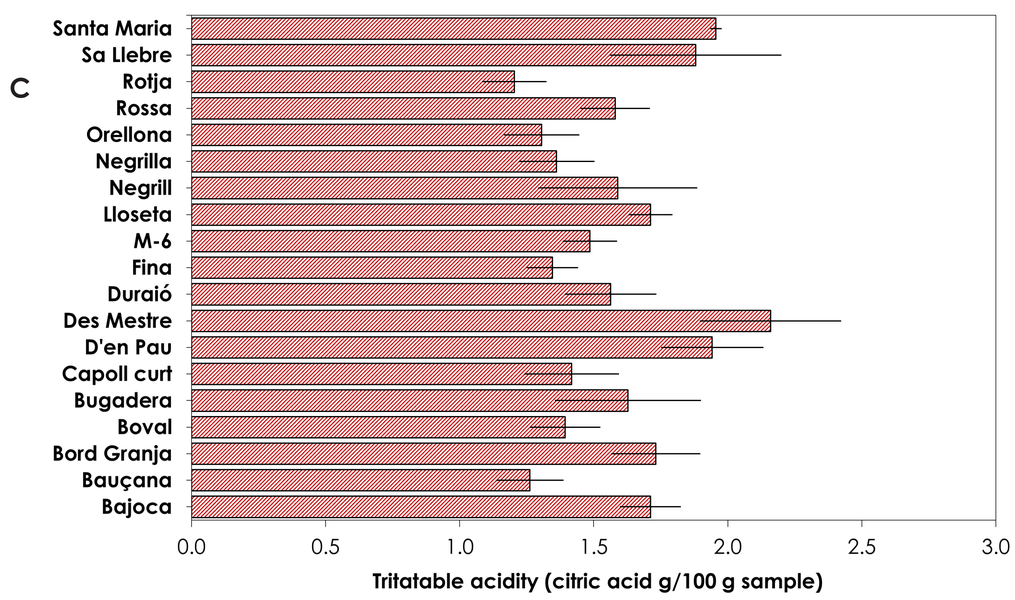
## Results

**Table 1. Physical parameters of carob pods for each cultivar (mean ± standard deviation).** Pod number evaluated were 20 per cultivar in 2021 and in 2022.

| Cultivar | Length (cm) | Width (cm) | Weigth (g) | Pedicel length (mm) | Thickness (mm) | Valley thickness (mm) | Seed quantity | Seed weigth (g) | Seed yield (%) |
|---|---|---|---|---|---|---|---|---|---|
| Bajoca | 18,53 ± 0,26 **jk** | 2,17 ± 0,04 **jk** | 18,40 ± 0,51 **gh** | 9,05 ± 0,35 **abcd** | 9,46 ± 0,18 **g** | 6,07 ± 0,16 **defg** | 9,08 ± 0,37 **abc** | 1,78 ± 0,07 **bcde** | 9,66 ± 0,32 **abc** |
| Bauçana | 14,98 ± 0,23 **cde** | 1,88 ± 0,02 **bcdef** | 13,63 ± 0,29 **bc** | 9,64 ± 0,21 **bcde** | 7,84 ± 0,20 **bcd** | 5,84 ± 0,15 **bcdefg** | 8,00 ± 0,18 **a** | 1,44 ± 0,05 **ab** | 10,71 ± 0,41 **bcd** |
| Boval | 17,22 ± 0,36 **hi** | 2,05 ± 0,02 **hij** | 16,08 ± 0,55 **cdefg** | 9,01 ± 0,29 **abc** | 8,19 ± 0,14 **cde** | 6,41 ± 0,10 **fgh** | 10,88 ± 2,08 **ab** | 1,30 ± 0,07 **a** | 8,05 ± 0,27 **a** |
| Bugadera | 16,48 ± 0,20 **fgh** | 2,18 ± 0,02 **jkl** | 16,05 ± 0,35 **cdefg** | 10,34 ± 0,22 **def** | 8,06 ± 0,10 **bcde** | 5,24 ± 0,07 **bc** | 12,13 ± 0,25 **gh** | 2,26 ± 0,06 **g** | 14,12 ± 0,30 **efg** |
| Capoll Curt | 13,43 ± 0,18 **ab** | 1,77 ± 0,01 **b** | 9,90 ± 0,24 **a** | 8,42 ± 0,19 **ab** | 6,65 ± 0,12 **a** | 6,02 ± 0,11 **defg** | 10,10 ± 0,30 **bcde** | 1,73 ± 0,07 **bcd** | 17,43 ± 0,50 **hi** |
| D'en Pau | 15,98 ± 0,29 **efgh** | 1,96 ± 0,02 **defghi** | 15,54 ± 0,50 **cde** | 10,6 ± 0,22 **ef** | 9,41 ± 0,17 **g** | 7,18 ± 0,12 **i** | 11,50 ± 0,35 **efgh** | 2,12 ± 0,08 **efg** | 13,66 ± 0,29 **ef** |
| Des Mestre | 19,87 ± 0,26 **l** | 1,93 ± 0,03 **cdefgh** | 18,01 ± 0,77 **efgh** | 10,49 ± 0,26 **ef** | 9,2 ± 0,22 **fg** | 5,82 ± 0,18 **bcdefg** | 9,68 ± 0,42 **bcd** | 1,53 ± 0,08 **abc** | 9,44 ± 0,75 **ab** |
| Duraió | 16,44 ± 0,22 **fgh** | 1,85 ± 0,02 **bcde** | 14,18 ± 0,44 **bcd** | 12,16 ± 0,33 **gh** | 8,92 ± 0,14 **efg** | 5,48 ± 0,20 **bcd** | 11,90 ± 0,34 **fgh** | 1,81 ± 0,07 **cde** | 12,98 ± 0,49 **def** |
| Fina | 12,96 ± 0,22 **a** | 2,31 ± 0,04 **l** | 15,86 ± 0,73 **cdefg** | 7,82 ± 0,22 **a** | 9,73 ± 0,20 **gh** | 6,52 ± 0,18 **ghi** | 8,55 ± 0,23 **ab** | 1,43 ± 0,08 **ab** | 9,04 ± 0,33 **ab** |
| Granja | 14,10 ± 0,23 **ab**c | 1,46 ± 0,02 **a** | 9,35 ± 0,26 **a** | 7,96 ± 0,22 **a** | 7,16 ± 0,16 **ab** | 8,06 ± 0,12 **j** | 10,80 ± 0,25 **defg** | 1,77 ± 0,07 **bcde** | 19,46 ± 0,75 **i** |
| Lloseta | 18,26 ± 0,29 **ijk** | 2,25 ± 0,03 **kl** | 21,56 ± 0,98 **i** | 12,39 ± 0,30 **h** | 10,83 ± 0,33 **i** | 6,38 ± 0,15 **efgh** | 12,93 ± 0,31 **h** | 2,21 ± 0,06 **fg** | 10,83 ± 0,44 **bcd** |
| H2-12 (E-13P) | 15,91 ± 0,24 **efg** | 1,89 ± 0,03 **bcdefg** | 11,62 ± 0,36 **ab** | 11,02 ± 0,28 **fg** | 6,88 ± 0,16 **a** | 5,17 ± 0,12 **ab** | 11,03 ± 0,34 **defg** | 1,87 ± 0,07 **cdef** | 16,41 ± 0,63 **gh** |
| Negrill | 14,57 ± 0,23 **bcd** | 1,82 ± 0,02 **bc** | 9,65 ± 0,25 **a** | 7,99 ± 0,23 **a** | 8,23 ± 0,14 **cde** | 5,40 ± 0,12 **bcd** | 10,88 ± 0,37 **defg** | 1,82 ± 0,07 **cde** | 19,14 ± 0,76 **i** |
| Negrilla | 17,27 ± 0,34 **hi** | 1,91 ± 0,02 **cdefgh** | 18,17 ± 0,62 **fgh** | 10,51 ± 0,26 **ef** | 10,56 ± 0,23 **hi** | 6,98 ± 0,12 **hi** | 12,80 ± 0,34 **h** | 2,74 ± 0,09 **h** | 15,53 ± 0,58 **fgh** |
| Orellona | 16,56 ± 0,28 **fgh** | 1,98 ± 0,03 **efghi** | 14,28 ± 0,49 **cd** | 9,91 ± 0,25 **cdef** | 8,42 ± 0,18 **def** | 4,51 ± 0,20 **a** | 11,43 ± 0,32 **efgh** | 1,94 ± 0,06 **defg** | 13,95 ± 0,51 **efg** |
| Rotja | 13,30 ± 0,23 **ab** | 1,84 ± 0,04 **bcd** | 12,39 ± 0,23 **a** | 9,61 ± 0,24 **bcde** | 7,53 ± 0,20 **abc** | 5,72 ± 0,16 **bcde** | 8,80 ± 0,39 **abc** | 1,24 ± 0,11 **a** | 11,75 ± 0,87 **cde** |
| Rossa | 18,86 ± 0,26 **kl** | 2,09 ± 0,02 **ij** | 19,04 ± 0,51 **hi** | 9,84 ± 0,19 **cdef** | 9,37 ± 0,16 **g** | 5,92 ± 0,11 **cdefg** | 10,60 ± 0,24 **cdefg** | 1,94 ± 0,06 **defg** | 10,33 ± 0,35 **abc** |
| Sa Llebre | 16,96 ± 0,29 **gh** | 2,00 ± 0,06 **fghi** | 16,68 ± 0,55 **defgh** | 13,34 ± 0,36 **h** | 9,75 ± 0,17 **gh** | 5,95 ± 0,11 **cdefg** | 10,40 ± 0,31 **cdef** | 1,67 ± 0,07 **bcd** | 10,10 ± 0,30 **abc** |
| Santa Maria | 15,63 ± 0,24 **def** | 2,02 ± 0,02 **ghi** | 15,70 ± 0,43 **cdef** | 10,87 ± 0,36 **efg** | 9,55 ± 0,14 **g** | 5,78 ± 0,15 **bcdef** | 11,68 ± 0,28 **fgh** | 2,26 ± 0,07 **g** | 14,42 ± 0,27 **efg** |


**Fig A. Pods from the differents cultivars from Balearic Islands. From left to right, podS from Lloseta, H2-12, d'en Pau, Duraió, Granja, Boval and Fina.**




Pod sugar content for each cultivar.

In terms of sucrose content, the most abundant sugar in the samples, there were no significant differences beetwen cultivars. The quantity of fructose and glucose per sample was significantly different between cultivars (fig. B). Rotja, Santa Maria, Orellona and d'en Pau cultivars shown significantly ($p<0.05$) the highest fructose values (3.89, 4.15, 4.30 and 4.59 g/100 g sample respectively), while Granja the lowest (0.98 g/100 g). Moreover, the quantity of glucose was higher in d'en Pau cultivar (6.56 g/100g), showing significant diferences with Granja cultivar (1.94 g/100 g).

Tritatable acidity and pH

Tritatable acidity values ranged from 2.15 (des Mestre) to 1.20 (Rotja) citric acid g/100 g (fig. C). There were only significant differences beetwen des Mestre and Rotja cultivars ($p<0.05$). In relation to pH, values ranged from 5.31in Fina cultivar, to 4.99 in Boval cultivar, both from Eivissa. There were no significant differences for this parameter.

## Conclusions

The Balearic Islands are an importat source of genetic material relative to *Ceratonia siliqua* L. as we can observe in fig. A and table1. The physical parameters analyzed presented differences among cultivars (table 1), being able to distinguish long and wide pods (Lloseta), short and wide pods (Fina), long and thin pods (H2-12) and short and thin pods (Granja). Length and weigth in tradicional Balearic cultivars show a positive correlation, being the longest the heaviest (des Mestre vs Rotja). We can observe too a correlation between pod weigth and seed yield. The heavier the pod, the more seed yield it has (Lloseta vs Granja). Concerning to chemical parameters, not much variability has been observed between cultivars, being d'en Pau significantly different from the others.

## References

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