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Assessment of nutritional composition of Carob pulp (*Ceratonia Siliqua* L.) collected from various locations in Morocco

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Abstract
Seven Moroccan carob provenances (Taroudant, Agadir, Essaouira, Marrakesh, Beni Mellal, Taza and Al Houceima were analysed for proximate (Dry matter, ash, total sugars, protein and fat) as well as for polyphenol and composition mineral. The average proximate composition range of raw carob pulp was: 86.53 –87.84% dry matter; 3.10 – 4.50% protein; 31.50 – 50.10% total sugar; 11.30 – 14.60% sugar reducing; carbohydrates; 40.69 – 54.74% sugars; 0.50 – 0.80% fat and 2.05 – 4.60 mg/g polyphenols. All samples contained all nine minerals analyzed for, in this study. Slight compositional variations (although statistically significant) were found among samples. The results obtained in this study suggest that the pulp of carob is highly nutritious and thus carob can be considered as an alternative food source for Morocco.

Keywords: Carob pods; Carob pulp; Chemical Composition; Minerals; Phenolic Compounds.

1. Introduction
Carob bean is the fruit of *Ceratonia siliqua* L., which belongs to the Leguminosae family. The tree has been extensively cultivated in most countries of the Mediterranean for years **[1,2].**
The fruit is a dark brown pod, with a straight, curved or twisted shape and it might be elongated or compressed in structure **[3]**. The pod mass ranges between 5 and 30 g **[4].** The pods can be up to 25 cm long, up to 1.3 cm thick and up to 4 cm **[4].**
The carob bean is composed of two main parts: the pulp and the seeds (figure 1). Seeds are used predominantly in the food industry for locust bean gum, which contains approximately 90% galactomannans. Deseeded pods are also are used in food industry **[5, 6].**
Up to 70% of the carob pulp is mainly sucrose (up to 95% of the carbohydrate content), with fructose and glucose contributing the remainder in relatively equal proportions **[7]**. Carob contains substantial amounts of protein (up to 7.6%) and because of its low fat content (0.2 – 2.3%), carob may be regarded as a healthy food source **[8]**. Dietary fiber and polyphenols have been reported to exhibit nutritional benefits in the human diet **[9, 10]**. Carob contains up to 39.8% dietary fiber and 20% polyphenols **[8, 11].**
The chemical composition of carob pods has been studied **[1, 4-8, 12-16]** but the findings from the researchers from different locations differ. Such variations can be attributed to the fact that carob composition is strongly influenced by differences between cultivars and horticultural conditions **[17].**
Carob is typically dried or roasted, and is mildly sweet. In powdered, chip, or syrup from it is used as an ingredient in cakes and cookies, and is used as a substitute for chocolate
Crushed pods may be used to make a beverage; compote, liqueur, and syrup are made from carob in Turkey, Malta, Portugal, Spain and Sicily **[18].** Several studies suggest that carob may add in treating diarrhea in infants **[19].** Carob powder is a natural sweetener with flour and appearance similar to chocolate; therefore it is often used as cocoa substitute. The advantage of using carob as a chocolate resides in that carob is an ingredient free

from caffeine and theobromine **[20].** Carob germ flour is used as dietetic human food **[21],** or as a potential ingredient in cereal – derived foods for celiac people **[22].**

Here, we report the results of chemical investigates carried out on pulp of carob tree fruit collected from various locations in Morocco where the plant is naturalized **[23].** In this study, the carob composition and its chemical characteristics were investigated in seven different types of Moroccan carob.

2. Experimental

2.1. Plant Material

Carob bean pods (*Ceratoniasiliqua* L.) (figure 1) were randomly harvested from various parts of several trees grown in different locations in Morocco. The samples were collected in the morning from August to September in 2010. The carob pods were of the same physiological maturity (dark brown) and of uniform shape and size. Fruits (50 g per sample) collected from each natural habitat were combined to provide composite samples of 800 g.These later were characterized according to the following morphological parameters: pods weight, seed yield and pulp yield.

Figure 1. The carob bean pod (a) the pulp (b) and the seeds (c)

Samples were sun dried, seeds were removed and the residue was ground in a mill (0.08 mm). From these stocks, three or four samples of gently milled pods were used for subsequent analyses. The grounded and milled samples were stored at -20C for further extraction.

2.2. *Methods*

2.2.1. *Determination of Gross Chemical Composition*

Moisture, crude protein, crude fat, crude fiber and ash contents were determined according to the procedures described in the AOAC **[24].**

2.2.2. *Minerals Contents*

Mineral concentrations (K, P, Mg, Ca, Na, Fe, Cu, Zn, and Mn) were determined using an Atomic Absorption Spectrophotometer and calculated using a standard curve **[25].** Phosphorus was determined according to the methods described by the Association of Official Analytical Chemists **[25].**

2.2.3. *Determination of total and reducing sugars*

Concentrations of total sugar, inverted sugar were determined by the Bertrand's method **[26].**

2.2.4. *Polyphenol determination*

The method of Makris & Kefalas **[8]** was used for the extraction of polyphenols. Acetone (80%) (Merck, analytical grade) was used as an extraction solvent. This provided samples for total polyphenol content determination via the Folin-Ciocalteu method **[27, 28].** This method measures polyphenols as gallic acid equivalent ($mg.g^{-1}$of dry matter).

2.2.5. *Statistical analysis*

Each analysis was done at least in triplicate and the results are expressed as mean and standard deviation (SD). The student's t-test was used to evaluate the differences between the means of each group. $P < 0.05$ was considered to be statistically significant.

3. Results and discussion

This work was carried out on different geographic regions of carob trees in agro-forestry systems. Climatic data were analyzed all over Morocco, a stratified sampling method was used in which topography, and vegetation homogeneity and altitude were regrouped in 7 geographic entities (figure 2). Each entity (provenance) is here defined as a region characterized by similar topographic and climatic conditions with a homogeneous flora. Geographic characteristics such as altitude slice, central latitude and longitude as well as the mean precipitation of these provenances are summarized in Table1.

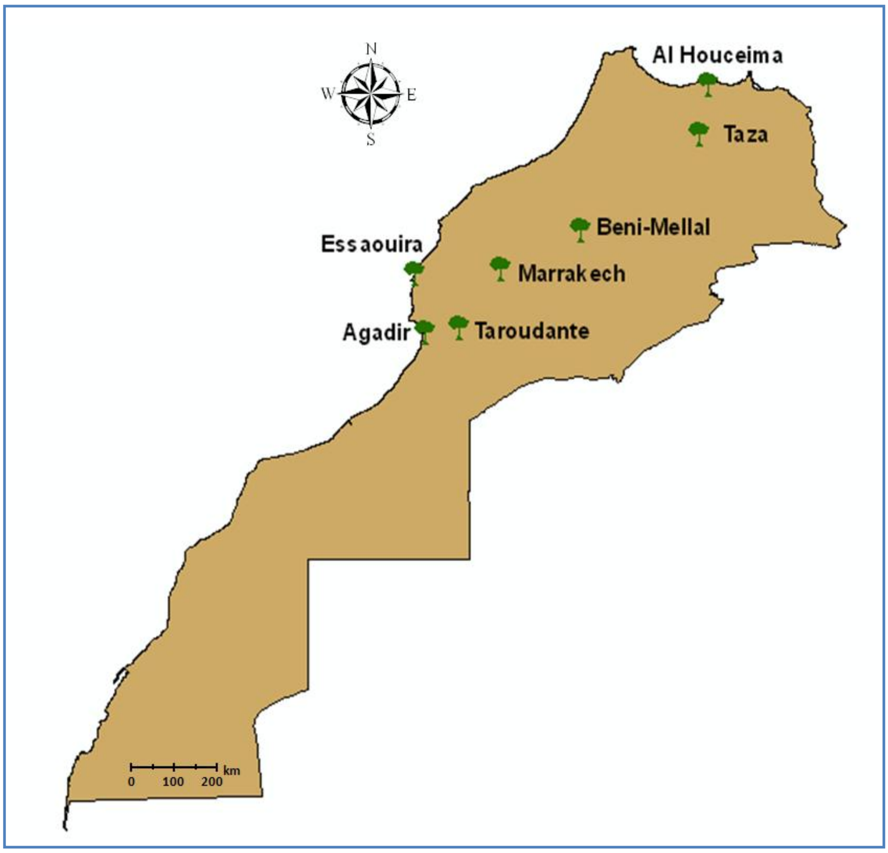

Figure 2. Repartition map of Morocco carob populations

Table 1. Geographic and meteorological conditions of provenance of carob.

Provenance	Geographic region	Latitude N	Longitude W	Altitude (m)	Rainfall (mm)
Taroudant	High Atlas (South-West)	30°37’	8°20’	200-400	250
Agadir	West costal	30°41’	9°33’	150-350	300
Essaouira	West costal	31°20’	9°40’	100-200	300
Marrakech	High Atlas mountain	31°29’	7°43’	700-1000	500
Beni Mellal	Middle Atlas mountain	32°30’	6°03’	500-800	550
Taza	Middle Atlas mountain	34°08’	4°08’	500-600	700
Al Houceima	North-costal	35°11’	3°57’	50-250	327

3.1.Measurement of carob pods

Results of carob pod measurements are shown in (Figure 3). The overall mean values for all parameters measured and their standard deviations are presented. High levels of variation were found considering the seven provenance studied. The data from this study showed that there were no significant differences (P>0.05) among the seven crops as far as the yield of pulp and seeds is concerned.

Data obtained from other studies showed a high diversity in the yield of pulp and seeds of carob. Moroccan crops are largely characterized by high seeds yield average [17.47-29.44g/100 g (%w/w)] content and medium pulp yield average [71.30-82.30g/100 g (%w/w)].

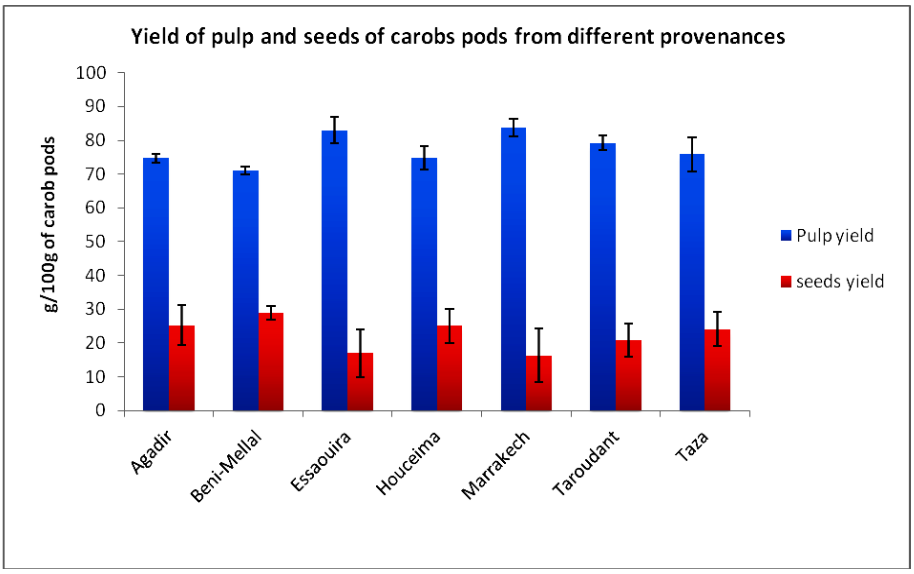

Figure 3. Yield of pulp and seeds of carobs pods from different provenances

3.2.Chemical characteristics

Dry matter

The data from this study showed that there were no significant differences (P > 0.05) among the seven samples as far as dry matter content is concerned (Fig. 4). The dry matter content ranged between 86.53 and 87.84 g.100 g^{-1}. These values are in agreement with findings of other researchers **[29].**

Ash

The ash contents of the 7 provenances studied (pulp) are given in (Fig. 4). Overall, the ash content in all provenancesin this study ranged between 2.44 and 3.89 g.100 g^{-1}. Slight variations in the ash content were present for the 7 provenances studied. The ash content of Taza differed significantly (P<0.05) from that of Agadir, Marrakesh and Al Hoceima.
The ash content gives a general indication of the mineral content present in the cultivars. The values found fall well within the range found by other researchers (1.00–4.1 g.100 g^{-1}) **[1,2,30].**

Crude fat

The fat content of each of the 7 provenances studied (pulp) investigated is given in (Fig. 4). The fat content ranged between 0.50 and 0.80 g.100 g^{-1}. Al Hoceima had a significantly (P<0.05) higher fat content than all the other provenances. No significant (P>0.05) differences were observed between the crude fat content of Taroudant, Agadir, Essaouira, Marrakech, Beni-Mellal and Taza. Overall, the fat content in all seven provenances was very low (below 1.0 g.100g^{-1}). This is in agreement with previous reports by other authors giving values of 0.2 – 2.3 g.100g^{-1}**[31].**
Foods with high fat content are often highly perishable as a result of lipid hydrolysis and oxidation leading to rancidity. A low fat content can, therefore, be assumed to have a positive effect on the shelf-life (2– 3 years) of carob pods **[32].** Theconsumption of high fat containing foods is also associated with increased risk of coronary circulatory disease, obesity and some types of cancers **[33].**Because of its low fat, carob may therefore be regarded as a healthier food source **[34].**

Protein content

The protein content of the 7 provenances analyzed in this study is given in (Figure4). Overall, the different carob samples contained appreciable amounts of protein (3.05 – 4.5 g.100 g^{-1}). These values were similar to findings of other investigators who reported ranges between 1.0 and 7.6 g.100 g^{-1}**[14,35].** In all seven provenances studied, the protein content was slightly lower than the minimum level (5 g.100 g^{-1}) required for any food to be labelled as a source of protein, as set by the labelling regulations **[36].** No significant (*P*>0.05) differences were observed between the protein content of d'Essaouira, Beni-Mellal and Al Hoceima.Marrakech and Taza had a significantly (*P*<0.05) lower protein content than all the others provenances.

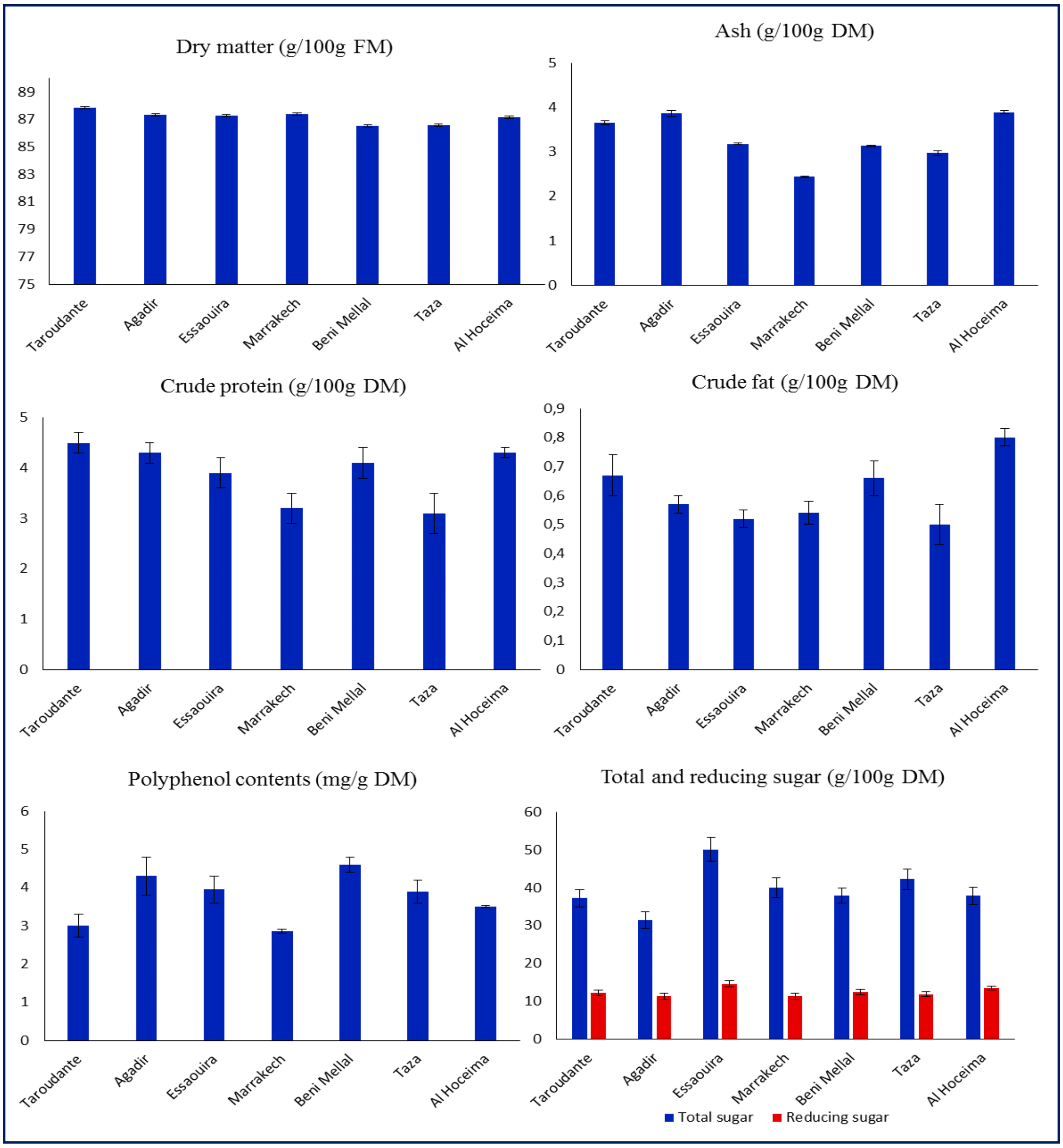

Figure 4. Chemical composition of pulp from seven different carob samples

Total and reducing sugar
The overall mean values for the total sugar and reducing sugar and their standard deviations were presented in (Fig. 4). The total sugar content varied between 31.5 and 50.1 g.100g^{-1} of dry pulp in populations of Agadir and Essaouira, respectively. There was only one carob for Essaouira, which values were the highest averages. In this study it was found that no significant (P > 0.05) difference was observed between Taroudannt, Marrakech, Beni-Mellal, Taza and El houceima.
Essaouira had significantly (P < 0.05) higher total sugar content than all the other crops (Fig. 1). The levels of reducing sugars varied between 11.3 and 14.6 g.100 g^{-1}, respectively, in the regions of Agadir, Marrakech and Essaouira. There was a relatively high average value (14.6 g.100g^{-1} of dry pulp) among the native population of

the West Coast (Essaouira). Taroudannt, Agadir, Marrakech, Beni-Mellal and Taza did not differ (P >0.05), but significantly differed (P <0.05) from El Houceima and Essaouira. These results are comparable to those reported by Albanell **[37]** in Spanish crops of about 46.95 and 12.75 g.100g^{-1}of dry pulp for total and reducing sugars, respectively.

Polyphenol contents
The polyphenol contents of the 7 provenances studied are given in (Figure4). Beni-Mellal had a significantly (P<0.05) higher fat content than all the other provenances. No significant (P>0.05) differences were observed between the polyphenol contents of Agadir, Essaouira and Taza. The polyphenolic content ranged between 2.85 and 4.60 mg.g^{-1}of dry pulps. These values are in agreement with findings of other researchers **[22, 38].**
Polyphenolic compounds have been reported to exhibit health benefits, especially with regard to cardiovascular diseases, due to their ability to scavenge free radicals, superoxide and hydroxyl radicals **[10].**Sakakibara et al **[39]** also reported that phenolic compounds have anti-allergic, cancer preventative and vasorelaxing effects.
In fact, carob is known to be a more efficient antioxidant source than some of the popular sources such as red wines **[8].** It should be noted that the analytical method used (Folin-Ciocalteau) in this study does not measure absolute contents of specific phenolic materials since the values are expressed as gallic acid equivalents (mg.g^{-1}of dry pulp) **[10].**

Mineral content
The mineral content of the seven provenances (pulp) investigated is given in Table 2. The average mineral composition ranges of raw carob pulp were (in mg.100 g^{-1}of dry matter): 237.1 – 350.6 calcium; 48.20 – 86.40 phosphorus; 850.80 – 1169.30 potassium; 45.30 – 137.70 magnesium; 4.11 – 13.60 sodium; 0.27 – 1.25 manganese; 0.73 – 2.90 iron; 0.16 – 0.85 copper; and 0.17 – 0.75 for zinc. Overall, significant (P<0.05) differences in individual mineral compositions could also be observed among thedifferent provenances. Moreover, all nine minerals (calcium, phosphorus, potassium, magnesium, sodium, manganese, iron, copper and zinc) analyzed for in this study were detected in all different provenances. The data are in good agreement with **[40, 41].**

Table 2. Mineral composition from seven different carob samples (mg/100g DM)

Provenance	K	P	Ca	Mg	Na	Fe	Mn	Zn	Cu
Taroudant	970.0± 10.1	71.5± 2.3	300.8± 3.0	60.4± 1.5	4.5± 0.3	1.88± 0.08	1.29± 0.01	0.75± 0.08	0.85± 0.09
Agadir	860.5± 7.6	82.3± 1.45	350.6± 2.7	50.2± 3.3	10.0± 0.6	2.90± 0.12	0.27± 0.01	0.21± 0.04	0.16± 0.06
Essaouira	1065.4 ± 13.3	52.1± 1.11	237.1± 1.2	66.8± 2.7	4.11± 0.9	0.73± 0.13	0.99± 0.03	0.69± 0.05	0.17± 0.07
Marrakesh	852.3± 8.5	48.2± 0.8	301.5± 2.1	92.1± 1.8	1 3.6± 1.3	0.98± 0.03	1.23± 0.06	0.67± 0.04	0.23± 0.03
Beni Mellal	1169.3 ± 12.6	55.7± 2.0	332.2± 2.1	137.7± 3.8	9.6± 0.7	2.40± 0.16	1.25± 0.05	0.20± 0.01	1.28± 0.09
Taza	990.2± 12.3	78.8± 1.4	380.9± 4.8	90.1± 1.5	12.9± 1.3	2.16± 0.11	0.75± 0.06	0.23± 0.02	0.17± 0.02
Al Hoceima	850.8± 7.6	86.4± 0.9	370.5± 2.7	45.3± 2.5	6.9± 0.5	1.15± 0.04	0.86± 0.07	0.17± 0.01	0.32± 0.06

Conclusion
The proportions of carob pulp show a great diversity between the populations of the Moroccan carob tree. This diversity seems to take place according to the geographical origin of the population.
This research shows the potential of carob as an important source of natural antioxidants andnutraceuticals and may be well considered a functional food. Analytical approaches and innovative processing technologies will open new avenues to further promote the use the pulp of carob in food, medicine, and pharmaceutical industries.

References

1. Battle, I., Tous, J., Carob tree. Ceratoniasiliqua L. promoting the conservation and use of underutilized and neglected crops. 17. Institute of Plant Genetics and Crop Plant Research. Gatersleben/International Plant Genetic Resources Institute, ISBN 92-9043-328-X Rome (1997) 1–79
2. El Hajaji H., Farah A., Ennabili A., Bousta D., Greche H., El Bali B., Lachkar M., Etude comparative de la composition minérale des constituants de trois catégories de Ceratonia siliqua L. (Comparative study of the mineral composition of the constituents of three varieties of Ceratonia siliqua L.). *J. Mater. Environ. Sci*. 4 (2) (2013) 165-170
3. Zografakis, N., Dasenakis, D., Biomass in Mediterranean. Project No. 238: Studies on the Exploitation of Carob for Bioethanol Production". Commission of the European Communities, Directorate General for energy and transport.Regional Energy Agency, Region of Crete, (2000).
4. Marakis, S.G., Carob bean in food and feed: status and future potentials – A critical appraisal. *Journal of Food Science and Technology,* 33(1996) 365-383.
5. El Batal H., Hasib A., Ouatmane A., Boulli A., Dehbi F., Jaouad A., Yield and composition of carob bean gum produced from different Moroccan populations of carob (Ceratonia siliqua L.). *J. Mater. Environ. Sci.* 4 (2) (2013) 309-314
6. El Batal H., Hasib A., Ouatmane A., Jaouad A., Naïmi M., Rheology and influence factor of Locust Bean Gum solution. *Revue de génie industriel*, 8 (2012) 55-62
7. Bravo, L., Grados, N.,Saura-Calixto, F., Composition and potential uses of Mesquite pods (Prosopis pallida L): Comparison with carob pods (Ceratoniasiliqua L.). *Journal of the Science of Food and Agriculture*, 65 (1994) 303-306.
8. Makris, D.P., Kefalas, P., Carob pods (Ceratoniasiliqua L.) as a source of polyphenolic antioxidants. *Food Technology and Biotechnology,* 42 (2004) 105-108.
9. Aurand W.L., Woods, A.E. & Wells, M.R., Food Composition and Analysis. New York, USA: Van Norstrand Reinhold Publishers Ltd. ISBN: 978-94-015-7400-6 (Print) 978-94-015-7398-6 (Online) (1987) 207-209.
10. Li, J.W., Fan, L.P., Ding, S.D. & Ding, X.L., Nutritional composition of five cultivars of Chinese jujube. *Food Chemistry,* 103(2007) 454-460.
11. USDA (United States Department of Agriculture) Agricultural Research Service., National nutrient database, NDB no. 16055 (2006).
12. Khlifa M., Bahloul A., Kitane S., Determination of Chemical Composition of Carob Pod (Ceratonia Siliqua L) and its Morphological Study. *J. Mater. Environ. Sci*. 4 (3) (2013) 348-353
13. Sęczyk, L., Świeca, M., Gawlik-Dziki, U., Effect of carob (Ceratoniasiliqua L.) flour on the antioxidant potential, nutritional quality, and sensory characteristics of fortified durum wheat pasta. *Food Chemistry*, 194 (2016) 637–642.
14. Bellaa, M., Scerrab, M., Cilioneb, C., Basilea, P., Lanzaa, M., A. Prioloa., Effect of including carob pulp in the diet of fattening pigs on the fatty acid composition and oxidative stability of pork. *Meat Science*, 100 (2015) 256–261.
15. Fadel F., Fattouch S., Tahrouch S., Lahmar R., Benddou A., Hatimi A., The phenolic compounds of Ceratonia siliqua pulps and seeds (Les composés phénoliques des pulpes et des graines de Ceratonia siliqua). *J. Mater. Environ. Sci.* 2 (3) (2011) 285-292
16. Oziycia, H.R., Tetika,N., Turhana,I., Yatmaza,E., Ucgunb,K., Akgulb,H., Gubbukc, H., Karhana, M., Mineral composition of pods and seeds of wild and grafted carob (Ceratoniasiliqua L.) fruits. *Scientia Horticulturae*, 167(2014) 149–152.
17. Zografakis, N.,Dasenakis, D., Biomass in Mediterranean. Project No. 238: "Studies on the Exploitation of Carob for Bioethanol Production". Commission of the European Communities, Directorate General for energy and transport. Regional Energy Agency, Region of Crete (2000).
18. Burg, B., Good treats for dogs cookbook for dogs: 50 Home-cooked treats for special occasions. Quarry Books. ISBN 1592533841 (2007) p 28.
19. Fortier, D., Lebel, G., Frechette, A., Carob flour in the treatment of diarrhoeal conditions. *Infants Candian Medical Association J.,* 68 (1953) 557 – 561.
20. Dakia, P. A., Wathelet, B., Paquot, M., Isolation and chemical evaluation of carob (CeratoniaSiliqua L.). *Food Chemistry*, 102(2007) 1368 – 1374.

21. Fillet, P.,Roulland, I. M ., Caroubin: A gluten-like protein isolate from carob bean germ. *Cereal Chem*., 75(1998) 488 – 492.
22. Bengoechea, C., Romero, A., Villanueva, A., M oreno, G., Alaiz, M., Millan, F., Guerrero, A., Puppo, M. C., Composition and structure of carob (CeratoniaSiliqua L.) germ proteins. *Food chem*. 107 (2008) 675 – 683.
23. Sidina , M. M., El Hansali , M., Wahid , N., Ouatmane , A .,Boulli , A ., Haddioui , A., Fruit and seed diversity of domesticated carob (Ceratoniasiliqua L.) in Morocco. *Scientia Horticulturae*. 123 (2009) 110–116
24. AOAC Association of Official Analytical Chemists. Official Methods Of Analysis. 18thed (edited by W. Horwitz) ISBN 0-935584-77-3. Gaithersburg, USA (2005).
25. AOAC Association of Official Analytical Chemists. Official Methods of Analysis.16ed.Association of Official Analytical Chemists. ISBN 0-935584-42-0. Washington. D.C (1990).
26. Browne, C.A., Zerban, F.W., Physical and Chemical Methods of Sugar Analysis, third ed. John Wiley and Sons, (1955) 497–512.
27. Singleton, V.l., Rossi, J.R., Colorimetry of total phenols with phosphomolybdic phoshotungstic acid reagents. *American Journal of Enology & Viticulture*, 16(1965) 144-158.
28. Singleton, V.L., Orthover, R.,Lamuela-Raventós, R.M., Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods in Enzymology*, 299 (1999) 152–178.
29. Yousif, A.K., Alghzawi, H.M., Processing and characterization of carob powder. *Food Chemistry* 6 (2000), 283–287.
30. Sánchez, S., Lozano, L.J., Godínez, C., Juan, D., Pérez, A., Hernández, F.J., Carob pod as a feedstock for the production of bioethanol in Mediterranean areas. *Applied Energy*, 87 (2010) 3417-3424.
31. Marakis. S., Carob bean in food and feed: current status and future potentials – a critical appraisal. *Journal of Food Science and Technology*, 33 (1996), 365–383.
32. Curtis, A., Race, D., Carob agroforestry in the low rainfall Murray valley: A market and economic assessment. Publication No. 98/8. Rural Industry Research and Development Corporation (RIRDC), ISBN 0642540306. Australia (1998).
33. Sikorski, Z.E., Chemical and Functional Properties of Food Components. Third edition USA: by CRC Press. ISBN 9780849396755 (2006) p116-117
34. Biner, B., Gubbuk, H., Karham, M., Aksu, M.,Pekmeczi, M., Sugar profiles of the pods of cultivated and wild types of carob bean (Ceratoniasiliqua L.) in Turkey. *Food Chemistry*, 100 (2007)1453-1455.
35. Owen, R.W., Haubner R., Hull, W.E., Erben, G., Spiegelhalder, B., Bartsch, H., Haber, B., Isolation and structure elucidation of the major individual polyphenols in carob fibre. *Food and Chemical Toxicology*, 41(2003) 1727-1738.
36. Anonymous, Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 Of 1972) No. 23714 GOVERNMENT GAZETTE, Pretoria, South Africa: South African Department of Health 8 AUGUST (2002)
37. Albanell, E., Caja, G., Plaixats, J., Characteristics of Spanish carob pods and nutritive value of carob kibbles. *Cahiers Options Mediterranean*, 16 (1991) 135-136.
38. Papagiannopoulos, M., Wollseifen, H., Mellenthin, A., Haber B.,Galensa R.J., Identification and quantification of polyphenolis in caros fruit (Ceratoniasiliqua L.) and derived products by HPLC-UV-ESI/MSn . *Agric Food Chem*, 52 (2004) 3784–3791.
39. Sakakibara, H., Honda, Y., Nakagawa, S., Ashida, H., Kanazawa, K., Simultaneous determination of all polyphenols in vegetables, fruits and teas. *J. of Agric. and Food Chem*., 51 (2003) 571-581.
40. Ayaz, F.A., Torun, H., Ayaz, S., Correia, P.J., Alaiz, M., Sanz, C., Gruz, J., Strnad, M., Determination of chemical composition of Anatolian carob pod (Ceratoniasiliqua L.): sugars,amino and organic acids, minerals and phenolic compounds. *J. Food Quality*, 30 (2007) 1040-1055.
41. El-Shatnawi, M.K.J., Ereifej, K.I., Chemical composition and livestock ingestion of carob (Ceratoniasiliqua L.) seeds. *J. Range Manage*, 54 (2001) 669-673.