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Research article

Nutritional and mineral composition of leaves, roots and seeds of *Moringa oleifera* Lam. tree from Tenerife, Spain

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Abstract: *Moringa oleifera*, known as "tree of life" is one of the species with the most potential in agriculture and alimentation. Their leaves, roots and seeds have nutritional and medicinal properties and can be consumed in different ways in our diet. Moringa grows in tropical and subtropical regions with high photoperiod, as India, Pakistan and many countries in Africa and Latin-America. In Europe, the best place for moringa tree cultivation is located in Canary Islands, Spain. In the present study, nutritional analysis of different parts of moringa grown in Tenerife (Canary Islands) was analysed. Our results seem to indicated that moringa leaves, roots and seeds are grown in Tenerife showed high quality compared to moringa plants grown in other regions. Our finding tends to indicate the importance of volcanic soil in the development of ecological or agroecological agriculture, as confers a wide range of minerals and natural nutrients to plants. Tenerife island is a place in Europe for moringa tree cultivation and developing a potential industry in the Canary Islands outermost region.

Keywords: Nutrients - Soil - Tree of Life - Canary Islands - Outermost region - Agroecology.

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INTRODUCTION

Moringa tree (*Moringa oleifera* Lam.) is the most important species belongs to the *Moringaceae* family, popularly known as "tree of life". Some parts of the plant, like leaves, roots and seeds, have several nutritional and medicinal properties used with industrial and medicinal purposes (Leone *et al.* 2015).

Moringa oleifera leaves are a source of proteins, essential amino acids, minerals like calcium, iron and potassium, vitamins A, group B, C and E, and several antioxidants and polyphenols (Stadtlander & Becker 2017, Nogueira *et al.* 2017). It is usually eating moringa leaves fresh or dried in powder to add in any food. It is possible one of the most nutritious species and considered as a superfood due to nutrient composition.

Moringa seeds have known for containing 38–54 % high-quality edible oil with a lot of good fatty acids, between 65–80 % oleic acid, and less than 15% of saturated fatty acids, who depends on extracting method (Bhutada *et al*. 2015). Their composition is very similar to olive oil, high appreciated oil for their properties and high consumed in Mediterranean diets (Rousseaux *et al*. 2020). Moringa oil has known as "Ben oil" or "Behen oil" and has been used both for food and non-food purposes, for example, hair care and perfume products due to fragrance and cosmetic value (Bhutada *et al*. 2015). The seeds powder can be used to remove contaminants like nickel, copper or iron from contaminated water due to his coagulant properties (Farrokhzadeh *et al*. 2013). Moringa seeds can consume fresh or cooked and their nutritional composition is similar to leaves in various minerals and amino acids (Stadtlander & Becker 2017).

Moringa have a principal tuberous taproot that helps to tolerate drought conditions. The root is rich in nutrients like phosphorus, magnesium, calcium and vitamin C, with the ability to reduce 87% of *Escherichia coli* colonies in contaminate water (Morgan *et al*. 2020). It can be consumed dry and grated in any food, or boiled with other herbs, but in a small proportion due to alkaloids content (Jideani & Diedericks 2014).

Moringa tree grows in tropical and subtropical regions of the planet, usually corresponds with the coffee strip. The most producer country is India, the native place of moringa, and also grows well in Pakistan and in

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some countries of Latin-American (*i.e.* Brazil, Cuba, Venezuela, Panamá) and Africa (*i.e.* Gambia, Senegal, Ethiopia, Madagascar) (Pandey *et al.* 2011). In Europe, the best place for moringa tree cultivation is located in the Canary Islands, belongs to Spain, and considered outermost region due to their distance with the continent: more than 1500 km from the European coast and approximately 200 km from the African coast. This place has a subtropical climate and long photoperiod needed for excellent development of moringa tree. Also, their soils have a lot of minerals due to the volcanic origin of the islands, who improved the development of moringa tree in a natural way (Rubio-Sanz *et al*. 2020).

In the present study, we analysed some important nutritional parameters of moringa grown in the south of Tenerife (Canary Island). The volcanic soil along the climatological properties render this area as the indicate for moringa cultivation with a promising development.

MATERIALS AND METHODS

Samples of leaves, seeds and roots were collected from field of *Moringa oleifera* tree in Playa San Juan (Tenerife, Spain) with coordinates N 28.1807 and W -16.8059 (Fig. 1).

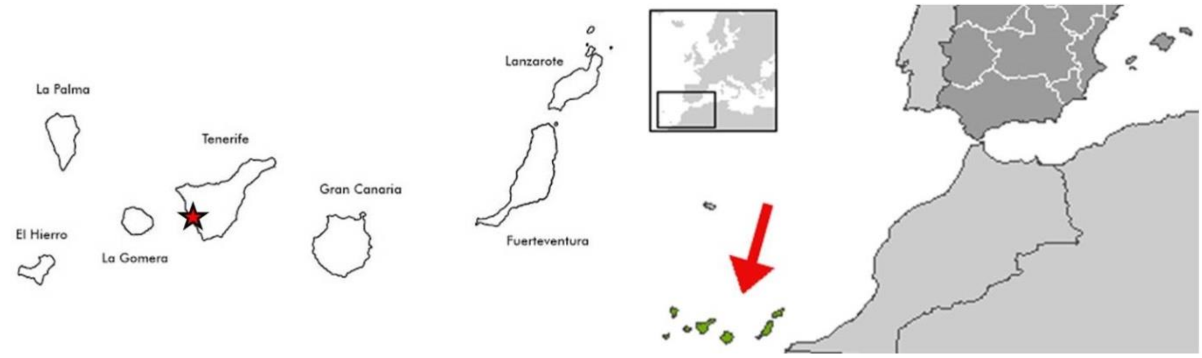

Figure 1. Moringa crop map localization (general and zoom map). Left, the seven Canary Islands and localization of field in the south of Tenerife. Right, general localization of Canary Islands respect to Spain and Africa.

Soil analysis

Soil sample from Playa San Juan field was air-dried and passed through a 2-mm sieve. Soil particle size distribution was determined by the hydrometer method (Bouyoucos 1936) and classified using the USDA texture triangle. Soil pH was measured in a 1:2.5 (w/v) soil/water mixture (Chapman & Pratt 1961) using a pH electrode (pH meter GLP21, Crison Instruments). Electrical conductivity was measured in a 1:5 (w:v) soil/water suspension previously filtered through Whatman 42 filter paper (Bower & Wilcox 1965) using a conductivity cell (Conductimeter GLP31, Crison Instruments). Available phosphorus was determined by the Olsen method (Watanabe & Olsen 1965) and total nitrogen was determined using a TruMac C/N analyser (Leco Corporation) with the combustion of the soil sample adjusted to 1350ºC. Exchangeable cations were determined as described by (Bower *et al.* 1952) using ammonium acetate 1N (pH 7) as extracting.

Leaves, roots and seeds analysis

All moringa samples were dried at 60ºC for 48 hours in a fan ventilated oven and reduced to powder (<0.01) in a millet. Nitrogen and carbon content was analysed by Dumas method in a TruMac C/N analyser (Leco Corporation) with the combustion of the soil sample adjusted to 1100ºC, and transform to total protein using factor conversion 5.75. For the determination of mineral elements, samples were mineralized following the method described previously (Mendoza *et al.* 2014). The macro and microelements calcium, magnesium, sodium, potassium, iron, zinc, manganese and copper, were determined in an atomic absorption spectrophotometer AAnalyst200 (PerkinElmer) with the correspond dilution for each element.

Statistical analysis

Data were expressed as the mean of three replicates with standard error and were statistically analysed through one-way analysis of variance (ANOVA) following by Fisher Test.

RESULTS

Analysis of soil physico-chemical composition

Fertility parameters of Playa San Juan soil (Fig. 1) was analysed following the methods described previously. The concentration of principal nutrients was normal or even high in comparison with normal values (Table 1). Nitrogen has a value of 0.17% and both phosphorous and potassium nutrients have very high concentration (121 and 2788 mg kg^{-1} respectively). On the other hand, organic matter that it was direct related to clay content, was slightly poor. Soil texture was slime franc with a high proportion of silt and normal sand and clay percentage.

Table 1. Physico-chemical soil analysis of field in Playa San Juan.

Determination	Units	Result	Interpretation*
pH (1:2.5)	-	8.40	Moderately basic
C.E. (1:5)	µS cm^{-1}	708	Slightly salty
Organic matter	%	1.70	Slightly poor
Nitrogen	%	0.17	Correct
Phosphorous	mg kg^{-1}	121	Very high
Potassium	mg kg^{-1}	2788	High
Calcium	mg kg^{-1}	3331	Correct
Magnesium	mg kg^{-1}	1230	High
Sodium	mg kg^{-1}	1054	High
Carbonates	%	2.25	Very low
Sand	%	36.3	Correct
Silt	%	51.9	High
Clay	%	11.8	Correct
Texture	-	Slime franc	-

***** Saña *et al*. 1995.

Nutritional composition of moringa samples

Leaves, roots and seeds of moringa (Fig. 2) was analysed in carbon, nitrogen and mineral composition. Leaves have a high amount of protein, 28.3%, close to seeds concentration with 27.0% and far to roots, with only 9.72% (Table 2). The mineral composition was studied in eight elements showing differences between the different samples: leaves have the high amount concentration in magnesium and manganese; roots in calcium, potassium, sodium, iron and copper; and seeds in zinc.

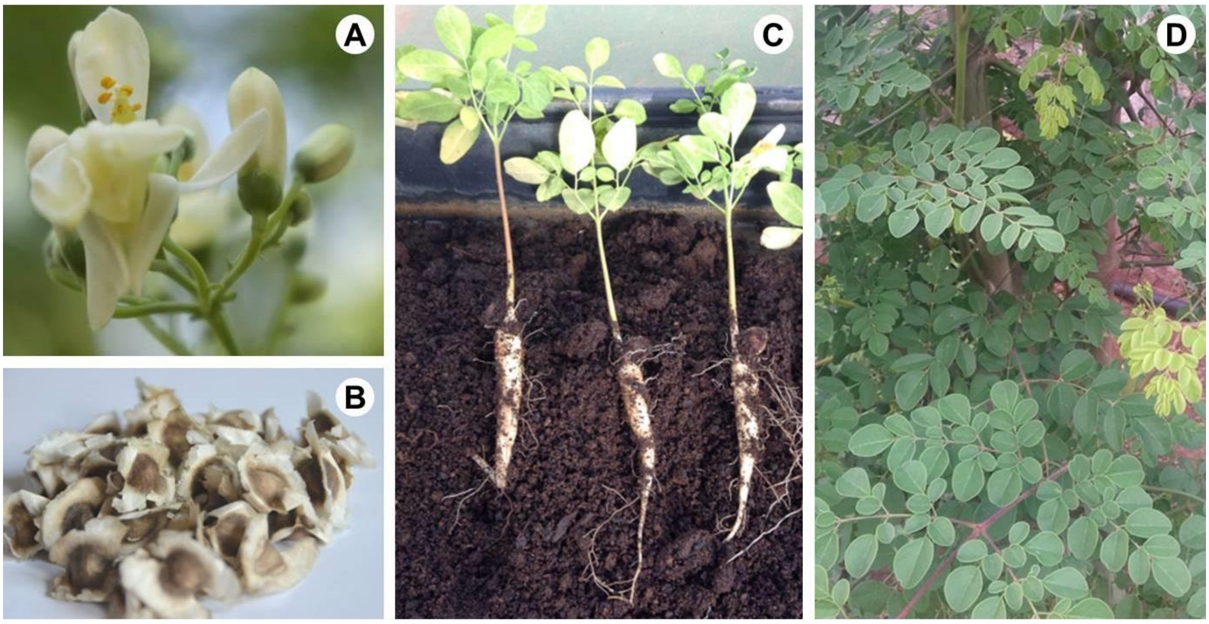

Figure 2. *Moringa oleifera* Lam.: **A**, Flowers; **B**, Seeds; **C**, Roots; **D**, Leaves.

Table 2. Chemical composition (%) of *Moringa oleifera* Lam. tree.

	Leaves	Roots	Seeds
Carbon	44.3±0.07	37.4±0.50	58.6±0.23
Nitrogen	4.93±0.01	1.69±0.27	4.70±0.01
Protein	28.3±0.08	9.72±1.53	27.0±0.08

Calcium has similar concentrations in leaves and roots, 11153 and 12834 mg kg^{-1} respectively, but in seeds were 22 times less (565 mg kg^{-1}) (Table 3). Similar results were observed in potassium, were leaves and roots have closer concentrations, but seeds were three times less. On the other hand, similar levels of magnesium were observed in all the parts of moringa tree studied, with values between 4303 mg kg^{-1} in leaves to 3263 mg kg^{-1} in seeds. Moringa roots have 10 times the concentration of sodium in comparison with leaves and seeds, and triplicate the iron levels in compare with leaves (492 mg kg^{-1} front 153 mg kg^{-1}). In cooper, the less amount corresponds with leaves, four times less than showing roots and seeds, with similar concentration (9.97 and 9.50 mg kg^{-1} respectively). Moringa leaves have the double concentration of manganese in compare with roots and seeds, and in the other side, moringa seeds have 2 times the levels of zinc in comparison with leaves and roots.

Table 3. Mineral composition (mg kg^{-1}) of different parts of *Moringa oleifera* Lam. tree.

	Leaves	**Roots**	**Seeds**
Calcium	11153±38.9	12834±30.4	565±26.9
Potassium	17207±688	18863±2190	6430±175
Magnesium	4303±84.1	3639±581	3263±12.0
Sodium	709±24.0	5678±1038	408±26.9
Iron	153±4.24	492±2.12	226±8.49
Cooper	2.80±0.28	9.97±2.16	9.50±2.12
Manganese	31.2±0.85	17.4±0.64	15.5±0.71
Zinc	26.3±0.35	15.8±0.07	41.5±2.12

DISCUSSION

Agricultural soils with volcanic origin have high concentrations of minerals in a natural way. In the case of Tenerife island, soils with canary banana cultivation was analysed showing high concentration in phosphorous, as the same level as observed in our study (Armas-Espinel *et al*. 2003). In tomato crop, extractable cations in soil (calcium, magnesium, sodium and potassium) have similar high concentrations that observed in moringa soils, even better if the ecological techniques, with no use of chemical fertilizers, was used (Rodríguez-Romero & López-Cepero 2006).

In other soil where moringa grown, fertilization is need it for moringa cultivation in order to obtain a high quality of harvesting products. In Abuja (Nigeria) soils reveal low nutrient concentrations in calcium, magnesium and organic matter (Sallau *et al*. 2018) and in Ghana it is necessary the use of treatments with compost or poultry manure mixed with the soil (Asante *et al*. 2012).

The nutritional composition of leaves, seeds and roots of moringa tree was analysed previously in some studies in different countries. In many cases, protein concentration was approximately between 24–28 % in leaves, 5–12 % in roots and 18–28 % in seeds (Mgbemena & Obodo 2016, Igwilo *et al*. 2017, Dilruni *et al*. 2019) in moringa grown in Sri Lanka and Nigeria. The values observed in our results from moringa tree in Tenerife are in the same range or even better in comparison with the latter countries (28.3% in leaves, 9.72% in roots and 27.0% in seeds).

Mineral composition depends on the place of cultivation. For example, in Nigeria potassium concentration are 8500, 7500 and 6250 mg kg^{-1} in leaves, roots and seeds respectively (Mgbemena & Obodo 2016), that is two times lower in comparison with moringa from Tenerife, in the case of leaves and roots (17207 and 18863 mg kg^{-1} respectively). Similar results have observed in moringa from central India, where iron concentration is 40 times lower in leaves and 100 times lower in roots and seeds in comparison with moringa trees grown in Tenerife (Verma & Nigan 2014).

CONCLUSION

Soils from Tenerife island have high concentrations of nutrients in a natural way that can help the moringa development with no use of chemical fertilizers. These allow the cultivation of fair and safe moringa trees following natural soil management like agroecology agriculture, where the use of chemical products is avoiding.

Additionally, nutrient and mineral composition of moringa leaves, roots and seeds showing higher values in comparison with other places where the tree was development. These results demonstrated the ability of moringa to grow in Tenerife island, in concordance with the ideal climatology and edaphological conditions. These conditions allow the development of one the highest quality moringa tree in an outermost region that can improve their primary sector.

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