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Short Communication

Quantification of bioelements in seed and oil of black chia (*Salvia hispanica L*)

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Abstract

The Aztec empire stood out from a nutritional point of view by having corn, beans, amaranth and chia, as main components of their diet. Chia had also medical applications such as in infusions for gastrointestinal problems, and respiratory, ophthalmology, obstetrics, skin treatments among others. This research was conducted to determine the concentration of the metals Ni, Zn, Mn, Fe, Cd, Cu, Ca, K and Na, using a Perkin-Elmer Precisely, Model 400 AAanalyst spectrophotometer, equipped with a flame atomization system. The results obtained for the chia seed were: nickel: 1.407 ppm, iron: 338.125 ppm, manganese: 6.937 ppm, zinc: 6.3 ppm, copper: 4.375, boron: 6.316 ppm, cadmium 0.0, calcium: 228 ppm, potassium: 24.743 ppm y sodium: 3.089 ppm. Calcium is essential for all organisms as it is a structural component of cell walls and bones, for the metabolism of bone fixation it is needed synergy with nickel, boron, zinc, manganese and copper, Iron deficiency is the most prevalent nutritional deficiency in the world and Mexico is no exception causing anemia, being chia an excellent source of these bioelements.

Keywords: Chia, Seed, Bioelements, Atomic absorption.

Introduction

The Aztec empire stood out from a nutritional point of view by having corn, beans, amaranth and chia, as main components of their diet. The relevance of these crops is well grounded in the historical Florentino Codex. Chia was as important as Corn in Mexico, but was also popular in other areas, the Mendoza Codex of the sixteenth century indicated that 21 of the 38 states under the rule of the Aztecs gave chia as an annual tribute to the Spanish. With the expansion of Spanish colonization, cultivation of chia was shifted quickly by flaxseed in traditional farming systems limiting ethnobotanical studies. This seed quickly became popular in artistic fields after oil paintings were introduced, and it was widely used in the culinary field and medicines, such as in infusions for gastrointestinal problems, and respiratory, ophthalmology, obstetrics, skin treatments among others. Chia was nearly reduced to extinction because it was considered to be sacrilegious; chia was a main element of religious ceremonies dedicated to the Aztec gods mainly to Chicomecóatl[1].

It has been determined that chia seeds contain oil quantities ranging between 32 and 39%[2]. This oil together with the linen, offer the highest naturally known percentage of α-linolenic acid (Ω 3). It has been reported[3,4] that the ratio of this acid to linoleic acid (Ω 6) ranges from 3.18 to 4.18 depending on the extraction method and the seed origin. At present, the fatty acid content Ω 6 has increased considerably as a result of the consumption of oils from grains rich in Ω 6, causing the ratio of omega-6 to omega-3 essential fatty acids in today's western diets to be around 15-20: 1, indicating a deficiency in omega-3 fatty acids. This may contribute to the high prevalence of many diseases such as heart disease, cancer etc., being a major problem in current nutrition[5]. In animal models lipid redistribution has been evaluated and it has been found that rats improved insulin sensitivity and glucose tolerance, reduced visceral adiposity, decreased hepatic steatosis and reduced cardiac and hepatic inflammation and fibrosis without changes in plasma lipids or in blood pressure[6].

This seed also contains a number of compounds with potent antioxidant activity: myricetin, quercetin, kaempferol, and caffeic acid. These compounds are primarily antioxidants, synergists and contribute to strong antioxidant activity of chia[7,8]. They are also good sources of dietary fiber, protein and minerals[9], in aqueous medium, is wrapped in a copious mucilaginous polysaccharide, which is excellent for digestion[10]. The consumption of dietary fiber improves the formation of fecal bolus and safe disposal of feces, which helps to prevent obesity, colon cancer and high levels of cholesterol and blood glucose[11]. In black chia seed from San Mateo Coatepec Atzitzihuacán, Puebla, México, it was found that it has 1224.3 mg / l of β-Sitosterol[12], phytosterol has the ability to lower cholesterol[13] and has been used in treatment of benign prostatic hyperplasia[14].

Materials and methods

We worked with black seed chia (*Salvia hispanica L*) from San Mateo Coatepec Atzitzihuacán Puebla, Mexico, and was conducted to determine the concentration of the metals Cu^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Fe^{2+}, Cd^{2+}, Ca^{2+}, Na^{+} and K^{+}, using a Perkin-Elmer Precisely, Model 400 AAanalyst spectrophotometer, equipped with a flame atomization system. The spectrophotometer was previously calibrated based on the Perkin-Elmer, USA calibration regulations. The calibration curves were prepared for each metal (Figure-1) from standard certified Perkin Elmer solutions with 1000 ppm diluted in a 5% HNO_3 v/v. solution. Measurements were made for seed and chia oil, which was extracted by a Soxhlet extractor using hexane as a solvent which was removed using a rotary evaporator controlling the temperature at 60°C for 40 minutes, using a high vacuum pump traces of hexane were removed to give a performance of 30% oil with a density of 0.966 g / ml.

Each sample was digested by wet process, in a CEM microwave digester; model Mars 5, equipped with 10 bottles of 50 ml capacity TFM (Teflon Fluor Modified). A mass of 2 g of seed and 1.1924 g of oil were transferred to Teflon containers adding 25 ml of 98% HNO_3, with a heating cycle in 3 steps: 5 min at 250 Watts, 5 min at 400 Watts and 5 min at 500 Watts, at a constant temperature of 115°C. In Table-1 the parameters used in atomic absorption for determination of each metal are shown.

Table-1: Parameters used in atomic absorption.

Element	λ nm	Slit mm	Sensitivity Check ppm
Cu^{2+}	249,22	2,7/0,8	1.3
Ni^{2+}	232	1,8/1,35	3.0
Mn^{2+}	403	1,8/0,6	1.0
Fe^{2+}	248	1,8/1,35	2.0
Zn^{2+}	213,86	2,7/1,8	0.3
Cd^{2+}	228,8	2,7/1,35	0.5
Ca^{2+}	422,67	2,7/0,6	1.0
Na^{+}	589	1,8/0,6	0.3
K^{+}	766,49	2,7/0,45	1.0

*Recommended conditions for the Perkin-Elmer Precisely, Model 400 AAanalyst spectrophotometer.

The determination of boron was conducted with the standard method APHA AWWA 4500-B, using UV/Visible, Brand Perkin Elmer Lambda 25, with cells of 1 cm optical path and λ = 540 nm spectrophotometer. The chemical reagents used were reactive grade, a 1 M stock solution of boron was prepared from dry boric acid (H_3BO_3, 99.9% sigma aldrich®), oxalic acid ($(COOH)_2$ $2H_2O$, 97% JT Baker) (HC_2O_4. $2H_2O$), hydrochloric acid (HCl, 98%, Reasol), curcumin ($C_{21}H_{20}O_6$sigma aldrich®), ethanol (CH_3CH_2OH, 60%, Meyer), nitric acid (HNO_3, 70%) and as blank solution, deionized water with a conductivity of 4 mS / cm at 25°C.

Results and discussion

Nine calibration curves were performed on different days, starting with a certified Perkin Elmer 1000 ppm pure standard to quantify each metal. The solutions prepared for the calibration curve were treated in the same way as the oil and seed samples using concentrated HNO_3 to ensure that all metals are quantitatively in the oxidation state. Each curve has 4 to 5 points, obtaining excellent correlation factors, which is an indication of having a linear range. Prior to obtaining the calibration curve, the spectrophotometer burner alignment was performed using a certified Perkin Elmer 2 ppm Cu standard solution and the correction of the background radiation was done with a deuterium lamp, using a flow of acetylene of 2.5 L / min and 10 L / min of air.

The calibration curves for the different bioelements are presented in Figure-1.

The concentration of the different bioelements of the seed and oil are reported in Table-2. Analytical data precision and accuracy was ensured with repeated analysis of sample (n=3) and the results were found to be within ±3%.

Table-2: Concentration of bioelements in chia's oil and seed.

Metals	Chia's oil ppm	Chia's seed ppm
Ni^{2+}	2.052	1.407
Fe^{2+}	501.410	338.125
Mn^{2+}	*	6.937
Zn^{2+}	1.320	6.300
Cu^{2+}	2.315	4.375
B	*	6.316
Cd^{2+}	*	*
K^{+}	20.641	24.743
Na^{+}	2.718	3.089
Ca^{2+}	17.000	228.000

*The limit of detection of the flame atomization system is in ppm, according to the results obtained it was not detectable in this system.

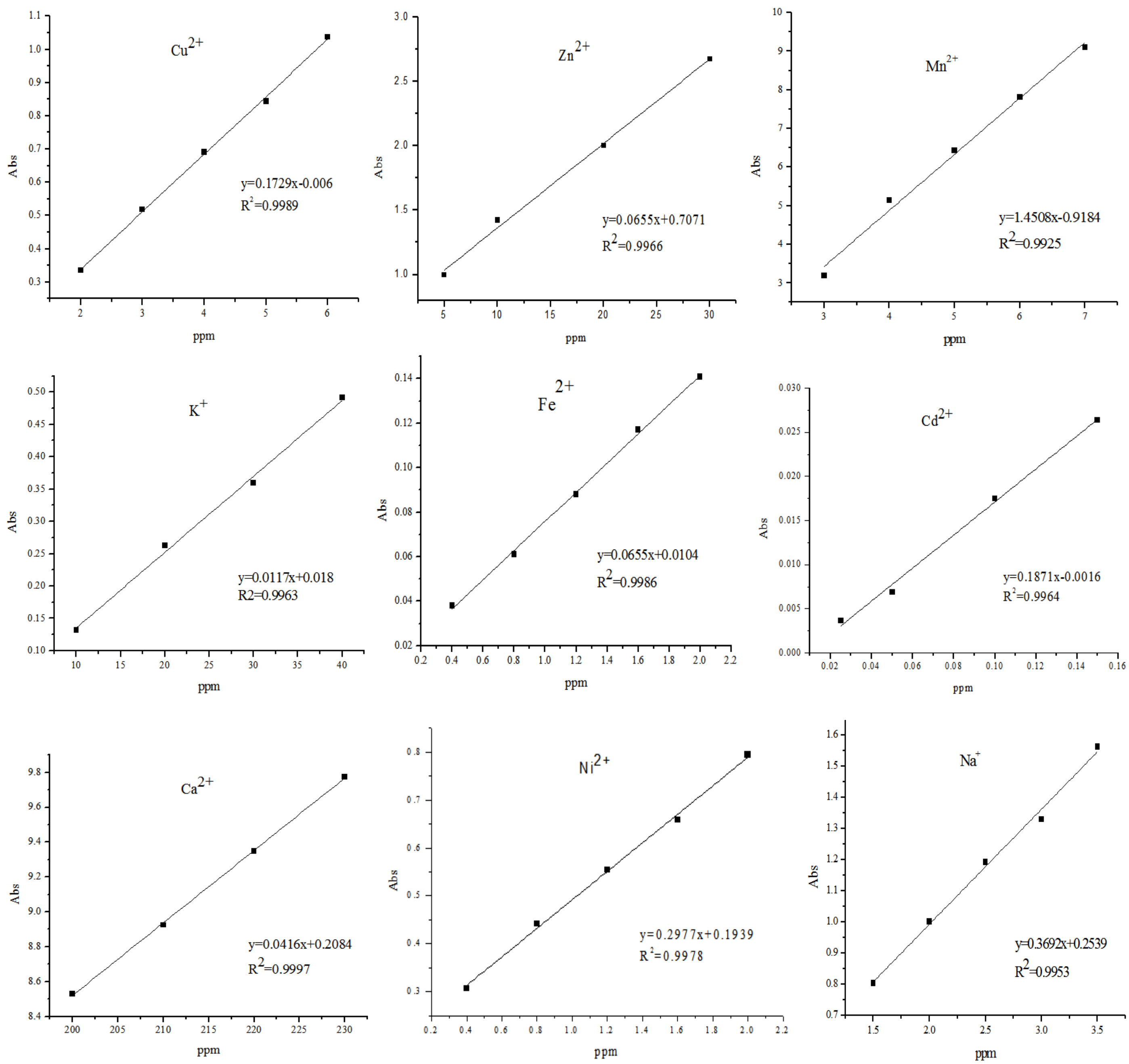

Figure-1: Calibration curves for the quantification of micronutrients by AAS.

The European Food Safety Authority (EFSA, 2009) has reported that chia seed contains 557 (mg/100 g) of calcium (Atomic Absorption Spectroscopy), 6.3 of iron (AAS), 3.7-of 4.95 of zinc, (AOAC 999.11,2000), 1.70-1.94 of cupper (US EPA 3050B Manual ISP 1998 – SGS Chile), < 0.02 nickel (Manual ISP 1998 – SGS Chile), 667 (mg /100 g) of potassium (AOAC 956.01), 0.94 (mg/100 g) of sodium (AOAC 956.01), On the other hand Bushway et al.[15] have reported 8700 ppm of calcium, 8900 ppm of potassium, 9 ppm of boron, 24.5 ppm of copper, 58.5 ppm of manganese, 74 ppm of zinc. Regardless of the technique used to quantify bioelements by the aforementioned authors, The results for chia seed obtained in this research were lower than those reported, with the exception of nickel found in a greater quantity, the heavy metal cadmium was not found in the chia seed studied although there are reports of having been found at <0.2 mg/100 g quantified by Atomic Absorption[16].

The difference of the concentrations of nickel and iron in seed and chia oil is due to the fact that 2 g of sample were used for the seed. If we have a yield of 30%, this is equivalent to 0.6 ml of oil, however we processed 0.96 g/ml, hence the higher values of these bio elements in oil, suggesting that during extraction these were concentrated in oil. With respect to the other bioelements only a fraction of these were found in the oil. With respect to the other bioelements only a fraction of these were found in the oil, remaining the rest in the solid residue.

Many enzymes rely on a metal ion for their activity, compounds containing metal get involved in the process of chemical and energy transfer[17]. In this research 2,059ppm and 1,407ppm nickel in oil and seed respectively were found, this is an essential element involved in vital functions in metabolism, it has been reported that nickel deficiency in humans causes histological and biochemical changes, as well as reduction in iron absorption leading to anemia, in addition to altering the incorporation of calcium from bones and cause similar damage to parakeratosis, can also alter the metabolism of zinc. Nickel deficiency affects the activity of different enzymes such as the dehydrogenases, transaminases and especially alpha-amylase and metabolism of carbohydrates. The requirements of nickel in humans are less than 500 micrograms/kg[18]. it has been also reported that the level of tolerable upper intake is 1 mg in adults, the best source of nickel is chocolate for example the bitter variety provides 2.6 ppm and pure cocoa 9.8 ppm of this metal chia is a good source of this bio element (Table-1).

In regard to boron, 6.316 ppm were found in the seed, which interacts with the metabolism of calcium and magnesium, as it is necessary to convert vitamin D to its active form[19], besides it has been reported that the addition of boron to postmenopausal women elevate serum levels of 17-β-estradiol and testosterone[20].

Zinc is the second most abundant metal in organisms, about 2 to 4 g of this metal are distributed throughout the human body, most are located in the brain, muscle, bone, prostate, eyes and liver[21], promotes the biochemical actions of vitamin D, and is involved in calcium absorption and prevention of osteoporosis, because of its essential role in DNA and protein synthesis, this element is required for the formation of osteoblasts[22]. It has also been shown that supplementation of this bioelement is beneficial in patients with diabetes, because it is important in the action of insulin and carbohydrate metabolism, zinc deficiency impairs the synthesis of superoxide dismutase which leads to an increase oxidative stress. With respect to manganese serves to fix calcium[23], detected 6,937 ppm chia seed, with regard to copper deficiency has been associated with osteoporosis[24] detecting this bioelement both seed and chia oil (Table-2).

Calcium is essential for all organisms as it is a structural component of cell walls and bones)[17], 228 ppm were quantified in the seed, for the metabolism of bone fixation it is needed synergy with nickel , boron, zinc, manganese and copper, being chia an excellent source of these bioelements.

338,125 ppm of iron were found in chia seeds, it has been reported the amount of iron for different sources such as: Seaweeds 22.94 mg/100 g, rice bran 12.38 mg/100 g, spinach 2.64 mg/100g,[25] based on the data obtained in this research black chia seed is an excellent source of iron, and contain nickel, favoring the absorption of this trace element.

Iron deficiency is the most prevalent nutritional deficiency in the world and Mexico is no exception causing anemia, affecting the quality of life in various forms, since in all cells (brain, muscle, etc.) is essential for iron power generation. Its deficiency is manifested in a reduced ability to do tasks that require physical or mental activity and difficulty maintaining body temperature in cold environments[26].

Conclusion

In this research it was shown that chia seed, which had a wide application in various fields in the Aztec empire contains the bioelements Ni, B, Zn, Mn and Cu important for the binding of calcium to the bone, besides the excellent amounts of iron, so it is important to rescue the consumption of this prehispanic seed and incorporate it into various foods.

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