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The *Chiton articulatus* source of minerals for human health

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Abstract: The marine cockroach *Chiton articulatus* is distributed in rocky coastlines intertidal zones all over the world. There are about 600 species of *Chiton* who play an important role in the tropic chain. Mexico has a long coastline with these characteristics. This herbivorous mollusc attached to the rocks, can be found throughout the year, however availability is low during the months of July to September due to deep water flow and flood tides as well as rough weather conditions that difficult their harvest. The aim of this research is to assess minerals in *Chiton articulatus* and to promote their consumption amongst the general population to help prevent chronic diseases from mineral deficiencies. Sampling was performed over 10 Km in the rocky seaboard of Acapulco port in the Pacific Ocean, once every four weeks for a period of six months. The material obtained was analysed to determine mineral composition of the mollusc: Na, K, Cu, Fe, Zn, Ca, and Mg were determined by atomic absorption spectrophotometry; P by colorimetric and I by titration. The data obtained was: Na 320mg/100g; K 17.00 mg/100g; Cu 0.52 mg/100g; Fe 2.66 mg/100g; Zn 1.68 mg/100g; Ca 125mg/100g; P 131 mg/100g; I 18.01 mg/100g and Mg 16.60 mg/100g. Not all minerals in the marine cockroach were quantified. Some of them were found in small amounts, but the nutrient value can be complemented with other foods in a mixed diet. The inorganic composition can vary according to the abiotic condition of the environment. The mineral content of the *Chiton* is related with inorganic biodiversity of the surrounding areas and can be modified by abiotic conditions. *Chiton* is well accepted by the population and, therefore, its consumption may play an important role in human health.

Key words: minerals, chiton, nutrition, human health, biodiversity.

دراسة (*Chiton articulatus*) كمصدر للمعادن الهامة لصحة الإنسان

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الملخص : تنتشر(*Chiton articulatus*) الرخوية البحرية في المناطق الساحلية في جميع أنحاء العالم.. يوجد أكثر من 600 نوع من الرخويات التي تلعب دورا هاما في المناطق المدارية وخاصة في المكسيك التي تمتلك شواطئ واسعة .. هذه الحشرات الرخوية آكلة للأعشاب وهي تلتصق بالحجارة والصخور ويمكن الحصول عليها طول العام وقد تقل خلال موسم الأمطار والظروف المناخية الصعبة خلال الفترة من يوليو وحتى سبتمبر من كل عام . تهدف هذه الدراسة إلى تقييم المحتوى المعدني (*Chiton articulatus*) وكذلك المساعدة على تشجيع استهلاكها بين أفراد المجتمع للوقاية من الأمراض المزمنة الناتجة من قلة المعادن . تم جمع العينات لكل 10 كيلو من ميناء اكبالوا بالمحيط البسفيكي مرة كل أربعة أسابيع لمدة ستة اشهر . تم تحليل العناصر المعدنية للكائن الرخوي (*Chiton articulatus*) بواسطة (*spectrophotometry*) و (*colorimetric*) بواسطة (*titration*) ولم يتم قياس كمية كل المعادن وذلك للعثور على بعض منها في كميات صغيرة، ولكن يمكن لهذه الكميات البسيطة أن تكون مكملات غذائية بخلطها مع غيرها من المركبات غير العضوية التي تختلف وفقا للبيئة التي تعيش فيها. هناك ارتباط بين المحتوى المعدني مع التنوع البيولوجي غير العضوي للمناطق المحيطة بها، مما يجعل (*Chiton articulatus*) مقبول من قبل السكان، وبالتالي استهلاكه قد يساهم في حل المشكلات الصحية.

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Introduction

Poor nutrition is a problem worldwide and this is getting worse every day (Pelletier et al., 2006). The natural sources of foods available are often less considered, whereas research of new technologies for synthesis and conservation, raises prices and makes the products inaccessible to the majority of people, particularly social groups far removed from urban zones. Poor nutrition affects an individual's performance and makes him/her vulnerable to different chronic degenerative diseases (Chavez et al., 2009). Mineral deficiency represents a serious problem in the development and behavior of the human being (Reilly, 2004). Absence of knowledge of both the edible species and their nutritional properties determines lack of consumption and decreases potential food benefit of a large variety of organisms existing in the environment (Greger, 1987). The *Chiton articulatus* is found in the coastal regions of Mexico. It is considered as a food source by few social groups, and has an acceptable nutritional value of macro and micronutrients. It contains elements that could contribute a substantial improvement in nutrition (Coultate, 2002). The study was undertaken to assess *Chiton articulatus* macronutrient and mineral content, this valuable information should be considered to contribute to decrease mineral deficiencies of excluded populations in coastal lands all over the world (F.A.O, 1995).

Materials and Methods

Materials

Caleta beach in Acapulco, Guerrero was monitored and material under study was found to be available there. Ten kilometers of a rocky zone was covered and the mollusc gregarious colonies were found adherent to stones at the height where the waves break. The *Chiton articulatus* were captured each two weeks during April and May of 2010, from 10 a.m. to 5 p.m. They were manually removed with a knife with care not to damage the mollusc and put it in a black plastic bag with two liters of sea water. The material obtained was transported by land to Mexico City, in a plastic container with ice at -2° C measured with a mercury thermometer; the samples obtained were kept frozen at -8ºC until analyzed 48 hours later.

Figure 1. Images of *Chiton articulatus*.

Methods

The *Chiton* from the samples studied were removed from their shells with a spoon and 265 g portions of the sample were weighed out on analytical scales and only mollusks weighing 2.5g were included for assessment. Six individuals from this sample were used for taxonomic determination (Barnes, 1994) and the 250g remaining used to perform a proximal analysis for the chemical quantification of their

micronutrients. The moisture content was measured by drying sample cut transversely in an oven at 80ºC for 24h. The dry product was powdered in a Willey Mill to 60 mesh size. The fine mollusk powder so obtained was used for further analysis. All the minerals with the exception of phosphorus and iodine were analyzed by Atomic Absorption Spectrophotometry. Phosphorus content in acid digested extracts was determined colorimetrically. Iodine was assessed by titration method. Briefly, the reaction mechanism is in two steps: liberation of free iodine and addition of sulfuric acid liberates free iodine from the iodate from the *Chiton*, then titration of free iodine with thiosulfate (A.O.A.C, 2003).

Results

The *Chiton articulatus* is classified as an invertebrate, class polyplacophora, family mollusc (Table 1). The nutrient contents of the *Chiton articulatus* shows that it is high in protein, low in lipid, lacks fiber and has a good energy source from soluble carbohydrates (Table 2). There is a difference between the value of the inorganic matter obtained from a proximal analysis and the results reported because only the mentioned minerals were assessed (Tables 3, 4 and 5). The articulatus Chiton can be found throughout the year, but its availability decreases in the months of July, August and September (Table 6).

Table 1. Taxonomy of the *Chiton articulatus*.

Phylum	**Mollusca**
Class	Polyplacophora
Family	Chitonidae Rafinesque 1815
Subfamily	Chitoninae
Genus	*Chiton* Linnaeus, 1758
Subgenus	*Chiton* s.s
specie	*Chiton (c.) articulatus* Sowerby, 1832
Scientific name	*Chiton articulatus*
Common name	marine cockroach

Table 2. Proximal analysis of the *Chiton articulatus*. g/100g.

Protein*	**69.96**
Fat	4.70
Inorganic matter	3.09
Fiber	0.00
Nitrogen free extractives (NFE)	22.25

All values are mean of triplicate determination expressed on dry basis.

NFE=soluble carbohydrates.

*Kjeldahl NX6.25.

Table 3. Chemical analysis of the inorganic matter of the Chiton articulatus. mg/100g.

Element	**mg/100g**
Calcium	1.25
Magnesium	16.60
Copper	0.52
Iron	2.66
Zinc	1.68
Sodium	320.00
Potassium	17.0

*By atomic absorption spectrophotometer.

Table 4. Chemical analysis of the Iodine in the *Chiton articulatus* mg/100g.

Element	**mg/100g**
Iodine	18.01

*By titration.

Table 5. Chemical analysis of phosphorous in the *Chiton articulatus*. mg/100g.

Element	**mg/100g**
Phosphorous	131.00

*By colorimetry

Table 6. *Chiton articulatus* availability on a year in Guerrero State, Mexico.

Jan	**Feb**	**Marc**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
X	X	X	X	X	X	Y	Y	Y	X	X	X

X=High availability season

Y=Low availability season

Discussion

The magnitude of the under-nutrition problem, due to lack of macronutrients and micronutrients, has reached significant proportions in the world population, principally

in developing countries like Mexico. The inadequate consumption of foods containing sufficient micronutrients for different social strata is closely related to physical and metal development and the good health of populations (Reilly, 2004). Sodium and potassium are important minerals in relation to the functioning of the sodium-potassium pump (Preus, 2006). Copper fulfills key metabolic functions in different organs and systems (Wapnier, 1998). Iron is important in avoiding different degrees of anemia which reduce the capacity of the individual to work; another characteristic is the incapacity to maintain body temperature in a cold environment. Low consumption of iron produces a deficiency in psychomotor development and intellectual activity, changes in the behavior of breast-fed infants up to two years of age and a lower resistance to infections. Iron deficiency induces a substantial increase in the risk of greater absorption of lead, however, excessive administration of iron competes with absorption of cooper that fulfills key metabolic functions in different organs and systems and with the absorption of zinc (Pennington et al., 1990). Zinc, a component of all cells, is important for the regulatory capacity of cells since its intracellular concentration can be homeostatically controlled in a specific way for each tissue. It also has functional and structural actions for many metalloenzymes and macromolecules (Mc Call, 2000). Calcium and phosphorous are indispensable for the formation of bone. Although phosphorus also acts as a structural part of high energy compounds, the amounts of calcium and phosphorous necessary to maintain metabolic equilibrium depend on the physiological needs for these minerals, on the capacity of the intestine to absorb them and the possibility of the kidneys conserving them (Weaver, 2006). Magnesium is an enzyme co-factor that intervenes in the metabolism of carbohydrates, cholesterol and proteins (Franz, 1989). A deficiency of iodine causes thyroid disorders and a reduction in mental functions that affect initiative and decision making capacity. The daily requirements of iodine for an adult are 1 to 2 µg/kg of body weight, although consumption of 150µg is considered adequate for older children and adults. These problems generally do not occur in the coastal zones since there are different foods containing iodine (Melo et al., 2004).

Conclusion

The *Chiton articulatus* and other species of chitons are available in rocky coastal regions throughout the year in México as well as in the rest of the world. There are many individuals who do not know the nutrient and mineral value of this mollusc. Consumption of this foodstuff is recommended for all population groups in low and high density populated regions. Its organoleptic characteristics give it a very pleasant flavor and texture. Including it in the diet could increase nutrition status of people living along the coastlines of the five continents. The *Chiton articulatus* can be found, throughout the year, at Pacific Ocean coastline from western coast of Mexico, from Mazatlan south to Puerto Guatulco (Hikman, 1985), but it´s availability decreases in the months of July, August and September due to weather conditions. It is consumed either raw or prepared with other foodstuffs and is well accepted by the population.

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