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Proximal and mineral composition analysis of castilla squash seeds (*C. moschata*), green pea (*P. sativum*) and green bean (*P. vulgaris*) for use in 4.0 Agribusiness

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ABSTRACT

Objective: To determine the proximal and mineral composition analysis of of castilla squash seeds (*C. moschata*), green pea (*P. sativum*) and pinto saltillo green bean (*P. vulgaris*).

Design/methodology/approach: The contents of macronutrients (carbohydrates, fats, crude fiber, protein, and ash) and micronutrients (minerals) of the evaluated species were determined using the AOAC standard procedures, and the quantification of minerals was performed by mass spectrometry with inductively coupled plasma. A variance analysis and means comparison were performed with Tukey's test (α=0.05).

Results: The squash seeds with shells contain 291,500 ppm of protein, 417,000 ppm of fat, 66,700 ppm of carbohydrates, 134,000 ppm of crude fiber, 972,319.678 ppm of phosphorus, 3,380.09158 ppm of potassium and 3,183.2744 ppm of magnesium. The whole pea pod has 230,600 ppm of protein, 17,200 ppm of fat, 456,000 ppm of carbohydrates, 220,800 ppm of crude fiber, 5,438.18,991 ppm of phosphorus, 7,349.23753 ppm of potassium and 1,719.56882 ppm of magnesium. The whole green bean pods had a content of protein (185100 ppm), fat (2540 ppm), carbohydrates (377500 ppm), fiber (208000 ppm), phosphorus (6068.44661 ppm), potassium (15626.9991 ppm) and magnesium (17222.16567 ppm).

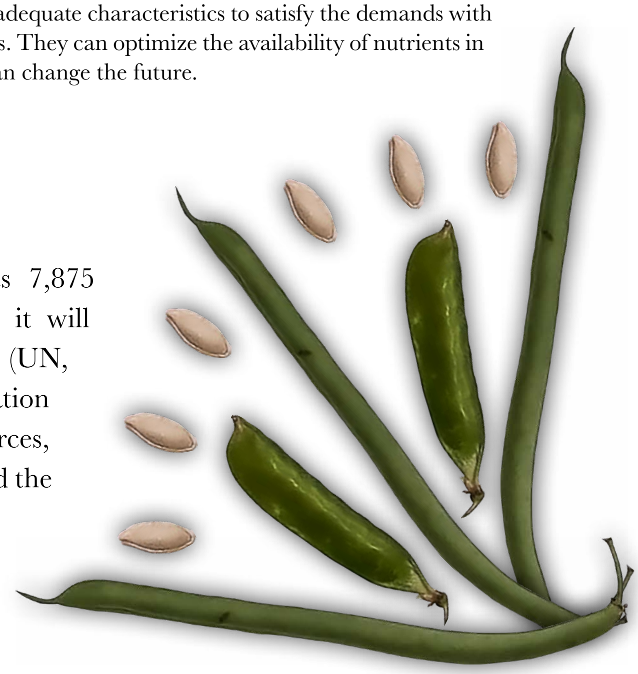
Study limitations/implications: Studies on the chemical characteristics of other agroindustrial residues should be carried out.

Findings/conclusions: The foods analyzed have adequate characteristics to satisfy the demands with respect to some macronutrients and micronutrients. They can optimize the availability of nutrients in the generation of natural or synthetic foods that can change the future.

Keywords: Chemical content, *Cucurbita moschata*, *Pisum sativum*, *Phaseolus vulgaris*.

INTRODUCTION

In 2021, worldwide population was 7,875 million people and it is expected that it will increase another 2,000 million by 2050 (UN, 2021). This excessive growth of the population is demanding more and more resources, which affects the planet's biodiversity, and the health and wellbeing of the population (Labrador, 2006). Therefore, the



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need arises to find new sources of good quality food which are also accessible and low cost, as well as to adapt new technologies for the management of raw materials, input downsizing in the process, and better use of the quality and quantity of food and non-food products.

Mexico has a great diversity of valuable food resources, and studying them provides information for an efficient use and to continue with sowing and consumption of traditional foods in order to counteract health problems, food security, to increase the country's economy, exploit industrial purposes, and generate new benefits with the elaboration of synthetic foods. Also, it is important to study non-conventional or non-traditional foods such as agro-industrial residues, which, in spite of not representing the main value of the transformation can be a complement for raw material of another product (Saval, 2012), contributing as an option to the grave worldwide food problem.

These residues can provide a nutritional balance in terms of macro and micronutrients, since, in order to increase food quality, crops that decrease vitamin and mineral deficiencies must be included in the population's diet as a sustainable long-term solution (Pachón, 2010).

The current lifestyle promotes inadequate dietary habits such as the consumption of foods of low nutritional quality. In addition to this, many foods lose a great part of their minerals through the industrial refining process, which is why their deficiencies are common among the population. However, minerals are essential for a broad range of metabolic functions in the human body and some of them participate directly or indirectly in many functions of the organism (Velasco-Lavín, 2016).

Legume pods and oilseed seeds can contribute to counteract health and food security problems; nevertheless, these are generally only used in a traditional way (as seeds, canned or frozen goods) and not as raw materials in the transformation of new flour-based products with added value. On the other hand, information on the content of mineral elements in foods is insufficient.

International agencies recommend daily intakes of calcium, magnesium, zinc, iodine, iron and selenium to the general population. For example, in children from one to eight years of age the recommended intake of calcium is 500 to 800 mg day^{-1}, magnesium 80 to 130 mg day^{-1}, zinc 3 to 5 mg day^{-1}, iron 7 to 10 mg day^{-1}, phosphorus 460 to 500 mg day^{-1}, iodine 90 μg day^{-1}, copper 340 to 440 μg day^{-1} and selenium 20 to 30 μg day^{-1} (WHO and FAO, 2004). Deficiency problems in protein, essential fatty acids, fiber, carbohydrates, vitamins and minerals in the diet get more and more complicated because of the lack of information about the chemical content, and this depends on many factors such as type of food, genetic origin, geographic location and agricultural procedure implemented.

Therefore, it is fundamental to revise, analyze and complete the existing information about mineral content that are found in food chemical composition tables, databases or nutritional software, in order to create health programs, plan healthy menus and produce quality market products. For the above reasons, the objective of this research is to characterize the proximal analysis and mineral composition of castilla squash (*C. moschata*) seeds, green pea (*P. sativum*) pods, and pinto saltillo green bean pods (*P. vulgaris*), with the aim of identifying a possible use in agroindustrial processes, improving the use of organic residues, and identifying a potential use in Agribusiness 4.0 for the creation of foods that allow to cover the possible deficiencies and demands from the population.

MATERIALS AND METHODS

The proximal content was analyzed of castilla squash seeds with shell, squash seeds without shell, squash seed shell, pea pods (seed and shell), pea seeds, pea pods (sheath), green bean pods (seed and shell), green bean seed, and green bean pods (sheath). As well, the mineral composition was determined in complete samples of castilla squash seeds (*C. moschata*), green pea pods (*P. sativum*) and green bean pods (*P. vulgaris*) (Figure 1), with three replications. The samples were obtained randomly from the municipality of Zacatón, Salinas de Hidalgo, S.L.P., and from the Ejido de Moras, Mexquitic de Carmona, S.L.P., during the month of July 2021. Subsequently, they were transported directly and without storage period to the laboratory for analysis.

The determinations were carried out at the Water-Soil-Plant Laboratory of the San Luis Potosí Campus of Colegio de Postgraduados (22° 63' 22" N and 101° 71' 25" W) and at Laboratory 2 of the Coordinación Académica Región Altiplano Oeste (CARAO) of Universidad Autónoma de San Luis Potosí (22° 38' 28.5" N and 101° 42' 10.0" W).

Ash

Ash content was determined according to AOAC method 942.05/90 (AOAC, 1990) and was expressed as percentage in weight of dry flour.

$$\%\ ashes = (weight\ of\ calcined\ ash\ sample)\ /\ (weight\ of\ sample) \times 100 \qquad (1)$$

Figure 1. Pea pods (*Pisum sativum*), pinto saltillo green bean pods (*Phaseolus vulgaris*) and castilla squash seeds (*Cucurbita moschata*).

Raw protein

Raw Protein was determined through the Kjeldalh method according to technique 955.04/09 (AOAC, 1990), which determines the nitrogen concentration present in the sample to then be transformed into protein through a factor.

Total carbohydrates

Total carbohydrate content was determined using the method based on AOAC 974.06 (AOAC, 1975).

Total fat

The fat content was determined using the 920.39C procedure described by the AOAC (AOAC, 1990), by means of the Soxhlet technique in a ST243 Soxtec TM Extraction Unit.

Crude fiber

The determination of fiber content was carried out on previously defatted samples, performing acid digestion in the presence of 1.25% H_2SO_4 and alkaline digestion in the presence of 3.52% NaOH, using the AOAC method Weende 962.09/90 (AOAC, 1990).

Open acid digestion

The procedure used is based on that described by Jakubowska *et al.* (2006) with some modifications. For this purpose, 0.5 g of sample was weighed on an analytical scale (OhausAdventurer, model H-5276) and transferred into a flat Teflon tube of 50 mL capacity. Subsequently, 25 ng mL^{-1} of Iridium and Indium were added to each sample as an internal standard to perform the method recovery. In addition, 10 mL of ultrapure concentrated HNO_3 were added and stored at room temperature for 12 h.

The samples with the HNO_3 were placed on a heating plate (NJBZH brand, model BZH29) and heated to conduct evaporation (hot acid digestion), without taking it to dryness; that is, approximately when the tubes had 1 mL of the concentrated sample, 10 mL of concentrated H_2O_2 were added drop by drop in order to destroy all the organic matter present in the sample (this process is also called total mineralization of the sample). Finally, the samples were calibrated to 25 mL in class A volumetric flasks with batch certificate.

Mineral analysis in ICP-MS

For the determination of the 63 mineral elements, the inductively coupled plasma mass spectrometry (ICP-MS) procedure was used with the iCAP™ RQ equipment, in KED mode and with a collision cell.

Statistical analysis

Data analysis was performed in r-project® (4.1.1) software under the RStudio® (2021.09.0) interface, both of free distribution, for which an analysis of variance was performed under a completely randomized design and a means comparison by Tukey's method (α=0.05).

RESULTS AND DISCUSSION

Proximal composition

According to the results of the proximal analysis (dry basis), a significant difference ($p<0.001$) was found in the five determinations. Pea presented the lowest fat content in the pod shell (12300 ppm), the highest protein (320900 ppm) and ash (32400 ppm) content in the seed and the highest total carbohydrate content in the complete pod (shell plus seed) (456000 ppm). Squash had the highest fat content (495000 ppm) and the lowest ash content (10000 ppm) in the shelled seed, while the shell of this species had the highest crude fiber content (711500 ppm) and the lowest total carbohydrate content (61100 ppm) (Table 1).

The values obtained for the proximal content of squash seeds, green bean pods and pea seeds were different from those found in the literature, in several cases due to factors such as determination techniques, types of solvents/reagents, geographical area, environmental factors where they are grown, among other aspects. Rössel-Kipping *et al.* (2018) found lower values from those of this study except for ash content with 6919.99 ppm, crude fiber with 45630 ppm, fat of 283240 ppm, protein of 1290 ppm and carbohydrates with 211190 ppm in castilla squash seeds (*C. moschata*). Similarly, the fat content found in this study (417000 ppm) is higher than that found in castilla squash seeds (*C. moschata*) with 331500 to 346000 ppm (Martinez *et al.*, 2011).

On the other hand, in the case of the whole green bean pod, Fernández-Valenciano and Sánchez-Chávez (2017) obtained carbohydrate values of 346700 ppm and protein 185100 ppm, similar to those of this study with values of 185100 ppm and 377500 ppm, respectively. However, the ash (82400 ppm), fat (13000 ppm) and fiber (7900 ppm) contents are different from those found in this study. As for *Pisum sativum* L., the values found in this study for pea pods (seed and shell), pea seed and pods (sheath) were between 182100 and 320900 ppm of protein, between 12300 and 17200 ppm of fat, and between 12900 and 32400 ppm of ash, values that are in the range of those reported in the literature. Mateos-Aparicio *et al.* (2010) reported 108000 ppm of protein, 13000 ppm fat and 66000 ppm ash. Similarly, Millar *et al.* (2019) report values of 215000 ppm protein, 12800 ppm fat and

Table 1. Mean and standard deviation of proximal concentration of squash seeds, green bean pods, pea pods and their byproducts.

Evaluated product	Protein (mg kg^{-1})	Grasa (mg kg^{-1})	Total carbohydrates totales (mg kg^{-1})	Crude fiber (mg kg^{-1})	Ash (mg kg^{-1})
Pea pod	182100±0.03h*	12300±0.02i	423000±0.37b	307000±0.28b	12900±0.06g
Pea seed	320900±0.03a	16000±0.09g	295800±0.18f	282000±0.05d	32400±0.05a
Pea mix	230600±0.02e	17200±0.02f	456000±0.01a	220800±0.01e	20100±0.04e
green bean pod	183000±0.02g	14000±0.01h	393100±0.02d	290800±0.01c	22400±0.04d
green bean seed	293000±0.02b	23000±0.02d	403900±0.02c	205600±0.03f	16300±0.03f
green bean mix	185100±0.04f	25400±0.03c	377500±0.02e	208000±0.01f	32000±0.03ab
pumpkin seed mix	291500±0.04c	417000±0.05b	66700±0.09h	134000±0.03g	31000±0.05b
shelled pumpkin seed	263000±0.03d	495000±0.03a	149700±0.03g	25800±0.03h	10000±0.05h
Pumpkin seed shell	90800±0.02i	19700±0.02e	61100±0.02i	711500±0.09a	28000±0.04c

*values with the same letter within columns show no significant difference, Tukey (α=0.05; n=3).

27600 ppm ash for green peas. Rempel *et al.* (2019) studied pea flour and obtained protein values from 420000 ppm to 500000 ppm, fat concentrations from 13300 ppm to 15700 ppm, and ash from 23400 ppm to 25600 ppm.

Meanwhile, Dahl *et al.* (2012) report protein values between 212000 ppm and 329000 ppm, fat 12000 ppm to 24000 ppm, and ash 23000 ppm to 34000 ppm for peas.

Mineral composition

According to the analysis of variance, the content of micronutrients (minerals and trace elements) of the seeds of castilla squash, pea pods and green bean showed significant difference ($p<0.001$). The dietary requirements of minerals in humans vary from a few micrograms per day to one gram per day and are essential for the proper functioning of the heart, the brain, as well as for blood clotting, nerve function, structural reconstruction of body tissues and bones, and are also involved in most metabolic processes, enzymatic reactions and muscle contraction (Ciudad, 2014). It is therefore important to supply these mineral nutrients in the diet. The essential micronutrients for human beings are divided into two classes: minerals that must be supplied in large amounts in the diet (100 mg or more) and essential trace elements that are necessary in only a few mg per day (Daza, 2001).

In relation to the concentrations of minerals in the castilla squash seeds, pea and green bean pods, the green bean pods had a higher content of sodium (139.0584 ppm) and potassium (15626.9991 ppm). On the other hand, squash seeds presented higher concentrations of magnesium (3183.2744 ppm) and phosphorus (9723.1968 ppm), while pea pods presented higher calcium content of 377.4985 ppm (Table 2).

Karanja *et al.* (2013) report the presence of potassium (1240-3350 ppm) in squash seeds which are like those found in this study. Similarly, Hussain *et al.* (2021) found potassium (3877 ppm) and calcium (56.7 ppm) values in squash seeds (*Cucurbita maxima*) similar to those of this research. Chí-Sánchez *et al.* (2020) studied six whole seed variants of squash (*Cucurbita moschata*) and found magnesium dry weight concentrations of between 2960 ppm and 24140 ppm, similar to those in this study which were 3183.27 ppm, in the case of phosphorus concentrations between 1750 ppm and 4370 ppm, potassium from 172100 ppm to 715600 ppm, and calcium from 41000 ppm to 103500 ppm different from those of this study, which were 9723.19 ppm of phosphorus, 3380.09 ppm of potassium and 50.22

Table 2. Mean and standard deviation of mineral concentrations of squash seeds, green bean pods and pea pods.

Evaluated product ($mg\ kg^{-1}$)	Pumpkin seed	Pea pod	Green bean pods
Calcium	50.22±0.02c*	377.49±0.02a	348.77±0.01b
Potassium	3380.09±0.36c	7349.23±0.03b	15626.99±0.01a
Magnesium	3183.27±0.36a	1719.56±0.02c	1722.16±0.01b
Sodium	116.56±0.03c	130.24±0.02b	139.05±0.02a
Phosphorus	9723.19±0.21a	5438.18±0.02c	6068.44±0.01b

*values with the same letter within rows do not show significant difference, Tukey ($\alpha=0.05$; $n=3$).

ppm of calcium. On the other hand, Fernández Valenciano and Sánchez Chávez (2017) obtained different values for ejojo bean pods of 0.18 ppm, 1.42 ppm, 0.33 ppm and 0.53 ppm of phosphorus, potassium, magnesium and calcium, respectively.

Meanwhile Mateos-Aparicio *et al.* (2010) studied pea pods (*Pisum sativum*) and found magnesium values of 2100 ppm, similar to those of this study (1719.56 ppm), in the case of potassium (10300 ppm) and calcium (7700 ppm) values were different, since those of this research were 7349.23 ppm potassium and 377.49 ppm calcium. Likewise, Millar *et al.* (2019) reported values of 1032 ppm magnesium, 11353 ppm calcium, and 10439.10 ppm potassium in green peas. The difference of the values of this study from those of the literature may be due to several factors that include the variety of squash, the techniques, equipment and solvents used for the determination of the content of these minerals, the climatic and cultivation conditions, as well as the post-harvest storage.

Essential trace elements

Bean pods showed higher contents of molybdenum (4.83011 ppm), iron (100.30591 ppm) and cobalt (0.13818 ppm). On the other hand, squash seeds showed higher concentrations of chromium (3.26827 ppm), manganese (31.832 ppm), copper (6.34767 ppm), zinc (35.43907 ppm) and selenium (0.01465 ppm), compared to pea and green bean pods. Meanwhile, pea pods presented molybdenum (1.42652 ppm), manganese (25.06485 ppm), copper (5.25487 ppm) and selenium (0.00763 ppm), with lower concentrations than squash seeds and green bean pods (Table 3).

The highest concentration in the 3 products evaluated was iron, and it was detected in the highest concentration in the bean pod (100.30591 ppm), followed by high concentrations of manganese, with the squash seed having the highest content of 31.83205 ppm. The concentrations reported by some authors are different from those of this research, but in the studies they report that there was significant difference in the content of essential trace elements between the species evaluated; this indicates the morphological variability present between variants of each species and the potential they have as sources of essential trace elements (Darrudi *et al.*, 2018). Zinc concentrations in this study were 35.43 ppm, similar

Table 3. Mean and standard deviation of the concentration of essential trace elements in squash seeds, green bean pods and pea pods.

Evaluated product (mg kg^{-1})	Pumpkin seed	Pea pod	Green bean pod
Cobalt	0.09±0.02c*	0.098±0.02b	0.13±0.02a
Chromium	3.26±0.02a	2.78±0.01c	3.05±0.01b
Copper	6.34±0.03a	5.25±0.02c	5.42±0.01b
Iron	86.70±0.02c	94.25±0.03b	100.30±0.01a
Manganese	31.83±0.02a	25.06±0.02c	31.02±0.01b
Molybdenum	1.70±0.03b	1.42±0.02c	4.830±0.01a
Selenium	0.01±0.02a	0.01±0.02c	0.01±0.02b
Zinc	35.43±0.02a	28.86±0.8b	19.46±0.02c

*values with the same letter within rows do not show significant difference, Tukey (α=0.05; n=3).

to those reported in other studies ranging from 3.1 to 65.54 ppm (Chí-Sánchez *et al*., 2020). However, iron, manganese and copper concentrations in whole squash seeds were different from those reported by Chí-Sánchez *et al*., (2020) with concentrations ranging from 0.93 to 13.75, 0.93 to 4.38 ppm and 0.59 to 3.3 ppm, respectively. Similarly Hussain *et al*. (2021) reported different concentrations of iron (61.6 ppm) and zinc (152.1 ppm) in squash seeds (*Cucurbita maxima*). In the case of green bean and peas pods, the values found are similar with the research by Fernandez Valenciano and Sanchez Chavez (2017) for green bean pod where values of 5.61 ppm copper, 25.21 ppm manganese, 73.45 ppm iron and 19.28 ppm zinc were found, and with those reported by Millar *et al*. (2019) of zinc (38.80 ppm) and iron (33.10 ppm) in green peas.

Toxic trace elements

It is necessary to know the amount of minerals found in foods for human consumption, especially minerals whose atomic weight is between 63.55 and 200.59, and depending on the concentration in which their ions and compounds are considered toxic to humans and the environment. Some minerals considered in this category are: Thallium, Aluminum, Antimony, Barium, Fluorine, Arsenic, Cadmium, Cobalt, Chromium, Copper, Mercury, Nickel, Lead, Tin and Zinc (Londoño-Franco *et al*., 2016).

Table 4 shows the results of the data obtained for the main toxic trace elements in both squash seeds and pea and green bean pods; squash is the product studied with the highest amount of toxic trace elements, the main ones being antimony (0.11372 ppm), arsenic (0.04697 ppm), mercury (0.0233 ppm), lead-208 (0.08066 ppm) and tin (90.0679 ppm).

The highest concentration of toxic trace elements was found in the green bean pods, while the lowest concentration was found in squash seeds. According to Berdonces (1996), data from the table of estimated daily intake of metals and trace elements and toxicity, the results do not exceed the maximum allowed daily intake limits for cadmium, arsenic, thallium, antimony, and lead; that is, up to 500 g of squash seeds can be consumed and do not exceed the allowed daily limit of mercury. There is little information on the toxic trace elements in whole squash seeds, pea pods and whole green beans. However, Fernández Valenciano and Sánchez Chávez (2017) obtained similar values of nickel (4.00 ppm) in ejojo bean pods to what was found in this study (3.70 ppm).

In general, heavy metal contamination is commonly associated with municipal and industrial discharges (inorganic waste, solid discharges of hazardous waste and domestic and industrial garbage) which go directly into water bodies; however, in this study the main factor that may explain the high concentrations of aluminum and tin is perhaps due to organic contamination and the use of agrichemicals applied before and during the production of squash, pea and green bean. According to Berdonces (1996), aluminum and tin exceeded the allowed limits in the three study products evaluated, which are different in each country.

Similarly, there were no concentrations of heavy metals such as europium, terbium, holmium, thulium, ytterbium, lutetium and rhenium in these seeds and pods, and low concentrations of gold, hafnium, erbium, dysprosium, gadolinium, samarium and praseodymium were observed.

Table 4. Mean and standard deviation of the concentration of toxic trace elements in squash seeds, green bean pods and pea pods.

Evaluated product (mg kg^{-1})	Pumpkin seed	Pea pod	Green bean pod
Aluminum	25.16±0.00c*	51.38±0.02a	45.94±0.01b
Silver	0.10±0.02a	0.06±0.01c	0.07±0.02b
Arsenic	0.04±0.02a	0.02±0.02c	0.04±0.02b
Barium	0.65±0.02c	7.21±0.02a	4.61±0.01b
Beryllium	0.01±0.01c	0.01±0.03a	0.01±0.01b
Cadmium	0.02±0.02b	0.01±0.01c	0.02±0.00a
Cesium	0.01±0.02c	0.07±0.02a	0.02±0.02b
Galium	0.01±0.02c	0.01±0.01b	0.01±0.01a
Mercury	0.02±0.01a	0.02±0.01b	0.01±0.02c
Lithium	0.15±0.08c	0.24±0.01b	0.30±0.02a
Nickel	2.41±0.03b	2.04±0.02c	3.70±0.02a
Lead 206	0.05±0.02a	0.01±0.02c	0.04±0.01b
Lead 207	0.05±0.01a	0.03±0.01c	0.05±0.01b
Lead 208	0.08±0.03a	0.07±0.01b	0.05±0.03c
Rubidium	3.39±0.02c	22.26±0.02a	16.28±0.01b
Antimony	0.11±0.03a	0.09±0.01c	0.10±0.01b
Tin	90.06±0.02a	40.50±0.03c	65.77±0.01b
Strontium	4.13±0.03c	26.10±0.02a	19.27±0.02b
Titanium	1.62±0.01c	12.06±0.00a	8.77±0.01b
Thallium	NP	0.02±0.01	NP
Uranium	0.01±0.00b	0.01±0.01c	0.01±0.02a
Vanadium	0.06±0.03c	0.09±0.02a	0.07±0.01b
Boron	2.51±0.00c	4.59±0.04b	4.87±0.02a
Bismuth	0.039±0.03c	0.05±0.01a	0.04±0.01b
Thorium	0.01±0.03b	0.01±0.02a	0.01±0.02a
Scandium	0.01±0.04b	0.01±0.01a	0.01±0.01a
Germanium	0.01±0.01c	0.01±0.02b	0.01±0.01a
Yttrium	0.01±0.02c	0.01±0.01b	0.02±0.01a
Zirconium	0.10±0.03b	0.07±0.02c	0.11±0.01a
Niobium	0.03±0.03a	0.02±0.02c	0.02±0.01b
Tellurium	0.01±0.02a	0.01±0.02c	0.01±0.01b
Lanthanum	0.01±0.02c	0.01±0.02b	0.01±0.01a
Cerium	0.02±0.03c	0.02±0.02b	0.03±0.01a
Praseodymium	0.01±0.02c	0.01±0.02b	0.01±0.01a
Neodymium	0.01±0.02c	0.01±0.00b	0.01±0.01a
Samarium	0.01±0.02c	0.01±0.02b	0.01±0.01a
Europium	NP	NP	NP
Gadolinium	0.01±0.02c	0.01±0.01b	0.01±0.00a
Terbium	NP	NP	NP
Dysprosium	0.01±0.02c	0.01±0.01b	0.01±0.02a
Holmium	NP	NP	NP
Erbium	0.01±0.02c	0.01±0.02a	0.01±0.02b
Thulium	NP	NP	NP
Ytterbium	NP	NP	NP
Lutetium	NP	NP	NP
Hafnium	0.01±0.01a	0.01±0.02b	0.01±0.01b
Tantalum	0.01±0.03a	0.01±0.01b	0.01±0.01c
Tungsten	0.01±0.01b	0.01±0.01a	0.01±0.01c
Rhenium	NP	NP	NP
Gold	0.01±0.01	NP	NP

*values with the same letter within the rows do not present significant difference, Tukey (α=0.05; n=3), where: NP=did not present.

To achieve optimal use of the products evaluated, the combined use of squash seeds, pea pods and green beans is recommended to help combat malnutrition with natural foods, to design diets for recovery of chronic patients and to prevent deficiency states in the general population (Cáceres and Cruz, 2019). These results also contribute to complete information on the chemical composition of foods or to generate databases such as the Swiss table (Switzerland, 2021).

CONCLUSIONS

According to the results, the shells of squash seeds, pea pods and green beans have a high composition of fiber, carbohydrates, protein and minerals, so they can be considered as an important source of essential nutrients and could be an alternative in the future to complement the commercial flours used also as natural or synthetic foods by the population.

The minerals with the highest concentrations in shelled squash seeds, complete pea and green bean pods were potassium, phosphorus and magnesium and the minerals with the lowest concentrations were erbium and dysprosium, while the concentrations of toxic minerals are very low and no concentrations of rhenium, lutetium, ytterbium, thulium, holmium, terbium and europium were found. For this reason, whole seeds and pods are an alternative for the sustainable development of food technology, health and nutrition, without causing environmental contamination. However, information is scarce to generate technology products, food and non-food; therefore, research is needed to use information optimally, rationally and effectively in Agribusiness 4.0 and for the consumer without harming the environment.

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