SHORT COMMUNICATION Indian Journal of Agricultural Research, Volume 56 Issue 3: 368-372 (June 2022)

Bioactive Compounds, Antioxidant Activity and Mineral Content of Common Bean Varieties Grown in Tabasco, Mexico

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10.18805/IJARe.A-587

ABSTRACT

Phaseolus vulgaris is the most important legume for its nutritional value and health benefits in Mexico. In this research mineral content, bioactive compounds and antioxidant activity of 18 bean collections were analyzed. Different grain beans were collected in rural communities in 12 municipalities of the state of Tabasco, Mexico and carried out from March to June 2018. They were analyzed for mineral content (N, P, K, Ca, Mg, Fe, Zn, Mn and Ni), proximal bromatological analysis (ash, crude fat, crude fiber and protein), phenolic compounds content (total phenols, flavonoids and anthocyanins) and antioxidant activity. The contents of zinc were low in all bean collections; additionally, collections C104, C109 and C113 recorded the highest concentration of total phenols (55.45 mg GA g^{-1}), flavonoids (1.46 mg CE g^{-1}) and anthocyanins (2.87 mg C3G g^{-1}) and antioxidant capacity (91.05%) respectively. This study has shown that common bean varieties grown in the state of Tabasco have high biological and antioxidant potential that could be beneficial to human health when consumed as nutraceutical foods.

Key words: Food and nutritional security, *Phaseolus vulgaris*, Phenols, Zinc.

The common bean is the most important legume and the fourth source of protein in America (Alcazar-Valle *et al.* 2020). There are about 52 known species of *Phaseolus* beans in Mexico, which are distributed in seven main groups (black, yellow, white, purple, cream, pinto and mottled) (Chavez-Mendoza *et al.* 2019). The seed coat contains antioxidants, flavonoids and anthocyanins, among other bioactive compounds, which have beneficial anti-cancer, antitumor, anti-inflammatory, chemopreventive, antiproliferative, hypocholesterolemic, hypoglycemic, antihypertensive and antithrombotic properties (Corzo-Ríos *et al.* 2020). High concentrations of bioactive compounds, such as flavonoids and anthocyanins, have biological activity. However, they can vary between color bean grains (Chavez-Mendoza *et al.* 2019).

In general, there is little literature on bioactive compounds content of the common bean produced in the humid tropics and the results obtained from other studies are mainly focused on the characterization of beans produced in Western and Central Mexico, therefore, this work aimed to determine mineral content, proximate composition, phenolic compounds and antioxidant activity of common beans grown in the state of Tabasco.

Different grain beans were collected in rural communities in 12 municipalities of the state of Tabasco, Mexico and carried out from March to June 2018 (Table 1). The nitrogen (N) content was determined with the Flash 2000 elemental analyzer (Thermo Scientific) (Reussi-Calvo *et al.* 2008). Phosphorus (P) content was determined by the ammonium metavanadate method. calcium (Ca), magnesium (Mg), potassium (K), iron (Fe), zinc (Zn), manganese (Mn) and nickel (Ni) were determined using the tri-acid mixture method and the atomic absorption spectrophotometry method (Jones *et al.* 1991).

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How to cite this article: Florvil, F., Márquez-Quiroz, C., Cruz-Lázaro, E. de-la., Osorio-Osorio, R. and Sánchez-Chávez, E. (2022). Bioactive Compounds, Antioxidant Activity and Mineral Content of Common Bean Varieties Grown in Tabasco, Mexico. Indian Journal of Agricultural Research. 56(3): 368-372. DOI: 10.18805/IJARe.A-587.

Submitted: 17-07-2020 **Accepted:** 02-04-2022 **Online:** 30-04-2022

Ash content was determined according to the Mexican Standard (NORMEX 2002). Fat levels were determined using the Goldfish method (AOAC 2002) and the percentage of fat was determined according to the Mexican Standard (NORMEX 2006). Crude fiber was determined according to the Official Mexican Standard (NOM 1978). Total phenols were determined using the Singleton and Rossi method (1965). Results for total phenols were expressed in mg of gallic acid per gram of sample (mg GA g^{-1} extract). Flavonoid content was determined using the method described by Zhishen *et al.* (1999). The results are shown in mg catechin equivalents per gram per sample (mg CE g^{-1}). The differential pH method described by Wrolstad (1993) was used to determine the anthocyanin content. The results are shown in mg Cyanidin-3-glucoside per gram of sample (mg C3G g^{-1} flour). Antioxidant capacity was determined using the method described by Brand-Williams *et al.* (1995) with the DPPH free-radical. Antioxidant capacity is reported in percentages (%). The data were subjected to an analysis of variance. The 95% Tukey's test was used to determine the difference between treatment means.

Proximal bromatological analysis

According to analysis of variance, there was a significant difference between the bean collections in terms of their ash, fats, fiber and protein content ($p<0.05$). Ash content ranged from 4.17 to 5.02%, fat content ranged from 1.15 to 1.90%, whereas, crude fiber content ranged from 1.75 to 2.93%. Finally, crude protein content ranged from 19.90 to 26.54% (Table 2). Our results are consistent with another research, where it was observed that ash, fat, crude fiber and protein content ranged from 2.53 to 4.36% (Fernández-Valenciano and Sánchez-Chávez 2017), 0.48 to 2.23% (Pliego-Marín *et al.* 2013), 1.40 to 3.21% (Armendáriz-Fernández *et al.*, 2019) and 14 to 33% (Alcazar-Valle *et al.* 2020) respectively. The protein content in *P. vulgaris* depends on the type of bean, fertilizer use, agricultural practices and soil-climate characteristics of cultivation sites (Alcazar-Valle *et al.* 2020).

Mineral content

There was a significant difference between the bean collections in terms of their N, K, Ca, Fe, Zn, Cu, Mn and Ni

Table 1: Common beans collected in the state of Tabasco, Mexico.

Sample	Origin	Date obtained	Picture
C101	Huimanguillo	March 15, 2018	
C102	Tacotalpa	April 17, 2018	
C103	Centro	April 14, 2018	
C104	Nacajuca	May 08, 2018	
C105	Tacotalpa	April 17, 2018	
C106	Teapa	May 23, 2018	
C107	Jalapa	June 10, 2018	
C108	Jalapa	June 10, 2018	
C109	Huimanguillo	March 15, 2018	
C110	Teapa	May 23, 2018	
C111	Huimanguillo	March 15, 2018	
C112	Jalpa de Méndez	April 04, 2018	
C113	Huimanguillo	March 15, 2018	
C114	Tacotalpa	April 17, 2018	
C115	Jalapa	June 10, 2018	
C116	Comalcalco	May 11, 2018	
C117	Tacotalpa	April 17, 2018	
C118	Huimanguillo	March 15, 2018	

content (p<0.05). The N content ranged from 3.66 to 4.88%. The P content ranged from 0.08 to 0.18%, while the content of K, Ca and Mg ranged from 0.88 to 1.54%, from 0.0003 to 0.051% and from 0.010 to 0.016% respectively (Table 3). On the other hand, Fe content ranged from 60.14 to 81.95 mg kg^{-1}, while Zn content ranged from 25.10 to 43.34 mg kg^{-1}, Cu content ranged from 10.10 to 15.58 mg kg^{-1}, Mn content ranged from 6.11 to 16.53 mg kg^{-1} and Ni content ranged from 1.02 to 1.61 mg kg^{-1}. Our results are consistent with another research, where it was observed that N, P, K, Ca, Mg, Fe, Zn, Cu, Mn and Ni content ranged from 2.75 to 4.75% (Sánchez ***et al.*** 2018), 0.01 to 0.17%, 0.33 to 1.05% (Armendáriz-Fernández ***et al.*** 2019), 0.08 to 1.42%, 0.03 to 0.11% (Espinoza-García ***et al.*** 2016), 21.61 to 105.29

Table 2: Proximate composition of bean grains collected in Tabasco, Mexico.

Sample	Ash (%)	Crude fat (%)	Crude fiber (%)	Crude protein (%)
C101	4.60^{cde}	1.70^{efg}	2.04^{abc}	22.21^{d}
C102	4.77^{def}	1.53^{bcde}	2.93^{g}	24.86^{h}
C103	4.64^{cde}	1.43^{abcde}	2.13^{bcd}	19.90^{a}
C104	5.02^{f}	1.84^{fg}	2.15^{bcd}	21.98^{d}
C105	4.38^{abc}	1.26^{ab}	2.82^{fg}	22.59^{e}
C106	4.55^{bcde}	1.59^{cdef}	2.29^{cde}	22.26^{d}
C107	4.27^{ab}	1.30^{abc}	2.68^{fg}	24.90^{h}
C108	4.45^{abc}	1.15^{a}	1.80^{a}	21.48^{c}
C109	4.22^{a}	1.86^{fg}	1.96^{ab}	22.27^{d}
C110	4.47^{abcd}	1.26^{ab}	2.22^{bcd}	21.28^{c}
C111	4.17^{a}	1.90^{g}	1.75^{a}	20.94^{b}
C112	4.47^{abcd}	1.41^{abcde}	2.31^{cde}	23.25^{f}
C113	4.67^{cde}	1.52^{bcde}	2.29^{cde}	21.21^{bc}
C114	4.55^{bcde}	1.59^{cdefg}	2.29^{cde}	22.26^{d}
C115	4.45^{abc}	1.58^{cdef}	2.73^{fg}	26.54^{i}
C116	4.19^{a}	1.38^{abcd}	2.34^{cde}	23.58^{g}
C117	4.40^{abc}	1.61^{defg}	2.55^{ef}	23.56^{g}
C118	4.78^{ef}	1.38^{abcd}	2.37^{de}	25.09^{h}
LSD	0.30	0.30	0.30	0.30

Values with the same lowercase letter within the same column are statistically equal based on the Tukey's test (p≤0.05).

Table 3: Macro and microelement content of common bean collected in Tabasco, Mexico.

Sample	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})	Ni (mg kg^{-1})
C101	4.08^{bc}	0.13^{a}	1.43^{fg}	0.033^{bc}	0.010^{a}	76.53^{j}	31.01^{ef}	11.47^{c}	12.68^{k}	1.14^{a}
C102	4.57^{de}	0.18^{a}	0.88^{a}	0.014^{ab}	0.013^{a}	80.29^{l}	30.69^{d}	10.10^{a}	12.27^{j}	1.61^{d}
C103	3.66^{a}	0.11^{a}	1.30^{cdefg}	0.017^{ab}	0.014^{a}	66.21^{bc}	33.37^{hi}	13.92^{ghi}	7.60^{b}	1.49^{bcd}
C104	4.04^{bc}	0.14^{a}	1.46^{fg}	0.151^{d}	0.014^{a}	79.45^{k}	33.07^{h}	10.45^{b}	8.32^{cd}	1.02^{a}
C105	4.15^{bc}	0.15^{a}	1.37^{defg}	0.023^{ab}	0.014^{a}	72.05^{h}	33.87^{j}	14.15^{i}	12.27^{j}	1.21^{ab}
C106	4.09^{bc}	0.15^{a}	1.54^{g}	0.007^{ab}	0.015^{a}	70.95^{f}	33.43^{i}	14.03^{hi}	9.20^{e}	1.14^{a}
C107	4.58^{def}	0.08^{a}	1.34^{defg}	0.021^{ab}	0.016^{a}	80.19^{l}	43.09^{n}	15.58^{k}	12.09^{j}	1.17^{a}
C108	3.95^{ab}	0.09^{a}	0.99^{ab}	0.0003^{a}	0.012^{a}	60.14^{a}	29.74^{c}	13.62^{fg}	8.60^{d}	1.19^{ab}
C109	4.09^{bc}	0.14^{a}	1.18^{abcdef}	0.030^{bc}	0.014^{a}	67.65^{d}	30.87^{de}	14.13^{i}	9.52^{fg}	1.05^{a}
C110	3.91^{ab}	0.10^{a}	1.31^{cdefg}	0.023^{ab}	0.011^{a}	71.52^{g}	28.78^{b}	14.78^{j}	8.18^{c}	1.02^{a}
C111	3.85^{ab}	0.15^{a}	1.03^{abc}	0.012^{ab}	0.014^{a}	66.42^{c}	31.28^{f}	12.78^{de}	6.11^{a}	1.32^{abcd}
C112	4.27^{cd}	0.15^{a}	1.42^{efg}	0.013^{ab}	0.012^{a}	73.05^{i}	25.10^{a}	13.47^{f}	7.81^{b}	1.32^{abcd}
C113	3.90^{ab}	0.11^{a}	1.09^{abcd}	0.011^{ab}	0.012^{a}	70.68^{f}	41.30^{m}	13.02^{e}	11.06^{i}	1.18^{a}
C114	4.09^{bc}	0.15^{a}	1.18^{abcdef}	0.020^{ab}	0.011^{a}	73.19^{i}	36.79^{k}	11.62^{c}	16.53^{l}	1.29^{abc}
C115	4.88^{f}	0.12^{a}	1.46^{fg}	0.012^{ab}	0.013^{a}	66.03^{b}	39.47^{l}	13.75^{fgh}	9.72^{g}	1.29^{abc}
C116	4.33^{cde}	0.11^{a}	1.24^{bcdefg}	0.025^{abc}	0.014^{a}	71.72^{g}	39.63^{l}	12.56^{d}	9.37^{ef}	1.13^{a}
C117	4.33^{cde}	0.16^{a}	1.12^{abcde}	0.007^{ab}	0.014^{a}	81.95^{m}	43.34^{n}	13.91^{ghi}	10.66^{h}	1.49^{bcd}
C118	4.61^{ef}	0.10^{a}	1.33^{cdefg}	0.051^{c}	0.012^{a}	68.37^{e}	32.02^{g}	11.76^{c}	9.40^{ef}	1.52^{cd}
LSD	0.30	0.28	0.30	0.27	0.30	0.30	0.30	0.30	0.30	0.30

Values with the same lowercase letter within the same column are statistically equal based on the Tukey's test (p≤0.05).

Table 4: Total phenolic (TPH), flavonoid (FLV), anthocyanin (ANT) content and radical scavenging activity (RSA) from common beans grown in Tabasco, Mexico.

Collections	TPH (mg GA g^{-1})	FLV (mg CE g^{-1})	ANT (mg C3G g^{-1})	RSA (%)
C101	3.88^{a}	0.34^{ab}	1.08^{abc}	87.21^{bc}
C102	6.04^{a}	0.48^{ab}	0.52^{a}	74.00^{a}
C103	10.69^{abcd}	1.00^{cd}	1.56^{cd}	83.03^{bc}
C104	55.45^{f}	1.04^{cd}	1.42^{bc}	83.51^{bc}
C105	13.32^{abcde}	0.95^{cd}	0.51^{a}	83.75^{bc}
C106	14.77^{abcde}	0.35^{ab}	0.92^{abc}	88.10^{bc}
C107	12.43^{abcd}	0.37^{ab}	1.16^{d}	88.56^{bc}
C108	15.37^{abcde}	0.66^{bc}	2.77^{f}	81.27^{ab}
C109	9.36^{abc}	1.46^{e}	0.72^{ab}	85.61^{bc}
C110	12.11^{abcd}	0.50^{ab}	1.67^{cde}	88.51^{bc}
C111	12.87^{abcde}	0.22^{a}	2.27^{def}	86.03^{bc}
C112	6.93^{ab}	0.55^{ab}	2.25^{def}	85.85^{bc}
C113	20.00^{bcde}	0.69^{bc}	2.87^{f}	91.05^{c}
C114	9.80^{abc}	0.50^{ab}	2.59^{f}	85.55^{bc}
C115	23.83^{de}	1.08^{de}	1.05^{abc}	87.05^{bc}
C116	26.36^{e}	1.09^{de}	2.37^{ef}	87.30^{bc}
C117	19.93^{bcde}	0.67^{bc}	0.55^{a}	89.57^{c}
C118	21.76^{cde}	0.98^{cd}	1.71^{cde}	88.65^{bc}
LSD	13.82	0.37	0.80	8.09

Values with the same lowercase letter within the same column are statistically equal based on the Tukey's test ($p \leq 0.05$).

mg kg^{-1}, 6.74 to 48.18 mg kg^{-1}, 8.34 to 13.24 mg kg^{-1} (Armendáriz-Fernández *et al.* 2019), 5.41 to 38.54 mg kg^{-1} and 2.03 to 10.4 mg kg^{-1} (Espinoza-García *et al.* 2016) respectively. Legume seeds provide 15 essential minerals required by humans, beans can provide 20% of the adult requirement for P, Mg and Ca (Sánchez-Chino *et al.* 2015), whereas, Fe is a constituent of a number of important macromolecules (Briat 2011). Finally, Zn is an essential component of various dehydrogenases, proteases and peptidases (Fageria and Baligar 2005).

Content of bioactive compounds

There was a significant difference between the bean collections in terms of their total phenols concentration, flavonoid content, anthocyanin content and antioxidant activity ($p<0.05$). The total phenols concentration ranged from 3.88 to 55.45 mg GA g^{-1} flour, flavonoid content ranged from 0.22 to 1.46 mg CE g^{-1} flour, whereas, anthocyanin content ranged from 0.51 to 2.87 mg C3G g^{-1}. Finally, the antioxidant activity ranged from 74.00 and 91.05% (Table 4). Our results are consistent with another research, where it was observed that total phenols concentration, flavonoid content, anthocyanin content and antioxidant activity ranged from 1.0 to 180.5 mg GA g^{-1} dry weight (García-Díaz *et al.* 2018), 0.33 to 2.18 mg CE g^{-1} flour (Herrera-Hernández *et al.* 2018), 0.01 to 6.76 mg C3G g^{-1} flour (García-Díaz *et al.* 2018) and 15.23 to 80.62% (Herrera-Hernández *et al.* 2018) respectively. Pigmented seed coats of common beans are overall rich in polyphenols, they are influenced by genotype, environmental conditions, storage and processing methods (Yang *et al.* 2018). Black beans exhibit a high content of anthocyanins and flavonoids; therefore, black beans are considered to have a higher antioxidant capacity than the other varieties (Corzo-Ríos *et al.* 2020).

CONCLUSION

This study has shown that common bean varieties grown in the state of Tabasco have high biological and antioxidant potential that could be beneficial to human health when consumed as nutraceutical foods.

Conflict of interest: None.

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