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Proximate composition and seed lipid components of "kabuli"-type chickpea (*Cicer arietinum* L.) from Argentina

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ABSTRACT

Chickpea is an important pulse crop with a wide range of potential nutritional benefits because of its chemical composition. The purpose of the current work was to provide the chemical composition of "kabuli"-type chickpea (*Cicer arietinum* L.) developed in Argentina for nutritional purpose. Protein, oil and ash contents, fatty acid, tocopherol and mineral element compositions were studied. Among the studied genotypes, protein content ranged from 18.46 to 24.46 g/100g, oil content ranged from 5.68 to 9.01 g/100g and ash from 3.55 to 4.46 g/100g. Linoleic, oleic and palmitic acids were the most abundant fatty acids. The average oleic-to-linoleic ratio was 0.62 and average iodine value was 117.82. Tocopherols, well-established natural antioxidants, were found in chickpea seeds in relatively similar amounts across all genotypes. Mineral element analysis showed that chickpea was rich in macronutrients such as K, P, Mg and Ca. The nutritional composition of chickpea genotypes developed and grown in Argentina provides useful information for breeding programs, food marketing and consumers and establishes chickpea as component of a balanced human diet.

Keywords: Chickpea; Pulse Crop; Fatty Acids; Tocopherols; Mineral Elements

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.), originally domesticated in Middle Eastern, African and Asian countries, is the third largest pulse crop in the world [1]. As a source of vegetable protein, carbohydrates, dietary fiber, vitamins and minerals, the demand for chickpea has increased over the last few years due to its notable nutritional value [2]. Additional health benefits include low allergenic properties and high *in vitro* protein digestibility [3-9].

The oil fraction in chickpea is the highest among dry pulses and represents the 3% to 10% of total dry seed weight [10-12]. Chickpea oil is mainly composed of unsaturated fatty acids [13]. Omega-6 linoleic fatty acid is the major fatty acid present in chickpea oil (46% - 62% of total acids) followed by omega-9 oleic acid [12]. Omega-6 fatty acid is one of the essential unsaturated fatty acids for human metabolism that must be incorporated through diet [14]. Omega-9 oleic fatty acid is desired in grains since it confers low oxidation properties during storage [15]. Incorporating chickpeas into a healthy diet helps to increase the polyunsaturated fatty acids (PUFA) intake, as well as the polyunsaturated to saturated fatty acid ratio. Both parameters are associated with reduced total serum cholesterol levels [16].

Chickpea oil is rich in tocopherols and it contains the highest amount of alpha tocopherol among pulses (up to 13.7 mg/100g) [12,17]. The major tocopherol in chickpea is gamma tocopherol, a natural seed antioxidant [17].

Mineral macronutrients, such as potassium (K), calcium (Ca), phosphorous (P) and magnesium (Mg), and micronutrients, such as ferrum (Fe), zinc (Zn), copper (Cu), manganese (Mn), are required in the human diet. A single 100 g serving of cooked chickpeas can provide 24%, 43% and 39% of the recommended dietary allowance (RDA) for the macronutrient P and for the micronutrients Mn and Cu, respectively [12]. Therefore, chickpea

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has become an important source of vitamins and minerals to the cereal-based daily diet of millions of people in under-developed countries [2].

In recent years, the number of chickpea hectares (ha) grown in Argentina has rapidly increased from roughly 5000 ha in 2008 to 42,000 ha in 2010 (+840%) [18]. Similarly, total chickpea production in Argentina increased from 8700 tn in 2008 to 78,000 tn in 2010 (+896%) [18]. In 2011, Argentina exported chickpea to 44 countries raising its exports by 42% since 2007. This expansion has fuelled the need to develop new genotypes that better meet the needs of the local and global market supply for human consumption.

An Argentinean chickpea breeding program was started in 1972 at the Facultad de Ciencias Agropecuarias, Universidad Nacional de Córdoba (Córdoba, Argentina). In 1990, the National Institute of Agricultural Technology (INTA) (Agricultural Experimental Station in Cerrillos, Argentina) joined to expand the program. The local chickpea landrace, Sauco, is believed to have been introduced from Spain [19] and the Argentinean commercial chickpea genotypes are Chañaritos S-156 and Norteño [19]. Currently, chickpea breeding programs are aimed at obtaining higher yields and better crop adaptability [20,21]. The chemical composition of chickpea genotypes provides useful information for breeding programs and scientists intended to work in this area. The objective of the current study was to determine the chemical and nutriational composition of the 14 chickpea genotypes from Argentina developed for human nutrition.

2. MATERIALS AND METHODS

2.1. Chickpea Samples

Seeds of 14 "kabuli"-type chickpea (*Cicer arietinum* L.) genotypes were provided by the chickpea breeding program at the National University of Córdoba (UNC) Argentina and the National Institute of Agricultural Technology (INTA) of Salta, Argentina. The studied material was G112, G58, G101, G47, P44, P39, P41, P98, P102, P56, L9, L2, Chañaritos S-156 and Norteño, being G = genotype; P = population; L = Line respectively. The agronomic features are listed in **Table 1**. Experimental field trial was laid out as a randomized complete-block design, with three replications in Chalacea (30˚45'52.24"S, 63˚40'19.86"O), Province of Córdoba, Argentina, during the winter season of 2010. Germplasm registration information was generated by the breeding program. Crops were grown under rain fed conditions and following cultural practices recommended by the chickpea breeding program. These practices include disease, insect, and weed control (with specific products for chickpea crop) to prevent any biotic factor that could alter the chemical quality of the kernel. Plant density for the trials was 25 pl/m^2 at 52 cm row spacing. Seed was harvested and stored at room temperature until analysis.

2.2. Proximate Composition

Samples, fifty g each, were finely ground (200 μm sieve) and stored in a fridge at −20˚C until analyze.

Table 1. Agronomic features of 14 "kabuli"-type chickpea genotypes (*Cicer Arietinum* L.) genotypes from Argentina.

Genotypes	Plant height	Yield/plant	Weight 100 seeds	Plant health
	(cm)	(g)	(g)	
G112	38.7 ± 2.4	16.7 ± 1.5	51.4 ± 1.3	Very good
G101	42.0 ± 1.0	21.1 ± 2.0	67.0 ± 2.0	Regular
G58	49.3 ± 3.0	16.4 ± 2.1	60.1 ± 2.0	Good
G47	47.0 ± 2.0	12.2 ± 2.0	53.4 ± 2.1	Regular
P44	44.4 ± 2.1	14.3 ± 3.1	59.0 ± 3.0	Good
P39	38.5 ± 2.2	14.5 ± 1.3	47.1 ± 7.0	Regular
P41	45.0 ± 2.0	23.3 ± 2.1	62.0 ± 3.0	Regular
P102	44.0 ± 4.0	16.0 ± 5.0	80.0 ± 3.0	Regular
P56	42.7 ± 2.3	16.6 ± 4.1	46.4 ± 6.0	Very Good
P98	42.7 ± 2.3	14.3 ± 2.0	42.9 ± 2.5	Good
L 9	49.7 ± 2.5	18.9 ± 1.2	50.1 ± 2.1	Very Good
L 2	43.3 ± 8.0	12.0 ± 1.1	40.8 ± 9.4	Regular
Norteño	42.9 ± 2.2	15.0 ± 2.0	47.3 ± 6.4	Very Good
Chañaritos-156	49.9 ± 3.3	26.8 ± 9.6	40.7 ± 9.6	Very Good

G: genotypes; P: population; L: line.

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Moisture (method Ab 2 - 49), protein N × 6.25 (method Ab 4 - 91), fat (method Am 2 - 93) and ash (method Bc 5 - 49) were determined following the procedures detailed by AOCS [22]. Total nitrogen was measured using the Kjeldahl method and protein content was calculated as N × 6.25. A digestion unit Tecator™ Auto 1001 3844/Rev 1 (Foss Tecator; Höganäs, Sweden), scrubber unit Tecator™ 1001 4329/Rev 1 (Foss Tecator; Höganäs, Sweden), and distillation unit K-350 (Büchi; Switzerland) were used. The fat fraction was extracted from finely ground chickpeas samples (10 g) with n-hexane in a Soxhlet apparatus for 12 h. The recovered oil was filtered to remove any possible meal contamination, before its quantification, and then, saved for fatty acid and tocopherol analysis. Ash content was determined after incineration of the sample in a muffle furnace at 550˚C for 6 h. Moisture content was measured based on weight loss after oven-drying for 2 h. Results were expressed as a percentage of total dry matter (g/100g). Total carbohydrates were calculated by difference following the equation:

% Carbohydrates = % Protein + % Oil + % Ashes (1)

2.3. Fatty Acids Composition

Methyl esters of fatty acids were prepared from the extracted oil following the specifications of the official method ISO 5509.2000 [23]. Fatty acid composition was then quantified by capillary gas chromatography, method Ce 1e-91 [22]. A gas chromatographer (Hewlett-Packard 6890, Wilmington, DE, USA) was used, equipped with a flame ionization detector and HP-INNOWAX capillary column (Crosslinked Polyethylene Glycol). Nitrogen was used as the carrier gas. The flow rate was 1.5 mL/min (12 min), and then, it was kept at 3.8 mL/min to the end of the run program. The temperature of inlet and detector was 260˚C. Oven temperature started at 200˚C and ramped at 2.5˚C/min to a final temperature of 230˚C. Results were recorded in a ChemStation Data System. Standard fatty acid mixture (FAME Mix Rapeseed, AOCS) was purchased from Sigma-Aldrich (St. Louis, MO) and used as a calibration standard for peak identification and quantification. Fatty acids were expressed as g/100g of total fatty acids. The oleic-to-linolenic acid ratio (O/L) and iodine values were calculated from fatty acid results, providing a general indication of oil quality. Iodine values were calculated using the following formula: IV = (% oleic × 0.8601) + (% linoleic × 1.7321) + (% eicosenoic × 0.7854) [24].

2.4. Tocopherol Composition

Tocopherol determination was performed according to AOCS recommended practice Ce 8 - 89 [22]. The oil was diluted in a proper volume of n-hexane and analyzed by High Performance Liquid Chromatography (HPLC) Agilent Technology 1100 Serie (Wilmington, DE), equipped with a diode array detector (DAD). UV absorbance was measured at 292 nm. A Zorbax RX-Sil column was used and maintained at 25.5˚C during analysis. The separation of the tocopherols was performed in isocratic mode with n-hexane:isopropanol (99.5:0.5, v/v) as mobile phase. The injection volume was 20 µL and flow rate was 1 mL/min. Calibration curves were obtained using commercial alpha tocopherol (AT) and delta tocopherol (DT) standards purchased from Sigma-Aldrich (St. Louis, MO, USA). Response factors of beta tocopherol (BT) and gamma tocopherol (GT) were calculated from AT and DT, respectively, and corrected for their molar extinction coefficient and molecular mass. Total tocopherol (TT) was calculated by adding up the content of individual isomers. Tocopherol results were expressed as g/100g oil.

2.5. Mineral Composition

Mineral elements were analyzed as described by Inga *et al*. [25]. Approximately 2 g of chickpea seeds were finely ground in a porcelain mortar (to avoid metal contamination) and placed in a digestion crucible in a muffle furnace at 550˚C. After incineration, the resulted ash was diluted with 50% HNO_3 and heated to 80˚C to complete the digestion. After digestion, 1mL of 50% HNO_3 was added to the crucible to remove the ash from the walls. The sample solution was transferred to a 50 mL plastic tube and diluted with deionized Millipore water to a known volume (50 mL). Mineral elements were analyzed from the solution by inductively coupled plasma-mass spectrometry (ICP-MS) with argon ionization. Mg, P, K, Ca, Fe, Mn, Cu and Zn were determined with a H_2/He collision cell to control isobaric interferences. All chemicals used were of analytical grade or higher purity. Mineral measurements were validated using NIST standard reference material N˚ SRM 2387 PEANUT BUTTER [26]. Results were expressed as mg/100g seed dry weight.

2.6. Statistical Analysis

All analyses of each chickpea genotype were done in triplicate and means and standard deviations were calculated. An analysis of variance was performed to identify differences among genotypes. Means were separated using a Fisher LSD test with a statistical significance of 5% [27]. Statistic analyses were performed with *InfoStat* [28].

3. RESULTS AND DISCUSSION

Protein, oil, ash and carbohydrate content of the different chickpea genotypes included in this study are shown in **Table 2**. Significant differences were observed among the genotypes. As shown in **Table 2**, carbohydrates represent the main fraction of chickpea seed com-

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Table 2. Proximate composition of 14 "kabuli" type ckickpea (*Cicer Arietinum sp*) genotypes from Argentina (g/100 g)[ab].

Cultivar	Protein	Oil	Ashes	Carbohydrates
G112	23.70 ± 0.17c	6.76 ± 0.53bc	3.81 ± 0.08cde	65.74 ± 0.28gh
G58	21.39 ± 0.18ef	6.11 ± 0.30bc	3.98 ± 0.02bcde	68.54 ± 0.11bcde
G101	19.87 ± 0.08h	6.77 ± 0.53bc	4.21 ± 0.05abc	69.16 ± 0.40bc
G47	21.15 ± 0.00f	6.82 ± 0.32bc	3.95 ± 0.04bcde	68.09 ± 0.28cde
P44	22.33 ± 0.34d	6.92 ± 0.52b	4.12 ± 0.05abcd	66.64 ± 0.13fg
P39	19.55 ± 0.18i	6.10 ± 0.75bc	3.55 ± 0.78e	70.81 ± 1.72a
P41	18.46 ± 0.18j	9.01 ± 0.08a	3.65 ± 0.03de	68.89 ± 0.29bcd
P98	22.36 ± 0.17d	6.26 ± 0.13bc	4.14 ± 0.01abc	67.24 ± 0.28ef
P102	21.14 ± 0.00f	6.76 ± 0.79bc	3.75 ± 0.02cde	68.36 ± 0.77bcde
P56	21.22 ± 0.09ef	7.09 ± 0.30b	3.65 ± 0.03de	68.05 ± 0.42cdef
L9	24.46 ± 0.08a	6.41 ± 0.40bc	4.33 ± 0.11ab	64.81 ± 0.38h
L2	24.14 ± 0.09b	5.68 ± 0.76c	4.47 ± 0.04a	65.72 ± 0.64gh
Chañaritos-156	20.26 ± 0.00g	6.25 ± 1.00bc	3.97 ± 0.06bcde	69.53 ± 1.055ab
Norteño	21.53 ± 0.08e	6.68 ± 0.27bc	4.20 ± 0.18abc	67.59 ± 0.54def
Mean[c]	21.54 ± 1.72	6.68 ± 0.85	3.98 ± 0.31	67.8 ± 1.67
Min	18.46	5.68	3.55	64.81
Max	24.46	9.01	4.47	70.81

[a]Data are expressed as g per 100g seed dry weight. [b]Values are means ± SD, n = 3. Means in a column with different letters are significant different, LSD Fisher ($\alpha = 0.05$). [c]Mean value of the total analyzed data in the same column.

position (64.81 - 70.81 g/100g). In the present study, the mean total carbohydrate value of 14 Argentinean chickpea genotypes was 67.8% ± 1.67%, slightly higher than 66% total carbohydrates obtained by Shad *et al*. [21]. Legumes are rich in complex carbohydrates and oligosaccharides, important components to human diet for keeping a healthy intestine flora [9,12]. P39 showed the highest carbohydrate percentage.

Protein mean value was 21.54 g/100g. Genotypes L9 and L2 exhibited the highest protein content (mean = 24.46 g/100g and 24.13 g/100g, respectively). Chañaritos-S156 and Norteño, the commercial Argentinean cultivars analyzed in this study, had lower values of protein (20.26 g/100g and 21.53 g/100g, respectively) than L9 and L2 genotypes. Similarly, El-Adawy [29] reported differences among genotypes on protein content (23.64 g/100g for Egyptian genotypes and 18.5 g/100g for Brazilian genotypes).

Oil content mean value of the evaluated genotypes was 6.68 ± 0.85 g/100g (**Table 2**). Similar results were reported by De Almeida Costa *et al*. [11] for Brazilian genotypes, Alajaji and El-Adawy [30] for local Egyptian chickpea seeds, and Boschin and Arnoldi [17] for commercially available seed in the Italian market. The P41 genotype exhibited a significantly higher oil content (mean = 9.01 g/100g) than the other genotypes.

The ash content ranged from 3.55 g/100g to 4.47g/100g in the 14 Argentinean chickpea genotypes, showing significant differences between them. L2 contained the highest ash content (mean = 4.47 g/100g) and P39 had the lowest ash content (mean = 3.55 g/100g). Shad *et al*. [9] also reported significant differences in ash content for Pakistani "desi"-type chickpea genotypes.

A summary of fatty acid composition is presented in **Table 3**. Significant variability in fatty acid composition was observed among the 14 Argentinean chickpea genotypes. Linoleic (18:2 omega-6) and linolenic (18:3 omega-3) are essential fatty acids that cannot be synthesized by the human body and must be supplied through diet [14]. Linoleic (18:2 omega-6) was the major unsaturated fatty acids in all chickpea genotypes (**Table 3**). G101 showed a significantly higher amount of linoleic acid (mean = 58.73 g/100g) than the other genotypes, while P39 contained the highest linolenic acid (mean = 3.06 g/100g). Finally, L9 had the highest oleic acid (18:1 omega-9) content (mean = 43.01 g/100g). Results from these analyses indicate that the Argentinean chickpeas are rich in omega-3 and -6 essential fatty acids, as well as omega-9.

Iodine value (IV) and the oleic-to-linoleic ratio (O/L) are both indicators of oil stability and shelf life in oil from legume seeds such as peanut oil [31]. The iodine value of Argentinean chickpea genotypes ranged from 110.43 p 121.02, which is higher than values reported for peanut oil that ranged from 99.2 - 110.4 [32]. Similar results to the current study were obtained by Zia-Ul-Haq *et al*. [33] and Shad *et al*. [9]. Genotype L9 showed the greatest oleic-to-linoleic ratio (1.02 ± 0.01) hence, it may have better oil stability and shelf life.

Gül *et al*. [13] showed that variability of chickpea fatty acid composition could be attributed to genotypic variation and climate conditions. Furthermore, planting date can also affect unsaturated fatty acid content [18].

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Table 3. Fatty acid composition, oleic-to-linoleic (O/L) ratio and Iodine Value (IV) of 14 "kabuli" type chickpea(*Cicer arietinum* L.) genotypes from Argentina.[c]

Genotype	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:00	C22:1	O/L[a]	IV[b]
	g/100g of total fatty acids										
G112	9.2 ± 0.2def	1.5 ± 0.1cde	36.0 ± 1.3b	48.8 ± 1.2g	2.45 ± 0.08de	0.63 ± 0.01cd	0.57 ± 0.01bc	0.42 ± 0.02bc	0.10 ± 0.00ef	0.74 ± 0.04b	116.01de
G58	9.7 ± 0.1bcd	1.4 ± 0.0cde	34.3 ± 1.4bc	50.3 ± 1.2fg	2.63 ± 0.08bcd	0.62 ± 0.01d	0.53 ± 0.01de	0.39 ± 0.01cde	0.09 ± 0.00ef	0.68 ± 0.04bc	117.06d
G101	9.3 ± 0.0def	5.2 ± 0.1b	21.7 ± 0.3h	58.7 ± 0.5a	2.52 ± 0.02cde	1.47 ± 0.03b	0.29 ± 0.01h	0.55 ± 0.02a	0.09 ± 0.02ef	0.37 ± 0.01h	120.60ab
G47	9.7 ± 0.0bcd	1.5 ± 0.0c	34.8 ± 0.6b	49.8 ± 0.7fg	2.50 ± 0.04cde	0.65 ± 0.03cd	0.54 ± 0.02cde	0.40 ± 0.02cd	0.08 ± 0.00f	0.70 ± 0.03bc	116.58de
P44	10 ± 0.1b	1.5 ± 0.0 cd	29.5 ± 0.1ef	54.4 ± 0.1bc	2.65 ± 0.02bcd	0.67 ± 0.03c	0.51 ± 0.01ef	0.42 ± 0.02bc	0.11 ± 0.00ef	0.54 ± 0.00ef	120.03ab
P39	9.0 ± 0.1f	1.2 ± 0.1f	31.2 ± 0.3de	53.6 ± 0.4cd	3.06 ± 0.06a	0.55 ± 0.03e	0.59 ± 0.02b	0.39 ± 0.02cde	0.08 ± 0.01f	0.58 ± 0.01e	120.20ab
P41	9.6 ± 0.1bcde	1.5 ± 0.0cd	31.9 ± 0.1cde	52.3 ± 0.1de	2.78 ± 0.02b	0.57 ± 0.03e	0.46 ± 0.01g	0.38 ± 0.02de	0.32 ± 0.00a	0.61 ± 0.00de	118.38c
P98	9.9 ± 0.0bc	1.5 ± 0.0cde	33.6 ± 0.9bcd	50.4 ± 0.9fg	2.56 ± 0.05cd	0.64 ± 0.02cd	0.56 ± 0.00bcd	0.45 ± 0.01b	0.16 ± 0.04de	0.67 ± 0.03bcd	116.65de
P102	9.2 ± 0.1def	6.6 ± 0.1a	24.4 ± 0.2g	54.5 ± 0.2bc	2.32 ± 0.01ef	1.80 ± 0.01a	0.29 ± 0.01h	0.57 ± 0.03a	0.09 ± 0.03ef	0.45 ± 0.00g	115.66e
P56	9.8 ± 0.0bc	1.4 ± 0.3de	30.5 ± 0.3e	54.1 ± 0.3cd	2.57 ± 0.01cd	0.62 ± 0.03d	0.50 ± 0.01f	0.38 ± 0.03de	0.09 ± 0.00ef	0.56 ± 0.01e	120.37ab
L9	9.1 ± 0.1ef	1.4 ± 0.0e	43.0 ± 0.1a	42.1 ± 0.2h	2.17 ± 0.02f	0.66 ± 0.03cd	0.69 ± 0.02a	0.42 ± 0.02bc	0.26 ± 0.01b	1.02 ± 0.01a	110.43f
L2	9.4 ± 0.8cdef	1.4 ± 0.1e	33.6 ± 3.1bcd	51.4 ± 2.1ef	2.23 ± 0.31f	0.64 ± 0.02cd	0.56 ± 0.05bc	0.38 ± 0.03de	0.21 ± 0.02c	0.65 ± 0.09cd	118.34c
Chañaritos S-156	9.9 ± 0.9bc	1.4 ± 0.1cde	30.7 ± 4.1e	53.5 ± 2.9cd	2.47 ± 0.32cde	0.65 ± 0.02cd	0.52 ± 0.04ef	0.37 ± 0.01e	0.20 ± 0.08cd	0.58 ± 0.11e	119.49bc
Norteño	10.7 ± 0.1a	1.5 ± 0.0cde	27.0 ± 0.3f	56.3 ± 0.4b	2.67 ± 0.01bc	0.67 ± 0.02c	0.49 ± 0.01f	0.40 ± 0.02cde	0.12 ± 0.02ef	0.48 ± 0.01fg	121.02a
Mean[d]	9.6 ± 0.5	2.1 ± 1.6	31.6 ± 5.2	52.2 ± 4	2.54 ± 0.24	0.77 ± 0.36	0.51 ± 0.11	0.42 ± 0.06	0.14 ± 0.08	0.62 ± 0.16	117.92 ± 2.83

[a]O/L: Oleic-to-linoleic ratio. [b]IV: Iodine Value. [c]Values are means ± SD, n = 3. Means in a column with different letters are significant different, LSD Fisher (α = 0.05). [d]Mean value of the total analyzed data in the same column.

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Additional studies are needed to characterize fatty acid genotypic variation in Argentinean chickpeas among different environments.

Tocopherols are bioactive compounds known for their antioxidant activity [34]. Zia-Ul-Haq *et al*. [33] have found four different forms of tocopherols (alpha, beta, gamma and delta) in chickpea oil, with relatively constant values among genotypes. In our study (**Table 4**) there were not significant differences among genotypes for alpha, beta, gamma, delta and total tocopherols and, it was consistent with the previous study [33]. Similar to other legumes, gamma tocopherol was the most abundant tocopherol isomer in Argentinean chickpeas [13,17].

Mineral elements need to be incorporated through diet [35]. Mg, P, K and Ca were the main mineral elements in chickpeas (**Table 5**), consistent with information from the USDA database [36] and results previously reported by Petterson *et al*. [37] for Australian chickpea seeds. In our study, Mg and Ca mean content were 156.91 mg/100g and 160.58 mg/100g, respectively, which were similar to values observed for Canadian "kabuli"-type chickpea seeds [38]. Mn, Fe, Cu, and Zn were also analyzed (**Table 5**). Mn content was higher in G58 and G47 than in most of the other genotypes evaluated. In agreement with previous studies (e.g. [38]), no significant differences were found for Fe content and Cu content was relatively constant across the genotypes as well. Conversely, significant variability was observed in Zn values among genotypes.

On the one hand, L2 showed consistently higher values for all mineral elements (**Table 5**) analyzed and also had the highest ash content (**Table 2**) compared to the rest of the genotypes. On the other hand, P39 exhibited a consistently lower mineral content (**Table 5**) and had the lowest ash content (**Table 2**) among all genotypes. Bueckert *et al*. [38] concluded in their study that combined genotype and environmental effects determined the differences on chickpea seed mineral content. According to them, further studies would be needed to determine that the observed differences are consistent through environments.

4. CONCLUSION

To our knowledge, this is the first publication of the chemical composition of Argentinean chickpeas. The chemical composition of the 14 chickpea genotypes developed in Argentina suggests that Argentinean chickpeas are an important vegetable source of carbohydrates, proteins and mineral nutrients and, their oily fraction is rich in unsaturated essential fatty acids and vitamin E. Most notably, genotypes L9 and L2 had the highest protein content, and genotype P41 contained the highest oil content among genotypes tested meanwhile P39 had the highest amount of carbohydrates. Genotype G101 had the highest linoleic acid content, while Genotype P39 contained the highest amount of linolenic acid, but the lowest mineral nutrient content in general. The greatest oleic-to-linoleic ratio was found in genotype L9, suggesting better oil stability and shelf life. Tocopherols, well-established natural antioxidants, are found in chickpea seeds in relatively similar amounts across all genotypes. Mg, P, K, Ca, Zn and Mn are the main macro and micronutrient essential minerals found in Argentinean chickpea seeds. The values found for Mn and Fe in chickpeas were higher than the typical values for these elements found in peanuts. This study provides useful information for breeding programs to further optimize the nutritional value of chickpea as they are intended for human consumption.

Table 4. Tocopherol composition of 14 "kabuli" type chickpea (*Cicer arietinum* L.)genotypes from Argentina.[a]

Genotype	Alfa	Beta	Gamma	Delta	Total Tocopherols
			mg/100g oil [c]		
G112	47.74 ± 0.00ab	11.89 ± 0.00a	202.04 ± 0.00 de	20.20 ± 0.00b	281.87 ± 0.00b
G58	49.04 ± 2.64ab	8.39 ± 2.15abc	289.74 ± 27.45ab	24.33 ± 1.34b	380.50 ± 27.58ab
G101	46.11 ± 16.02b	5.60 ± 0.89bc	210.76 ± 24.10 de	20.73 ± 5.99b	283.20 ± 40.16b
G47	46.29 ± 3.39b	6.05 ± 1.28bc	261.75 ± 13.00bcd	24.07 ± 1.46b	338.16 ± 12.42ab
P44	55.90 ± 10.48ab	8.76 ± 2.01ab	253.81 ± 35.77bcd	28.11 ± 7.35ab	346.58 ± 51.39ab
P39	43.95 ± 2.38b	5.17 ± 0.79c	325.78 ± 12.44a	27.64 ± 1.82ab	402.54 ± 11.47a
P41	50.82 ± 15.03ab	5.78 ± 0.35bc	206.19 ± 35.40 de	27.21 ± 5.65ab	289.99 ± 55.64b
P98	61.82 ± 15.02ab	8.76 ± 2.98ab	278.94 ± 39.52abc	39.29 ± 8.21ab	388.80 ± 57.58ab
P102	56.21 ± 17.82ab	6.98 ± 3.80bc	198.42 ± 26.82e	32.47 ± 0.13ab	294.07 ± 40.82b
P56	43.03 ± 1.90b	5.49 ± 0.71bc	227.88 ± 1.39 de	30.30 ± 7.36ab	306.69 ± 5.84b
L9	83.65 ± 23.56a	7.08 ± 3.30bc	252.19 ± 36.09bcd	33.53 ± 9.73ab	376.45 ± 65.94ab
L2	86.33 ± 26.60a	7.74 ± 2.03abc	221.11 ± 28.99 de	29.35 ± 10.80ab	344.54 ± 64.37ab
Chañaritos-156	80.25 ± 35.96a	5.76 ± 0.46bc	234.08 ± 28.83cde	35.63 ± 16.37ab	355.71 ± 78.53ab
Norteño	65.21 ± 24.67a	8.50 ± 0.28ab	233.50 ± 23.20cde	40.66 ± 13.53a	347.87 ± 59.27ab
Mean [b]	58.84 ± 21.07	7.05 ± 2.23	245.29 ± 43.28	30.00 ± 9.04	341.11 ± 56.06

[a]Values are means ± SD, n = 3. Means in a column with different letters are significant different, LSD Fisher ($\alpha = 0.05$). [b]Mean value of the total analyzed data in the same column. [c]Data expressed as mg per 100 g chickpea oil.

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Table 5. Mineral composition of 14 chickpea (*Cicerarietinum* L.) genotypes from Argentina.[a]

Genotype	Mineral macronutrient				Mineral micronutrient			
	Mg	P	K	Ca	Mn	Fe	Cu	Zn
	(mg/100g)[b]							
G112	145 ± 0bc	442 ± 8cd	1254 ± 34ab	145 ± 3cd	3.3 ± 0.1bc	5.7 ± 0.1ab	1.04 ± 0.24a	3.36 ± 0.02d
G58	160 ± 1abc	459 ± 1bcd	1328 ± 71a	132 ± 2 d	4.1 ± 0.0a	5.2 ± 0.5ab	0.96 ± 0.11a	3.11 ± 0.01de
G101	170 ± 2a	503 ± 11abc	1364 ± 11a	189 ± 10a	2.8 ± 0.6cde	6.2 ± 0.4ab	0.94 ± 0.01a	4.05 ± 0.17bc
G47	156 ± 3abc	475 ± 1bc	1280 ± 8ab	137 ± 14cd	4.1 ± 0.1a	4.6 ± 0.1b	0.97 ± 0.16a	3.47 ± 0.05d
P44	157 ± 4abc	501 ± 14abc	1275 ± 29ab	169 ± 0abc	3.7 ± 0.1ab	5.0 ± 0.2ab	1.11 ± 0.35a	3.52 ± 0.03cd
P39	137 ± 0c	407 ± 0 d	1044 ± 0c	152 ± 0bcd	2.0 ± 0.0 f	5.9 ± 0.0ab	1.05 ± 0.00a	3.02 ± 0.00def
P41	156 ± 11abc	497 ± 38abc	1229 ± 94ab	164 ± 15abcd	3.4 ± 0.1bc	6.1 ± 0.3ab	1.18 ± 0.07a	4.11 ± 0.18b
P98	145 ± 3bc	459 ± 12bcd	1177 ± 2bc	164 ± 9abcd	3.2 ± 0.0bc	4.6 ± 0.1b	1.12 ± 0.19a	3.52 ± 0.12cd
P102	165 ± 4ab	497 ± 1abc	1299 ± 53ab	191 ± 15a	2.5 ± 0.2 def	6.3 ± 0.9ab	0.98 ± 0.26a	3.48 ± 0.00cd
P56	148 ± 2abc	457 ± 1bcd	1172 ± 12bc	163 ± 3abcd	2.2 ± 0.3ef	5.4 ± 0.8ab	0.94 ± 0.21a	2.71 ± 0.03ef
L9	160 ± 4abc	514 ± 22ab	1338 ± 74a	144 ± 4cd	3.0 ± 0.6cd	4.8 ± 0.2b	0.99 ± 0.03a	3.32+0.12d
L2	164 ± 10ab	553 ± 18a	1352 ± 9a	167 ± 14abc	3.4 ± 0.3abc	5.6 ± 0.9ab	1.30 ± 0.39a	3.53 ± 0.01cd
Chañaritos-156	170 ± 21a	507 ± 59abc	1333 ± 94a	184 ± 14ab	3.2 ± 0.4bc	5.9 ± 0.2ab	1.39 ± 0.02a	5.22 ± 0.71a
Norteño	164 ± 4ab	480 ± 14bc	1248 ± 84ab	146 ± 3cd	2.1 ± 0.3ef	6.7 ± 0.5a	1.09 ± 0.48a	2.53 ± 0.08f
Mean[c]	157 ± 13	482 ± 42	1264 ± 99	161 ± 22	3.1 ± 0.7	5.6 ± 0.9	1.1 ± 0.3	3.5 ± 0.7

[a]Data are expressed as mg per 100 g seed dry weight. [b]Values are means ± SD, n = 3. Means in a column with different letters are significant different, LSD Fisher ($\alpha = 0.05$). [c]Mean value of the total analyzed data in the same column.

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