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ORIGINAL PAPER

Comparison of the nutrient content of commercially purchased medium seed brown lentils with the world's leading database

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Abstract

The purpose of our study was to ensure that comparing the mineral content of the lentil and the amount of nutrients published by the world's leading organizations. The samples were randomly and subjectively selected from different retail outlets. Fifteen types of medium seed brown lentil from fifteen different distributors were obtained and analyzed for moisture, protein, Na, K, Ca, Mg, P, Fe, Cu, Zn, Mn, and S content. Descriptive statistics were done and for comparisons. Shapiro–Wilk test was first conducted to assess normality. When data followed a normal distribution, T-test was used, and when not, Wilcoxon signed rank test (P-values = 0.05). The results of the measurements were compared with data from several FAO/INFOODS food composition databases, as well as the Canadian National Food Composition Database, USDA Food Data Central, United Kingdom, Australian Food Composition Database, and Indian food composition tables. The evaluation of the measurement results showed significant differences ($p = 0.05$) in the amount of Na, K, Ca, Mg, P, Fe, and Cu compared to the amounts listed in the world's leading databases in most cases. Our results were also examined from a dietary perspective to determine if the differences had practical significance. The results of the Canadian samples were compared with the Canadian database, there was a significant difference amount of Na, K, Ca, Mg, P, Fe, Cu, and Mn. For each discrepancy, more than the quantitative values published in the databases were measured, in the case of Ca, Mg, and Fe almost double.

Keywords Food analysis · Lentil · Mineral element · Food composition data · Database · Comparison

Introduction

One of the foundations and drivers of globalization is food trade [1]. As a result, products or foods produced anywhere in the world can easily reach customers on the other side of the globe. According to the Food and Agriculture Organization (FAO), one of the export-oriented products is lentil (Lens Culinaris Medik. SSP. Culinaris). Lentils are legumes important for human and animal nutritional needs, whereas their seeds have recently been classified as functional foods due to their high nutritional value, polyphenols, and other bioactive compounds [2, 3]. The average annual production of lentil was about 5 million tons according to FAO statistical databases. The main lentil-producing countries in the world are Canada (38.3%), India (21.8%), Turkey (8.1%), and Australia (7.6%). Both Canada and Australia produce lentil mainly for export. In 2011–2013, 77% of lentil produced in Canada and 82% in Australia were exported [4]. The main foods in the diet of the poorest population are rice, wheat, and corn, which contain a limited amount of microelements, including minerals (iron, zinc, iodine, selenium, etc.) and vitamins. This quantity is not guaranteed. The recommended daily requirement should be given careful attention, as a deficiency in minerals poses a high health risk [5, 6].

Lentil is one of the oldest cultivated plants known to humankind. Archaeological evidence suggests that it was cultivated in central Europe as early as the Stone Age [7], but it was also an important part of the diet in ancient Egypt [8]. Today, it is grown on five continents, and the area under cultivation reached 6.5 million hectares in 2017. Lentil has three main components: seed coat (8%), cotyledons (90%), and embryo (2%) of the total seed weight [9]. It is a drought-tolerant type of crop suitable for human and

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animal consumption. Lentils are an excellent dietary source of protein and starch [10, 11]. It is found in many parts of the world, including the Middle East and India, and is a primary source of protein [12]. Furthermore, lentil contains about twice as much protein as wheat and about three times as much as rice. Lentil is a well-adapted plant that grows in a wide range of climate and soil conditions. It is cultivated in the Mediterranean and subtropical dryland regions, and usually no synthetic fertilizers are applied for cultivation due to the ability to fix atmospheric nitrogen (N_2) [13–15]. It is important to note that lentil consumption is positively correlated with the prevention of various diseases such as obesity, cardiovascular disease, diabetes, and several cancers like thyroid, colon, liver, breast, and prostate cancers [2, 16–19]. In terms of nutrient content, it is a type of crop rich in protein, fiber, and minerals [20]. Protein levels have high variability [21], which depends on genotype and environmental effects [22]. According to research by Vandemark et al., lentils are a good source of mineral nutrients [23]. Mineral nutrients are important for human health, and mineral-derived malnutrition is a major global health problem [24, 25]. Mineral malnutrition is one of the biggest global health problems, and increasing the mineral content of lens grains can have great benefits for human health in certain parts of the world [26–28].

FAO established the International Network of Food Data Systems (INFOODS) in 1984. This is a global network system of food composition experts that aims to improve the quality, availability, reliability, and use of food composition data. INFOODS is organized into several regional data centers with a global coordinator. In this context, INFOODS and FAO provide guidelines, standards, compilation tools, databases, capacity development tools, policy advice, advocacy tools, and technical assistance at the country level, and provide a forum for linking agriculture, biodiversity, food systems, health, and nutrition to achieve better nutrition worldwide. Since September 1988, available data on nutrient content have been organized based on geographical location. In the FAO/INFOOD databases, the data series are grouped according to geographical location; Asia, Africa, Canada, the Caribbean, the United States, Europe, Latin America, the Middle East, as well as Oceania and provide further breakdown of data by country.

This study aimed to (1) determine the nutrient content of commercially purchased lentil (medium seed, brown), (2) perform descriptive statistical analysis and (3) statistically analyze to determine significant differences between the measured values and the mineral database of the world's leading food and agriculture organizations.

Materials and methods

Materials

The samples were purchased in December 2021 through random subjective selection from various retail outlets in Hungary. The selection criteria were that the samples should differ according to their country of origin. Sixteen samples (Table 1) from 13 different distributors and two countries and two unknown of origin were analyzed, and the nutrient content was determined.

Table 1 Sample-characteristics and their origin

Sample ID	Characteristics	Country of origin
1	Medium seed, brown	no data
2	Medium seed, brown	no data
3	Medium seed, brown	Russia
4	Medium seed, brown	Russia
5	Medium seed, brown	Russia
6	Medium seed, brown	Canada
7	Medium seed, brown	Canada
8	Medium seed, brown	Canada
9	Medium seed, brown	Canada
10	Medium seed, brown	Canada
11	Medium seed, brown	Canada
12	Medium seed, brown	Canada
13	Medium seed, brown	Canada
14	Medium seed, brown	Canada
15	Medium seed, brown	Canada

Analytical methods

The analyses were conducted at the Central Laboratory of Agricultural and Food Products, Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen. The laboratory responsible for conducting the sample treatment and metal analyses was accredited by the National Accreditation Body of Hungary, which is a member of the European Accreditation Organization. To ensure quality control, the laboratory routinely participates in inter-laboratory comparisons for testing the analysis of elements in grains. Additionally, we also regularly utilized in-house standards.

Dry weight

The dry matter content of samples is defined as the residue obtained by drying the products to constant weight at 130 °C per 100 g of the product. The measurement was repeated twice. The standard deviation of the measurement was below ± 0.4 m/m%.

$$\text{Dry weight } \% = (M3 - M1)/(M2 - M1) * 100$$

$M1$: mass of the vessel in grams
$M2$: initial mass in grams of sample and vessel
$M3$: weight in grams of dried sample and container

Element analysis

For shredding, a Retch grinder (SK1) was used, the sieve size of which is 1 mm. The destruction was done with a LABOR MIM OE-718/A type electric block destroyer (LABOR-MIM, Budapest, Hungary). During digestion, for 1 g sample, 10 ml of distilled cc. HNO_3 (VWR, France) is added to the sample and heated to 60 °C for 30 min. After allowing it to cool, 3 ml of 30% purified H_2O_2 was added and kept at 120 °C for 90 min. After cooling the digestion product, the volume was made up to 50 ml with deionized water and filtered on MN 640W (Macherey–Nagel) filter paper.

The measurement was made with an inductively coupled plasma-excited optical emission spectrophotometer (ICP-OES) (ICAP 7400, Thermo Scientific). The ICP-OES is a quantitative elemental analysis method for which samples were dried and milled with a Retsch SK-1 or SK-3 (Retsch GmbH Haan Germany) hammer mill using a 1-mm sieve. The analysis of the samples from the experiments was performed after wet digestion [29] in the Central Chemical Laboratory of the Agricultural Center, University of Debrecen.

For calibration, a multielement standard solution was used, which is compiled from mono-element standards (VWR International, Leuven, Belgium). The result of one measurement point is displayed as the average of three measurements. At the end of the measurement, Qtegra ISDS (Thermo Scientific) computer program was used to evaluate the data. To check the accuracy of the measurements an authentic wheat sample marked BCR CRM 189 (whole grain) was used and participated in national (Wessling Hungary Ltd.) and international round (International Plant Exchange Network by Wageningen University) measurements.

Protein

The Kjeldahl method was used based on the ISO 20483:2014 standard. 1.0000 g of the suitably prepared (homogenized) sample was measured in a digestion tube. Then 14 ml cc. H_2SO_4 and 2 pieces Se-containing catalyst tablets were added. It was placed on a digestion block and digested at 420 °C. After cooling the sample, it was distilled in a VELP UDK-149 distillation apparatus. The nitrogen content was liberated with an excess quantity of alkali (33 m/m %) NaOH solution) and converted into ammonium salt and distilled into a 4 w/w% boric acid solution. Nitrogen is determined by titration with 0.2 N sulphuric acid solution (TITROLINE 5000 automatic titrator, VELP). All chemicals were from the VWR International Ltd. (Geldenaaksebaan, Belgium). Nitrogen content is calculated by the following formula:

$$N(m/m)\% = \left((Vm - Vv) * \mathrm{f}H_2SO_4 * 1.401 * 0.2\right)/m\,(g)$$

Vm = The quantity of sulphuric acid in ml was consumed during titration of the sample solution
Vv = The quantity of sulphuric acid in ml consumed during titration of the blank solution
f = normal sulphuric acid factor of 0.2
1.401 = constant
0.2 = normality of sulfuric acid
m = weight of sample in analysis (g)

The protein content of the samples is calculated from the nitrogen content using a conversion factor (6.25).

Analytical methods are listed in Table 2. All results were determined by the dry matter content.

Statistical analysis

Statistical analyses were performed using R Studio [30]. All data from the World's Lead database were converted to dry matter, and comparisons were made in mg/100 g. Descriptive statistics including mean, standard deviation, median, range, minimum, maximum, standard error, and coefficient of variation were calculated. For comparisons, we first conducted the Shapiro–Wilk test to assess normality. If the data followed a normal distribution, we used the T-test, and if it did not, the Wilcoxon test (P-values = 0.05) was used. Our

Table 2 Analytical methods

Parameter analyzed (unit)	Permitted analytical deviation
Moisture (m/m) %, drying, weighing	±0.4 m/m%
Crude protein (m/m) %, Kjeldahl method	±0.3 m/m%
Ca (mg/kg) ICP-OES	±10% R
Cu (mg/kg) ICP-OES	±10% R
Fe (mg/kg) ICP-OES	±10% R
K (mg/kg) ICP-OES	±10% R
Mg (mg/kg) ICP-OES	±10% R
Mn(mg/kg) ICP-OES	±10% R
Na ((mg/kg) ICP-OES	±10% R
P (mg/kg) ICP-OES	±10% R
S (mg/kg) ICP-OES	±10% R
Zn(mg/kg) ICP-OES	±10% R

Table 3 Dry matters amount of samples

Sample	Dry matter (m/m) %	Sample	Dry matter (m/m) %	Sample	Dry matter (m/m) %
1	88.6	6	88.4	11	88.5
2	88.6	7	88.4	12	88.7
3	88.6	8	88.7	13	88.6
4	88.6	9	88.6	14	88.5
5	88.5	10	88.4	15	88.8

data were compared to exact values in databases where they were marked, and to averages in databases where they were indicated.

Results and discussion

The results of the dry matter content are shown in Table 3. The results of protein and nutrient analysis of the lentil samples, based on dry matter content, are shown in Fig. 1a–k. The amount of each mineral refers to the amount in dry matter.

The protein content of the samples has an average of 26.8 g/100 g and a median of 27.0. The minimum value was 24.4 and the maximum was 28.6 g/100 g. The coefficient of variation was 4.0 which is considered homogeneous.

During measurements, an abnormally high Na value was observed for sample number 17. These results were carefully examined, and a verified value of 14.58 mg/kg for the dry matter (based on an 88.8% dry matter content) was obtained, which corresponds to 13.0 mg/kg calculated as the weight of the original material. The Na content of this lentil sample was found to be highly variable and almost twice as high as in other samples, which led us to reject this particular result. Table 4**.** displays the results of the descriptive statistical analysis.

Based on the samples' statistical analysis, the homogeneous minerals were Mg, K, Zn, S, P, Cu, S and Ca. Medium variability was Fe and Mn. The results of descriptive statistical analysis of the Canadian sample are presented in Table 5**.**

According to the Canadian sample's descriptive statistical analysis, the protein amount and the Na, K, Ca, Mg, P, Zn, S, Mn, and Sulphur amounts were homogenous. Medium variability had Cu and Fe.

The results of the statistical analysis (total amount of sample for the world's lead database) are shown in Table 6**.** In the case of each sample analyzed, many significant differences were found. The Na, Ca, Mg, and Cu were significant differences to USDA, England, Australia, all of FAO and the Indian databases. Partially differed the K, Fe, P and the amount of Mn differed least for values published to databases. The most agreement in protein results was found.

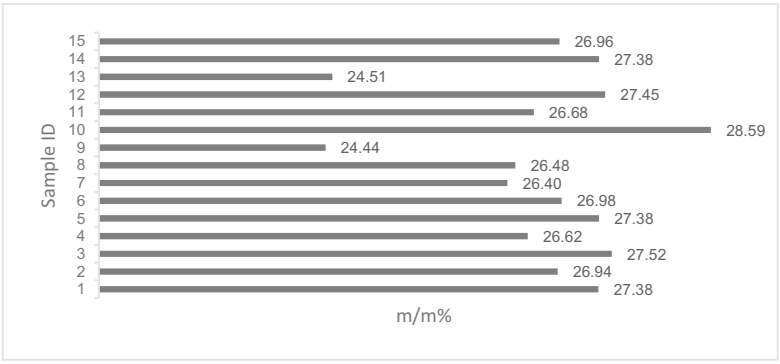
The amount of Zn showed no significant difference ($p=0.05$), except for the Australian data, which is acceptable and understandable due to geographical distance. Regarding the databases, in the case of the Australian database, the values measured by us and those in the database differed significantly. A possible lack of correspondence with the Australian samples is perfectly acceptable due to the large geographical distance. For the other databases, there were similarities in 2–4 minerals or proteins tested, but the amount of most minerals showed a statistically significant difference despite the high homogeneity of the samples.

Examining the direction of the deviations, it can be stated that the values measured were positive, the differences were due to the fact that measured higher values than the reference values indicated in the databases. In the case of Ca, Mg, Fe was almost double, according to our view this is a very significant deviation.

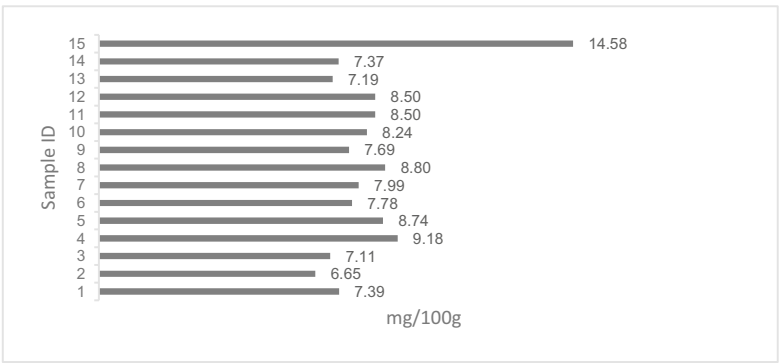
The results of the Canadian sample for Canadian database statistical analysis are shown in Table 7**.** The Canadian samples were separated and compared with the North American databases. In our measurements, Fe and Cu showed low variance, and the other elements tested were homogeneous, the possibility of a false conclusion was ruled out due to low diversity. In the case of tested Minas, protein and Zn did not show any significant difference and can be considered statistically identical ($p=0.05$). The amount of Mn did not differ significantly from the USDA database. However, in all cases, the amount of Na, K, Ca, Mg, P, Fe, and Cu was significantly different from the value in the database. The direction of deviation is positive and significant for Ca, Mg, and Fe.

The samples were purchased in Hungary, our measurement results were compared with the Hungarian database [40], the results are shown in Table 8. There were significant differences in the amount of Na, K, Ca, Fe, and Cu.

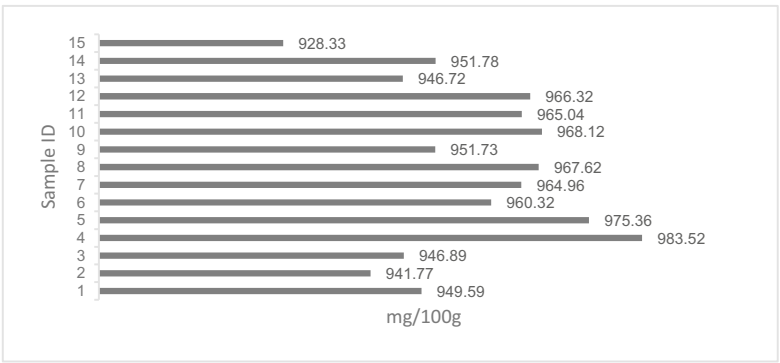
Fig. 1a Protein content of samples**. b** Na content of samples**. c** K content of samples**. d** Ca content of samples**. e** Mg content of samples**. f** P content of samples**. g** Fe content of samples**. h** Cu content of samples**. i** Zn content of samples**. j** Mn content of samples**. k** S content of samples



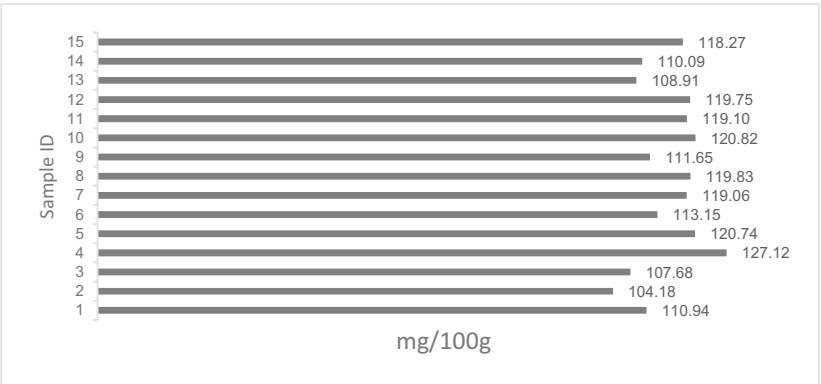
a Protein content of samples



b Na content of samples

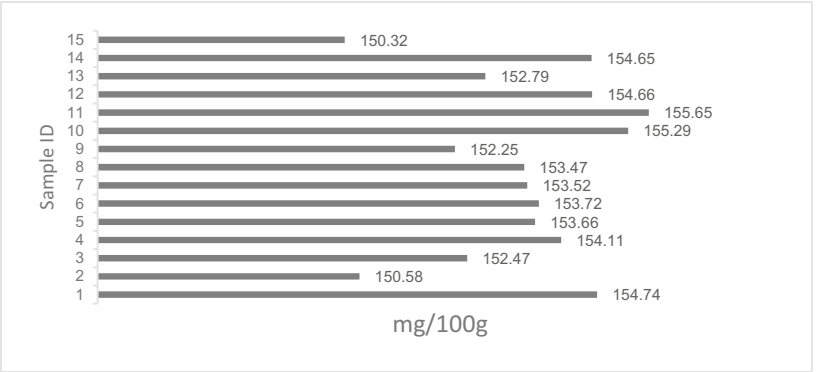


c K content of samples

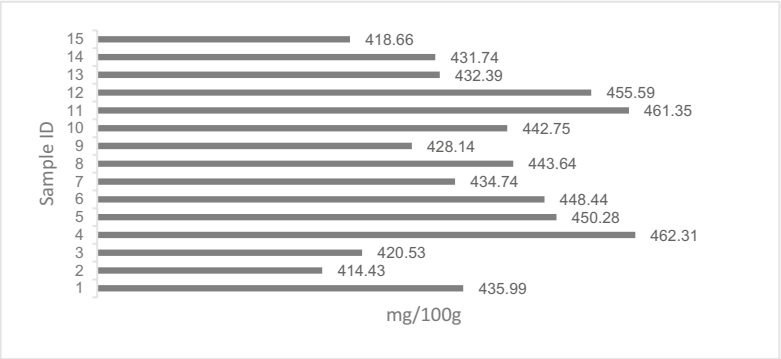


d Ca content of samples

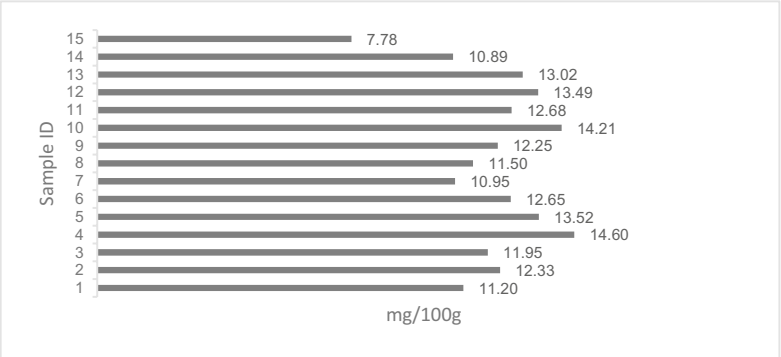
Fig. 1a (continued)



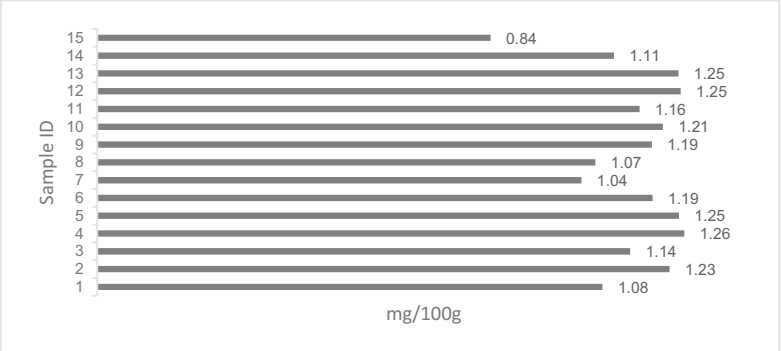
e Mg content of samples



f P content of samples

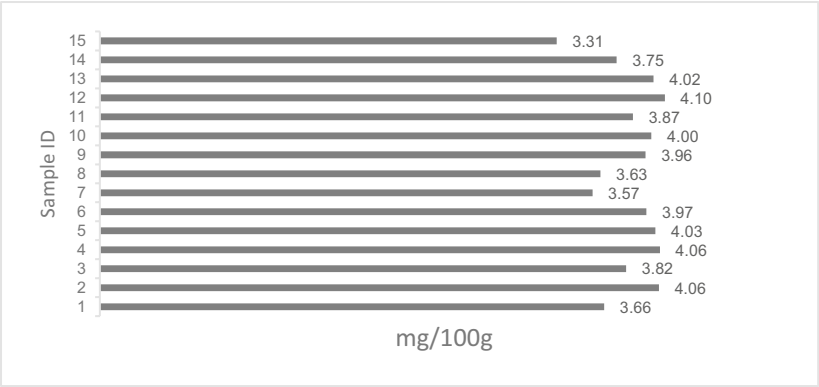


g Fe content of samples

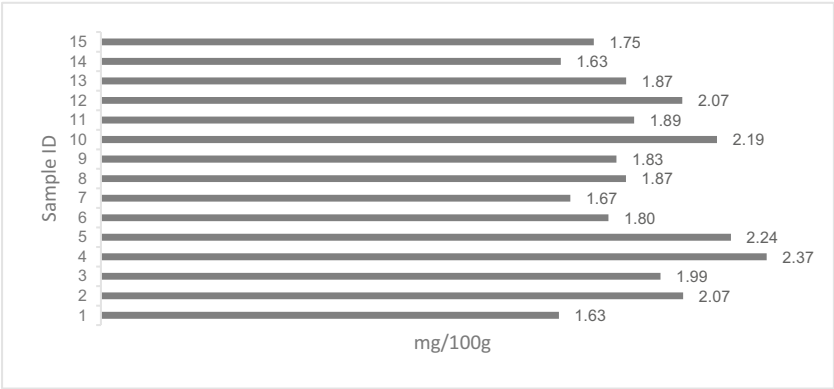


h Cu content of samples

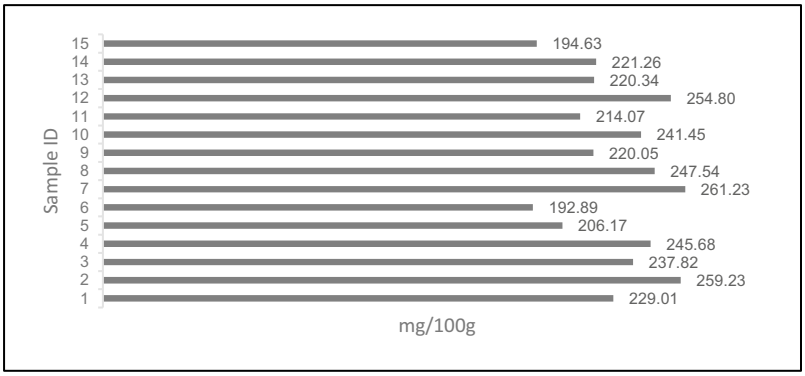
Fig. 1a (continued)



i Zn content of samples



j Mn content of samples



k S content of samples

Discussion

Several studies are engaged in the determination of lentils' mineral content. The mineral content of the crop is significantly influenced by several factors such as cultivar, location, and year effects were found for yield, protein, starch, and minerals [41], It has been reported in several studies that the protein content of lentils varies by variety [42–44], climate [45–47]. The amount of protein is also influenced by genetic and environmental influences [48, 49]. Organic and inorganic nitrogen fertilizers have shown positive effects on lentil yields and protein concentrations [47, 50]. In their study, Ansari and Jha concluded that the amount of nutrients is significantly influenced by soil composition and environmental factors [51]. Based on the above list, many external influences affect the amount of protein in the crop.

Our study showed significant differences between the mineral content of commercially available lentil and the guideline databases published by the world's major agricultural and food organizations. Only a few values were found from the other reference databases that could be considered identical ($p = 0.05$) based on the statistical tests used. Most

Table 4 The descriptive statistical evaluation of data is presented for the total amount of sample (mg/100 g)

Mineral	Mean	Standard deviation	Median	Range	Minimum	Maximum	SE	n	CV%
Protein	26.78	1.08	26.96	4.15	24.44	28.59	0.28	15	4.03
Na	7.94	0.75	7.89	2.53	6.65	9.18	0.20	14	9.41
K	957.87	14.30	960.32	55.19	928.33	983.52	3.69	15	1.49
Ca	115.42	6.35	118.27	22.95	104.18	127.12	1.64	15	5.50
Mg	153.46	1.56	153.66	5.32	150.32	155.65	0.40	15	1.02
P	438.73	15.05	435.99	47.88	414.43	462.31	3.88	15	3.43
Fe	12.20	1.66	12.33	6.82	7.78	14.60	0.43	15	13.63*
Cu	1.15	0.11	1.19	0.42	0.84	1.26	0.03	15	9.67
Zn	3.85	0.23	3.96	0.78	3.31	4.10	0.06	15	5.87
Mn	1.92	0.22	1.87	0.74	1.63	2.37	0.06	15	11.69*
S	229.75	22.22	229.01	22.22	192.89	261.23	5.74	15	9.67

*moderate variability

Table 5 The descriptive statistical evaluation of data is presented for Canadian sample (mg/100 g)

Mineral	Mean	Standard deviation	Median	Range	Minimum	Maximum	SE	*n*	CV%
Protein	26.59	1.28	26.82	4.15	24.44	28.59	0.40	10	4.80
Na	8.01	0.55	7.99	1.62	7.19	8.80	0.18	9	6.83
K	957.09	12.67	962.64	39.79	928.33	968.12	4.01	10	1.32
Ca	116.06	4.58	118.67	11.91	108.91	120.82	1.45	10	3.94
Mg	153.63	1.58	153.62	5.32	150.32	155.65	0.50	10	1.03
P	439.74	13.08	438.74	42.69	418.66	461.35	4.14	10	2.97
Fe	11.94	1.81	12.45	6.43	7.78	14.21	0.57	10	15.15*
Cu	1.13	0.12	1.18	0.41	0.84	1.25	0.04	10	10.96*
Zn	3.82	0.25	3.91	0.78	3.31	4.10	0.08	10	6.47
Mn	1.86	0.17	1.85	0.56	1.63	2.19	0.05	10	9.08
S	230.93	20.20	229.54	64.61	194.63	259.23	6.39	10	8.75

matches were found in the FAO databases. In various dietary or dietetic planning, it is inevitable to know the exact nutritional composition. Dietary planning is based on data from the world's large nutrient databases. Most of our mineral content measurement results were homogeneous, which provides a stable basis for further analysis, but when comparing our measurement results to large databases, significant differences were found, even in the case of the same country. This means that it is not possible to design sufficiently accurate dietary recommendations with currently available data.

These tables are identical to the tables that were used for comparison, with which have compared our own measurement results, and significant differences were detected. In our view, our studies provide an excellent basis and underline the need to update the nutrient tables used as reference for accurate dietetic planning.

The differences also have practical significance in North America. The basis for dietetic planning recommended by the U.S. Department of Health and Human Services is the Dietary Reference Intakes (DRI). The DRI are issued by the Food and Nutrition Board of the National Academies of Sciences Engineering, and Medicine. The Food and Nutrition Board addresses issues of safety, quality, and adequacy of the food supply; establishes principles and guidelines of adequate dietary intake; and renders authoritative judgments on the relationships among food intake, nutrition, and health. DRI is a general term for a set of references used to plan and evaluate nutrient intake in healthy people. It includes the Recommended Dietary Allowance (RDA), which is the average daily intake level sufficient to meet the nutritional needs of almost all (97–98%) healthy individuals; Adequate intake (AI): The intake at this level is assumed to ensure adequate nutrition, the estimated average need (EAR): The average daily intake level corresponding to 50% of healthy individuals; and Tolerable Upper Intake (UL) [52]. Based on the above, proper level diet planning is a rather complex process that takes into account several factors. The DRI tables recommended for design contain exact µg and mg values by sex, age group, and biological characteristics [53]. As a further step in planning, the nutrient and mineral content

Table 6 Statistical analysis (p-value) of all sample for word's lead database ($p = 0.05$)

Mineral and protein	Shapiro–wilk normality test *P*-value	data is distributed	USDA [31]	ENGLAND [32]	AUSTRALIA [33]	FAO/ INFOODS [34]	FAO/ INFOODS [35]	INDIAN [36]	FAO/ INFOODS [37]	FAO/ INFOODS [38]**	FAO/ INFOODS [38]***
Protein	0.0184	Not normal	0.550	no data	0.000122*	0.00235*	0.000122*	0.000305*	0.599	0.804	0.639
Na	1.855e -05	Not normal	0.000122*	0.000122*	0.000244*	0.000122*	0.000122*	0.000122*	0.000122*	0.000122*	0.000122*
K	0.895	Normal	5.61e -10*	0.246	1.07919e -09*	1.08e -07*	0.75	1.73004e -09*	0.143	7e -07*	6,89e -07*
Ca	0.403	Normal	1.18e -08*	8.95379e -06*	3.46289e -06*	4.59e -05*	4.34576 e-06*	3.29784e -05*	6.80086e-09*	3.6e -08*	0,000274*
Mg	0.307	Normal	1.27e -18*	1.827e -13*	2.9984e -14*	1.33e -07*	9.19102 e-13*	1.36243e -14*	6.37704e-16*	3.5e -17*	2.71e -13*
P	0.763	Normal	6.51e -07*	5.38645e -05*	1.52314e -07*	0.468	0.857	4.51057e -08*	0.05	3.04e -06*	4.35e -07*
Fe	0.196	Normal	0.0100*	0.531	0.0157*	0.0382*	0.0226*	0.0173*	0.0103*	0.0242*	0.0409*
Cu	0.0147	Not normal	0.000122*	0.000122*	no data	0.000122*	6.104 e-05*	0.0255*	6.104e-05*	6.104e -05*	0.0255*
Zn	0.0584	Normal	0.235	0.847	2.00438e -06*	0.121	0.0532	0.295	0.00166*	0.750	0.643
Mn	0.513	Normal	0.100	0.0405*	no data	no data	no data	0.129	0.0738	0.139	0.366
S	0.525	Normal	No data	No data	No data	No data	No data	No data	No data	No data	No data

*significant difference

** Sample: LEC001_DM

*** Sample: LEC006_DM

Table 7 Statistical analysis (p-value) of Canadian sample for North American database (p=0.05)

Mineral	Shapiro-wilk normality test P-value	Distribution	Test	Canadian [40]	USDA [32]
Protein	0.2155	Normal	t-test	0.177	0.0850
Na	0.0003242	Not normal	Wilcoxon test	0.00909*	0.00909*
K	0.03412	Not normal	Wilcoxon test	0.00909*	0.00195*
Ca	0.03797	Not normal	Wilcoxon test	0.00909*	0.00195*
Mg	0.5889	Normal	t-test	2.67e -13*	3.85e -13*
P	0.9516	Normal	t-test	1.05e -06*	4.5e -06*
Fe	0.2201	Normal	t-test	0.0187*	0.0310*
Cu	0.06656	Normal	t-test	0.0177*	0.0417*
Zn	0.2478	Normal	t-test	0.0633	0.352
Mn	0.5147	Normal	t-test	0.0275*	0.0850
S	0.7239	Normal	t-test	No data	No data

*significant difference

of foods must be known. The U.S. Department of Health and Human Services recommends data tables from the U.S. Department of Agriculture's Food Data Center. These tables are identical to the tables that were used for comparison, with which were compared our own measurement results and significant differences were detected.

In 2007, Padovani et al. conducted a database comparison study in which they found that borrowing data on food composition from one country to be used in another country is limited by the lack of equivalency in the foods consumed in these countries. Because of genetic and environmental variation in the composition of a given food, even in foods that could be considered equivalent, appreciable differences in the concentrations of food components can exist, making the practice of borrowing data questionable, especially for micronutrients [54]. This confirms the importance of updating data and taking your own measurements. The precise databases are necessary because the nutrient profile of the lens and the processing methods affect the composition and functional properties [55].

Table 8 Statistical analysis of all sample for hungarian database [53] (p=0.05)

Mineral and protein	HUNGARIAN [40]
Protein	0.05688
Na	0.002092*
K	1.41E-06*
Ca	4.34E-06*
Mg	1.71E-08*
P	0.24798
Fe	0.005051*
Cu	6.104e-05*
Zn	0.151861
Mn	0.129617
S	No data

*significant difference

Conclusion

Based on our study, we recommend organizing and implementing a large circle survey, which can also contribute to the updating of data and more frequent periodic data updates. We recommend that the world's large databases be limited to smaller geographical areas, taking into account the nature of geographical and dominant cultivated varieties, thus reducing the degree of nutrient and mineral content differences. Breeders give more and more varieties, so it is necessary to constantly check and update databases.

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Data availability The data that support the findings of this study are available on request from the corresponding author (repas.zoltan@agr.unideb.hu; zoltan_repas@yahoo.com).

Declarations

Conflict of interest The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Compliance with ethics requirements This article does not contain any studies with human or animal subjects.

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