Acta fytotechn zootechn, 26, 2023(2): 147–154
http://www.acta.fapz.uniag.sk

Original Paper

Assessment of the nutritional quality of four lentils (*Lens culinaris* Med) varieties cultivated in Algeria before and after cooking and their sensory characterization

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Article Details: Received: 2022-10-26 | Accepted: 2023-02-02 | Available online: 2023-06-30

https://doi.org/10.15414/afz.2023.26.02.147-154

Lentil (*Lens culinaris* Med is an important dietary source of energy, protein, carbohydrates, fibre, minerals and vitamins. The nutritional status of four lentil Algerians cultivars (Metropol, Idleb1, Syrie 229 and Ibla), were accessed. Carbohydrate composition, Crude proteins, Fibre, Dry matter, Fats and Ashes were determined. The culinary qualities and sensory analysis are respectively based on cooking time and tasting tests which carried out with 28 samples of consumers. The highest protein contents were recorded in Metropol (24.38%) followed by Idleb1 (22.87%). Ibla presented the highest fibre content (06.11%) and the lowest value was recorded in Idleb1 (4.01%). The highest carbohydrate contents were shown by Ibla and Metropol with 74.43% and 62.40% respectively. However, Syrie 229 and exhibit the lowest value with 11.91%. Descriptive sensory analysis of prepared samples showed that all extruded treatments were similar to each other. By applying statistical techniques, consumer acceptability testing (4-point hedonic scale) indicated that there were no significant differences ($P > 0.05$) in acceptability among the selected treatments. This study contributes to the available information concerning nutritional quality of Algerian lentil varieties before and after cooking and their sensory characterization. The current results can be assured of enhanced nutrient potential and sensory quality of lentil.

Keywords: culinary qualities, lentil, nutritional status, protein contents, sensory analysis

1 Introduction

Nutrition is considered the first need for humankind. Among the crop with valuable nutrition value for human being pulses. Legumes which include pulses and beans are the most widely used foods in the world (Ahuja, 2014). They are consumed after cooking both in the form of whole seeds and decorticated splits in various types of food (Wang & Daun, 2005). In terms of nutritional quality, proteins, limiting amino acids, calcium, iron and vitamins, food legumes are of great significance because of their complementary effects on cereal-based diets (Tosh et al., 2013). For this reason, legumes have been the subject of several scientific studies focused on their chemical and nutritional profiles, bioactive properties, and the beneficial health effects derived from their consumption (Liberal et al., 2021). Among leguminous species, lentil (*Lens culinaris* Med) is an ancient crop of classical Mediterranean civilization (Karakoy et al., 2012) consumed in appreciable amounts in Middle East countries (Bamdad et al., 2009; Ying et al., 2017). Nowadays, lentil is an important pulse crop which is cultivated worldwide for human food security especially in developing countries (Gupta et al., 2021; Benbrahim et al., 2019; Moldovan et al., 2015). Interest in the production and use of lentil in food formulation and preparation has grown in the last decades due to their high nutritional value and fast cooking times (Barbana & Boye, 2013). In fact, lentils are an excellent source of proteins, carbohydrates, dietary fiber, minerals and vitamins (Anoma et al., 2014; Vidal-Valverde et al., 2002). According to Jabeen et al. (2018) because of its fast-cooking lentil is the most desired legume in many regions. In Algeria, although, lentils continue to occupy an important place in the dietary habits of Algerian population, especially,

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as a rich source of protein, vitamins and minerals, Algeria is still completely dependent on lentil imports. The objectives of this study were to assess nutritional quality of four Algerian lentil varieties before and after cooking along with their sensory evaluation.

2 Material and methods

This work was conducted at National Research Center for Biotechnology (CRBt) in the laboratory of food chemistry. Fresh seed harvest (1 Kg lots) of four lentil varieties was provided by seed private company (*Axium* sp.).

2.1 Sample preparation and cooking methods

All varieties were grown at the same location in the same year using the same agronomic practices (e.g. fertilizer, irrigation) during 2016 growing season (Table 1, Figure 1). Part of the grains of each variety (500 g) was ground into a fine powder in an electric grinder and stored in air tight plastic containers (sample S0).The remaining seeds (500 g from each variety) were soaked in tap water (1 : 10 w/v) for 1 h at room temperature (25 °C). The soaked seeds were drained and rinsed three times with 1,000 ml tap water and then cooked by the following methods:

- Sample S1: were cooked on a heating plate at 200 °C for 60 minute.
- Sample S2: were cooked in a hot air oven at 150 °C for 90 minute.
- Sample S3: were cooked in an autoclave at 120 °C for 15 minute.

The uncooked sample (S0) was used for the proximate analysis and chemical determination and the cooked seeds (S1; S2 and S3 samples) were used for chemical determination. For sensory evaluation only sample S1 was given to the consumers.

Table 1 The name of the four lentil varieties and the samples codes

Varieties	Samples code
Ibla	620
Idleb1	833
Syrie 229	712
Metropol	921

2.2 Chemical determinations

The chemical compositions were fallowing standard procedures of American Association of Cereal Chemists (ACCC, 2000):

- Crud protein content (CPC): Total protein content in the seed samples were quantified by chemical Kjeldahl method. Protein values were expressed as total nitrogen multiplied by 6.25 correction factor.
- Lipids: Lipids were extracted using Soxhlet method of extraction and the content was determined using gas chromatography mass spectrometry.
- Carbohydrate: Quantitative determination of total soluble sugars was carried out according to the colorimetric method. The carbohydrate content was estimated by differences between the dry extract (obtained after oven drying) and the rest of the components. The compounds were identified by high-performance liquid chromatography with a refraction index detector (HPLC-RI).

2.3 Proximate composition

These analyses were performed only for original raw samples (S0).

Crude fibre content (CFC): Contents of crude fibres of the samples are determined by Weend's method.

Ash content: Was determined by quantifying the residue after combustion of the dry sample in a muffle furnace at 540 °C for 6 h under conditions corresponding to the gravimetric method.

Moisture content: Moisture content was determined by drying the samples at 80 °C in a vacuum oven until no further change in weight was observed.

Total dry matter (TDM): The dry matter is determined by drying at a temperature of 105 °C in an oven ventilated until a constant mass of samples is obtained.

Figure 1 The four lentil varieties used in this work: (1) IBLA; (2) Syrie 229; (3) IDLEB1; (4) METROPOL

2.4 Sensory evaluation

A panel of around 28 amateur tasters was recruited within the institution. For each participant, 4 g of sample S1 was served in small plastic cups labelled with three-digit random numbers. Participants were instructed to taste the S1 sample with a plastic tablespoon cleaned with water between the fourth varieties. Sensory analysis consisted of classification tests and general acceptability adopting the 4-point hedonic scale (1 =poor, 2 =fair, 3 = good and 4 = excellent). The participants were also asked to rate cooking (1 = undercooked, 2 = cooked, 3 = slightly cooked, 4 = overcooked).

2.5 Statistics analysis

Three replications were performed on four different treatments. The analysis of variance (ANOVA) and means comparison were conducted by ANOVA procedures with statistical analysis addinsoft, XLSTAT software version 2.1 (Addinsoft, 2022). Comparisons among treatments were analysed by the Tukey test, with a significance level at $P<0.05$.

Results are presented as mean ±SD (Standard deviation) of tree separate determinations. A multivariate data analysis based on principal components analysis (PCA), were performed on the data obtained from proximate composition. A sensory characteristic was carried out following quantitative descriptive analysis (Stone et al., 1974).

3 Results and discussion

In this study, all the fourth varieties were grown in the same region under the same agro-geoclimatic conditions. The compositional parameters analysed exhibited an important source of nutritional and chemical compounds, showing they are of high nutritional value.

3.1 Proximate composition (total fiber, moisture content, ash and total dry matter)

According to Gharibzahedi et al. (2012), the proximate composition of lentils can be affected by many factors such as variety. The data on the proximate composition, along with ranges, means and SD are summarized in Table 2.

The results obtained of proximate analysis are in part similar in range to those from a study performed by Liberal et al. (2021), who investigated the proximate composition and nutritional properties of different cultivars of the Pardina lentil grown in different regions of Spain. In a study accomplished by Benayad et al. (2021) where they compared lentil couscous nutrition composition with wheat couscous composition. The results showed that lentil couscous presents the higher contents of ash, and fibres, and the lower contents of moisture, compared to wheat couscous.

Metropol, Idleb1 and Syrie 229 exhibited nearly similar total fibre contents (about 4%), which were lower than in Ibla (06.11%). The values of fibre content were comparatively similar to those reported by Boyle et al., 2010 (3.40% to 6.1%).

Slight differences were shown among varieties moisture content; Idleb1 had the highest value (10.13%) and Metropol was the lowest one (9.46%), the mean value was 9.70 ±0.28. There were statistical differences regarding moisture content, all varieties showed moisture values well below 15%. Plaza et al. (2021) reported that this value is considered the maximum admissible moisture limit for lentils according to the quality standards of the Spanish protected geographical indication.

There were significant differences in the ash value among the varieties. Ash contents ranged from 1.07% for Metropol and Syrie 229 to 1.08% for Idleb1 and Ibla. The ash content in the four varieties was much lower than that reported in lentil analog (Abu-Ghoushi et al., 2014) and other crops such as Barely (Jabeen et al., 2018) and Potato (Tosh et al., 2013).

Total dry mater, decreased in the following order: Metropol (90.53%) > Syrie 229 (90.46%) > Ibla (90.33%) > Idleb1 (89.86%).

Principal compound analysis (PCA) as shown in figure 2 includes varieties and proximate variables evaluated

Table 2 Total fibre, moisture content, ash and total dry matter in four lentil cultivars (mean ±SD, n =3)

Genotypes	Total fibre (%)	Moisture (%)	Ash (%)	Total dry matter (%)
Metropol	4.78 ±0.63^{ab}	9.46 ±0.11^{b}	1.07 ±0.002^{b}	90.53 ±0.11^{a}
Idleb1	4.01 ±0.35^{b}	10.13 ±0.11^{a}	1.08 ±0.001^{a}	89.86 ±0.11^{b}
Syrie 229	4.25 ±0.99^{b}	9.53 ±0.11^{b}	1.07 ±0.001^{b}c	90.46 ±0.11^{a}
Ibla	6.11 ±1.66^{a}	9.66 ±0.11^{b}	1.08 ±0.001^{b}	90.33 ±0.11^{a}
Mean	1.08 ±0.006	9.70 ±0.28	1.08 ±0.006	90.30 ±0.28
P-value	0.013	0.000	0.000	0.000

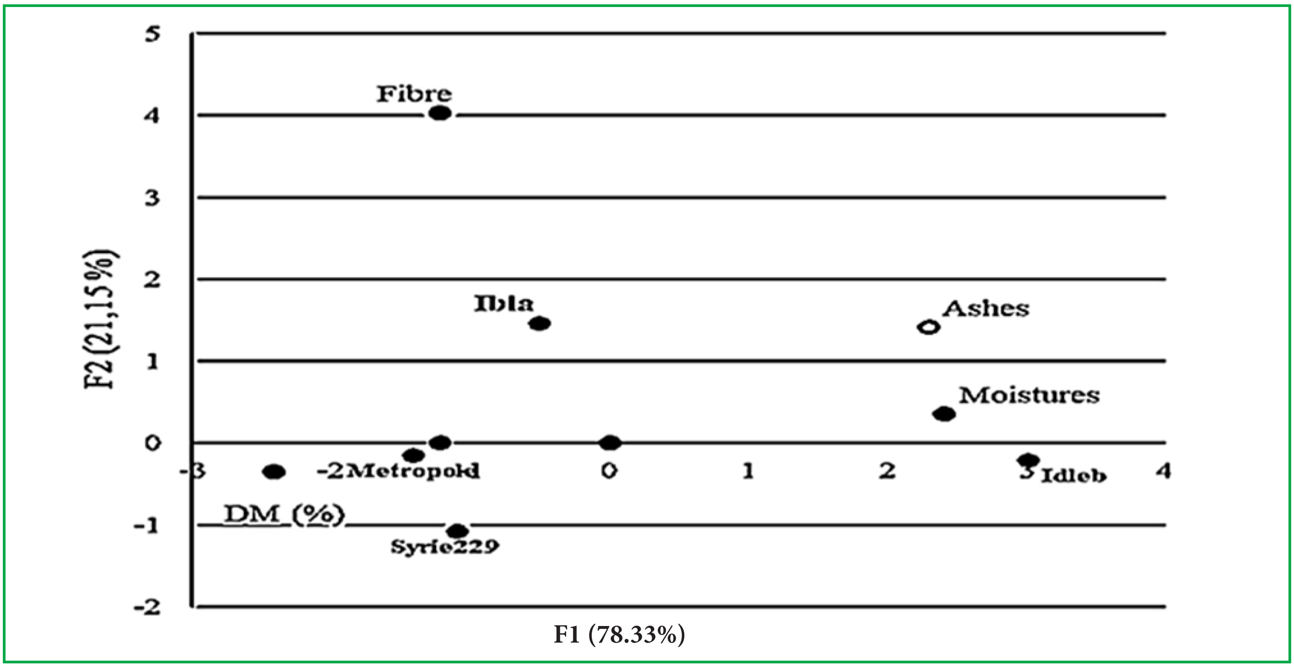

Figure 2 Principal component analysis (PCA) conducted on the descriptive data, including four treatments and attributes of different treatments

in this study. The first two principal components explain 99.48% of the total variability between varieties.

This PCA was conducted on average values and the correlation matrix was used. This analysis shows that all genotypes are different. Ibla has higher fibre content. Metropol and Syrie 229 were usually lower in the dry matter and Ashe. However, Idleb1 present higher moisture content.

3.2 Chemical determinations

Mean values for crud protein (%), crud fats (%), carbohydrate (%) and reducing sugar (MS %) are shown in table 3. There were no significant differences among the treatments S1; S3 including the control (S0) after using Tukey's test for the following compounds: crud protein; crud fats and reducing sugar. While, there were significant differences in the percentage of crud protein among the S1 (19.83 ±1.31%) and S2 (21.67 ±1.96%) treatments. The control (S0) had significantly the highest amount of percentage of crud fat (00.91 ±0.63%) as compared with all other treatments. All the treatments present a significant difference for carbohydrate content and S2 (52.24 ±6.72%) treatment had a higher amount.

The percentage of reducing sugar was significantly higher in the treatments that contain higher amount of carbohydrate (S3). There were no significant differences in the crud protein content between the S0 and S3.

The percentage of protein contents in Idleb1 and Metropol ranged from 21.81 ±0.54% to 22.71 ±0.28% respectively. Fat contents varied from 00.01 ±0.00% (Syrie 229; Idleb1) to 01.65 ±2.26% (Metropol).

The range of carbohydrate contents found in Metropol and Ibla is ranged from 11.06 ±0.26% and 74.43 ±8.71% respectively. The range of reducing sugars ranged from 07.09 ±1.12 to 11.06 ±0.26% did not differ significantly among genotypes for the respective treatment S1 and S3. Whereas reducing sugars were found significantly (from 4.65 ±1.31% to 12.14 ±1.12% (S0 and S2 respectively).

Cooking time is an important component of legume grain quality (Yeung et al., 2009). According to Silva-Cristobal et al. (2017), the cooking time is a primary factor in the choice of a cultivar by consumers who aim to save time in meal preparation. Processing concentration of many important nutrients found in pulses can be greatly affected by soaking and cooking (Tosh et al., 2013); Silva-Cristobal et al. (2017) stated that cooking had a reduced effect on the contents of protein in cowpea grains. Wang et Daune (2005), reported that long cooking times are a major constraint to wider acceptance and use of pulses. Furthermore, they estimated that overcooking of pulses has been reported to result in a reduction in the nutritive value of the protein.

Protein content in both crud and cooking lentil varieties has been estimated to range between 18 and 29% (Gupta et al., 2021; Ying et al., 2017; Abu-Ghoushi et al., 2014; Alghamidi et al., 2014; Barbana et Boy 2013; Tosh et al., 2013; Karakoy et al., 2012; Lazou et al., 2010; Boyle et al., 2010; Almeida Costa et al., 2004).

Table 3 Means of chemical properties of four lentil varieties. Before (S0) and after cooking (S1; S2 and S3) (mean ±SD, *n* = 3)

	Crud protein (%)	Crud fats (%)	Carbohydrate (%)	Reducing sugar (MS %)
Before cooking (S0)				
Metropol	21.28 ±0.91[a]	1.65 ±2.26[a]	51.63 ±1.61[b]	4.22 ±1.12[a]
Idleb1	22.87 ±0.53[a]	1.29 ±0.32[a]	55.29 ±3.81[ab]	4.01 ±0.35[a]
Syrie 229	21.93 ±0.01[a]	0.55 ±0.00[b]	49.42 ±3.11[b]	4.25 ±0.99[a]
Ibla	22.20 ±1.96[a]	0.14 ±0.06[b]	59.39 ±0.93[a]	6.11 ±1.66[a]
Mean	22.07 ±1.02	0.91 ±0.63	53.93 ±4.54	4.65 ±1.31
P-value	0.325	<0.0001	0.008	0.162
Cooking on a heating plate (S1)				
Metropol	19.02 ±0.54[b]	0.02 ±0.01[a]	62.40 ±0.51[ab]	8.67 ±3.42[a]
Idleb1	21.81 ±0.54[a]	0.02 ±0.01[a]	58.29 ±1.47[ab]	12.13 ±0.98[a]
Syrie 229	18.81 ±0.35[b]	0.02 ±0.00[a]	51.15 ±2.00[a]	11.91 ±0.92[a]
Ibla	19.68 ±0.61[b]	0.01 ±0.00[a]	74.43 ±8.71[b]	13.48 ±0.74[a]
Mean	19.83 ±1.31	0.019 ±0.007	50.21 ±3.78	7.91 ±1.69
P-value	0.000	0.931	0.013	0.760
Cooking in a hot air oven (S2)				
Metropol	22.71 ±0.28[a]	0.02 ±0.01[b]	11.06 ±0.26[b]	7.31 ±1.15[b]
Idleb1	20.37 ±2.24[b]	0.03 ±0.01[ab]	12.13 ±0.98[b]	8.04 ±0.23[ab]
Syrie 229	20.19 ±0.35c	0.01 ±0.00[a]	11.91 ±0.92[ab]	5.74 ±0.40[ab]
Ibla	20.12 ±0.54[b]	0.04 ±0.01[a]	13.48 ±0.74[a]	7.26 ±0.40[a]
Mean	21.67 ±1.96	0.01 ±0.008	52.24 ±6.72	12.14 ±1.12
P-value	0.000	0.022	0.017	0.032
Cooking in an autoclave (S3)				
Metropol	24.38 ±1.07[a]	0.01 ±4.10[a]	46.15 ±0.37[b]	11.06 ±0.26[ab]
Idleb1	21.44 ±0.40[a]	0.01 ±0.00[a]	48.22 ±1.53[b]	7.12 ±0.82[a]
Syrie 229	19.34 ±0.11[a]	0.02 ±0.01[a]	54.12 ±6.94[b]	8.22 ±0.28[b]
Ibla	21.52 ±0.86[a]	0.02 ±0.05[a]	60.18 ±4.84[a]	7.64 ±1.15[ab]
Mean	20.85 ±1.49	0.02 ±0.01	61.57 ±9.63	7.09 ±1.12
P-value	0.069	0.046	0.002	0.052

values within a row with the same letter are not significantly different ($P > 0.05$); means within the same row with different superscript letters are significantly different according to its *P*-value

In a study undertaken by Biju et al. (2020) on two lentil genotypes (drought tolerant, G1 and drought sensitive, G2), the seeds from drought plants supplemented with Silicon (Si) seemed to have no influence on the fat content, even though according to the author Si is known to play a key role in the saturation of fatty acids in plants under stressed environments. The fat content in legumes may be of importance in the formation of amylose-lipid complexes that could be developed during starch gelatinization upon cooking, a phenomenon that tends to limit starch bioavailability (Silva-Cristobal et al., 2017).

The mean carbohydrate contents reported by different workers (Benbrahim et al., 2019; Plaza et al., 2021) agree with the values reported in the present study. Dissimilar results were reported by Liberal et al. (2021) and Alghamdi et al. (2014).

Sugar content of lentils flours obtained after short-time soaking processes of whole seeds ranged between 0.95 ±0.03 and 3.21 ±0.04 (Vidal-Valverde et al., 2002). Differently, Tovar and Melito (1996), when studying the effect of thermal processing in some varieties of raw and cooked (conventionally and at high pressure) beans, found values of reducing sugar three to five times greater in the cooked samples. While the sugars content was

8.76% in the case of red lentil and 6.17% for the green variety. Total soluble sugar content in five cultivars and thirty-nine advance breeding lines of lentil was between 43.38–61.13 mg.g^{-1} (Ahuja, 2014).

3.3 Sensory evaluation of S1 sample

The sensory analysis is carried out using the acceptance test by the classification test by rank; the results of the analysis are presented in table 4. The critical value calculated for a significance level of 5% for 28 tasters and 4 samples is equal to 25 according to the table of differences of rank sums by critical absolute rank. The differences in the sums between the samples are all less than the critical value (25) which means that there is no significant difference between the four samples. Tasters found the texture of lentil varieties A, C, D to be less acceptable than that of variety B. The differences between the pairs of odds totals are as follows: A–B = 74 –57 = 17; A–C = 74–69 = 5; D–A = 80–74 = 6; D–C = 80–69 = 11; D–B = 80–57 = 23; C–B = 69–57 = 12.

Sensory attribute intensities and acceptance scores are commonly used to assess the acceptability of food and beverage products (Biju et al., 2020). In the present work, the S1 sample was subjected to sensory evaluation. The results have shown no significant difference in acceptability of four varieties. According to Rao and Vaki (1985), the lower scores compared to the normal range is attributed to blandness of the samples, cooked without addition of the conventional spices. Benayad et al. (2021) compare the acceptability by consumers of enriched wheat couscous at 25% ratio of lentil semolina and wheat couscous; the results indicated that the consumers' indications require lower cooking duration of enriched couscous as compared to wheat couscous and higher need of water. Sensory characteristics of corn and corn-lentil extrudes were investigated as affected by extrusion conditions and legume-to-corn ratio. Overall acceptability of extrudes generally decreased with the addition of lentil flour (Lazou et al., 2010).

4 Conclusions

Lentil is an important source of nutritional and chemical compounds. Therefore, by including lentil in our daily diet helps in acquisition of all essential nutriments necessary for improving human health. This study contributes to the available information concerning nutritional quality of Algerian lentil varieties before and after cooking and their sensory characterization. The present work shows that Metropol was observed to be the best variety because it possessed the highest amount of protein (24.38 ±1.07) and the lowest amount of total carbohydrates (11.06 ±0.26). Further deep studies of nutrition qualities of Algerian lentil varieties may be useful in understanding the way that this pulse bring health benefits. Although, the consumer acceptability testing (4-point hedonic scale) indicated that there were no significant differences (P <0.05) in acceptability among the varieties, further Integration of lentils in our daily diets can thus enhance nutritional status.

Table 4 Acceptance ranking test data

Taster	620(A)	833(B)	712(C)	921(D)	Taster	620(A)	833(B)	712(C)	921(D)
1	2	1	4	3	16	1	3	3	4
2	2	3	1	4	17	1	1	2	3
3	4	1	3	2	18	4	3	2	1
4	2	1	4	3	19	2	1	4	2
5	3	1	2	4	20	3	4	4	1
6	4	1	3	2	21	3	4	2	2
7	3	2	4	1	22	1	1	3	4
8	3	2	1	4	23	2	1	3	4
9	3	4	1	2	24	3	3	2	4
10	4	1	2	3	25	2	2	1	3
11	3	1	2	4	26	4	1	1	3
12	1	2	3	2	27	4	1	2	2
13	3	3	4	1	28	3		4	
14	2	3	1	4	Total	74	57	69	80
15	2	2	1	4					

Acknowledgments

This study is a part of project carried out in 2013 and ended in 2016, with the support of the ministry of higher education and scientific research we gratefully acknowledge them. And AXIUM sp. a private company for providing lentil seed samples.

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