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SHORT COMMUNICATION

Determination of the mineral profile of raw and roasted lentil flour after addition to yogurt

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Abstract

Introduction: Lentil (*Lens culinaris*) is a pulse largely consumed in the world, especially in Algeria. This legume can be consumed in different forms (pottage, soup), but also flour can be produced after roasting treatment of the lentils. Resulted flour can be used as a food or ingredient in the formulation of food products. **Aims**: The main objective of this study is to determine the variation in the main mineral content of lentil flour. The flour was analyzed at its native state (raw), after roasting, raw before addition to yogurt, and roasted after addition in yogurt as a functional ingredient at a rate of 4%. **Material and Methods:** The lentil flours analysis was carried out by means of Scanning Electron Microscopy (SEM) associated with Dispersive X-ray Energy (EDX) microanalysis (SEM-EDX). **Results:** The results show that the roasting treatment does not have a marked effect on the mineral content of lentil flours. However, the addition to the yogurt made it possible to raise the mineral content of the raw and roasted lentil flour remarkably. **Conclusions**: Adding lentil flour to yogurt is an effective way to increase the mineral content of yogurts made from these flours.

Keywords: *Lens culinaris*, flour, roasting, SEM-EDX, mineral.

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1 Introduction

The lentil (*Lens culinaris*) is a legume widely cultivated and consumed throughout the world. It got much interest with regards to their single nutritional density and functional characteristics. Indeed, *Lens culinaris* constitutes an excellent source of bioactive proteins, vitamins, minerals, and fiber [1-3]. It represents a good source of phytochemicals such as polyphenols, carotenoïds, and lycopene [4]. Results from the epidemiological studies have shown that lentil may have a protective effect against various forms of cancer [5], type 2 diabetes, cardiovascular diseases [6], and several other health benefits summarized in the work of Faris *et al.* [7]. This is due to the macro and micro composition of lentils. Amongst the micronutrients, the minerals that the body requires but in quantities from less than 1 to 2500 mg per day, depending on the mineral [8]; unlike the macronutrients which are needed in quantities of grams per day. Minerals are vital elements for the living organism because they are involved in almost all the reactions that occur in different cells of the body required for health and life. Minerals are not biochemically synthesized by the human body, they are obtained from animal and plant -based food and the consumption of water [9]. The beneficial health effects of minerals have been previously well documented. In fact, they assign the structure of bone and membrane (Ca, P, Mg, F), water and electrolyte balance (Na, K, Cl), metabolic catalysis (Zn, Cu, Se, Mg, Mn, Mo), oxygen binding (Fe), and hormone functions (I, Cr) [10]. To quantify the minerals in different food matrices, several techniques are available such as atomic absorption spectrophotometry and inductively coupled plasma optical emission spectrometer (ICP-OES) [11,12]. In the present study, scanning electron microscopy coupled with energy-dispersing X-rays was used to determine the mineral profile in samples of roasted or unroasted lentil flour before and after addition to yogurt as a functional ingredient.

2 Material and Methods

2.1 Sample collection

A quantity of 1 kg of green lentil (*Lens culinaris*) seeds was purchased at a minimarket located in the city center of the Municipality of Drean, El-Tarf Province - Algeria.

2.2 Lentil flours preparation

After cleaning and sorting, the lenses were divided into two batches, one of them was roasted at 150°C for 30 min. After roasting, the sample along with the raw lentils were ground in an industrial mill and sieved. The obtained flours (<500 μm) were packed in resistant and waterproof food bags and stored at room

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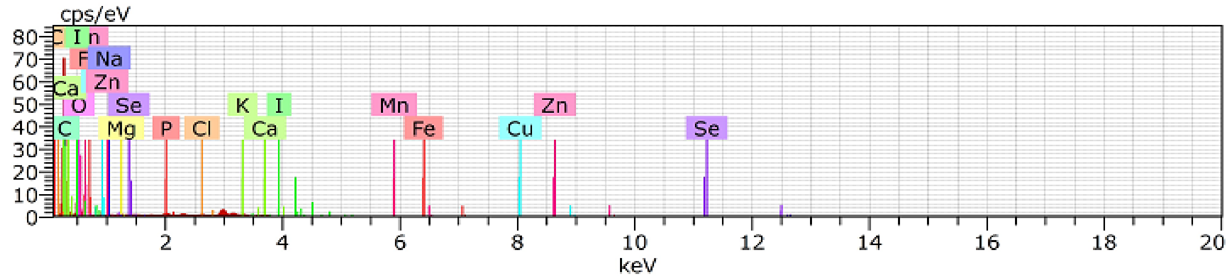

Figure 1: The spectrum of selected minerals provided by SEM-EDX analysis

temperature in a cool and dry place until use. Lentil flours have been characterized in terms of physicochemical quality, functional properties, and content of bioactive molecules, and the results were presented in our previous work [4]. The resulted flours were used as functional ingredients at a rate of 4% in yogurt made according to the standard diagram of manufacturing a plain yogurt followed in the dairy company Edough - Annaba, Algeria.

2.3 Lentil flour extraction from yogurt

The yogurts with raw and roasted lentil flour added were filtered through a colander to remove large particles, especially coagulated caseins, followed by washing with distilled water to remove the last traces of milk and recover only the flour. The flours thus recovered underwent drying in an oven at 103 ± 2 ° C until constant weight.

2.4 SEM-EDX analysis

The percentage of some minerals was recorded by applying scanning electron microscopy (SEM) in combination with an energy-dispersive X-ray (EDX) spectrometer. For this, lentil flours samples are first compressed into pellets after undergoing metallization and placed in the SEM sample holder. The samples are then bombarded with an electron beam. The latter is generally produced by an electron gun brought to a high voltage (a few tens of kV). The EDX analyses were performed using an EDX detector from "JEOL, model JSM 6390LV scanning electron microscope" from the Laboratory of Physics of Thin Films and Applications, University of Biskra – Algeria.

3 Results

Element distribution and their quantitative composition in the different lentil flour samples were evaluated by SEM-EDX. To our knowledge, there is no published data regarding the SEM-EDX mineral analysis of *Lens culinaris*. The profile of the minerals sought is shown in Figure 1; while, the presence and abundance percentage of macro and micro minerals is shown in Table 1.

The major elements (K, P, Mg, Ca, Na, Cl) are present in a relatively high percentage which reaches 1.20 % in roasted lentil flour, while the minor elements (Mn, Fe, Cu, Zn, Se, I) have lower percentages with a maximum of 0.12 % in raw lentil.

Table 1: Macro and micro minerals content in raw and roasted lentil flour before and after addition in yogurt (%*)

Elements	LF1	LF2	LF3	LF4
C (Carbon)	54.18	54.46	7.18	60.54
O (Oxygen)	44.09	43.97	0.63	38.17
K (potassium)	0.78	0.69	.20	0.35
P (phosphorus)	0.32	0.22	.52	0.23
Mg (Magnesium)	0.16	0.20	.13	0.04
Ca (Calcium)	0.16	0.21	.11	0.25
Cu (Copper)	0.13	0.03	.05	0.02
Na (Sodium)	0.07	0.13	.04	0.13
Cl (Chlorine)	0.07	0.06	.04	0.14
Fe (Iron)	0.04	0.02	.07	0.05
Zn (Zinc)	0.01	0.00	.03	0.02
Mn (Manganese)	0.00	0.00	.00	0.00
Se (Selenium)	0.00	0.00	.00	0.07
I (Iodine)	0.00	0.01	.00	0.00
Na/ K ration	0.09	0.19	.03	0.37
Ca /P ration	0.5	0.95	.21	1.09

* Number of element particles / 100 particles
LF1: Raw lentil flour;
LF2: Raw lentil flour after addition in yogurt;
LF3: Roasted lentil flour
LF4: Roasted lentil flour after addition in yogurt

Table 2: Precision ranges of lentils flours minerals obtained using the EDX spectroscopy

Type	Elements	Range			
		LF1	LF2	LF3	LF4
Major elements	K, P, Mg, Ca, Na	0.07 – 0.78	0.06 – 0.69	0.04 – 1.20	0.04 – 0.25
Essential trace elements	Mn, Fe, Cu, Zn, : I	0.00 – 0.12	0.00 – 0.03	0.00 – 0.07	0.00 – 0.07

LF1: Raw lentil flour
LF2: Raw lentil flour after addition in yogurt
LF3: Roasted lentil flour
LF4: Roasted lentil flour after addition in yogurt

4 Discussion

According to the obtained results, it appears that lentil flour is composed of carbon and oxygen as the most dominant elements (table 1), which is expected since it is an organic matter. The roasting treatment had increased considerably the abundance of the carbon by 5.25% as the abundance was 54.18 % in the raw lentil flour (LF1) and increased to 57.18% in the roasted lentil flour (LF3).

However, after addition to yogurt, it was observed that the abundance of the carbon was slightly elevated by 0.51% from 54.18% in the raw lentil flour (LF1) to 54.46% in the raw lentil flour after addition in yogurt (LF2). The same trend was noted in the roasted lentil flour but with an increase of 5.55% from 57.18% in roasted lentil flour (LF3) to 60.54% in roasted lentil flour after addition in (LF4) yogurt. This can be explained by the fact that during the extraction of the flour from the yogurt, other elements of dairy origin were extracted, which increased the presence of carbon in the extracted flour. The same result was noted by Fouad & Rehab [13] on the mineral content of amaranth grains after roasting and popping. However, the boiling has reduced the carbon content. An opposite situation was observed for oxygen, where sample LF1 showed the highest abundance percentage of 44.09% which decreased in the rest of the samples to reach a rate of 38.17% in the LF4 sample. This can be explained by the fact that roasting and drying caused the departure of oxygen in the air following the temperature rise. Therefore, this flour can be stored longer comparing to other studied samples.

As for the other elements, several inorganic elements were present; the K was the most abundant with percentages of 0.78, 0.69, and 1.20% in Lf1, Lf2, and LF3 samples respectively, excepting the sample LF4, where the Ca was the mineral the most dominant (0.25%), followed by P as the second predominant inorganic element. Hefnawy [11], Zia-Ul-Haq *et al.* [1] and Benayad & Aboussaleh [14] obtained identical results where the K and P were the major elements in the lentil. The addition of lentil flour in yogurt had elevated the rate of Ca from 0.16 to 0.21% and from 0.11 to 0.25%; and that of Na from 0.07 to 0.13% and from 0.04 to 0.13% for the raw and roasted lentil flour, respectively. The increase in the percentage of Ca and Na in the two samples LF2 and LF4 compared to the flours before addition to the yogurt, may be due to the presence of particles of dairy origin where Ca and Na are among the major elements of milk as it was noted by Parween *et al.* [15] after analysis of the mineral composition of cow's milk by SEM-EDX and by Denholm *et al.* [16] after analysis of mineral content in milk collected from 479 Holstein-Friesian dairy cows by ICP-MS. Furthermore, the lentil flours have exhibited low Na and comparatively high K percentages with respective Na/K ratios of 0.09, 0.19, 0.03, and 0.37 for LF1, LF2, LF3, and LF4, such situation makes lentils interesting as an ingredient in a healthy diet for people suffering from hypertension problems as stated previously by Benmeziane-Derradji [17] and Faris & Attlee [18]. As for the Ca/P ratio, this was 0.5, 0.75, 0.21, and 1.09 for LF1, LF2, LF3, and LF4, respectively. Sample LF4 exhibited the highest Na/K and Ca/P ratios (> 1) denoting the richness of this sample in Na and Ca than in K and P. In comparison to the elements C, O, K and P, the other major elements Ca, Na, and Mg were less abundant in all samples (Table 1). Our results are close to those of Gonçalves *et al.* [19] where authors stated that K was the predominant main element in the chestnut and low contents of P, Ca and Mg were noted. The abundance percentage of trace elements (Mn, Fe, Cu, Zn, Se, I) was found in the range of 0.00 – 0.12%; 0.00 – 0.03%, 0.03 – 0.07% and 0.00 – 0.07% for LF1, LF2, LF3 and LF4 samples, respectively (Table 2). Among these, Cu and Fe were present at higher levels compared to Zn. Mn was absent in all the flours analyzed, while Se was present only in the LF4 sample, as was iodine which was only present in the LF2 sample, but at very low levels. The appearance of Se and Iodine may have a dairy origin. It was noted that the roasting treatment increased the content of C, K, P, Fe, and Zn; but not those of Mg, Ca, Cu, Na, and Cl. This increase can be partly explained by the departure of oxygen, thus causing their concentrations to increase. These results were close to those reported previously by Alder *et al.* [20] who stated that the average contents of Na, K, Ca, Mg, Zn, Ni, Ni and Cd in roasted coffee samples compared to green coffee were higher, while average contents for Al have not changed, and for three metals Fe, Cu and Pb were lower; but were not in agreement with those reported by Agume *et al.* [21] where they concluded that soaking time and roasting did not cause a significant difference in the ash content of the soybean flour.

5 Conclusions

SEM-EDX analysis showed that the mineral profile of lentil flour changed after roasting and after addition as a functional ingredient in yogurt. The results have shown the abundance of C and O_2. Among the other determining elements, K remains the most abundant mineral. Despite this variation with the different treatments that lentil flour has undergone, it remains an important source of minerals beneficial to human health and well-being.

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References

[1] Zia-Ul-Haq, M., Ahmad, S., Aslam Shad, M., Iqbal, S., Qayum, M., Ahmad, A., Luthria, D.L, & Amarowicz, R. (2011). Compositional studies of lentil (*Lens culinaris* medik.) cultivars commonly grown in Pakistan. *Pakistan Journal of Botany*. 43(3): 1563-1567.

[2] Margier, M., Georgé, S., Hafnaoui, N., Remond, D., Nowicki, M., Du Chaffaut, L., Amiot, M., & Reboul, E. (2018). Nutritional composition and Bioactive content of legumes: Characterization of pulses frequently consumed in France and effect of the cooking method. *Nutrients*, 10(11), 1668. https://doi.org/10.3390/nu10111668

[3] Khazaei, H., Subedi, M., Nickerson, M., Martínez-Villaluenga, C., Frias, J., & Vandenberg, A. (2019). Seed

protein of lentils: Current status, progress, and food applications. *Foods*, 8(9), 391. https://doi.org/10.3390/foods8090391

[4] Benmeziane-Derradji, F., Djermoune Arkoub, L., Ayat NEH., & Aoufi, D. (2020). Impact of roasting on the physicochemical, functional properties, antioxidant content and microstructure changes of Algerian lentil (*Lens culinaris*) flour. *Journal Food Measurement and Characterization*, https://doi.org/10.1007/s11694-020-00529-7.

[5] Faris, M. A., Takruri, H. R., Shomaf, M. S., & Bustanji, Y. K. (2009). Chemopreventive effect of raw and cooked lentils (*Lens culinaris* L) and soybeans (*Glycine Max*) against azoxymethane-induced aberrant crypt foci. *Nutrition Research*, 29(5), 355-362. https://doi.org/10.1016/j.nutres.2009.05.005

[6] Aslani, Z. (2015). Lentil's (Lens Culinaris L.) functional properties in prevention and treatment of non-communicable chronic diseases: A review. *International Journal of Nutrition and Food Sciences*, 4(2), 15. https://doi.org/10.11648/j.ijnfs.s.2015040201.14

[7] Faris, M. A., Takruri, H. R., & Issa, A. Y. (2012). Role of lentils (Lens culinaris L.) in human health and nutrition: A review. Mediterranean Journal of Nutrition and Metabolism, 6(1), 3-16. https://doi.org/10.3233/s12349-012-0109-8

[8] Huang, S., Wang, P., Yamaji, N., & Ma, J. F. (2020). Plant nutrition for human nutrition: Hints from rice research and future perspectives. *Molecular Plant*, 13(6), 825-835. https://doi.org/10.1016/j.molp.2020.05.007

[9] Marles, R. J. (2017). Mineral nutrient composition of vegetables, fruits and grains: The context of reports of apparent historical declines. *Journal of Food Composition and Analysis*, 56, 93-103. https://doi.org/10.1016/j.jfca.2016.11.012

[10] WHO. World Health Organization. Nutrients in Drinking Water, 196p. 2005. ISBN: 9241593989. Available at: https://www.who.int/water_sanitation_health/dwq/nutrientsindw.pdf

[11] Hefnawy, T. (2011). Effect of processing methods on nutritional composition and anti-nutritional factors in lentils (*Lens culinaris*). *Annals of Agricultural Sciences*, 56(2), 57-61. https://doi.org/10.1016/j.aoas.2011.07.001

[12] Idowu, A. T., Benjakul, S., Sinthusamran, S., Pongsetkul, J., Sae-Leaw, T., & Sookchoo, P. (2019). Whole wheat cracker fortified with biocalcium and protein hydrolysate powders from salmon frame: Characteristics and nutritional value. *Food Quality and Safety*, 3(3), 191-199. https://doi.org/10.1093/fqsafe/fyz012

[13] Fouad, A. A., & Rehab, F. M. (2015). Effect of germination time on proximate analysis, bioactive compounds and antioxidant activity of lentil (Lens culinaris Medik.) sprouts. *Acta Scientiarum Polonorum Technologia Alimentaria*, 14(3), 233-246. https://doi.org/10.17306/j.afs.2015.3.25

[14] Benayad, A., & Aboussaleh, Y. 2021. Mineral Composition of Lentils Physiological Functions, Antinational Effects, and Bioavailability Enhancement. *Journal of Food Quality*, 2021, Article ID 5515654, 9 pages. http://doi.org/10.1155/2021/5515654.

[15] Parween, R., Ara, D., & Shahid, M. (2016). Elemental analysis of cow's milk applying SEM-EDX spectroscopy technique. *Fuuast Journal of Biology*, 6(2), 161–164.

[16] Denholm, S. J., Sneddon, A. A., McNeilly, T. N., Bashir, S., Mitchell, M. C., & Wall, E. (2019). Phenotypic and genetic analysis of milk and serum element concentrations in dairy cows. *Journal of Dairy Science*, 102(12), 11180-11192. https://doi.org/10.3168/jds.2019-16960

[17] Benmeziane-Derradji, F. (2019). Nutritional value, phytochemical composition, and biological activities of Middle Eastern and North African date fruit: An overview. *Euro-Mediterranean Journal for Environmental Integration*, 4(1). https://doi.org/10.1007/s41207-019-0132-y

[18] Faris, M.I.E., & Attlee A. (2017). Lentils (Lens culinaris, L.): A Novel Functional Food In "Exploring the Nutrition and Health Benefits of Functional Foods". 1st Ed. IGI, 42 – 72. https://doi.org/10.4018/978-1-5225-0591-4.ch003

[19] Gonçalves, B., Borges, O., Rosa, E., Coutinho, J., & Silva, A. P. (2012). Effect of cooking on free amino acid and mineral profiles of sweet chestnut (*Castanea sativa* Mill.). *Fruits*, 67(3), 201-214. https://doi.org/10.1051/fruits/2012013

[20] Adler, G., Nędzarek, A., & Tórz, A. (2019). Concentrations of selected metals (Na, K, Ca, mg, FE, CU, Zn, al, Ni, PB, cd) in coffee. *Slovenian Journal of Public Health*, 58(4), 187-193. https://doi.org/10.2478/sjph-2019-0024

[21] Agume, A., Njintang, N., & Mbofung, C. (2017). Effect of soaking and roasting on the physicochemical and pasting properties of soybean flour. *Foods*, 6(2), 12. https://doi.org/10.3390/foods6020012

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