Mineral composition of flours produced from modern and ancient wheat varieties cultivated in Romania

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Abstract

Introduction. The aim of the present research was to study the mineral composition of flours produced from different wheat varieties from the collection of the Plant Genetic Resources Bank "Mihai Cristea" Suceava, Romania cultivated under the same conditions.

Materials and methods. Twenty four samples of whole wheat flour produced from different wheat varieties namely fifteen from common wheat (*Triticum aestivum* L.), five from einkorn wheat (*Triticum monococcum* L.) and four from spelt wheat (*Triticum spelta* L.) were analyzed to determine their mineral composition using an Energy Dispersive X-ray Analysis. The statistical analysis of the results was made using the hierarchical cluster analysis technique with a WARD method as a grouping algorithm.

Results and discussion. Generally, the ancient species of wheat were characterized by higher total mineral content than the modern ones, especially einkorn varieties. For all samples of flours significant differences were found in the amount of potassium (K), phosphorus (P), calcium (Ca), manganese (Mn), iron (Fe), zinc (Zn) and copper (Cu). However, all wheat varieties had high potassium and low copper amounts comparative to the other determined elements. Some of the most important microminerals for human nutrition, for example, Fe and Zn, were found in high amounts in flours from different wheat varieties but the samples from ancient wheat were characterized with bigger amounts of these elements than the modern ones. Meanwhile, in some modern wheat varieties these minerals were also present in sufficient quantities. The content of minerals depended more on the agronomic yield than on whether wheat varieties belonged to ancient or modern species.

Conclusions. The results show high variation in the mineral amount between different varieties. The knowledge of this variation can be useful in further breeding studies which aim to improve the nutritional quality of wheat grain and to develop micronutrient biofortification strategies. Both spelt and common wheat varieties showed overall a high mineral content. It seems that the agronomic yield has a significant impact on the mineral nutrients amount in wheat.

Introduction

Many valuable nutritional and sensorial qualities of some wheat varieties have been lost over time due to the need to increase wheat productivity, which is currently being carried out for modern commercial varieties (Velimirovic et al., 2021). So, the requirement for high-yielding wheat often leads to a decrease in its mineral content and modifications of its composition (Magallanes-López et al., 2017). Nowadays, consumers are more and more concerned about their health and demand food products of high quality (Codină et al., 2019). Thus, it is expected that significant breeding efforts will be made in the coming decades to improve the nutritional quality of the modern wheat varieties (Alvarez & Guzmán, 2018). It has been reported that the healthier alternatives to modern varieties of wheat are the ancient ones which are still being explored nowadays (Arzani & Ashraf, 2017). They are mainly used for human consumption in the bread making of various types of fermented bread and unleavened bread, but are also used as animal feed (Shewry, 2018). The ancient wheat term refers only to wheat varieties from *Triticum* genus which were not subjected to intensive genetic improvement programs and characterized as an origin prior to 1961. This includes *Triticum spelta*, *Triticum monococcum* and *Triticum dicoccum* as ancient wheat varieties (Cappelli & Cini, 2021). Grains of old wheat varieties are used for salads and for different products after processing; for example, spelt wheat is mainly used for bakery products, whereas einkorn and emmer grains are mainly used for pasta production (de Sousa et al., 2021; Mastrangelo & Cattivelli, 2021; Witczak & Gałkowska, 2021).

Production of microelements-enriched food is considered as one of the trends for the manufacturing of the breaking edge food in the next decade and wheat flour with a high content of mineral elements is of particular interest as a widespread consumer product (Ivanov et al., 2021). Ancient wheat varieties are used for food preparation because consumption trends are constantly changing and there is a growing demand for sustainable, regional and artisanal products that promote food diversity (Geisslitz & Scherf, 2020). However, the reasons why ancient wheat varieties are more valuable for health and have a higher nutritional value than modern ones are still unclear for now (Csákvári et al., 2021). For a healthy diet, it is recommended to use wheat flour, which is obtained by milling of the whole wheat grain (Gómez et al., 2020). This means that all the component parts of the wheat (bran, germ and endosperm) remain in the flour and nothing is lost in the milling process of the wheat grains (Šramková et al., 2008). Mineral substances are mainly located in the peripheral parts of the grain, so the whole meal flour has higher contents of minerals than the refined flour (Gómez et al., 2020). In wheat grains, the main minerals are potassium, phosphorus, magnesium and calcium, followed by zinc, manganese and iron in smaller amounts. Also, the presence of copper and selenium as oligominerals has been reported (Anglani, 1998).

The content of oligominerals in wheat grains depends on wheat variety, genetic predisposition, agricultural practices, type of soil and climatic conditions, as well as the technological and culinary practices that have been applied (Fan et al., 2008). The nutritional value of wheat products can be improved by the general use of less refined flour and by the selection of wheat varieties with high content of minerals (Cubadda et al., 2009).

Due to the widespread use of wheat flour in human nutrition, it is an effective way to supply the human diet with the required amounts of micronutrients thus preventing their deficiencies (Zhao et al., 2009). The content of minerals in bakery products is determined by their amount in the grains. Although their content can be increased by post-harvest processing, such as fermentation and micro-milling, it seems that modern breeding approaches may be the only way to achieve the significant increases in the amounts of mineral elements in wheat (Balk et al., 2019).

The significant differences in the mineral contents in different wheat varieties were reported (Magallanes-López, 2017; Zhao et al., 2009). However, these studies were performed for the wheat varieties grown in different geographical areas. Romania is one of the most important wheat producers within the European, being on the 4th rank for wheat production (Ionescu et al., 2020). In the present work, the amount of different minerals in various varieties of wheat stored in the current collection of BRGV and cultivated under the same conditions was studied. Evaluation of the potassium (K), phosphorus (P), calcium (Ca), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) present in ancient (einkorn, spelt) and modern wheat varieties was made.

Materials and methods

Materials

Twenty four samples of wheat grains from the active collection of BRGV Suceava were used to determine their mineral amount (Table 1).

The wheat samples were of various origins namely Romanian, German, French, Austrian and Russian. From the analyzed samples, fifteen samples were of common wheat (*Triticum aestivum* L.), five samples of einkorn (*Triticum monococcum* L.) and four samples of spelt (*Triticum spelta* L.). All varieties of wheat were cultivated in the experimental field of the BRGV Suceava, under the same growing conditions. All samples were collected in 2021, when the wheat grains reached the optimum stage of maturation. The mature whole grains were milled using the laboratory disc mill 3100 (Perten Instruments, Hägersten, Sweden). The wholemeal flours obtained were kept at a temperature of 4 ºC, until be analyzed for mineral amount.

Mineral composition analysis

The total mineral content of the wheat flours were determined by using the ICC standard method 104/1. To determine the mineral composition of the flour from wheat varieties a non-destructive method using an EDX system (Energy Dispersive X-ray Analysis), was used (Atudorei et al., 2020; Golea et al., 2021; Mironeasa et al., 2016). For this purpose a spectrometer Shimadzu EDX-900HS (Shimadzu Corporation, Kyoto, Japan) was used. The method is an analytical one, which exploits the emission of X-rays (of a certain wavelength), generated by an electron beam, accelerated incident on the sample.

The method of X-ray spectral analysis is based on a fundamental principle, which states that each chemical element has a unique atomic structure. According to the theory, the X-ray emission is made in high vacuum tubes, which contain a heat-emitting cathode and a metal anode, which emits high-energy electrons, acquired by acceleration at direct voltage, tens or hundreds of volts. Thus, in order to stimulate the characteristic X-ray emission of the samples, an energy-charged beam, such as electrons or protons, or cannon X-rays, is directed to the sample to be analyzed. The photons emitted by the sample are captured by a detector, a silicon-doped silicon semiconductor or SDD (silicon drift detector), cooled by the Peltier effect. Photons of different wavelengths reach the detector, which turns them into pulses proportional to their energy (Golea et al., 2021; Mironeasa et al., 2016). The working parameters used were: collimator diameter – 10 mm, atmosphere in the sample chamber – air, concentration unit – % , the measuring channel used was Na-U, the measurement time of the flour samples was 100 seconds.

Table 1

Wheat samples

Variety	Sample number	Accession name	Biological status	Origin
Triticum aestivum L.	1	Izvor	Modern [1]	Romania
	2	Glosa	Modern [1]	Romania
	3	Miranda	Modern [1]	Romania
	4	Andrada	Modern [1]	Romania
	5	Dumbrava	Modern [1]	Romania
	6	Aurelius	Modern [1]	Austria
	7	Sofru	Modern [1]	France
	8	Sosthene	Modern [1]	France
	9	Amicus	Modern [1]	Austria
	10	Sothys	Modern [1]	France
	11	Flavor	Modern [1]	France
	12	Solindo	Modern [1]	France
	13	Izalco	Modern [1]	France
	14	Tonnage	Modern [1]	Austria
	15	Sophie	Modern [1]	France
Triticum monoccocum L.	16	SVGB-11842	Landrace [2]	Romania
	17	SVGB-11861	Breeding line [3]	Romania
	18	SVGB-11865	Breeding line [3]	Romania
	19	SVGB-11887	Breeding line [3]	Romania
	20	SVGB-11886	Breeding line [3]	Romania
Triticum spelta L.	21	Ebners Rotkorn	Modern [1]	Austria
	22	Frankenkorn	Modern [1]	Austria
	23	Alkoran	Modern [1]	Russia
	24	Oberkulmer Rotkorn	Modern [1]	Germania

Currently cultivated variety, which has a high production potential and uniformity compared to a primitive variety and which constitutes a major part of working collections and is extensively used as a parent in the breeding program.
[2]Local variety of a plant species that has distinctive characteristics arising from development and adaptation over time to conditions of a localized geographic region.
[3]Biological material developed by breeders to be used in modern scientific plant breeding.

Statistical analysis

Data were expressed as means ±standard deviations for triplicate determination. Statistical analysis was performed using the Statistical Package for Social Science (free trial, SPSS, Chicago, IL, USA). The data were subjected to the hierarchical cluster analysis (HCA) technique, using the WARD method of the program as a grouping algorithm (Golea et al., 2021).

Results and discussion

Mineral content of the flour from different wheat varieties

The composition of minerals in the studied wheat samples is shown in Table 2.

The samples from 1 to 15 are flours obtained from common wheat (*Triticum aestivum* L.), the samples from 16 to 20 are (*Triticum monococcum* L.) flours from einkorn wheat, and the samples from 21 to 24 are flours from spelt wheat (*Triticum spelta* L.). The macrominerals analyzed were: potassium (K), phosphorus (P) and calcium (Ca). The microminerals analyzed were: iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu). The wheat flour samples with the highest amounts of mineral elements were: sample 4 (common wheat, Romanian variety Andrada) with 57.62% K; sample 9 (common wheat, Austrian variety Amicus) with 1.53% Fe; sample 13 (common wheat, French variety Izalco) with 44.39% P and 1.80% Mn. A high amount of mineral elements 8.29% Ca, 0.08% Cu and 0.97 Zn% was observed in einkorn (sample 18).

The lowest amount of mineral elements were obtained in sample 5 (common wheat, Romanian variety Dumbrava): 0.92% Ca, 0.39% Mn and 0.29% Fe; in sample 8 (common wheat, French variety Sosthene) with 0.01% Cu and 0.15% Zn; in sample 20 (spelt wheat) with 28.12% K, and in sample 23 (spelt wheat) with 27.74% P.

According to our data, the descending order of the macroelements was K >P >Ca for all wheat varieties analyzed which is in the agreement with those reported by Biel with co-authors (2021). Literature data (Arzani &Ashraf, 2017; Shewry, 2018) indicate the higher levels of mineral content for ancient wheat species which is partially confirmed by our study (an einkorn sample showed the highest Ca amount from all wheat samples). According to Fan and co-authors (2008) this variation could be due to a mineral dilution caused by the increased yields and that newer wheat cultivars have lower amounts of minerals in the grains.

Sample 24 contained the lowest amount of calcium, and sample 23 had the highest amount of calcium. Both samples belong to the species *Triticum spelta*, which indicates a high intraspecific variability in the amount of Ca. This variation is in agreement with the results obtained by Suchowilska and co-authors (2012) and Biel with co-authors (2021), who observed a large intraspecific variability in the amount of Ca as well as in common wheat varieties (*Triticum aestivum*). In the data obtained for the analyzed wheat samples, a large variation was found for all macromineral elements, confirming the results obtained by Krochmal-Marczak & Sawicka (2016). According to Simsek and co-authors (2019), these variations are related to the age of the wheat variety (year of introduction in cultivation) and a possible reduction in bran content in relation to grain yield.

A great variation was found for all macromineral elements, confirming the results obtained by Krochmal-Marczak & Sawicka (2016). According to Simsek and co-authors (2019), these variations are related to the age of the wheat variety (the year of introduction into the crop) and a possible reduction in the content of bran in relation to the yield of cereals. However, from all the macroelements, calcium is the least associated with the launch year, indicating that this element has changed the least in the historical period. Studies by Morgounov with co-authors (2013) showed that old wheat varieties had higher amounts of calcium than modern varieties. In our study, the amount of calcium did not show higher values in the samples of ancient wheat compared to modern ones. This aspect is important for wheat varieties, because calcium plays an essential role in human health, helping to strengthen the immune system, and to regulate the heartbeat (Pravina et al., 2013).

Table 2

Content of potassium (K), phosphorus (P), calcium (Ca), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) in wheat varieties,% of total mineral composition

Sample	K	Ca	P	Mn	Fe	Cu	Zn	Total mineral content, % of dry matter
1	55.19 ±0.11	4.25 ±0.08	37.89 ±0.23	1.18 ±1.18	0.82 ±0.01	0.04 ±0.01	0.42 ±0.01	1.64 ±0.08
2	55.25 ±0.09	2.50 ±0.06	39.46 ±0.20	1.26 ±0.01	0.85 ±0.01	0.05 ±0.01	0.41 ±0.01	1.74 ±0.07
3	55.75 ±0.09	3.35 ±0.06	37.38 ±0.19	1.21 ±0.01	0.68 ±0.01	0.04 ±0.01	0.36 ±0.01	1.63 ±0.06
4	57.62 ±0.10	1.21 ±0.05	37.20 ±0.21	1.08 ±0.01	0.91 ±0.01	0.06 ±0.01	0.50 ±0.01	1.83 ±0.06
5	29.92 ±0.05	0.93 ±0.02	32.38 ±0.16	0.39 ±0.02	0.29 ±0.01	0.01 ±0.00	0.18 ±0.01	1.85 ±0.07
6	53.61 ±0.08	8.11 ±0.05	35.31 ±0.18	1.52 ±0.01	0.90 ±0.01	0.04 ±0.00	0.49 ±0.01	1.83 ±0.06
7	57.38 ±0.08	7.48 ±0.05	32.37 ±0.16	0.92 ±0.01	0.58 ±0.01	0.02 ±0.00	0.31 ±0.01	1.83 ±0.05
8	29.37 ±0.05	2.09 ±0.02	32.56 ±0.16	0.57 ±0.01	0.29 ±0.01	0.01 ±0.00	0.14 ±0.01	1.85 ±0.06
9	52.53 ±0.09	3.75 ±0.06	39.89 ±0.21	1.56 ±0.01	1.53 ±0.01	0.04 ±0.00	0.57 ±0.01	2.25 ±0.07
10	56.85 ±0.09	3.69 ±0.05	35.62 ±0.19	1.34 ±0.01	0.96 ±0.01	0.04 ±0.00	0.47 ±0.01	1.63 ±0.08
11	29.78 ±0.05	1.62 ±0.02	32.44 ±0.16	0.52 ±0.01	0.26 ±0.01	0.01 ±0.000	0.16 ±0.01	1.78 ±0.07
12	55.80 ±0.09	3.55 ±0.06	38.14 ±0.20	1.28 ±0.01	0.64 ±0.01	0.03 ±0.00	0.36 ±0.01	1.69 ±0.07
13	48.17 ±0.10	3.73 ±0.06	44.39 ±0.24	1.80 ±0.01	1.00 ±0.01	0.05 ±0.00	0.69 ±0.01	1.68 ±0.08
14	57.48 ±0.09	3.84 ±0.06	34.58 ±0.19	1.14 ±0.01	0.79 ±0.01	0.03 ±0.01	0.42 ±0.01	1.68 ±0.07
15	56.01 ±0.09	3.97 ±0.05	37.39 ±0.19	1.20 ±0.01	0.88 ±0.01	0.04 ±0.01	0.44 ±0.01	1.72 ±0.11
16	38.91 ±0.07	2.44 ±0.29	28.27 ±0.23	0.71 ±0.01	0.94 ±0.01	0.07 ±0.00	0.53 ±0.01	2.61 ±0.10
17	35.82 ±0.08	2.23 ±0.28	31.05 ±0.23	0.67 ±0.01	1.05 ±0.01	0.05 ±0.01	0.44 ±0.01	2.47 ±0.07
18	49.57 ±0.08	8.29 ±0.05	38.19 ±0.20	1.57 ±0.01	1.31 ±0.01	0.08 ±0.01	0.97 ±0.01	2.34 ±0.07
19	51.247 ±0.098	3.50 ±0.05	41.66 ±0.21	1.47 ±0.01	1.12 ±0.01	0.04 ±0.01	0.83 ±0.01	2.56 ±0.07
20	28.119 ±0.051	1.19 ±0.02	33.49 ±0.16	0.58 ±0.01	0.52 ±0.01	0.03 ±0.00	0.35 ±0.01	2.37 ±0.11
21	36.36 ±0.09	2.23 ±0.25	27.86 ±0.33	0.54 ±0.01	1.12 ±0.01	0.04 ±0.01	0.50 ±0.01	1.83 ±0.11
22	35.79 ±0.08	2.92 ±0.04	30.76 ±0.23	0.51 ±0.01	0.75 ±0.01	0.05 ±0.00	0.45 ±0.01	1.96 ±0.10
23	46.26 ±0.08	6.24 ±0.04	27.73 ±0.18	0.58 ±0.01	0.82 ±0.01	0.05 ±0.01	0.40 ±0.00	1.82 ±0.11
24	47.80 ±0.08	0.97 ±0.05	30.84 ±0.21	0.58 ±0.01	0.94 ±0.01	0.06 ±0.00	0.49 ±0.01	2.54 ±0.09

The potassium amount varied between 28.119 and 57.617%, which indicates that this mineral element did not show significant differences compared to the rest of the analyzed samples, which showed a rather large variance interval. Ca amount ranged from 0.92 to 8.29% in wheat flour samples analyzed in this study. Also, the amount of Ca in the flour of wheat varieties showed significant differences between all the analyzed samples. The phosphorus amounts ranged from 27.74 to 44.39%, which was overall higher in modern wheat varieties compared to the ancient ones in agreement with the results reported by Biel with co-authors (2021).

Regarding the analyzed microelements, all of them varied between grain samples no matter of their variety. These results were unexpected since wheat varieties have been cultivated in the same conditions and no fertilization has been made. It seems that wheat lines producing higher grain yields may lead to lower contents of trace elements. That way, depending on grain yields the trace elements may vary. This is a consequence of concentration-dilution by the dry matter accumulated in wheat grains. Interestingly, it was reported that increasing grain yield by nitrogen fertilization did not influence the micronutrient content of the grains and that only the grain yield has a major impact on trace elements (McGrath, 1985; McDonald et al., 2008). This may explain the high variability between microlements which was obtained between our wheat variety samples. According to our data the Mn amount of the analyzed wheat varieties varied between 0.39 and 1.80%, observing significant differences between samples. The Fe amount ranged from 0.29 to 1.53%, resulting in significant differences between samples with similar data reported also by others (Zhao et al., 2009). Regarding the Cu amount, significant differences were observed between the analyzed samples, except the spelt wheat. The variance range of Cu amount was between 0.011 and 0.076%. It presented the lowest content from all wheat samples, this data are in agreement with those reported by Biel with co-authors (2021). Also, the Zn amount determined for the samples in our study varied between 0.145 and 0.966%, indicating significant differences between samples. Generally, it may be seen that the modern varieties presented a lower value of Zn than ancient ones, being in agreement with those reported by Zhao et al. (2009) which concluded that this may be due to the genetic improvement of wheat which seems to dilute.

According to our study, it can be seen that all the samples of ancient wheat have a high amount of Zn and Fe, except for sample 20. These results are relevant because studies have shown that these two microelements are deficient among children and women in developing countries (Zhao et al., 2009). Also, it was estimated that one-third of the world's population present deficiencies in these minerals (Hotz & Brown, 2004) and therefore their content in wheat grains is very important.

This concludes that ancient wheat is richer in these minerals, a result which is important regarding wheat grains cultivation. However, there are some modern wheat varieties which have high levels of Fe and Zn, but among these are some samples with a very low amount in these minerals (for example samples 5, 8, 11). A possible reason for the low amount of minerals, respectively Zn and Fe microelements, could be the fact that plant improvement is oriented towards a high agronomic yield (Biel, 2021).

Cluster analysis of wheat varieties flours based upon its mineral amount

In order to analyze in a more complex way the mineral amount determined for the twenty-four wheat varieties grown in Romania, in the experimental field of BRGV Suceava the hierarchical analysis of clusters (HCA) was used. The WARD method was used as a grouping algorithm, which determines for each cluster, the average of each variable, and the distance between the clusters, is determined as the average of the distances from the middle element to all the elements of the other cluster.

By applying HCA, the similarities between wheat genotypes were analyzed, based on their mineral constituents and quality traits. Depending on the selected parameters, namely the geometric mean given by the concentrations of the seven determined mineral elements, the wheat samples were delimited into three groups called clusters, presented in the form of a dendrogram in Figure 1.

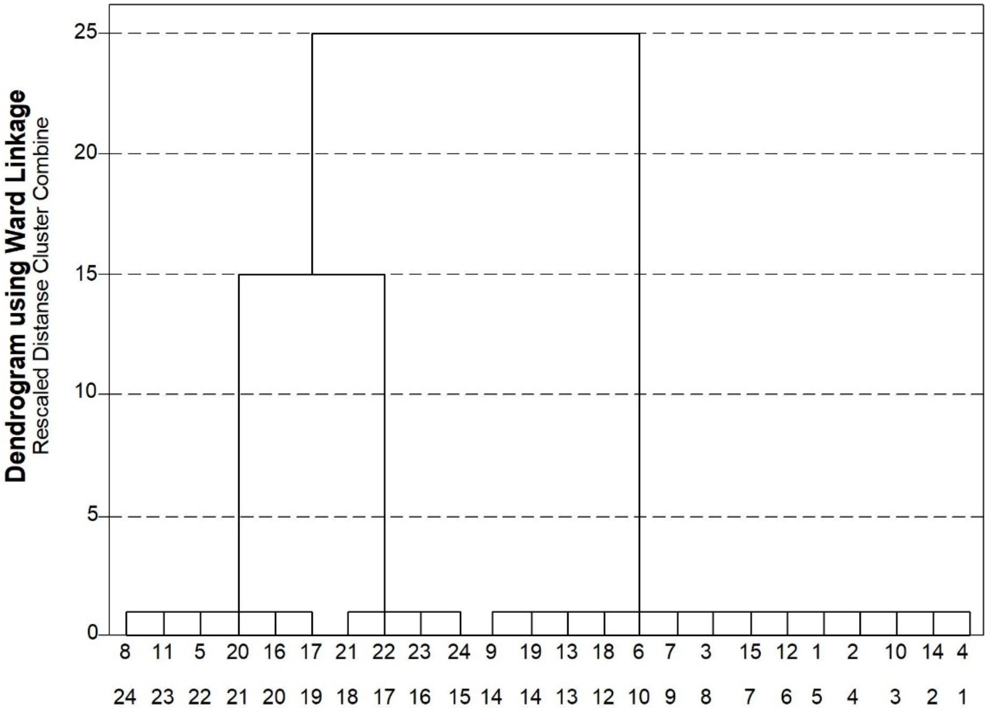

Figure 1. Dendrogram for wheat flour samples showing single linkage with Euclidean distances based on mineral amount

Thus, the use of HCA was effective for the classification of wheat varieties, based on the similarity of mineral compositions, resulting in three groups (clusters) of the twenty four samples of wheat studied as it may be seen from Table 3.

Table 3

Clusters grouped of the wheat varieties

Clusters	Wheat varieties
Cluster 1	*Sosthene (8), Flavor (11), Dumbrava (5), T.monococcum (20), T.monococcum (16), T.monococcum (17)*
Cluster 2	*Ebners Rotkorn (21), Frankenkorn (22), Alkoran (23), Oberkulmer Rotkorn (24)*
Cluster 3	*Amicus (9), T. monococcum (19), Izalco (13), T .monococcum (18), Aurelius (6), Sofru (7), Miranda (3), Sophie(15), Solindo (12), Izvor (1), Glosa(2), Sothys(10), Tonnage (14), Andrada (4)*

The first group includes six wheat samples (8, 11, 5, 20, 16, 17), of which 3 belong to the species *Triticum aestivum* (8, 11, 5) and the other three to the species *Triticum monoccocum* (20, 16, 17). It could be seen that in this group the wheat samples that had the lowest amounts of: K (sample 20); Ca, Mn and Fe (sample 5), Cu and Zn (sample 8) are present.

The second cluster comprises all four *Triticum spelta* samples studied in this experiment and includes sample 23, which had the lowest amounts values of P content. In this group we can highlight that there are no significant differences between the samples, except for the values of Ca amounts, at which a considerable range of variance is observed.

In terms of the number of samples, the third group is the largest, comprising 14 samples, of which 12 were *Triticum aestivum* and two were *Triticum monoccocum* (samples 18 and 19). In this cluster were found the samples with the largest amounts of minerals, determined in this study. Thus, sample 9 had the highest amount of Fe, sample 13 had the highest amount of P and Mn, also sample 18 had the highest amounts of Ca, Cu and Zn, and sample 4 had the highest amount of K.

All the wheat samples presented a large variability of the mineral compositions. The einkorn and modern wheat varieties are grouped in a mixed way in clusters 1 and 3 indicating no significant differences between these wheat flours. However, all the spelt grains flours are grouped together only in one cluster indicating some homogeneity between samples.

Mineral average amount for each cluster obtained for wheat flour varieties

The averages of the amounts of the seven mineral elements, corresponding to each of the 3 clusters formed, are presented in Table 4.

Table 4

Potassium (K), phosphorus (P), calcium (Ca), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) average amount for each cluster obtained

Clusters	Mineral contents,% of total mineral composition							
	K	P	Ca	Mn	Fe	Zn	Cu	Total mineral content,% of DM
Cluster 1	31.99 ±4.32	31.17 ±1.85	1.73 ±0.60	0.57 ±0,11	0.56 ±0.35	0.30 ±0.16	0.03 ±0.02	2.03 ±0.29
Cluster 2	41.55 ±6.36	29.30 ±1.73	3.09 ±2.25	0.55 ±0.04	0.91 ±0.16	0.46 ±0.05	0.05 ±0.01	1.84 ±0.28
Cluster 3	54.46 ±3.02	37.82 ±3.00	4.37 ±2.08	1.32 ±0.23	0.97 ±0.26	0.52 ±0.18	0.04 ±0.01	1.97 ±0.37

It may be seen that all three groups have a higher amount of micronutrients, as well as an improved nutritional value of wheat samples. Also, the genotypes in the same group are similar to each other and differ from the genotypes in the other groups. From all the analyzed samples, spelt grains presented the highest homogeneity. These results were similar with those reported by Gomez-Becerra with co-authors (2010) who concluded that spelt grains had a good broad adaptation, stability across various environments and high heritability values. It presents a genomic affinity and comparable yields with common wheats being a valuable source of mineral nutrients.

Conclusion

Mineral contents of twenty four samples of wheat flour from modern and ancient varieties were determined. A high variability has been recorded among the samples with no significant differences between modern and ancient ones. From all the wheat flour samples the highest homogeneity were obtained for spelt wheat flours which had higher mineral amounts compared to the einkorn and common wheat flours ones. Among all the analyzed mineral elements, potassium was in the largest amount followed by phosphorus and calcium. Copper was in the lowest amounts in all wheat flour samples. Among the minerals analyzed the highest interest presented calcium, zinc and iron which have the most important role in human health. Calcium is a structural component in the human body which prevents osteoporosis and maintains bone health, whereas iron combats anemia and zinc activates body enzymes essential for cell division. The calcium amount significantly varied among the samples. However, from all analyzed varieties einkorn ones presented the highest homogeneity with high amounts in this mineral. All the ancient samples had high amounts of iron and zinc. Also, many samples of modern wheat varieties also showed high amounts of minerals including calcium, zinc and iron. These are more due to the high agronomic yield of the grains that lead to a lower density in minerals. That way, the mineral amount profile in wheat, especially for the most relevant ones for the human body, should be a breeding target, aiming to improve the consumption of these important nutritional components in the diet.

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