JMBFS

Journal of Microbiology, Biotechnology and Food Sciences

International peer-reviewed scientific online journal

Published by Faculty of Biotechnology and Food Sciences

NUTRITIONAL CHARACTERISTICS OF EMMER WHEAT VARIETIES

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doi: 10.15414/jmbfs.2015.4.special3.95-98

ARTICLE INFO

Received 5. 11. 2014
Revised 10. 11. 2014
Accepted 11. 11. 2014
Published 2. 2. 2015

Regular article

OPEN ACCESS

ABSTRACT

The objective of this study was to evaluate the nutritional compounds (fat, sugars, crude protein, soluble fiber, ash and starch) of four emmer wheat varieties grown under the conditions of organic farming system. The experiment was established on Scientific Research base Dolná Malanta, near Nitra in Slovakia during 2010 – 2011 and 2011 – 2012 growing seasons. Nutritional parameters, except crude protein content, were not influenced by the variety and weather conditions. Agnone variety had the highest content of fat, crude protein and starch but the lowest content of soluble dietary fiber. The lowest values of fat, crude protein had Molise sel Colli variety; Farvento variety had the lowest sugars and starch content. Emmer wheat as ancient wheat has a unique composition in secondary components, such as starch, which may play a role as functional food ingredients.

Keywords: Emmer wheat, nutritional quality, organic farming

INTRODUCTION

The development of new speciality foods based on grain blends has permitted the use of the so – called "ancients wheats" as components that convey naturalness, unconventional and nutritional properties. The attention towards these ancient species have also been renewed by the increasing demand for traditional products, the request for species suitable to be grown in marginal areas and the need to preserve genetic diversity. Thus, it has been rediscovered their better performance in disadvantageous pedo – climatic condition as compared to modern cultivars **(D´Antuono, 1994; D´Antuono *et al.*, 1996)**.
Triticum dicoccum Schubler, (syn. *Triticum dicoccon* Schrank, *Triticum turgidum* ssp. *dicoccum* Schubler), otherwise known as emmer wheat is an ancient cereal crop of the Mediterranean region **(Zohary, Hopf, 1994)**. Emmer was among the earliest domesticated *Triticae* by humankind and the principal wheat of old – world agriculture in the neolitic and early bronze ages **(Nevo *et al.*, 2002)**. **Konvalina *et al*. (2008)** noted that the Middle East (Iran, Iraq, Jordan, Syria and Palestine) is its area of origin, where the wild predecessor (*Triticum dicoccoides*) is still cultivated. At present, it is still cultivated in mountain regions and small areas in the Balkans, Turkey, Caucasia, Ethiopia, India, France, Italy and Spain **(Marconi, Cubadda, 2005)**. The increased demand by consumers for natural and traditional food has involved emmer in several food products: in soups (in the form of whole grain or broken and clean grain) **(De Vita *et al.*, 2006)**. Its flour is mixed with durum wheat or common wheat to make a pasta, bread and biscuits. Also available is home – made pasta produced exclusively with emmer **(Galterio *et al.*, 2003).** Emmer is rich in starch, minerals, fiber, and poor in fats; it has been recognized as a very healthy cereal and is recommended in the diet of people suffering from allergies, colitis and high blood cholesterol. Scientists are also interested in emmer as a genetic depository for many agronomic and nutritional traits with important commercial issue **(Barcaccia *et al.*, 2002)**.
The objective of present study was to evaluate influence of growing season and varieties on nutritional quality (content of fat, sugars, crude protein, soluble fiber, ash and starch) of selected emmer wheat varieties grown in organic farming in the south Slovakia.

MATERIAL AND METHODS

A field stationary experiment was carried out at the Research Experimental Station of the Slovak University of Agriculture in Nitra, situated in cadastre of Dolná Malanta village (48°19´N, 18°07´E). Geographically, locality is located in the western part of the river Žitava. The experimental locality has flat character with little declination to south. The altitude is 178 metres above sea level **(Hanes *et al.*, 1993)**. The location has a continental climate with an average long - term (1961–1990) annual precipitation 532.5 mm, for the vegetation period it is 309.4 mm. An average long - term (1961–1990) annual temperature is 9.8°C and for the vegetation period it is 16.4°C **(Špánik *et al.*, 1996)**. The average temperature for 2011 vegetation period was 12.7°C, average precipitation was 339.10 mm. (Figure 1). The average temperature for 2012 vegetation period was 13.06°C, average precipitation was 305.30 mm. (Figure 2).
Four emmer wheat cultivars [*Triticum dicoccum* (Schrank) Schuebl.] - Agnone, Farvento, Guardiaregia and Molise sel Colli were cultivated in organic farming system without fertilization and any chemical treatment. The field trial was order into randomized blocks (the average plot size was $10m^2$) in three repetitions. Sowing rate was $200kg.ha^{-1}$.
During 2010 – 2011 and 2011 – 2012 growing seasons the nutritional parameters (starch, soluble fiber, fat content, sugars, crude protein content and ash content) were evaluated. The nutritional quality parameters were determined by the following methods: starch content by the Ewers polarimetric method (STN 461011 – 37); soluble fiber by EXTRACTOR DOSI - FIBER according to Weende; fat content by Soxhlet extraction (ICC 136) by EXTRACTOR DET - GRAS; sugars were determined on a Spectophotometer SP – 880 by Somoghyi. The crude protein content was determined with the Kjeldahl (N x 5.7) method according to AACC 1983. Ash content was determined according to STN 56 0512 – 8.
Within each experiment, data were subjected to multifactor analysis of variance (ANOVA). Treatment means were compared using Fisher´s least significant difference (LSD) test at $P < 0.05$.

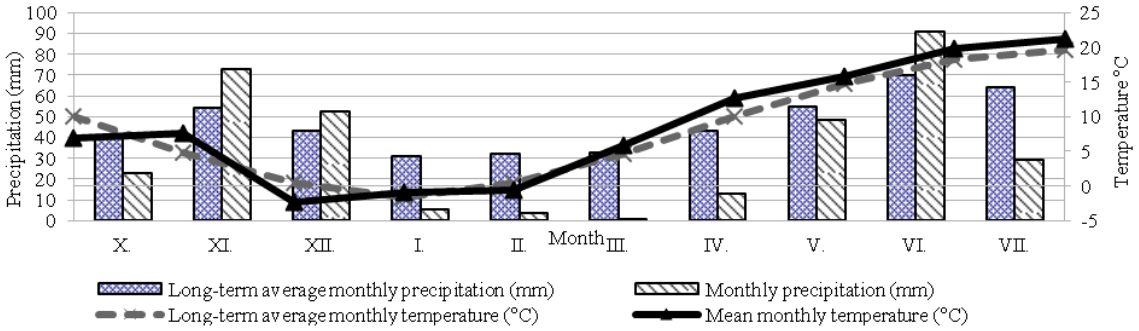

Figure 1 Detailed information on weather conditions during 2010 – 2011 growing season

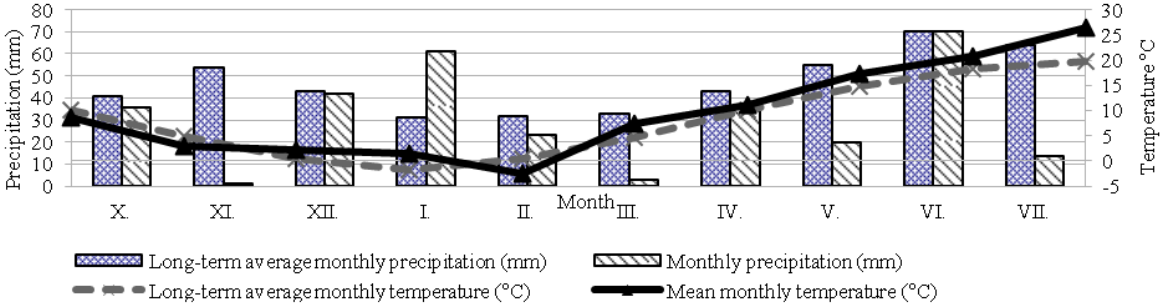

Figure 2 Detailed information on weather conditions during 2011 – 2012 growing season

RESULTS AND DISCUSSION

All varieties used in this study were analyzed for nutritional composition (fat, sugars, crude protein, soluble fibre, ash and starch content) of flour. Results are shown in table 1.

Fat content

Lipids are minor grain constituents, according for about 3% of the wheat kernel. They are more concentrated in germ (which contains 28.5% of lipids) and in the aleurone layer (8.0%) than in endosperm (1.5%) **(Delcour *et al.*, 2010)**. Even though being a minor constituent, cereal lipids are quite a complex family of components, present both as free and bound to various other constituents in the cereal, including proteins and starch **(Ruibal – Mendieta *et al.*, 2002)**.

The average content of fat of four winter emmer varieties was 0.96% and fluctuated between 0.91% (Molise sel Colli) and 0.99% (Agnone). Statistical analysis not confirmed significant differences between varieties. Weather condition had no significant influence on fat content. There is a lack of information about fat content in emmer wheat in scientific literature. Other authors found out higher content of fat than was evaluated under organic farming in southern part of Slovakia during 2011 and 2012 growing seasons. **Piergiovanni *et al.* (1996)** conducted a research about characteristics of meal from hulled wheats where the fat contents were determined. The fat content was not significantly different between emmer and spelt. The highest value of fat content was 2.8% the lowest value was 1.4%. According to **Giacintucii *et al.* (2014)** spring emmer wheat showed a higher fat content of grain (2.33%) than winter emmer wheat (1.52%).

Table 1 Nutritional composition of winter emmer varieties (%)

	Fat	Sugars	Crude protein	Soluble fiber	Ash	Starch
Varieties						
Agnone	0.99 n.s.	0.74 n.s.	14.17 n.s.	0.40 n.s.	3.75 n.s.	66.00 n.s.
Farvento	0.97 n.s.	0.64 n.s.	14.02 n.s.	0.44 n.s.	3.96 n.s.	63.67 n.s.
Guardiaregia	0.98 n.s.	0.82 n.s.	13.26 n.s.	0.40 n.s.	3.65 n.s.	65.32 n.s.
Molise sel Colli	0.91 n.s.	0.65 n.s.	13.48 n.s.	0.41 n.s.	3.94 n.s.	65.12 n.s.
Year						
2011	0.95 n.s.	0.68 n.s.	12.60 a	0.41 n.s.	3.82 n.s.	65.77 n.s.
2012	0.98 n.s.	0.74 n.s.	14.86 b	0.41 n.s.	3.82 n.s.	64.28 n.s.
Mean	0,96±0,08	0,71±0,19	13,73±1,39	0,41±0,05	3,82±0,46	65,03±1,68

Different small letters in the same column mean significant difference at alpha 0.05. No significant difference (n.s.) at alpha 0.05.

Content of starch and sugars

Starch is the main storage carbohydrate in wheat kernels, accounting for 61 – 68% of the grain, whereas sugars account for 2 – 3% **(Abdel – Aal *et al.*, 2005).** It is a primary functional component in cereal grains, its content and characteristics are known to substantially affect the quality of wheat and its end products. Our study of four varieties of winter emmer found that the starch content was not significantly influenced by weather conditions and variety. Starch content varied from 63.67% (Farvento) to 66% (Agnone), with an average of 65.03% (Table 1). The average sugars content was 0.71% and ranged from 0.64% (Farvento) to 0.82% (Guardiaregia), but differences between varieties and growing seasons were not significant. **Konvalina *et al.* (2008)** determined starch content (%) in six varieties of spring emmer wheat, grown at two stations, at the Research Institute of the Crop Production in Prague and at the Faculty of Agriculture in České Budějovice. Starch content was the same in case of all varieties and was very fixed. The lower starch content provided varieties D2 and D4 at both locations. The higher content provide variety D3 (65.9% in Prague and 64.8% in České Budějovice) at both locations. An average starch content reached 47.7% in Prague and 40.9% in České Budějovice. **Galterio *et al.* (1994)** featured the lower value of starch content (52.7 – 56.8%). **Galterio *et al.* (2003)** conducted research in 2003, too. Starch content ranged from 45.7 to 65.1%. The new Davide, Mosé and Padre Pio varieties reveal a starch amount close (54.3 – 55.6%) to that of the older population (55.5 – 56.8%), whereas, the two varieties of *Triticum spelta* had the lowest starch content (50.0, resp. 51.5%). As far as starch is concerned, it is well known that this component highly contribute to the chemical composition and to nutritional value of cereals. The investigation carried out on the new lines highlighted starch contents ranging from 55.4 to 73.3%. It is known that starch digestibility may be reduced during processing because of the formation of enzyme resistant starch (RS) **(Galterio *et al.*, 2001)**. As reported **Massaux *et al.* (2008)** inter – species variability in starch content was observed, which could be explained by the genotype and growing season conditions.

Crude protein content

Proteins are a source of energy and provide essential amino acids. They are concentrated in the cells of the aleurone layer, the pericarp and the germ, with a lower content in endosperm. In our research, the highest crude protein content had Agnone variety (14.17%). Not significantly the lowest protein content had Guardiaregia (13.48 %). The content of protein was significantly influenced by weather conditions (Table 1).

The few data available in the literature on protein content of emmer wheat show a great variability of this parameter. Samples examined had a good protein level that ranged from 14.0 to 20.4% calculated on dry basis **(Galterio *et al.*, 2001). Perrino *et al.* (1993)** found high mean values of 17.1% in 50 emmer accessions cultivated in the same experimental field, whereas other researches, on the contrary, found very low values (<10%) in three Italian emmer populations cultivated in three different locations **(Galterio *et al.*,1994).** Such high variability in protein content was further confirmed by other workers, for example: **Blanco *et al.* (1990)** found in 50 emmer accessions a protein content ranging from 8.7 to 18%, assessments carried out by Cubadda and Marconi (1994) over two years (1992 – 93) on emmer landraces cultivated in Apulia (southern Italy) revealed mean protein content of 20.6 – 21.9% **(Cabudda, Marconi, 1995)**. **Giacintucci *et al.* (2014)** compared spring emmer, winter emmer and common wheat quality and composition of grains and flours. Spring emmer showed a higher crude protein content in grain (14.4 %) than winter emmer (11.2 %) and common wheat (11.8 %). As far as the flours are concerned, spring emmer showed a protein content similar (11.8%) to that of wheat (11.5%), and the winter emmer much lower protein content (10.0%), which indicates that the emmer milling process carried out in a laboratory mill resulted in a reduction of protein content due to the removal of the outer parts of endosperm together with bran.

Intra – species protein content varies widely in the different studies. If all analyses were performed using Kjeldhal method, the variability could be explained by the growing conditions (environment and nitrogen fertilization) and genetic background that influence protein content **(Dupont *et al.*, 2003)**. Since the degree of nitrogen absorption from the soil and its conversion into proteins were greatly dependent on the genotypes and on cultivation conditions, the authors stressed the need to compare samples grown under the same conditions. This fact is in contrast with the observations of Galterio *et al.* (1994) for which the nitrogen fertilization ($50 kg.ha^{-1}$) is reported to have not modified the protein content, which was 9.7% d.m. in the three emmer populations, with or without fertilization **(Cabudda, Marconi, 1995)**.

Soluble dietary fiber content

However, from a nutritional point of view, it is important to differentiate between soluble and insoluble fiber, since each form is considered to have particular physiological effects and benefits as a constituent of the human diet. Soluble fiber is known for its hypocholesterolaemic effect **(Jenkins *et al.*, 1995)**. In wheat, whole grain flour and its bran fraction are a reliable source of fibre, especially the water – insoluble type **(Ranhotra, 1994)**. In contrast, white flour is not rich in total fibre, but it is relatively rich in soluble fiber. In the study of **Arzani (2011)** the content of total fiber was in emmer wheat 2.7 g/100g. The content was higher than in durum wheat (2.4 g/100g) and in common wheat (2.5 g/100g). The average soluble fiber was 0.41% and ranged between 0.40% (Agnone, Guardiaregia) and 0.44% (Farvento). Statistical analysis not confirmed significant differences between varieties and weather condition had no significant influence on soluble fiber content. In the study by **Fares *et al.* (2008)** the soluble dietary fiber (SDF) ranged from 1.36% of Line 399 to 2.32% of Line 390. The lowest content of SDF was 1.36%. Regarding SDF, the values found in our lines were at the same level as those found by **Loje *et al.* (2003)** for einkorn and emmer (0.21 – 1.74%), but lower than those quoted in the study by **Bonafaccia *et al.* (2000)** for spelt and common wheat.

Ash content

The average ash content was 3.82% and ranged between 3.65% (Guardiaregia) to 3.96 (Farvento). Weather condition had no significant influence on ash content and statistical analysis not confirmed significant differences between varieties. According to **De Vita *et al.* (2006)** the ash content showed a reduction of somelina ash content. Modern cultivars of emmer (Mosé and Padre Pio) had average ash content 1.96 %. Landraces and genotypes selected from landraces reached ash content from 2.14 to 2.34%. It is in agreement with a previous study by **Fares *et al.* (2008)**. The ash content was higher in emmer flours than in wheat (0.55%) and in particular in spring emmer flours (0.85%) **(Giacintucci *et al.*, 2014)**. **Marino *et al.* (20011)** found out N fertilization had impact to ash content. Emmer responded to N applications increasing ash content by 22.5% for N_{30}, 37% for N_{60} and 47% for N_{90}, in comparison with N_0. The low ash content of present – day wheat cultivars is the result of a selection to increase the milling yield. Therefore, this parameter could be an indicator of the primitiveness of hulled wheats. Breeding for low mineral contents might be possible for hulled wheats since a broad range of ash contents has been observed in **Piergiovanni *et al.* (1996)** study, however, this will be associated with a decrease of microelement supply to the diet.

CONCLUSIONS

The nutritional parameters as fat, soluble fiber, ash content, starch and sugars of four emmer wheat varieties grown under organic farming in southern part of Slovakia were not significantly influenced by weather conditions and variety. Statistical analysis confirmed significant differences between growing seasons only in crude protein content. Agnone variety had the highest content of fat, crude protein and starch but the lowest content of soluble dietary fiber. The lowest values of fat, crude protein had Molise sel Colli variety; Farvento variety had the lowest sugars and starch content. Emmer wheat as ancient wheat has a unique composition in secondary components, such as starch, which may play a role as functional food ingredients. Because it is rich in fiber, protein, minerals, carotenoids, antioxidant compounds, and vitamins, emmer is a complete protein source when combined with legumes, making emmer bread and pasta ideal for vegetarians or for anyone simply wanting a plant – based high – quality protein source.

Acknowledgments: The research presented in this paper was supported by VEGA No. 1/0513/12 "Research of agroecosystems to reduce climate change, ecological food production and improve nutrition and health parameters of human" and ITEBIO "Support and innovations of a special and organic products technologies for human healthy nutrition" ITMS: 26 220 220 115 implemented under Operational Programme Research and Development.

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