

Organic Wheat Grains and Flour Quality *versus* Conventional Ones – Consumer *versus* Industry Expectations

Received for publication, July 20, 2010

Accepted, October 1, 2011

MIHAELA DRAGHICI^{A*}, PETRU NICULITA^A, MONA POPA^A, DENISA DUTA^B

^a University of Agronomic Science and Veterinary Medicine Bucharest, 59 Marasti Blvd,
Bucharest 011464, Romania

^b National Institute of Research & Development for Food Bioresources – IBA, 6 Dinu Vintila
Street, Bucharest 021102, Romania

Corresponding author: mihaeladraghici38@gmail.com

Abstract

Consumers have become more aware of healthy and safe food with low environmental impact. However, there is a considerable risk regarding the avoidance of chemical inputs in organic farming with result in poor quality of raw materials for food industry. The reduced chemical inputs in agriculture could influence the consumer purchasing decision on organic products based on their health concerns. In the same time, this can create difficult problems for food industry operators related to a poor quality of the grains. The Romanian Boema wheat type was used in this study to compare the quality of organic products (grains, flours and bread) with conventional products (grains, flours and bread). Wheat grains, wheat flours and baked products were sensorial, physicochemical and rheological analyzed. The quality of organic products was lower than the quality of conventional ones. The quality and quantity of protein and gluten were lower for organic products. The rheological behavior demonstrated a poor quality of organic flour. The baked products had similar physicochemical characteristics, but a moderate grey color was observed for the organic bread crumb. Fisher test was applied for the existing experimental data and no significant differences were observed for the indicators considered for organic and conventional grains and flours.

Key words: cereal quality, descriptive analysis, organic and conventional, wheat bread, wheat grain

Introduction

Wheat is a staple food in many countries of the world. Wheat flour is used to make a large variety of products such as bread, pasta, biscuits, cake and pastries. Naturally consumers prefer to buy breads that are produced from organically grown wheat. In conventionally grown wheat, the use of chemicals and fertilizers influence the quality, and also cause a negative impact on the environment. Evaluation of the quality of wheat includes the functional properties of wheat flour for bread making and the nutritional composition of wheat flour [1].

Most published findings relating to wheat quality are based on market research studies or data collected from farm comparisons [2]. Grain-quality analyses may be used to compare organically and conventionally produced wheat. Such analyses commonly include chemical analysis of the grain and/or the physicochemical analysis of the flour. Grain protein content is an important predictor of bread making quality as high amounts may indicate better dough strength [3].

The conclusion of the study by Eva Johansson from Department of Plant Breeding Research, The Swedish University of Agricultural Sciences and Gunnar Svensson from Svalof Weibull Sweden showed positive relationships between the bread volume and the grain protein concentration and quality and the weather conditions [4].

Both protein content and protein quality have major influence on the baking potential of wheat flours. The protein content is determined mainly by nitrogen fertilization, whereas the protein quality depends primarily on the wheat genotype. Climatic conditions during

maturation can affect both the content and the quality of wheat proteins [5]. Increased protein content, however, generally increases dough extensibility. For pan bread, both protein content and the protein quality affect loaf volume positively [5]. The ability of wheat flour to be processed into different foods is largely determined by the gluten proteins [6]. Baking quality depends largely upon wheat protein content and starch structure [4].

In Romania, organic wheat is difficult to be obtained because it is not produced and distributed on a large scale. The Boema wheat type (registered in the year 2000) is autumn wheat extremely productive and has high quality indices for bread making. The type is adapted to the climatic conditions in the south planes of Romania and in Moldavia.

Materials and Methods

Materials

BOEMA wheat type and flour obtained by milling the wheat type were provided by the National Institute of Research and Development, Fundulea in Romania and it was chosen for comparative qualitative analyses between conventional and organic production systems.

Methods

Physic-chemical measurements

Wheat samples obtained both in conventional and organic agricultural conditions were analyzed for: moisture content (%; ISO 712:2009), mass per hectoliter (kg/hl; ISO 7971-3:2009), protein content (%; ISO 20483:2006), falling number (seconds; ISO 3093:2009), gluten content (%; ISO 21415-2:2008), gluten deformation index (mm; ISO 21415-2:2008), gluten index (ICC 155-94), Zeleny index (ml; ISO 5529:2007) (1, 2). The Boema wheat flours, conventional and organic, were further analyzed for: moisture content (%; ISO 712:2009), ash content (%; SR 90:2007), gluten content (%; ISO 21415-2:2008), gluten deformation index (mm; ISO 21415-2:2008), gluten index (ICC 155-94), protein content (%; SR 90:2007), falling number (seconds; ISO 3093:2009), Zeleny index (ml; ISO 5529:2007) [7,8,9,10,11,12,13,14,15,16,17].

Dough rheology properties

The rheological behavior of wheat flours was investigated by a Brabender farinograph-E (Brabender GmbH&Co.KG, Duisburg, Germany). A 300 g of flour samples were loaded in the farinograph. From the farinograph curves, the water absorption (the percentage of water required to yield a dough consistency of 500 BU, Brabender Units), dough development time (DDT, time to reach consistency of 500 BU) and elasticity (band width of the curve at the 500 BU consistency) were obtained.

Bread formulations

All bread formulations contained conventional or organic wheat flour (1000 g), fresh yeast (30 g) and salt (15 g). The amount of added water was around 600 g for 1000 g wheat flour; this quantity was adequate to give consistent dough.

Breadmaking process

The baking tests were carried out in an electric oven with an incorporated proofing chamber (Mondial Formi, 4T 40/60, Italy). Firstly, yeast was dissolved in warm water (35-40°C) and this was added to the dry ingredients-flour and salt, and then the mixture was blended with a 2-speed mixer (Diosna, Germany) for 5 min at first speed and 7 minutes at second speed (more intense). The dough proofed at 30°C for 20 minutes and was subsequently divided in loaves of around 600 g, which were proofed at 30°C for 40 minutes. The proofed samples were baked at 230-240°C for 30-35 min following steaming for 10 s. Measurements of the loaves were carried out after cooling to room temperature for 2 h.

Bread quality evaluation

Some physicochemical parameters of fresh bread: volume, porosity and elasticity were determined following the standard methods (SR 91:2007). Bread volume was determined by a bread volumeter (Fornet, Chopin, France) using rapeseed displacement. For determination of bread porosity (%) a cylindrical piece of crumb was cut from a 60 mm slice obtained from the middle of the loaf by a cylindrical sharpened brass perforator (internal diameter 45 mm) and weighed; the total volume of “voids” was determined for the known volume of bread crumb from its density and mass. For determination of bread crumb elasticity (%) a piece of bread crumb was cut as previously described and pressed to the half of its height for 1 min using a screw-driven pressing device which consisted of a fixed and a mobile plate and a ruler. Then, the pressure was removed and after 1 min the height of the compressed piece of crumb was measured. The elasticity values were obtained as the ratio (given as percentage) between the height after compression and recovery, and the initial height. Measurements of all the above quality parameters were performed in two replicates.

Sensory analysis of fresh breads was carried out using a 5-point hedonic scale scoring 1 (lowest) to 5 (highest). Sensory evaluation was performed by 10 trained panelists. Six attributes of bread, i.e., volume, aspect of crust, color of crumb, crumb porosity, texture and flavor were selected. For each of the attributes, the average of the panelist scores was calculated.

Statistical analysis

Analysis of variance is a statistical technique applied to solve such situations, by the achievement of a study on the simultaneous activity of several variability factors and pointing out in the same time their interactions [18, 19].

It was intended to establish how the factors A and B act on the character X by applying Fisher test. This involves the calculation of a value based on experimental observations, which is compared with a theoretical value corresponding to a particular confidence probability. If the experimental value is greater than the tabular one, then the influence of the factor on the studied character is significant. The values involved in the problem of bifactorial variance analysis for finding the experimental value, noted F_{exp} , can be arranged in a table [18, 19].

Results and Discussion

The physicochemical characteristics of the wheat samples are presented in Table 1 and compared with the recommended values in quality standards of wheat for bread making.

Table 1. The physico-chemical indices of conventional and organic wheat samples from the crop of year 2010

Wheat samples	Moisture content %	Mass per hectoliter kg/hl	Protein content % d.m.*	Gluten content %	Deformation index mm	Gluten index	Falling number seconds	Zeleny index ml
Conventional	10.28	75.50	13.81	26.76	3.90	89	210	31
Organic	10.21	73.0	10.59	11.90	1.00	96	90	19

* *d.m.* - dry matter

The moisture contents of the wheat samples, both organic and conventional, are smaller than the maximum recommended value of 14%, which can be explained through the fact that the samples were stockpiled for a longer in a silo.

The mass per hectoliter, which influences the flour efficiency and gives information on the general quality of the wheat, was between 73-76 kg/hl, which represents a satisfactory quality comparing with the value of 78 kg/hl for a very good quality.

The conventional wheat sample had good wet gluten content, 26.76%, as the minimum recommended value is 22%. However, the organic wheat sample had lower wet

gluten content, only 11.9% [20, 21, 22, 23]. The wet gluten content is correlated with the protein content, which was lower for organic samples than for conventional ones. Also, the deformation index was lower for organic samples, showing gluten with high elasticity and low extensibility. A deformation indexes around 5-13 mm shows a good quality of gluten. So, the conventional samples with 3.9 mm gluten deformation showed a relatively good quality of gluten, while the organic sample with a deformation index of 1 mm denotes highly non-elastic gluten.

The falling number, which has an optimal value between 220-260 seconds, was much lower for the organic wheat samples than the conventional ones, which demonstrates a more intense α -amylase activity. As the organic samples had a very low falling number, 90 seconds, it can be considered unsatisfactory for bread making [20, 21, 22, 23].

The sedimentation value according to the Zeleny index describes the sedimentation degree of a flour sample, suspended in a lactic acid solution in a standard amount of time. This experiment is a measure of the bread making quality. The swelling of the gluten fraction in lactic acid solution affects the sedimentation degree. The wheat with high gluten content and a higher quality will have a slower sedimentation and higher values of the Zeleny test. The sedimentation value is influenced by the protein content in the wheat and it is correlated with the protein content, wheat hardness and bread volume. Wheat with a Zeleny index between 22 and 30 ml is considered acceptable in bread making [11, 20, 21].

The physic-chemical characteristics of the flour samples are presented in Table 2 and compared with the recommended values in quality standards of flours for bread making.

Table 2 The physic-chemical indices of conventional and organic flour samples from the crop of year 2010

Flour samples	Moisture content %	Ash content %	Protein content % d.m.*	Gluten content %	Deformation index mm	Gluten index	Falling number seconds	Zeleny index ml
Conventional	10.40	0.35	10.56	26.75	2.0	98	237	34
Organic	10.11	0,36	7.95	14.7	2.5	100	136	23

The moisture content of organic flour samples (10.11%) is slightly lower than the conventional ones (10.4%) but they are in the limits of the standard (maximum allowed value for water content is 14.5%). Both flour samples, resulted from the milling of the wheat grains, had ash content close to 0.35%, being considered white flours. The minimum protein content for a flour to be used in bread making is 7%. In our case, both flour samples had a protein content that fitted into the allowed limits, but it is obvious that the organic flour had a much lower content than the conventional one.

In consequence, the gluten content followed the same observation: the gluten content was very low for the organic flour in comparison with the standard quality values for bread making flour. The deformation index was relatively low, with a similar value for both flour samples, but in the limits of standard for bread making. The optimal values of the gluten index are between 65 and 80. In our case, for both flour samples the gluten index was above 80 which indicated a good gluten, but very elastic. The falling number was optimal for the conventional flour sample and a bit lower for organic flour samples, which showed an intense α -amylase activity.

The Zeleny index was a bit low but into the normal limits [11, 20, 21]. The rheological indicators obtained from the readings on the farinograms for both organic and conventional flour samples, resulted from the wheat crop of year 2010, are presented in Figures 1(a) and 1(b). The farinographic method gave information about the quality of the flour samples using constant consistency dough set at 500 Brabender units (U.B.).

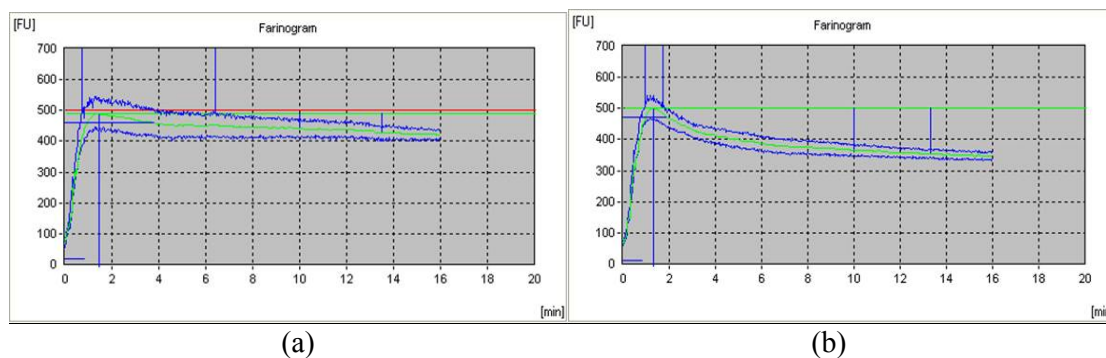


Figure 1 Farinograms of conventional flour (a) and organic flour (b)

The rheological analysis of the flours showed that the two types of flour samples had a similar - hydration capacity of approximately 60% and a relatively short development time of 1.3-1.5 minutes. The kneading stability of conventional flour was relatively low, 5.7 minutes, while the organic flours stability was very low, only 0.8 minutes. This result was in accordance with the extremely high soaking index for organic flour samples of 135 farinographic units compared with only 47 farinographic units for conventional samples. The power of flour samples characterizes the technological behavior and the obtaining of dough that holds its shape and retains gases, so it will be elastic and extensible enough to be stretched into films under the action of fermentation gases. The total power of organic flour was much smaller - 19, than the one for conventional flour-38. The quality of both flour samples can be considered poor on the basis of farinographic indices.

Table 3. The physic-chemical indices of organic and conventional breads

Bread samples	Conventional	Organic
Mass, kg	0.555	0.546
Moisture content, %	43.61	43.89
Volume, cmc/100g	315	337
Diameter, mm	15.4	15.65
Height, mm	9.7	10
Height/Diameter	0.63	0.64
Porosity, %	80.2	83.97
Elasticity, %	97	95
Acidity, grades	0.8	0.8

The conventional and organic bread samples had similar physical-chemical characteristics. The organic bread had a slightly larger volume and a better porosity, but the conventional bread had a more elastic crumb. From a sensorial point of view, the organic bread had a visibly larger volume, a patchy and pleasant color of the crust, a color of the crumb of a slightly grayish white and so a score of 90 close to the conventional breads score of 91 [24]. The sensorial attributes of the baked products are described using the spider diagrams in Figure 2.

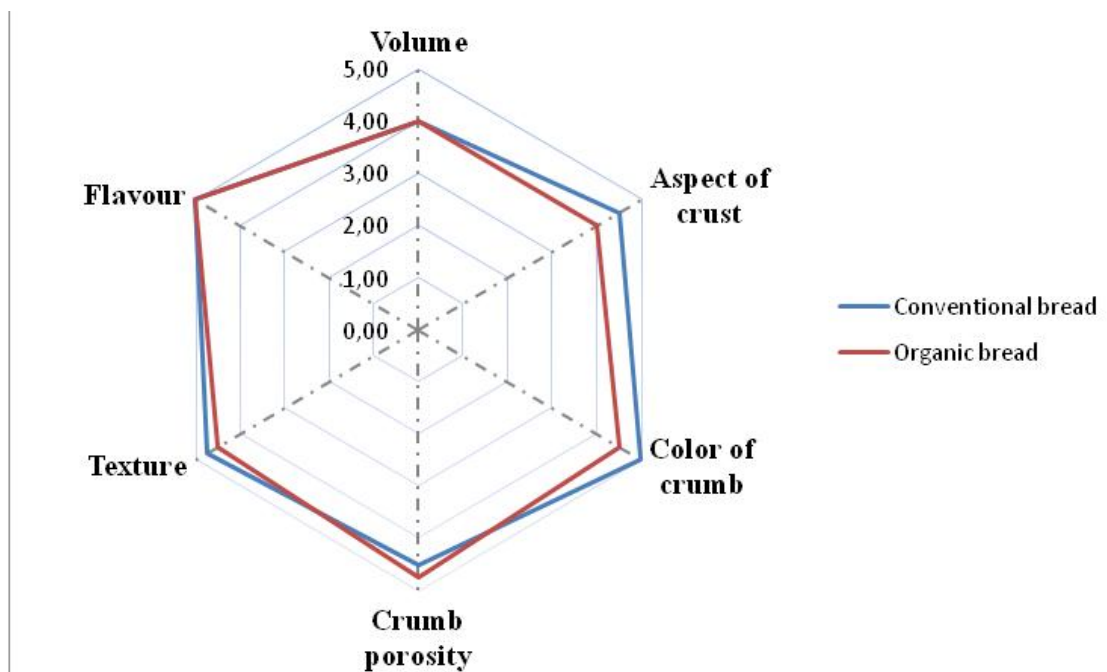


Figure 2. Sensorial “spider diagrams” of the bread samples

Results from using the Fisher test and bifactorial dispersion analysis for two factors of variability were considered, with $m = 3$, respectively $n = 4$ variants each are presented in Table 4.

Table 4. The experimental values for factors A, B, X_i and Y_j by applying the Fisher test

	Moisture % (A_1)	Protein % (A_2)	Gluten % (A_3)	\bar{Y}_j
Conventional grain (B_1)	10.28	13.81	26.76	16.95
Organic grain (B_2)	10.21	10.59	11.90	10.9
Conventional flour (B_3)	10.40	10.56	26.75	15.90
Organic flour (B_4)	10.11	7.95	14.7	10.92
\bar{X}_i	10.25	10.72	20.02	

The application of described statistical method for the existing experimental data, has conducted to the following result: if the risk is considered $\alpha = 5\%$, the superior limit of Fisher test is 9.55. Results of the bifactorial dispersion analysis can be found in Table 5.

Table 5. Bifactorial dispersion analysis

Sources of variation	Sum of square	Degrees of freedom	Variances	F
A	$SPA_A = 3 \sum_{j=1}^4 (X_j - \bar{X})^2 = 182.1$	$GL_A = (m-1) = 3-1=2$	$S_A^2 = SPA_A / GL_A = 91.05$	$F_{\text{expA}} = \frac{S_A^2}{S_B^2} = 2.71$
B	$SPA_B = 4 \sum_{i=1}^3 (Y_i - \bar{Y})^2 = 123.76$	$GL_B = (n-1) = 4-1=3$	$S_B^2 = SPA_B / GL_B = 41.25$	$F_{\text{expB}} = \frac{S_A^2}{S_B^2} = 1.68$
T	$SPA_T = \sum_{i=1}^3 \sum_{j=1}^4 (X_{ij} - \bar{X})^2 = 452.92$	$GL_T = m*n-1 = 3*4-1=11$		
R	$SPA_R = SPA_T - SPA_A - SPA_B = 147.06$	$GL_E = (3-1)(4-1) = 6$	$S_R^2 = \frac{SPA_R}{GL_R} = 24.51$	

Conclusions

In this study on the bread making quality of Romanian wheat type BOEMA from the crop of year 2010, the results showed that the quality of the organic wheat, organic flour and organic bread was lower than the quality of conventional products. However, the consumer purchasing behavior is more influenced by the health and safety aspects of the food products and less by the aspect of the product. Also, consumers choose is linked to their income and the prices of the organic food products. The study will continue with the analysis of the safety aspects of the organic wheat and the derivatives.

Because the experimental values $F_{\text{expA}} = 3.71$ and $F_{\text{expB}} = 1.68$ of Fisher test after processing observation data (in table dispersion analysis) are smaller than the tabular value (9.55), than the influence of considered indicators (humidity, protein, gluten) for different types of grain and flour (conventional or organic) has no statistically significant difference.

Acknowledgements

The research is part of the project CONSUMECO, contract 92-075/2008, financed by the Romanian Executive Agency for Finance of Higher Education, Research, Development and Innovation during 2008 – 2011.

References

1. HUSSAIN, H. LARSSON, R. KUKTAITE, M.L. PRIETO-LINDE AND E. JOHANSSON, Protein content and composition in organically grown wheat: influence of genotype, *Agronomy Research* 7 (Special issue II), (2009) 599–605
2. P. MÄDER, D. HAHN, D. DUBOIS, L. GUNST, T. ALFÖLDI, H. BERGMANN, M.OEHME, R. AMADÓ, H. SCHNEIDER, U. GRAF, A. VELIMIROV, A. FLIEBBACH, U. NIGGLI, Wheat quality in organic and conventional farming: results of a 21 year field experiment, *Journal of the Science of Food and Agriculture*, Volume 87, Issue 10, (2007), pages 1826-1835,
3. N.L., KENT, A.D., Evers, *Technology of cereals: an introduction for students of food science and agriculture*. 4th ed. New York : Pergamon. p 334, ISBN 0080408338 (1994)
4. E. JOHANSSON, G. SVENSSON, Variation in Bread-Making Quality: Effects of Weather Parameters on Protein Concentration and Quality in some Swedish Wheat Cultivars Grown during the Period 1975 - 1996, *Journal of the Science of Food and Agriculture*, Volume 78, Issue 1, (1999)
5. A.K. UHLEN, S. SAHLSTRØM, E. M MAGNUS, E. M FÆRGESTAD, J. A. DIESETH, K. Ringlund, Influence of genotype and protein content on the baking quality of hearth bread, *Journal of the Science of Food and Agriculture*, Volume 84, Issue 8, (2004) pages 887 – 894,
6. RAMUNĖ KUKTAITĖ, Protein Quality in Wheat: Changes in Protein Polymer Composition during Grain Development and Dough Processing, *PhD Thesis*, Swedish University of Agricultural Sciences Alnarp (2004)
7. D. BORDEI, Modern technology of baking, Ed. Agir, Bucharest, Romania (2004) (in Romanian).
8. D. BORDEI, Quality control in the baking industry, Ed. Academica, Galati, Romania (2007) (in Romanian).
9. ICC 155-94 – Wet gluten determination using mechanical method
10. ISO 20483:2006 - Cereals and pulses -- Determination of the nitrogen content and calculation of the crude protein content - Kjeldahl method
11. ISO 5529:2007 - Wheat - Determination of the sedimentation index - Zeleny test
12. SR 90:2007 – Wheat. Analytical methods
13. ISO 21415-2:2008 - Wheat and wheat flour - Gluten content
14. ISO 712:2009 - Cereals and cereal products - Determination of moisture content - Reference method
15. ISO 7971-3:2009 - Cereals - Determination of bulk density, called mass per hectolitre
16. ISO 3093:2009 - Wheat, rye and their flours, durum wheat and durum wheat semolina - Determination of the falling number according to Hagberg - Perten
17. ISO 712:2009 - Cereals and cereal products -- Determination of moisture content - Reference method

18. VARGA M., POPA C., TAMBA-BEREHOIU R., An application of variance analysis for establishing the effect of the saturated fats and of the manganese ions concentrations from the food ration on the cholesterol levels, *Romanian Biotechnological Letters*, Vol. 15, No. 6, (2010)
19. VARGA M., *Elements of Mathematics and Statistics with applications in biotechnology* Printech Ed., Bucharest, (2009), pp.199-204 (in Romanian).
20. RADUCANU A., Research regarding maithe use of dietary fiber in bakery products, *PhD Thesis*, University of Agronomic Sciences and Veterinary Medicine Bucharest, Faculty of Agriculture, Bucharest, Romania (2008) (in Romanian).
21. C. Mosoiu, Researches regarding assurance of ecological food – feed resources through the wheat culture system in Campia Romana, *PhD Thesis*, University of Agronomic Sciences and Veterinary Medicine Bucharest, Faculty of Agriculture, Bucharest, Romania (2010) (in Romanian).
22. Commission Regulation (EC) No 1881/2006 (<http://eur-lex.europa.eu/>).
23. Health Ministry Order 975/1998, Romania (<http://www.cdep.ro>)
24. L.E. Annett, D. Spaner, W.V. Wismer, Sensory Profiles of Bread Made from Paired Samples of Organic and Conventionally Grown Wheat Grain, *Journal of Food Science*, Volume 72, Issue 4, (2007), pages S254 – S260.