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Investigation in Physically-Chemical Parameters of in Latvia Harvested Conventional and Organic Triticale Grains

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Abstract**—**Triticale is a manmade hybrid of wheat and rye that carries the A and B genome of durum wheat and the R genome of rye. In the scientific literature information about in Latvia harvested organic and conventional triticale grain physically-chemical composition was not found in general. Therefore, the main purpose of the current research was to investigate physically-chemical parameters of in Latvia harvested organic and convectional triticale grains. The research was accomplished on in Year 2012 from State Priekuli Plant Breeding Institute (Latvia) harvested organic and conventional triticale grains: "Dinaro", "9403-97", "9405-23" and "9402-3". In the present research significant differences in chemical composition between organic and conventional triticale grains harvested in Latvia was found. It is necessary to mention that higher 1000 grain weight, bulk density and gluten index was obtained for conventional and organic triticale grain variety "9403-97". However higher falling number, gluten and protein content was obtained for triticale grain variety "9405-23".

Keywords**—**Physically-chemical parameters, technological properties, triticale grains.

I. Introduction

CEREAL-BASED foods have been staples for humans for millennia. Cereal grains contain the macronutrients (protein, fat and carbohydrate) required by humans for growth and maintenance. They also supply important minerals, vitamins and other micronutrients essential for optimal health. However, it is becoming apparent that cereals in general have the potential for health enhancement beyond the simple provision of these nutrients and that their consumption can lower the risk of significant diet-related diseases quite substantially. This is an important attribute given the social and personal impact of these conditions [1].

Triticale (Triticosecale) is a man-made hybrid of wheat and rye that carries the A and B genome of durum wheat and the R genome of rye. Triticale is intended to combine the high yield potential and good grain quality of wheat with the disease resistance and environmental tolerance of rye, including winter hardiness. It can be grown in poor soils, giving high yield where wheat does not perform well. Triticale is mainly used as an ingredient in animal feed, but also on a smaller scale as a food ingredient, for example in bread [2].

Up to now, triticale is very little studied as healthy food. Triticale (X Triticosecale Wittmack) is a man-made cereal grain species resulting from a plant breeder's cross between wheat (Triticum) and rye (Secale). Historically, triticale (X Triticosecale Wittmack) incorporating the functionality and high yield of wheat and the durability of rye, has mostly been used as animal food. Therefore, in the literature, one can find research data on the growing conditions of triticale and on its uses for animal feeding, but less is known about the use of triticale in the human diet. Some investigations indicate that triticale has potential for use in bread production. However, because most of the varieties available are not suitable for leavened bread making on their own, due to the production of a weak and sticky gluten, they can only be successfully used for producing a range of unleavened products such as cakes, cookies, biscuits, waffles, noodles, pastas and breakfast cereals. Recently, efforts to enlarge food resources have resulted in new approaches to expanding triticale's applicability for human consumption. For example, certain triticale varieties have been used to produce bread of acceptable quality under special bread making conditions [3].

Triticale's properties for milling and baking, the two main uses of its parent species, have been examined widely. Some studies have shown that triticale flours produce weak dough due to its low gluten content, weak gluten strength and high levels of alpha-amylase activity. Potential of triticale as a substitute in wheat tortilla production has been reported. Triticale flour significantly reduced optimum water absorption and mixing time of tortilla dough, concluding that a proportion of 50:50 (wheat–triticale) flour mix produced dough with acceptable rheological properties and good quality tortillas. Triticale could be acceptable as a partial substitute of corn for making tortillas, because gluten protein-related factors, which are deficient in triticale, are not critical for the development of tortilla characteristics. In that sense, the aim of this research was to evaluate the effect of triticale flour as a partial substitute for commercial nixtamalized corn flour on some functional properties of dough and tortillas [4].

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Since the beginning of the 21st century, the development of organic farming worldwide has showed a strong growth. Almost 23 million hectares are managed organically worldwide in 2002. Compared to 2000 this is an increase of 31.4% [5]. Agriculture is multifunctional, it provides food, water and other biological goods, and influences the environment, biological diversity, recreation value, and landscape aesthetics. Increasing intensity of agricultural practices in the last decades caused environmental problems such as water contamination, soil degradation, and biodiversity losses. Organic and low-intensity farming systems are reported to produce food in a more sustainable way than conventional farming, are financially supported by the EU via agri-environmental schemes, and may contribute to the conservation of biodiversity [6].

In organic farming systems under temperate climatic conditions, cereals have lower yields compared with similar conventional systems. In organic cereal production, the management practices adopted to control weeds, pests and diseases and the optimization of nutrient availability to the crops determine to a large extent the yields obtained. As the best management practices for organic systems are still being tested for specific crop species and sites, there is a high potential to improve organic cereal grain yields. This is in contrast with the intensive systems using high amounts of fertilizers and pesticides, where evidences of yield stagnation are now being reported [7].

Conventional farming has played an important role in improving food and fiber productivity to meet human demands but has been largely dependent on intensive inputs of synthetic fertilizers, pesticides, and herbicides. Certain conventional farming practices and associated chemical inputs have raised many environmental and public health concerns. Prominent among these are the reduction in biodiversity, environmental contamination, and soil erosion. Public concerns over environmental health and food quality and safety have led to an increasing interest in alternative farming practices with both lower inputs of synthetic chemicals and greater dependence on natural biological processes [8].

In the scientific literature information about in Latvia harvested organic and conventional triticale grain physically-chemical composition was not found in general. Therefore, the main purpose of the current research was to investigate physically-chemical parameters of in Latvia harvested organic and convectional triticale grains.

II. Materials and Methods

A. Materials

The research was accomplished on in Year 2012 from State Priekuli Plant Breeding Institute (Latvia) harvested organic and conventional triticale grains: “Dinaro”, “9403-97”, “9405-23” and “9402-3”.

For the determination of grain technological properties they was ground in laboratory mill *Hawos* (Hawos Kornmuhle GmbH, Germany) obtaining fine whole grain flour.

B. Protein, Starch, Bulk Density

For measurement of protein, starch content and bulk density in triticale grains an *Infratec*^{TM} model 1241 Grain Analyzer from Foss Tecator AB has been used for the spectroscopic investigations of the grain samples according to ISO 12099. The instrument had an extended wavelength range of 570–1100nm. Ten subsamples of whole kernels were scanned for each grain sample [9].

C. Thousand-Grain Weight

Thousand-grain weight was measured in grams as the average weight of two different samples of 1000 grains from each line [10] according to the ISO 520:2010 standard method.

D. Falling Number

The Falling number of grains was analysed using standard Hagberg-Perten method [11] according the ISO 3093:2009.

E. Gluten

Gluten content was analyzed using standard method *Glutomatic* (Sweden) equipment [12].

F. Moisture

Moisture content of flour samples was determined using air-oven method [13] according AACC method 44-15A from 2000.

G. Mathematical Data Processing

Data are expressed as mean ± standard deviation; for the mathematical data processing p-value at 0.05 (One Way analysis of variance, ANOVA), was used to determine the significant differences. In case of establishing statistically significant differences, homogeneous groups were determined by Tukey’s multiple comparison test the level of confidence $\alpha=0.05$. The statistical analyses were performed using Microsoft Excel 2007.

III. Results and Discussion

A. Physically-Chemical Parameters

The nutritional value of triticale is close to that of wheat and rye. Triticale flours have been found suitable for the manufacture of products like cookies and crackers. Triticale flours have similar values of free sulfhydryl groups than those reported in wheat. Although triticale can be a suitable grain for human diet, the overall food market for triticale has remained very small [14].

The starch composition of cereal grains plays a major part in the digestibility and bread-making quality of flour. In general, lower starch amylose content corresponds to higher peak viscosity of paste, lower peak viscosity temperature and greater resistance to retrogradation [15]. There are not found significant differences ($p=0.118$) in starch content between analyzed organic and conventional triticale grains samples (Table I). The content of starch range from 78% to 83% in general. Obtained results are very close with starch content in whole rye flour (75.9%) and white wheat flour (73.9%) [16], what mainly could indicate on good brad-making properties of analyzed triticale grain.

TABLE I
PHYSICALLY-CHEMICAL PARAMETERS OF TRITICALE GRAINS

Grain variety	Parameter				
	Moisture %	Starch % in dry matter	Protein % in dry matter	1000 grain weight, g	Bulk density kg/hL
Conventional					
“Dinaro”	15.5±0.1	81.2±1.1	13.1±0.1	39.1±2.1	676±7
“9403-97”	14.7±0.2	78.1±2.1	13.4±0.1	51.3±3.4	715±4
“9405-23”	14.9±0.2	78.1±1.3	14.3±0.1	39.1±1.2	692±4
“9402-3”	15.2±0.1	79.6±2.8	13.3±0.1	34.7±2.2	654±9
Organic					
“Dinaro”	14.6±0.1	82.3±1.1	10.4±0.1	40.9±1.1	709±4
“9403 97”	14.2±0.1	80.9±2.1	10.8±0.1	53.6±1.9	749±6
“9405 23”	15.0±0.2	81.3±1.8	12.4±0.1	43.8±3.1	748±6
“9402-3”	14.9±0.1	82.9±1.8	10.6±0.1	41.0±1.4	709±9

Because of cereal different production systems and levels of fertilizer use, it is difficult to obtain comparative values for the protein contents of different cereals. However, consideration of values reported indicates that relatively small differences exist within and between species and that these are amplified by environmental factors. Thus, ranges of 5.8–7.7% of protein on a dry weight basis have been quoted for rice; 8–15% for barley, 9–11% for maize [17], 10–14% for wheat [18], 8–13% for rye [19]. It is necessary to mention that significant differences ($p=0.004$) was obtained in protein content of analyzed organic and conventional triticale grains (Table I). Higher protein content was obtained in conventional grains, what mainly could be explained with possible fertilizer use for soil fertilization. However higher protein content as 14.3 and 12.4% was obtained in variety “9405-23” conventional and organic triticale grains respectively (Table I). Obtained results are very close to previously described data from scientific literature.

Grain weight (GW), one of the three main agronomic (or numerical) components of grain yield in cereals, is among the traits already involved in the emergence of agriculture and crop domestication. Automatic selection due to planting and harvesting seeds of cereals may have increased seedling vigour through an increase in seed size [10], [20]. In the present experiments significant differences ($p=0.557$) were found in 1000 grain weight of analyzed conventional and organic grains. The 1000 grain weight of organic grains was higher comparing to conventional grains (Table I). However, very similar results was obtained for variety “9403-97” organic and conventional triticale grains as 51.3 and 53g respectively ($p=0.004$). Lower 1000g weight mainly indicates not complete grain turgescence, what mainly could influence grain future quality parameter dynamics.

Bulk density is a direct measure of the closeness of packing of particles in a defined volume; it depends on the local conditions when the measurement is made, and unlike a density or the skeletal density of a specified material, does not have a unique value [21]. Higher bulk density was obtained for organic triticale grains (Table I). In the scientific literature different data was mentioned on bulk density of several types of grains for example: for barley minimally 60.5kg/hL, for rye – 72.1kg/hL, for wheat – 77.2kg/hL [22]. Within present experiments significant differences ($p=0.001$) was obtained in bulk density of conventional and organic grains, what mainly could be explained with variety properties and growing conditions.

The Falling Number System measures the effected of α-amylase enzyme activity in grain meal to detect sprout damage and guarantee the soundness of treated grains [23]. Low falling number is generally associated with pre-harvest sprouting; however, it is now clear that there are a number of additional causes of low falling number [24]. It is high falling number – low α-amylase activity and against low falling number – high α-amylase activity. In the present research higher falling number was obtained for organic triticale grains, what was significantly higher ($p=0.008$) comparing to falling number of conventional grains (Table II).

TABLE II
FALLING NUMBER, GLUTEN CONTENT AND GLUTEN INDEX OF TRITICALE GRAINS

Grain variety	Parameter		
	Falling number, s	Gluten content, %	Gluten index, unit
Conventional			
“Dinaro”	62±1	13.2±0.8	97±2
“9403-97”	62±1	9.2±0.5	99±1
“9405-23”	70±1	23.6±0.4	64±1
“9402-3”	63±1	15.5±0.8	96±2
Organic			
“Dinaro”	83±1	7.1±0.9	99±4
“9403-97”	62±1	5.1±0.5	99±1
“9405-23”	93±1	16.2±0.6	68±5
“9402-3”	101±1	7.5±0.1	99±2

For wheat grains generally, a falling number value of 350 seconds or longer indicates a low enzyme activity and very sound wheat quality; values below 200 seconds indicate high levels of enzyme activity [25]. In the European Community, rye is defined according to the support criteria as having a Falling Number of least 120s, however the Falling Number for bread rye are about 120 to 130s [23]. In scientific literature is mentioned, that the Falling Number of triticale grain range from 70 to 62s [26] what is very similar to obtained results in the present research (Table II). Higher Falling number was obtained for organic “9402-3” as 101s and conventional “9405-23” as 70s triticale grains what mainly could indicate lower α-amylase activity.

Gluten is mainly composed of monomeric gliadins and polymeric glutenins responsible for viscous and elastic properties, respectively. Gluten, isolated gliadin and glutenin fractions or various mixtures of them provide a large range of starting materials for food and non-food use [27]. Different varieties of each grain will also vary in their gluten content. Flour made with a type of wheat called hard wheat contains 12% to 14% gluten by weight. Bread flour is lower, at 10% to

13%. All-purpose flour contains 9% to 12% [28]; however wheat grains contain glutin ~28%, rye – 5.3–9.3% [29], [30]. In the present research higher gluten content was obtained in conventional triticale grains (Table II) especially in variety "9405-23" what mainly could be explained with variety genotype and growing conditions mainly fertilizers use.

The gluten index (GI), traditionally, is a measurement of wheat protein that provides a simultaneous determination of gluten quality and quantity. The GI value expresses the weight percentage of the wet gluten remaining on a sieve after automatic washing with salt solution and centrifugation. Wheat with GI < 40 is classified as feed wheat, bringing a lower price than bread-making wheat. In addition, there are penalties for the 40–55 GI class, while the 55–100 GI class is considered suitable for bread-making [31]. In experiments obtained gluten index of analyzed triticale varieties was very high for conventional and organic grains as ~99 units (Table II), except organic and conventional triticale grains "9405-23". Therefore for analyzed triticale grains good bread-making properties could be foreseeing.

IV. Conclusions

In the present research significant differences in chemical composition between organic and conventional triticale grains harvested in Latvia was found. It is necessary to mention that higher 1000 grain weight, bulk density and gluten index was obtained for conventional and organic triticale grain variety "9403-97". However higher falling number, gluten and protein content was obtained for triticale grain variety "9405-23".

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