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The Biochemical Composition And Correlation Estimates For Grain Quality In Maize

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Abstract

In the present study the nutritional characteristics of corn hybrids (*Zea mays L.*) were determinated in order to identify different correlations between them. The experimental material comprised 19 varieties of seeds created at ARDS Turda, Romania. In the agricultural year of 2011/2012 an experiment was conducted in Cluj-Napoca, Romania, with the objective to determin the quality level of maize hybrids and realtionships between traits. Significance between individual means was identified using the Pearson's multiple range test. Mean differences were considered significant at $p<0.05$. Positively correlation existed between ash content and protein content and test weight as well as between protein content and 1000 kernels weight among tested corn hybrids. Negatively correlation existed between grain starch and protein content as well as starch and ash content.

Keywords: *Zea mays L.*, hybrids, correlation, quality

1. Introduction

It is estimated that more than half of the increased demand for cereals as a whole will come from maize farmers and consumers [19]. Some breeding programs are routing the specific traits for different usage of maize grain, such as increasing of oil, protein or starch content in grain [6,11,13,14].Cereals are predominantly composed of carbohydrates, mostly in the form of starch, with considerable amounts of protein as well as some lipids, minerals [2] and crude fibre. Because maize is a relevant food source, the quantification of the grain constituents with a nutritional role is important for the best exploitation of the different genotypes [3].

In this context, the traditional germplasm represents a good source of genetic variability to explore and may help to identify the most suitable materials for the development of more nutritious food [17]. The protein content is a quantitative trait and several studies have pointd out that there is a great number of genes involved in it's control. Protein is an expensive but necessary constituent of both food and feed [1].

Starch is a reserve polysaccharide occurring in granular form in higher plants and provides 70-80% of the calories consumed by human's worldwide [4]. Among all kinds of starches, maize starch is a valuable ingredient in the production of food, making up more than 80% of the world market for starch [7,15].

The objective of this study was to establish the quality level of maize hybrids. The relationships between traits have been examined by Pearson's

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correlation coefficients (r). Seed quality is one of the primary factors which affecting yield agricultural production crops.

2. Materials and methods

Raw Materials. The experimental material used in this study consisted of 19 maize genotypes from Agricultural Research and Development Station Turda. The experiment was carried out during two seasons 2011 and 2012. After harvest, samples were taken for chemical analysis. The physical-chemical quality tests were conducted in Food Quality Control laboratory, Department IPA of UASVM Cluj – Napoca. All chemicals were obtained from Sigma-Aldrich or Merck (Darmstadt, Germany).

*Chemical analyses.*The protocol used for the moisture content determination was based on the method prescribed by SR EN ISO 6540/2010 [20]. Test weight was determinated in accordance with the reference method SR EN ISO 7971-1/2010 [21]. Thousand seeds weight is very important parameter to study the net productivity of hybrids corn. The seeds were counted and their mass was measured with help of electronic balance (SR EN ISO 520/2011) [22]. Protein content was determined by available nitrogen in sample by Kjeldhal, method SR EN ISO 5983-1/2006 [23]. One gram sample was digested in 20 ml sulphuric acid, at 400ºC using copper sulfate and potassium sulfate as catalyst mixture. Digested sample was distilled using 33-35% NaOH. Nitrogen is converted to ammonia, which is distilled and titrated with 0.1 N HCl to estimate the protein content. Crude protein content was estimated using a conversion factor of 6.25 for corn. Crude fat was extracted with petroleum ether by a Soxhlet apparatus. The fat content is calculated from the difference between the initial sample weight and the weight of the dried residue after extraction. The results are expressed as percentage (%) of total fat (SR EN ISO 6492:2001) [24]. Ash contents of each sample was determined by the interaction of dried sample in an electric muffle furnace at 550°C until the residue obtained was of grey colour and calculated (SR EN ISO 2171:2010) [25]. Crude fiber was determinated by using SR EN ISO 6865:2002 [26]. All nutritional components of the sample, except pulp, are solubilised by boiling successively with sulfuric acid solution and sodium hydroxide. The residue is filtered, dried and weighed ash. The starch content was determined by Ewers polarimetric method, was used International Standard, ISO 10520:1997 [27].

Statistical Analysis. The data reported in all the tables are the average for two experimental years. For each year, the samples were performed in triplicate and were subjected to two-way analysis of variance (ANOVA). Test of difference significance between genotypes were estimated by LSD. Pearson correlation coefficients (r) for the relationships between all traits were also calculated using Statistical Package for the Social Sciences (SPSS) Software, version 19.

3. Results and discussions

We have considered the average of quality indices which are significant when evaluating the quality of maize hybrids over two experimental years (2011-2012). As shown by the data generated from the analysis of polyfactorial variance (Table 1), weight test, thousand kernel weight of the seed, protein content, oil and starch content were influenced distinctively and significantly, in a positive way, by genotype, pedoclimatic conditions of the two experimental years, respectively. The crude fiber content is influenced firstly by genotype and secondly by pedoclimatic conditions, except for ash content which is not significantly influenced by pedoclimatic conditions.

Table 1. Analysis of variance for quality indices of traditional maize hybrids in a polyfactorial experiment.

Cause of variability	Weight test (kg/hl)	1000 kernel weight (g)	Protein content (%)	Oil content (%)	Ash content (%)	Crude fiber content (%)	Starch content (%)
Years (A)	**	**	**	**	-	*	**
Genotypes (G)	**	**	**	**	**	**	**

Table 2. The influence of variety on the grain quality traits (ARDS Turda, 2011-2012)

Crt. no.	Variety	Grain type	Weight test (kg/hl)	1000 kernel weight (g)	Protein content %	Oil content %	Ash content %	Crude fiber content %	Starch content %
1.	HST 129	dent	72.98^{000}	254.00^{000}	8.73^{000}	3.99^{000}	1.40^{000}	3.00^{***}	61.17^{00}
2.	Turda 165	dent	76.47^{***}	298.00^{ns}	9.71^{000}	4.62^{***}	1.43^{00}	1.35^{000}	60.02^{000}
3.	Turda 213	dent	78.80^{***}	295.17^{00}	10.98^{***}	4.48^{ns}	1.44^{0}	2.34^{***}	59.22^{000}
4.	Turda Star	semi-dent	77.68^{***}	286.83^{000}	9.49^{000}	4.02^{000}	1.43^{0}	1.65^{000}	58.96^{000}
5.	Turda Favorit	semi-dent	79.00^{***}	320.83^{***}	10.94^{***}	4.21^{000}	1.44^{0}	1.75^{000}	59.58^{000}
6.	Turda Mold 188	dent	74.88^{000}	280.50^{000}	9.59^{000}	4.58^{**}	1.37^{000}	1.71^{000}	62.06^{ns}
7.	HST 132	semi-dent	75.95^{ns}	306.17^{ns}	9.76^{000}	4.17^{000}	1.52^{*}	3.16^{***}	60.47^{000}
8.	HD 115	flint	76.53^{***}	321.83^{***}	10.17^{000}	4.13^{000}	1.40^{000}	2.60^{***}	63.43^{***}
9.	Elan	semi-dent	78.37^{***}	300.83^{ns}	10.99^{***}	4.05^{000}	1.38^{000}	3.19^{***}	62.17^{*}
10.	Turda 215	flint	78.60^{***}	281.17^{000}	9.43^{000}	4.27^{000}	1.38^{000}	2.83^{***}	63.27^{***}
11.	Turda 100	flint	76.83^{***}	295.67^{00}	11.43^{***}	4.06^{000}	1.53^{**}	2.92^{***}	61.15^{00}
12.	Turda SU 181	flint	76.52^{***}	294.17^{000}	10.12^{000}	4.04^{000}	1.43^{00}	2.11^{***}	62.62^{***}
13.	HS 105	dent	73.82^{000}	310.67^{***}	10.77^{***}	4.04^{000}	1.44^{0}	1.77^{000}	61.32^{0}
14.	Turda 248	dent	74.95^{00}	289.50^{000}	8.37^{000}	4.05^{000}	1.47^{ns}	1.75^{000}	63.90^{***}
15.	HST 131	semi-dent	70.95^{000}	301.33^{ns}	8.05^{000}	3.72^{000}	1.34^{000}	3.30^{***}	63.71^{***}
16.	Turda 260	dent	78.87^{***}	282.83^{000}	10.88^{***}	3.80^{000}	1.48^{ns}	2.60^{***}	63.00^{***}
17.	Turda 201	dent	76.65^{***}	297.83^{ns}	9.27^{000}	3.86^{000}	1.42^{000}	2.36^{***}	62.07^{ns}
18.	Turda 145	dent	77.28^{***}	292.33^{000}	9.66^{000}	5.02^{***}	1.43^{00}	2.78^{***}	62.11^{*}
19.	Turda 200 (Mt.)	dent	75.65	301.83	10.33	4.49	1.48	1.99	61.72
	LSD (p 5%)		0.44	4.37	0.08	0.06	0.03	0.06	0.36
	LSD (p 1%)		0.59	5.82	0.11	0.08	0.05	0.07	0.47
	LSD (p 0.1%)		0.76	7.53	0.15	0.11	0.06	0.10	0.61

The significance of effect: ns not significant, * significant positive, ** significant distinct positive, *** very significant positive, ^{0}significant negative; ^{00} significant distinct negative, ^{000} very significant negative

Table 3. Phenotypic correlations between grain quality traits for crop year 2011

Trait	Moisture content (%)	Weight test (kg/hl)	1000 kernel weight (g)	Protein content (%)	Oil content (%)	Ash content (%)	Crude fiber content (%)	Starch content (%)
Moisture content (%)	1.000							
Weight test (kg/hl)	0.141	1.000						
1000 kernel weight (g)	-0.067	0.361^{**}	1.000					
Protein content (%)	0.020	0.531^{**}	0.552^{**}	1.000				
Oil content (%)	-0.356^{**}	0.348^{**}	0.264^{*}	0.258	1.000			
Ash content (%)	0.018	0.026	0.073	0.029	-0.188	1.000		
Crude fiber content (%)	0.166	-0.090	0.119	-0.010	-0.083	-0.197	1.000	
Starch content (%)	0.121	-0.317^{*}	-0.122	-0.377^{**}	-0.162	-0.140	0.325^{*}	1.000

N = 57, *Correlation is significant at the 0.05 level/**Correlation is distinctly significant at the 0.01 level

Table 4. Phenotypic correlations between grain quality traits for crop year 2012

Trait	Moisture content (%)	Weight test (kg/hl)	1000 kernel weight (g)	Protein content (%)	Oil content (%)	Ash content (%)	Crude fiber content(%)	Starch content (%)
Moisture content (%)	1.000							
Weight test (kg/hl)	0.305*	1.000						
1000 kernel weight (g)	0.010	-0.132	1.000					
Protein content (%)	-0.149	0.341**	0.314*	1.000				
Oil content (%)	-0.370**	0.031	-0.105	0.096	1.000			
Ash content (%)	0.132	0.409**	0.149	0.678**	0.054	1.000		
Crude fiber content (%)	-0.192	0.024	0.125	0.012	0.137	0.100	1.000	
Starch content (%)	-0.084	-0.053	-0.233	-0.378**	-0.119	-0.342**	-0.061	1.000

N = 57 *Correlation is significant at the 0.05 level/**Correlation is distinctly significant at the 0.01 level

According to conducted research, the high values of the physical characteristics indicate a higher quality of maize grains (Table 1). Mean values for weight test per hybrid ranged from 70.95 kg/hl (HST 131) to 79 kg/hl (Turda Favorit). Out of the 19 maize hybrids studied, for 12 hybrids positive significant differences were observed in comparison with the control sample (Turda 200, 75.65 kh / hl) as follows: Turda Favorit (79 kg/hl), Turda 260 (78.87 kg/hl), Turda 213 (78.80 kg/hl), Turda 215 (78.60 kg/hl), Elan (78.37 kg/hl), Turda Star (77.68 kg/hl), Turda 145 (77.28 kg/hl), Turda 100 (76.83 kg/hl), Turda 201 (76.65 kg/hl), HD 115 (76.53 kg/hl), Turda SU 181 (76.52 kg/hl), Turda 165 (76.47 kg/hl). The weight of 1000 kernels varied upon maize hybrids from 254.00 g (HST 129) to 321.83 g (HD 115). The maize hybrids HD 115 (321.83 g), Turda Favorit (320.83 g), HS 105 (310.67 g) recorded values very significantly positive compared to the control sample, Turda 200 (301.83 g) (Table 2).

The second largest chemical component of the corn kernel is protein. In this study was visibly significant differences between all the samples for the main values obtained of protein content (Table 2). The mean values recorded for protein content were found in the range of 8.05 to 11.43%. Statistically, was recorded as very significantly positive at corn hybrids: Turda 213 (10.98%), Turda Favorit (10.94%), Elan (10.99%), Turda 100 (11.43%), HS 105 (10.77%) and Turda 260 (10.88%). This results are agreement with findings of Saleem et al. (2008) [13], Idikut et al. (2009) [6], Berardo et al. (2009) [3] and Ullah et al. (2010) [16]. Berardo et al. (2009) [3] collected 1245 maize varieties from different Italian regions as well as from other countries. He shows that procent protein content varied between 7.39 to 15.42%. Saleem et al. (2008) [13], Idikut et al. (2009) [6] and Randjelovic et al. (2011) [12], were found that hybrids had a significant effect on the protein content. Oil provides a concentrated source of energy for animals and therefore there is interest in increasing the oil content of maize grain to increase the caloric content of the grain [11]. Improving the quantity and quality of maize kernel oil content is consequently an important objective for the breeding programs. The quantity of triacylglycerol and the capacity of the triacylglycerol storage organ are the two key factors affecting oil accumulation in kernels [18].

Motto et al. (2011) [9] reported that the intensive use of the maize kernel is due not only to its high starch content, but also to the oil stored in the embryo. Oil, in fact, is the most valuable co-product from industrial processing of maize grain through wet milling or dry milling and iit represents a source of high-quality oil for humans. The mean value recorded for oil content were found in the range of 3.72 % (HST 131) and 5.02% (Turda 145) (Table 2). Similarly, Saleem et al. (2008) [13], KeShun Liu (2009) [8], Berardo et al. (2009) [3], Ullah et al. (2010) [16] and Ntuli et al. (2013) [10] reported the oil variation in maize flour ranged from 2.13 – 8.38%, 2.64 – 3.70%, 2.53 – 8.30%, 3.21 – 7.71%, 2.00 – 5.29 % respectively. The ash content of 19 maize hybrids ranged from 1.34% (HST 131) to 1.53% (Turda 100). Similar results (0.70 – 2.50%) for ash content in different maize hybrids were reported by Saleem et al. (2008) [13], KeShun Liu (2009) [8], Ullah et al. (2010) [16], Egesel and Kahriman (2012) [5] and Ntuli et al. (2013) [10]. The results of the present study show that HST 129, Turda 213, HST 132, HD 115, Elan, Turda 215, Turda 100, Turda SU 181, HST 131, Turda 260, Turda 201 and Turda 145 contain high crude fiber content of > 2%. The maize hybrids values have been very significantly positive as compared to control sample. The mean values recorded for crude fiber content were found in the range of 1.35% (Turda 165) to 3.30% (HST 131). The variation of the crude fiber content has been well demonstrated by numerous studies. Ullah et al. (2010) [16] raported the crude fiber variation in maize hybrids ranged from 0.80 to 2.32%.

As previously observed by several authors: KeShun Liu (2009) [8], Idikut et al. (2009) [6], Berardo et al. (2009) [3], Randjelovic et al. (2011) [12], Stevanović et al. (2012) [14] the starch content variability depended of the genotypes and the climatic conditions. The genotypes had a significant effect on the starch content. Therefore, the maize hybrids HD 115 (63.43%), Turda 215 (63.27%), Turda SU 181 (62.62%), Turda 248 (63.90%), HST 131 (63.71%), Turda 260 (63.00%) recorded values very significantly positive compared to the control sample, Turda 200 (61.72%).

Several positively and distinctly significant correlations between grain quality traits were observed (Table 3). Starch content was positively correlated to crude fiber ($r = 0.325$, $p < 0.05$). Protein content was positively and distinctly significant correlated to 1000 kernel weight and weight test ($r = 0.552$ and 0.531, respectively, $p < 0.01$). Weight test was observed to be positively correlated with 1000 kernel weight and oil content ($r = 0.361$ and 0.348, respectively $p < 0.01$). Negatively relationship between starch and protein content was observed ($r = - 0.377$, $p < 0.01$). Similar negative correlations between oil and moisture content has been reported in table 3 and 4. The data presented in table 4 indicated, the weight test were positively and significantly correlated with moisture content ($r = 0.305$, $p < 0.05$), protein content and 1000 kernel weight ($r = 0.314$, $p < 0.05$) respectively. Weight test was positively correlated to protein, ash ($r = 0.341$ and 0.409, $p < 0.01$), ash and protein content ($r = 0.678$, $p < 0.01$), respectively. Saleem et al. (2008) [13] reported that the results showed an increase in protein contents may decrease grain yield ultimately, so breeding for high protein genotypes require moderate balance between these two characters. Negative and distinctly significant correlation was found between starch and protein content ($r = -0.378$, $p <0.01$), starch and ash content ($r = -0.342$, $p< 0.01$) respectively. Also, negative correlation between starch content and protein content has been reported by Idikut et al (2009) [6], Randjelovic et al. (2011) [12], Aliu et al. (2012) [1] and Stevanovic et al.(2012) [14]. This negative correlation slows down the efforts to improve quality of maize hybrids.

4.Conclusion

As a result, the research revealed maize hybrids with high yielding potential and superior qualitative traits as compared to other autochthonous or foreign varieties. Both genotype and pedoclimatic conditions significantly influenced the quality of maize grains. Maize hybrids Turda 213, Elan, Turda 215, Turda 100, Turda SU 181, Turda 260 and Turda 145 respectively, recorded highly significant positive values for at least three of the traits studied. The results showed that in case of maize genotypes (Turda 248, HST 131 and HST 129) with a high starch content of grains, protein content is slightly low; this draws our attention to the difficulties encountered by improvement programs conducted by research stations around the world. Although the limits of variation for protein and oil content in grains are low in the germplasm analyzed, yet there are differences between genotypes.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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