Determination of Chemical Quality Parameters with Yield and Yield Components of Maize (*Zea mays* L.) Hybrids According to Various FAO Maturity Groups

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This study was set up at three locations (Samsun, Adapazari and Adana) in Turkey in 2008. The test was set up as factoriel in randomised block design with three replications. At each location 24 hybrids were tested from each of four maturity groups (FAO 400, FAO 600, FAO 650 and FAO 700). Measurements were made of the yield average (kg/da) and the yield components (kernel/cob ratio, plant height, cob height, moisture) were. The protein, oil and starch content of the kernels was determined. In each maturity group the highest yield averages were associated with the greatest average starch content, except for the FAO 400 group in Adana. The variety caused greater differences in protein content than the location. The highest oil content were found in the FAO 650 and FAO 700 groups, but the highest starch content were found FAO 600, FAO 650 and FAO700.

Key words: Maize, FAO maturity group, yield component, protein, oil, starch

Farklı Olum Grubuna Sahip Mısır (*Zea mays* L.) Çeşitlerinde Verim, Verim Öğeleri ve Bazı Kalite Parametrelerinin Belirlenmesi

Bu çalışma 2008 yılında Samsun, Adapazarı ve Adana olmak üzere 3 lokasyonfda yürütülmüştür. Deneme tesadüf bloklarında faktöriyel düzenlemeler olacak şekilde 3 tekrarlamalı olarak kurulmuştur. Her lokasyonda 4 farklı olum grubuna sahip (FAO 400, FAO 600, FAO 650 ve FAO 700) 24 adet hibrit çeşit kullanılmıştır. Denemede verim (kg/da), tane /koçan oranı (%), bitki boyu (cm), ilk koçan yüksekliği (cm) ve nem (%) değerleri tespit edilmiştir. Çalışmada kalite parametreleri olarak ise protein, yağ ve nişasta oranları (%) olarak belirlenmiştir. Her olum grubunda en yüksek verim ve en yüksek nişasta içeriği FAO 400 olum grubu hariç Adana lokasyonundan elde edilmiştir. Araştırma sonucunda protein oranındaki değişim çeşitlerde lokasyonlara göre daha fazla bulunmuştur. En yüksek yağ içeriği FAO 650 ve FAO 700 olum gruplarından elde edilmişken, en yüksek nişasta içerikleri ise FAO 600, FAO 650 ve FAO 700 olum grubundan sağlanmıştır.

Anahtar Kelimeler: Mıısır, FAO olum grubu, verim komponentleri, protein, yağ, nişasta

Introduction

Interest of developing maize hybrids that have enhanced content of starch, protein or oil. This interest has reinforced recently with efforts to develop value-added hybrids for specific dry and wet milling end-use, animal feed and processing applications such as ethanol production. So many studies have documented genetic variability for grain composition traits in maize hybrids. On the other hand, breeding progress for high quality maize grain has been somewhat limited by an apparent inverse genetic relationship between grain yield and protein concentration (Fabıjanac et al., 2006).

Cereal grains play a role over 60% of the total world food production (Lasztity 1999). Cereals are predominantly composed of carbohydrates, mostly in the form of starch, with considerable amounts of protein as well as some lipids, vitamins, and minerals. Both genetic and environmental effects create significant variation in the amount and quality of each of these constituents. Multiple methods have been developed to help breeders screen crops for various seed composition traits (Baye et al. 2006).

The environment has minor influence on the oil content than on the protein content (Gyenesne-Hegyi et al. 2001). But, the difference between hybrids was greater than that between locations. Samples were found to have lower protein content in damp years (Prokszáné Paplogó et al., 1995). Near infrared spectroscopy supplies an alternative, nondestructive technology for

measuring constituents of biological materials (Williams and Norris, 2001).

Maize is used for human food as well as animal feed. It has ahigher level of starch and provides a source of protein higherin lysine compared to the winter cereals. More recently its high starch content has been of interest in the fuel (ethanol) manufacturing sector, resulting in debate on the use of grain for food versus fuel (Fox and Manley 2009).

The grain of corn is composed of several chemicals of commercial value. The mature kernel is composed of 70 to 75% starch, 8 to 10% protein and 4 to 5% oil. The two main structures of the kernel, the endosperm and the embryo, constitute approximately 80 and 10% of the mature kernel dry weight, respectively. The endosperm is largely starch (approaching 90%) and the embriyo contains high level of oil (30%) and protein (18%). The oil and protein are commercial value. By utilizing genetic variation, the composition of the kernel can be changed for the structure and chemical diversity of starch, protein, and oil throughout kernel development (Hallauer 2001). Coalitions between protein and oil content varied from not significant (Dorsey-Redding et al., 1991; Séne et al., 2001) to highly positive values (Song et al., 1999). Others one study, between protein and oil content exist pozitive and significant correlation (Mittelman et al. 2003).

In Turkey, corn cultivation area is 592.000 ha, corn production is 4.25 million tons and corn yields is 71.8 kg/ha. Corn has the third highest cultivation area and production and it is the highest yield in cereals at Turkey. (Anonymous 2011). The aim of the research was determination of chemical quality parameters with yield and yield components of maize hybrids according to various fao maturity groups

Material and Method

This study was set up at three locations in Turkey (Samsun, Adana and Adapazari) in 2008, in a randomised block design with three replications. At each location 24 hybrids were tested from each of four maturity groups (FAO 400, FAO 600, FAO 650 and FAO 700). Eachplot consisted of a row 5 m long with an inter and intra row plant spacing of 0.75 × 0.25 m. The experiments were sown and harvested mechanically. Prior to harvest, ten sample ears were taken from each plot, and the yield average per decare of each hybrid was corrected based on the ear mass of the sample ears. Half of the nitrogen rates with the starter amounts of P and K each at 100 kg ha-1 were applied before planting. The rests of nitrogen rates were sidedressed when plants attained 40-50 cm heights.

Evaluations were made of the yield average (kg/da) and the yield components of the sample ears: kernel/cob ratio, plant height, cob height, and moisture. This was followed by chemical analysis to determine the protein, oil and starch contents of the kernels. The measurements were made using IC1020-WE corn calibration set with a NIRS spectrometer.

The yield data, yield components and chemical parameters were evaluated for each maturity group to determine the correlation between yield data and chemical parameters. Then, all data obtained from measurements were subjected to analyses of variance by using SAS-JMP 5.0 program.

Results

Chemical analysis of maize hybrids and the improvement of chemical quality parameters (protein, oil and starch content) are important for maize breeding. Among the chemical components can be empierced to a substantial effect by breeding (Hegyi et al., 2007).

The yield average in the FAO 400 maturity group was 933 kg/da (Table 1). The significantly highest yield was obtained in Adana (1187 kg/da). There was no significant difference between the yields in Adapazari and Samsun (973 and 739 kg/da, respectively). There was no significant difference among the kernel/cob ratio, plant height, cob height, oil and starch content all locations. There was significant difference between moisture and protein contents all locations. The significantly highest moisture (%) was obtained in Samsun (18.40, %). The significantly highest protein content (%) was obtained in Adana and Adapazari locations (11.65 and 10.43 %, respectively).The yield average in the FAO 600 maturity group was 1171.44 kg/da (Table 2).

Table 1. Average yield and yield component data for maize hybrids in maturity group FAO 400 at each location

Location	Yield kg/da	Kernel/cob ratio (%)	Plant height (cm)	Cob height (cm)	Moisture (%)	Protein content (%)	Oil content (%)	Starch content (%)
Samsun	739.00b	86.50	270.00	95.00	18.40a	7.72b	3.30	73.59
Adana	1187.00a	89.00	270.00	100.00	12.50c	11.65a	3.59	69.88
Adapazari	873.00b	84.50	262.50	105.00	15.85b	10.43a	3.74	72.06
Sig.	0.005	0.130	0.686	0.192	0.011	0.014	0.842	0.171
Mean	933.00	86.67	267.50	100.00	15.58	9.93	3.54	71.84

Table 2. Average yield and yield component data for maize hybrids in maturity group FAO 600 at each location

Location	Yield kg/da	Kernel/cob ratio (%)	Plant height (cm)	Cob height (cm)	Moisture (%)	Protein content (%)	Oil content (%)	Starch content (%)
Samsun	1118.33b	90.83a	279.17	107.50	21.13a	8.20c	3.52	73.46a
Adana	1261.83a	89.00b	276.67	103.33	16.70b	9.77a	3.75	72.16b
Adapazarı	1134.17ab	84.50c	271.67	100.83	21.43a	8.99b	3.99	72.48b
Sig.	0.049	0.000	0.203	0.363	0.000	0.001	0.191	0.010
Mean	1171.44	88.11	275.83	103.89	19.76	8.99	3.75	72.70

The significantly highest yield was obtained in Adana and Adapazari (1261.83 kg/da and 1134.17 kg/da). There was no significant difference among plant height and oil content all locations. There was significant difference among kernel/cob ratio, moisture, protein content and strarch content all locations. The highest kernel/cob ratio was measured in Samsun (90.83%). The significantly highest moisture was obtained in Samsun and Adapazari (21.13% and 21.43%). The highest protein content was obtained in Adana (9.77 %) and starch content was obtained in Samsun (73.46%). The yield average in the FAO 650 maturity group was 1177.10 kg/da (Table 3). The highest yield was obtained in Adana and Adapazari (1306.00 kg/da and 1122.20 kg/da). There was no significant difference among plant height, cob height and protein content all locations. There was significant difference among kernel/cob ratio, moisture, oil content and starch content all locations. The highest kernel/cob ratio was measured in Samsun and Adana (91.00% and 88.40%). The highest moisture was obtained in Adapazari (22.80%). The highest oil content was obtained in Adapazari and Adana (4.21% and 3.82%) and the highest starch content was obtained in Samsun and Adana (73.26% and 72.09%). The yield average in the FAO 700 maturity group was 1062.13 kg/da (Table 4). The highest yield was obtained in Adana (1285.10 kg/da). There was no significant difference between plant height and cob height all locations. There was significant difference among kernel/cob ratio, moisture; protein content, oil content and starch content all locations. The highest kernel/cob ratio was measured in Samsun and Adana (90.20% and 88.00%). The highest moisture was obtained in Adapazari (24.26%). The highest protein content was obtained in Adapazari and Adana (9.16% and 8.88%). The highest oil content was obtained in Adapazari (3.94%) and the highest starch content was obtained in Samsun (73.64%).

Table 3. Average yield and yield component data for maize hybrids in maturity group FAO 650 at each location

Location	Yield kg/da	Kernel/cob ratio (%)	Plant height (cm)	Cob height (cm)	Moisture (%)	Protein content (%)	Oil Content (%)	Starch content (%)
Samsun	1102.80b	91.00a	289.00	113.00	20.46b	8.78	3.39b	73.26a
Adana	1306.40a	88.40a	282.00	110.00	15.04c	9.32	3.82ab	72.09ab
Adapazarı	1122.20ab	83.80b	270.00	105.00	22.80a	9.37	4.21a	71.62b
Sig.	0.075	0.002	0.093	0.340	0.000	0.321	0.017	0.067
Mean	1177.10	87.73	280.33	109.33	19.43	9.16	3.81	72.32

Table 4. Average yield and yield component data for maize hybrids in maturity group FAO 700 at each location

Location	Yield kg/da	Kernel/cob ratio (%)	Plant height (cm)	Cob height (cm)	Moisture (%)	Protein content (%)	Oil Content (%)	Starch content (%)
Samsun	926.40b	90.20a	291.00	117.50a	21.61b	8.36b	3.50b	73.64a
Adana	1285.10a	88.00a	287.00	112.00ab	16.32c	8.88ab	3.25b	72.55b
Adapazarı	974.90b	81.70b	280.50	104.40b	24.26a	9.16a	3.94a	72.37b
Sig.	0.001	0.000	0.323	0.014	0.000	0.058	0.006	0.007
Mean	1062.13	86.63	286.17	111.30	20.73	8.80	3.56	72.85

Table 5 and Table 6 show us that the analysis was also occurred all FAO maturity groups of the range over which the chemical quality traits varied between varieties and locations. The difference in protein content between the locations was significantly greater in FAO 400, FAO 600 and FAO 700 maturity groups. The difference in protein content between the varieties was significantly greater in FAO 650 and FAO 700 maturity groups. The difference between the varieties was greatest in the FAO 400 (4.37%) and smallest in the FAO 650 (2.37%). The difference between locations for this parameter was greatest in the FAO 400 (3.93%) and smallest for the FAO 650 (0.59%).

The analysis was also occurred all FAO maturity groups of the range over which the chemical quality traits varied between varieties and locations. The difference in oil content between the locations was significantly greater in FAO 650 and FAO 700. The difference in oil content of varieties was significantly greater in FAO 400. The difference between the varieties was greatest in the FAO 700 (2.05%) and smallest in the FAO 400 (1.53%). The difference between locations for this parameter was greatest in the FAO 650 (0.82%) and smallest for the FAO 400 (0.44%) (Table 5 and Table 6).

According to the analysis was also occurred all FAO maturity groups of the range over which the chemical quality traits varied between varieties and locations. The difference in starch content between the locations was significantly greater in FAO 600 and FAO 700 maturity groups. There was no significant in starch content for all FAO maturity groups. The difference between locations for this parameter was greatest in the FAO 400 (3.71%) and smallest for the FAO 700 (1.27%) (Table 5 and Table 6).

The result of Pearson's correlation coefficients were calculated between the traits it was found that the average yield per dectare was correlated but not statistically significant with the kernel/cob ratio, plant height, cob height, protein content and oil content. Moisture was negative and very significant correlated with yield (-0.373**). Kernel /cob ratio was positive and significant correlated with plant height (0.292*), positive and very significant correlated cob height (0.357**) and negative very significant correlated moisture (-0.386**), oil content (-0.399**). Plant height was positive and very significant correlated with cob height (0.543**) and negative significant correlated with protein content (-0.265*). Cob height was negative and very significant correlated with oil content (-0.334**), positive and very significant correlated with starch content (0.330*). Moisture was negative and significant correlated with protein content (-0.405**) and positive significant correlated with starch content (0.279*). Starch content was negative and very significant correlated with protein content (-0.545**) and oil content (-0.581**) (Table 7).

Correlations of starch content, protein content and oil content for each maturity group was showed in Figure 1, Figure 2 and Figure 3. The highest starch content (72.8%) was found FAO 700 maturity group. The highest protein (9.93%) content was found FAO 400 maturity group and the highest oil content (3.81%) was found FAO 650 maturity group.

Table 5. Difference (%) between the effects of varieties and locations on the chemical quality traits of maize hybrids in the FAO 400 and FAO 600 maturity groups

	FAO 400		FAO 600	
Traits	Range	Deviation	Range	Deviation
		Protein content (%)		
Between varieties	7.44 – 11.81	4.37	7.19 – 11.07	3.88
Sig.	0.848		0.727	
Between locations	7.72 – 11.65	3.93	8.20 – 9.77	1.57
Sig.	0.014		0.001	
		Oil content (%)		
Between varieties	2.80 – 4.33	1.53	3.08 – 4.66	1.58
Sig.	0.006		0.331	
Between locations	3.30 – 3.74	0.44	3.52 – 3.99	0.47
Sig.	0.842		0.191	
		Starch content (%)		
Between varieties	68.78 – 74.89	6.11	70.90 – 73.72	2.82
Sig.	0.290		0.806	
Between locations	69.88 – 73.59	3.71	72.16 – 73.46	1.30
Sig.	0.171		0.010	

Table 6. Difference (%) between the effects of varieties and locations on the chemical quality traits of maize hybrids in the FAO 650 and FAO 700 maturity groups

	FAO 650		FAO 700	
Traits	Range	Deviation	Range	Deviation
		Protein content (%)		
Between varieties	8.07 – 10.44	2.37	6.36 – 10.21	3.85
Sig.	0.025		0.007	
Between locations	8.78 – 9.37	0.59	8.36 – 9.16	0.80
Sig.	0.321		0.058	
		Oil content (%)		
Between varieties	3.12 – 4.97	1.85	2.61 – 4.66	2.05
Sig.	0.546		0.226	
Between locations	3.39 – 4.21	0.82	3.25 – 3.94	0.69
Sig.	0.017		0.006	
		Starch content (%)		
Between varieties	70.41 – 74.71	4.30	70.66 – 75.74	5.08
Sig.	0.418		0.210	
Between locations	71.62 – 73.26	1.64	72.37 – 73.64	1.27
Sig.	0.067		0.007	

Table7. Correlations among the yield, yield components and chemical quality traits for all FAO maturity groups.

	Yield	Kernel/cob ratio	Plant height	Cob height	Moisture	Protein cont.	Oil cont.
Kernel/cob ratio	0,218						
Plant height	0,171	0,292*					
Cob height	0,155	0,357**	0,543**				
Moisture	-0,373**	-0,386**	0,109	-0,007			
Protein cont.	0,177	0,001	-0,265*	-0,142	-0,405**		
Oil cont.	0,009	-0,399**	-0,185	-0,334**	0,179	0,012	
Starch cont.	-0,210	0,229	0,152	0,330**	0,279*	-0,545**	-0,581**

** Correlation is significant at the 0.01 level and *. Correlation is significant at the 0.05 level

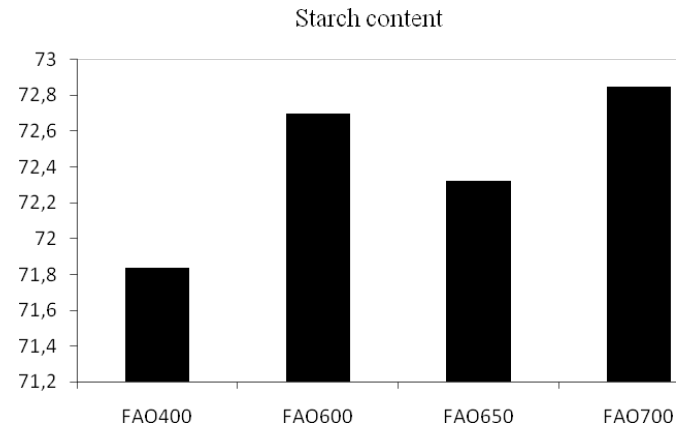

Fig. 1. Correlations between starch content for each maturity group

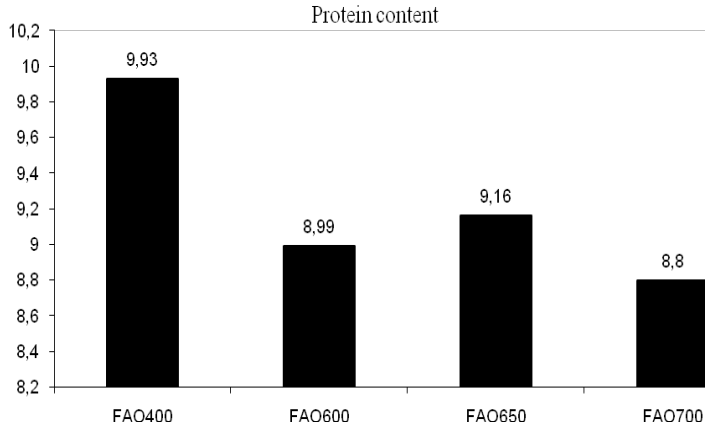

Fig. 2. Correlations between protein content for each maturity group

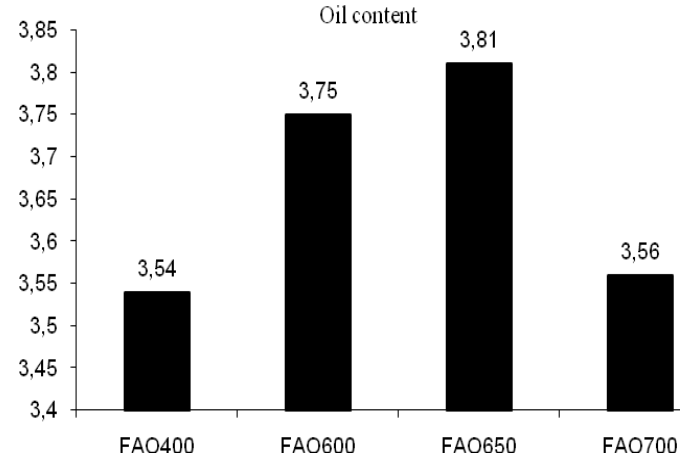

Fig. 3. Correlations between oil content for each maturity group

Discussion

The chemical quality parameters were recorded IC1020-WE NIRS calibrations set, and the correlations of the protein, oil and starch contents with yield and yield components were analysed. As 80% of the protein content is to be found in the endosperm, where all the carbohydrate is accumulated, it is understandable that maize with the highest starch content had the lowest relative protein content (Figure 1 and Figure 2).

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