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Chemical and Nutritional Properties of Some Maize (*Zea mays* L.) Varieties Grown in NWFP, Pakistan

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Abstract: Grains of ten maize varieties grown in NWFP, Pakistan were obtained and investigated for physicochemical characteristics, proximate composition, energy content and mineral composition. Mean electrical conductivity and thousand seed mass were determined in the range of 9.26-33.83 µS and 319-230.4 g, respectively. Proximate composition shows moisture content in the range of 9.201-10.908%, ash (0.7-1.3%), fats (3.21-7.71%), protein (7.71-14.60%), crude fiber (0.80-2.32%) and carbohydrates (69.659-74.549%). The data indicate that seeds of these varieties vary greatly in term of protein, fats and crude fiber contents. Pahari, Jalal 2003, WD- 2*8 and Azam varieties were determined to contain high protein content (>10% protein) while WD-2*8, Pop. 2004B, PSEV 3-2 and Sarhad (W) contain high fats content of >6%. The energy value of the grains of these varieties was determined in the range of 307.047-394.066 kcal/100 g which shows that the grains of these varieties are rich source of energy. In minerals the level of sodium is 540.30-620.41ppm, K (2915-3471 ppm), Ca (410-590 ppm), Fe (38.02-56.14 ppm), Zn (37.05-52.4 ppm), Mg (985.2-1125.3 ppm) and Cu (11.02-14.25 ppm).

Key words: Proximate composition, minerals, maize varieties, energy value, maize

INTRODUCTION

In Pakistan, maize is the third most important cereal crop after wheat and rice and is used as a staple food for humans, as feed for livestock and as raw material for industry. During 2006, it was planted on 1030 thousand hectares in Pakistan, with total production of 3560 thousand tons and having an average yield of 3.458 tons ha-1 (Ministry of Food, Agriculture and Livestock, 2006; Khan *et al*., 2009). Maize accounts for 4.8% of the total cropped area and 3.5% of the value of agricultural output of Pakistan. It is planted on an estimated area of 0.9 million hectare with an annual production of 1.3 million tones. The bulk (97%) of the total production come from two major provinces (NWFP and Punjab), NWFP, accounting for 57% of the total area and 68% of total production (PARC, 2007).

World collections of maize comprise about 12,000 accessions that are represented in 256 races, of which about 30 are in the process of extermination. Genetic erosion and habitat destruction by modern agriculture has increased the importance of germplasm characterization of plant materials (Carvalho *et al*., 2004). Maize is a multipurpose crop, providing food and fuel for human beings, feed for animals, poultry and livestock. Its grains have great nutritional value and are used as raw material for manufacturing many industrial products (Afzal *et al*., 2009). Its grains are important for the production of oil, starch and glucose (Krishnamurthi, 1969; Niaz and Dawar, 2009). Moreover, Food composition data is important in nutritional planning and provides data for epidemiological studies (Bruce and Bergstrom, 1983; Ali *et al*., 2008). However, there is limited information about the nutritional composition of the different maize varieties growing in Pakistan. The present study aims to investigate physicochemical characteristics, proximate composition and mineral composition of the different maize varieties grown in NWFP province of Pakistan.

MATERIALS AND METHODS

Plant material and physicochemical characteristics: Seeds of 10 maize varieties grown at the Cereal Crop Research Institute (CCRI), NWFP Pakistan were collected and studied for their morphological characters, chemical and nutritional properties. This collection includes the dent and flat kernel types with yellow and white endosperm. Seeds were analyzed for their kernel color and kernel texture as described by Carvalho *et al*. (2004).

Electrical conductivity: Then electrical conductivity of the whole imbibed seeds was determined on eight replications of 10 seeds for each variety, placed in conical flasks with 75 ml deionised water at equal interval of 10, 20, 30, 40, 50, 60, 70 and 80 min. Total of eight reading were taken for each variety. Electrical conductivity was determined by the following formula:

Electrical Conductivity of Seeds = Conductivity of Seeds + D.W - Conductivity of D.W

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Thousand Seeds Mass (TSM): Thousand seeds weight (TSM) is very important parameter to study the net productivity of *Zea mays*. Hundred seeds were counted and their average mass was measured with help of Shimadzu electronic balance. The method is reported in work of Zeb *et al.* (2006).

Proximate composition: Fats contents were determined by using AOAC (1990) 22.034 and protein content AOAC, PN-75/A-04018. Crude fiber was determined by treating oil-free sample by sulphuric acid (0.26 N) and potassium hydroxide (0.23 N) solution in refluxing systems, followed by oven drying and muffle furnace incineration (AOAC, 1984).

For the determination of ash content 3 g of grinded *Zea mays* seeds were taken in desiccated china dishes. The samples were then charred and ashed by using muffle-furnace in two shocks first at 550°C for 30 min and then at 850°C for 30 min. The dishes were removed and when cool to room temperature each dish was reweighed containing white appearing ash. By difference the weight of ash was calculated.

$$\text{Ash}(\%) = \frac{(w2 - w) \times 100}{w1 - w}$$

Where

W2 = Weight in gm of the dish with the ash
W = Weight in gm of empty dish
W1 = Weight in gm of the dish with the dried material taken for test

Moisture Contents were determined according to the method used by Khan and Kulachi (2002). For this purpose 10 seeds were taken and their fresh weight was determined. Then they were placed in oven at 72°C for 48 h and were again weighted. The moisture content was determined according to the formula:

$$\text{Moisture content (\%)} = \frac{\text{Weight of fresh seeds-weight of dry seeds} \times 100}{\text{Weight of fresh}}$$

The digestible carbohydrates were calculated by difference.

Total energy values were calculated by multiplying the amounts of protein and carbohydrate by the factor of 4 kcal/g and lipid by the factor of 9 kcal/g as described by Bazi Yabani *et al.* (2009).

Mineral composition: The mineral composition (Na+ and K+) was determined with the help of flame photometer (Jenway PFP7) by the method describe recently (Khan and Zeb, 2007). Heavy metals like Ca, Fe, Mg, Zn and Cu were determined with help of Atomic Adsorption Spectrometer (Perkin Elmer, model Analyst 700) with air/acetylene flame at 2200-2400K (photo multiplier tube detector), against the standard (Hanlon, 1992).

All the parameters were determined at least in triplicate and the results were presented in mean±standard deviation (SD) by using SPSS version 12.0 software package.

RESULTS AND DISCUSSION

Electrical conductivity and 1000 Seeds Mass (TSM): The physicochemical composition investigated maize varieties are shown in Table 1. Maize varieties used in the present study shows significant differences for Electrical Conductivity (EC). The lowest mean EC of Seeds of 9.26 µS was determined for the PSEV 3-2 variety give while the highest (33.83 µS) were obtained for Pahari. The variety WD-2*8 have mean EC of 11.14 µS. The EC of the Jalal 2003 was 13.86 µS, Pop.2006 (13.3 µS) and Pop. 2004B (13.1 µS), Sarhad-W (16.31 µS) and Azam (17.75 µS), WD-3*6 (23.2 µS) and Gh-3*Tam1 (27.38 µS). Munamava *et al.* (2004) also found the mean EC in the same range for different maize varieties.

1000 seeds mass was obtained in the range of 319 g (Jalal 2003 variety) to 230.4 g (WD-2*8). This notion is in agreement with the results obtained by (Kipkech and Kipserem, 2001; Jayan and Kumar, 2004) for different maize varieties.

Proximate composition: Proximate composition and calculated energy values for the maize varieties are shown in (Table 2).

Seed moisture content: Data regarding moisture contents of different maize varieties is given in Table 2. The highest value of moisture content was found for Sarhad (W) (10.908%) and the lowest was found for WD-2*8 varieties (9.201%). Samir *et al.* (1998) measured the moisture content in the range of 9-19%, which is in close consistency with our results. Aisha and El-Tinay (2004) found the moisture value in 12 corn genotypes in the range of 4.3-6.7% which is also in close agreement with our results. Dorsey-Redding *et al.* (1990) found out the moisture content for 10 different hybrids maize varieties in the ranges of 8.43-22.77%. This notion is not in agreement with the results of study.

% Ash value: Ash is defined as the quantity of mineral matter which, after application of the described working methods, remains as incombustible residue of the tested substance. Percent ash content of different maize varieties were found in the range of 0.7% (Jalal, 2003) to 1.3% (WD-3*6) the highest. Peplinski *et al.* (1989) reported values of ash between 1.3 and 1.5%. This notion is in agreement with the results of the present study. Maziya-Dixon *et al.* (2000) found results in the range of 1.4-3.3%, which are higher than the values determined in the present study. Aisha and El-Tinay (2004) investigated the ash value in the range of 1.0-2.0% which is in close consistency with present results of our study.

Table 1: Physicochemical properties of the maize varieties

S/N	Varieties	Variety Type	Kernel colour	Kernel texture	EC Value (µS)	TSW (g)
1	Jalal 2003	Composite	White	Flint grain	13.86	319.0
2	Azam	Composite	White	Flint grain	17.75	278.8
3	WD-3*6	Candidate	White	Flint grain	23.2	272.5
4	PSEV 3-2	Candidate	Yellow	Dented	9.26	307.4
5	Gh-3*Tam1	Candidate	Yellow	Dented	27.38	279.0
6	Pahari	Composite	Yellow	Flint grain	33.83	286.3
7	WD- 2*8	Candidate	Yellow	Flinted	11.14	230.4
8	Sarhad (W)	Composite	Yellow	Dent grain	16.31	252.1
9	Pop. 2006	Composite	Yellow	Dented	13.3	247.0
10	Pop. 2004 B	Candidate	White	Dented	13.1	233.1

Table 2: Proximate composition and calculated energy values of the maize varieties grown in Pakistan

S/N	Varieties	Moisture content (%)	% Ash Value (g)	% Fats	Protein (%)	% Crude Fiber	Carbohydrates (%)	Energy (kcal/100 g)
1	Jalal 2003	9.843±0.1	0.70±0.05	5.30±0.15	12.58±0.05	1.04±0.01	70.615±2.5	380.488±5.01
2	Azam	9.684±0.2	0.93±0.051	4.62±0.24	11.14±0.07	1.00±0.01	72.626±2.3	376.644±4.01
3	WD-3*6	10.311±0.15	1.3±0.38	4.32±0.14	8.72±0.024	0.80±0.02	74.549±3.07	371.95±3.18
4	PSEV 3-2	9.954±0.12	1.06±0.40	6.75±0.31	8.49±0.22	2.11±0.02	71.636±3.17	381.254±4.25
5	Gh-3*Tam1	10.501±0.22	0.91±0.09	5.73±0.5	7.71±0.32	2.30±0.01	72.849±5.10	373.806±3.27
6	Pahari	10.164±0.09	0.93±0.071	3.21±0.34	14.60±0.21	2.9±0.01	70.196±3.70	307.047±2.91
7	WD- 2*8	9.201±0.081	1.03±0.51	7.71±0.12	11.51±0.05	0.89±0.00	69.659±4.15	394.066±5.41
8	Sarhad (W)	10.908±0.12	1.16±0.23	6.30±0.47	8.50±0.12	1.15±0.04	71.982±5.10	378.592±5.04
9	Pop. 2006	10.607±0.21	1.20±0.35	5.20±0.25	9.31±0.07	1.27±0.14	72.36±4.37	373.692±4.71
10	Pop. 2004 B	10.853±0.13	0.86±0.12	7.14±0.47	8.67±0.04	2.32±0.03	70.157±5.09	379.568±3.95

*Mean±standard deviation

The grains with high ash contained a greater proportion of non-endosperm material. Ash Values are determined in order to indicate the level to which non-endosperm components are present (Evers, 2001).

% Fats: Percent Fats were determined in the range of 3.21% (Pahari variety) to 7.71% (WD-2*8 variety). Ijabadeniyi and Adebolu (2005) determined the %fat content of three maize varieties grown in Nigeria in the range of 4.77-5.00% for the maize grains, which is in an agreement with the present study. The results of the present study show that WD-2*8, Pop. 2004B, PSEV 3-2 and Sarhad (W) contain high fats content of >6%.

% Protein: The second largest chemical component of the kernel is protein. Percent protein content was found in the range of 7.71-14.60%. Ijabadeniyi and Adebolu, (2005) found the % protein content of three maize varieties grown in Nigeria in the range of 10.67-11.27% for the maize grains. This notion is in agreement with the results of the present study.

Maize kernels contain albumins, globulins, prolamins, and glutelins. However, two types of storage proteins predominate in the seed: the embryo contains globulin and the endosperm, the major site of storage protein accumulation, contains predominantly prolamins, the so-called zein fraction (Woo *et al*., 2001). These proteins are used as genetic markers for the identification of a variety, for the determination of some important characteristics and traits and for the determination of genetic constitution of the variety. Sampling and assays have been successfully used to study the geographic variation of seed storage protein (Bogyo *et al*., 1980; Erskine and Muehlbauer, 1991). The present study shows that Pahari, Jalal 2003, WD- 2*8 and Azam varieties contain high protein content of 14.60%, 12.58%, 8.72% and 11.51% (>10% protein).

% Crude fiber: Crude fiber was found fourth largest chemical present in the maize grains after carbohydrates, protein, fats and moisture content. Percent crude fiber was found in the range of 0.80-2.32%. Ijabadeniyi and Adebolu (2005) reported slightly higher values (2.07-2.77%) of the fiber content for the maize varieties grown in Nigeria.

% Carbohydrates: Carbohydrates are the major chemical component of the maize grains. It was found in the range of 69.659 (WD-2*8 variety)-74.549% (WD-3*6 variety). Ijabadeniyi and Adebolu (2005) reported slightly lower values (65.63-70.23%) of the carbohydrate content for the maize varieties grown in Nigeria.

Energy value (kcal/100 g): Calculated energy values of maize varieties grown in Pakistan varied from 307.047 kcal/100g (Pahari variety) to 394.066 kcal/100g (WD-2*8 variety) in dry matter basis (Table 2). Kouakou *et al.* (2008) showed the energy level of maize grains as 387.7 kcal/100 g. This notion is in agreement with the results of the present study. In another study Ejigue *et al.* (2005) found the energy value of 447kcal/100 g for yellow maize, which is higher than the values determined in this study. The difference in the energy level is due to differences in the proximate composition of the varieties. The results of the present study show that these maize varieties are rich source of energy.

Table 3: Mineral composition of the maize grains

S/N	Varieties	Na	K	Ca	Fe	Zn	Mg	Cu
1	Jalal 2003	550.52±21	3210.3±20	430±15	42.3±2.1	39.2±2.5	985.2±11.2	14.25±0.5
2	Azam	590.05±35	3458.7±15	410±25	42.5±1.5	45.2±2.3	1625±10.5	14.03±0.6
3	WD-3*6	540.30±32	2980±12	564±10	43.15±1.04	37.05±1.5	1125±11.5	14.12±0.5
4	PSEV 3-2	620.41±10.5	2915±4.1	390±10	56.14±0.05	52.4±0.08	986.2±9.3	11.02±0.2
5	Gh-3*Tam1	550.45±5.3	3471±5	425±15	45.5±0.84	38.6±4.1	1150±5.5	14.01±1.3
6	Pahari	587.02±15	3211±25	590±14	39.2±1.25	45.06±8.7	1125.3±1.15	13.25±0.5
7	WD- 2*8	596.65±12	3245±14	520±12	38.02±1.02	48.2±5.3	1065±12.3	12.48±0.14
8	Sarhad (W)	560.61±10.2	3105±11	540±5.2	45.5±2.3	52.15±2.40	1024±2.5	12.62±0.58
9	Pop. 2006	559.22±8.2	3314±9.2	525±6.5	45.3±0.87	50.04±2.3	1087±3.7	13.08±0.30
10	Pop. 2004 B	573.80±7.9	2948±3.2	510±23	50.06±0.75	49.87±1.04	1125±5.4	12.05±1.20

*Mean±standard deviation

Mineral composition: The result of the mineral composition grains of different maize varieties is shown in Table 3. The analysis shows the level of Na (540.30-620.41 ppm), K (2915-3471 ppm), Ca (410-590 ppm), Fe (38.02-56.14 ppm), Zn (37.05-52.4 ppm), Mg (985.2-1125.3 ppm) and Cu (11.02-14.25 ppm). Hassan *et al.* (2009) determined the mineral content of two maize varieties grown in Sudan and showed the level of Na in the range of 15-18 ppm, K (93-108 ppm), Ca (216-162 ppm), Fe (18 ppm) and Zn (5 ppm). These results are not in agreement with the results of the present study. Hussaini *et al.* (2008), determined mineral content of K in the range of 3400-3600 ppm, Ca (350-360) and Mg (1060-1120 ppm). This notion is in agreement with the results of the present study. Feil *et al.* (2005) showed the concentration of K in the range of 3930-3710 ppm, Mg (1120-1130 ppm), Ca (82-137 ppm), Zn (23.1-25 ppm) and Cu (2.21-2.36 ppm). The concentration of K and Mg are in agreement with the results of the present study while, that of Ca, Zn and Cu are less than it. Hussaini *et al.* (2008) showed that nitrogen fertilizer application up to 60 kg N ha^{-1} significantly increased the concentrations of N, P, Ca and Mg in maize grain. Hence, the differences in the mineral composition may be due to genetic factors or environmental factors like irrigation frequency, soil composition and fertilizer used.

Conclusion: The data indicate that seeds of these varieties vary greatly in term of protein, fats and crude fiber contents. The variability observed in carbohydrates, protein, fats, ash content, crude fiber and moisture content is both genetic and environmental which may influence the individual chemical composition and weight distribution of the endosperm and hull of the kernels. Moreover, Pahari, Jalal 2003, WD- 2*8 and Azam varieties were determined to contain high protein content (>10% protein). The varieties WD-2*8, Pop. 2004B, PSEV 3-2 and Sarhad (W) contain high (>6%) fats content of 7.71, 7.14, 6.75 and 6.30, respectively. These results will be useful to know about the nutritional properties of the local maize varieties and may guide us in designing strategies that maximize the utility of maize germplasm.

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