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COMPARATIVE STUDY FOR THE DETERMINATION OF NUTRITIONAL COMPOSITION IN COMMERCIAL AND NONCOMMERCIAL MAIZE FLOURS

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Abstract

This study aimed to evaluate the nutritional analysis of the commercially available white maize flours and noncommercial yellow maize flour obtained from the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan. The proximate chemical composition, minerals calcium (Ca), copper (Cu), iron (Fe), manganese (Mn), magnesium (Mg), potassium (K), sodium (Na) and zinc (Zn) and were determined in white and yellow maize flours. In the dry weight basis white maize flours significantly ($p<0.05$) contained moisture 9-15 %, ash 1.4-2.6%, protein 7.82-12.02%, crude fiber 0.95-2.01%, and total carbohydrates 65.38-78.74% and yellow maize flour significantly ($p<0.05$) contained moisture 17%,ash 3.3%, protein 12.45%, crude fiber 2.97%, and total carbohydrates 60.23%. The detection of inorganic selective nutrients (Mg, K, Na, Ca, Mn, Zn, Fe, Cu) was performed using inductively coupled plasma-mass spectrometry (ICP-MS). The results of ICP-MS analysis in white and yellow maize flours revealed that yellow maize flour contains 16, 26.21, 7.43, 5.29, 1.40, 2.11 times higher value of Mg, K Mn, Zn, Fe and Cu as compared to white maize flours, where as white maize flours contain 1.50, 1.02 times higher value of Na and Ca as compared to yellow maize flour obtained from the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan.

Key words: Maize, Flour, Proximate composition, Inorganic nutrients.

Introduction

Maize (*Zea mays* L.) is one of the most widely known and utilized species from the family of grasses (Poaceae). It is an economically important vegetable crop grown in many parts of the world including Middle East, Africa, India, Pakistan, Malaysia, Brazil, Turkey, southern states of USA etc(Brutnell *et al.*, 2015; Ramírez-Moreno *et al.*, 2015). In Pakistan, maize (*Zea mays* L.) is grown in spring and autumn seasons. It is the third dominant crop next to wheat and rice among the cereals grown in Pakistan (Rahman *et al*., 2015). The total production and yield of maize grown in various parts of Pakistan is roughly 3.13 million tons and 3264 kg/ha respectively. In world, it is cultivated on more than 142 million hectare of land with an estimated production of 913 million tons approximately (Farooq *et al.*, 2015). Maize is a rich source of vitamins, minerals and dietary fiber (Ullah *et al*., 2010). It is used in various forms such as whole corn, corn flour, cornstarch, corn gluten, corn syrup, tortillas, tortilla chips, polenta cornmeal, corn oil, popcorn, cornflakes, etc. It is reported that maize seeds have moisture (11.6-20.0%), ash (1.10-2.95%), protein (4.50-9.87%), fat (2.17-4.43%), fiber (2.10-26.70%) and carbohydrates contents (44.60-69.60%) (Enyisi *et al*., 2014a; Ullah *et al*., 2010). Maize also provides many of the B vitamins along with fiber, but lack some other nutrients, such as vitamin B12 and vitamin C (Cowieson, 2005; Höcherl *et al*., 2012). In addition to nutrients (high level of vitamins, minerals and dietary fibers), maize grain also contain a number of elements (Cu, Fe, Ni, Mn and Zn) (Gorsline *et al*., 1964; Nascimento *et al*., 2014), that are vital for our biological functions, but hazardous if taken in high concentrations (Olivares & Uauy, 1996). It also comprise some toxic elements (As, Pb, and Cd) which are rated as the first, second and seventh in toxicity as per CERCLA Priority List (Hentz *et al*., 2012). The regular consumption of maize not only helps to remove the toxic food substances, but also speed up the passage of faces through the intestine. Also, it provides protection to the digestive tract which reduces the stomach acidity and enhance the function of the gall-bladder (Elsgaard *et al*., 2012; Li *et al*., 2001). The composition of maize have wide discrepancy between its different species and subspecies which depends upon the various environmental and topographical conditions. The research on chemical composition of the maize seeds is very limited and there have been no reports concerning the comparison of chemical composition of commercially available white flours of maize and the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan. According to our knowledge, this is the first detailed comparative study of composition and nutritive value of the maize grains that are grown at University of Agriculture, Faisalabad, Pakistan with that of commercially available white flour in Pakistani market.

Materials and Methods

Seeds of the maize grown (collected from Institute of Agri-Biotechnology & Genetic Resources (IABGR) National Agricultural Research Centre, Islamabad, Pakistan (NARC) at research area of the Department of Plant Breeding and Genetics, University of Agriculture (PBG-UAF), Faisalabad, Pakistan were collected and studied for their composition and nutritive properties. Before the analysis the grains of maize were well grinned and pass through 1mm sieve of millimicro mill (Model Culatti, DFH-48) and it was shaken for 8h at 50°C whereas white maize flour samples (made of three different companies) was purchased from the local market in Pakistan. Moisture contents in the seeds grown at PBG-

UAF and commercially purchased white maize flours was measured using the method explained by Enyisi *et al*., 2014b. The moisture content is expressed as percentage of the dry weight:

$$\text{Moisture content} = \frac{\text{Weight loss of maize}}{\text{Weight of the original maize}} \times 100$$

The crude fiber content (%) and fat contents in the seeds grown at UAF and commercially purchased white maize flour was measured using the well know Soxhlet extraction method (Anon., 1995) in which two grams of maize grain grinned powder grown was at UAF and commercially purchased white maize flour extracted with petroleum ether. The yellow and white powder of maize was transferred to two different beakers contain 1 L water and then 200 ml boiling 1.20% Sulfuric acid, 1 gram of freshly prepared asbestos, bumping chips and single drop of dilute antifoam was added. After that beakers were placed on the digestion apparatus having pre-adjusted hot plate and heated for 30 mins. Finally, beakers were detached and the solution were filtered and desiccated for 2 hours at 135ºC, cooled and weighed, ignited for 30 min at 600ºC in the oven, cooled and reweighed. The crude fiber contents in maize is expressed as:

Crude fiber in maize (%) = (Loss in wt. on ignition – loss in wt. of asbestos blank) × 100

Ash contents in the seeds grown at UAF and commercially purchased white maize flour was measured using method described by Enyisi *et al*., 2014b.The percentage ash content was calculated by using the following formula:

$$\%\ \text{Ash} = \frac{\text{Weight of ash}}{\text{Weight of the original maize}} \times 100$$

The protein contents in the seeds grown at UAF and commercially purchased white maize flour was calculates using the method described by Kjeldhal method of Bremner & Mulvaney (1982). The ash contents was calculated using the following formula:

Crude Protein (%) = nitrogen content x 6.25 (*factor for cereals)

Carbohydrate contents in the seeds grown at UAF and commercially purchased white maize flour was calculated using differential method, as described in the formula below:

% Carbohydrate = (100 – (% moisture + % ash+ % fat + % protein + % fiber)

Results and Discussion

Maize or corn flour comprises extraordinary levels of several vital vitamins and minerals, including calcium, folate vitamin, iron, niacin, potassium, phosphorus, thiamine and zinc (Afzal *et al*., 2009; Tokatlidis & Koutroubas, 2004) and its proximate and mineral element compositions shows discrepancy between different species and even in some subspecies depending on environmental and geographical conditions. For effective guide on dietetics, it is very important to determine the proximate and mineral element compositions in commercial white and noncommercial yellow maize flour. The moisture contents in compositions of commercial white and noncommercial yellow maize flours were consistent with the literature 9-19% (Enyisi *et al*., 2014a; Enyisi *et al*., 2014b; Trabelsi *et al*., 1998) as shown in Fig. 1(a)., however, it is interesting to note that the moisture contents in yellow maize flour are higher than of commercial white maize flours. The variation of moisture contents in both maize flours may be attributed different factors such as agronomic, environmental factors and the maize variety. Ash content of noncommercial yellow maize flour were also in good agreement with the literature 1.4–3.3% (Enyisi *et al*., 2014b; Mlay*et al*., 2005), whereas it is lower in commercial white maize flour as shown in Fig. 1(b). The percentage protein contents in commercial white and noncommercial yellow maize in the present study was found in the range of 7.82-12.45% as shown in Fig. 2(a). This is in accordance with the reports published on various maize varieties (Enyisi *et al*., 2014a; Enyisi *et al*., 2014b; Ijabadeniyi & Adebolu, 2005; Ullah *et al*., 2010). We found that that the protein contents in yellow maize flour are higher than of commercial white maize flour. The variation of protein contents in both maize flours may be attributed different factors such agronomic practices, various environmental factors and the maize verities used. The percentage crude fiber contents was found in the range of 0.95-2.97, as shown in Fig. 2(b) which is slightly higher than the reported values in literature (Enyisi *et al*., 2014a; Enyisi *et al*., 2014b; Ijabadeniyi & Adebolu, 2005; Ullah *et al*., 2010). The yellow maize flour showed higher fiber contents as compared to commercial white maize flours, but consistent with the findings of Mlay *et al.*, 2005, as the yellow maize flour bran which contains higher values of fiber contents. The percentage fat contents was found in the range of 2.09-4.05, as shown in Fig. 3(a) and carbohydrate content of commercial white and noncommercial yellow maize flours obtained for this study varies are also in good agreement with (Ayatse *et al*., 1983; Enyisi *et al*., 2014b; Ijabadeniyi & Adebolu, 2005; Ullah *et al*., 2010)and slightly lower than(Wilson, 1987) as shown in Fig 3(b). The carbohydrate contents ranges (60.23-78.74%) for commercial white and noncommercial yellow maize, and found that it was higher in white flour as compared to yellow maize flours. The observed variation in the properties of maize flours maybe due to that yellow maize flour contained the bran which was removed in commercial white maize flour.

The mineral composition in commercial white and noncommercial yellow maize flour for the determination of magnesium (Mg), potassium (K), sodium (Na), calcium (Ca), manganese (Mn), zinc (Zn) iron (Fe) and copper (Cu) was determined by using ICP-MS (Inductively Coupled Plasma-Mass Spectrometer): Nex ION 300 D (Perkin Elmer, USA). All analyses were performed in triplicate and the corresponding results are shown in Table 1.

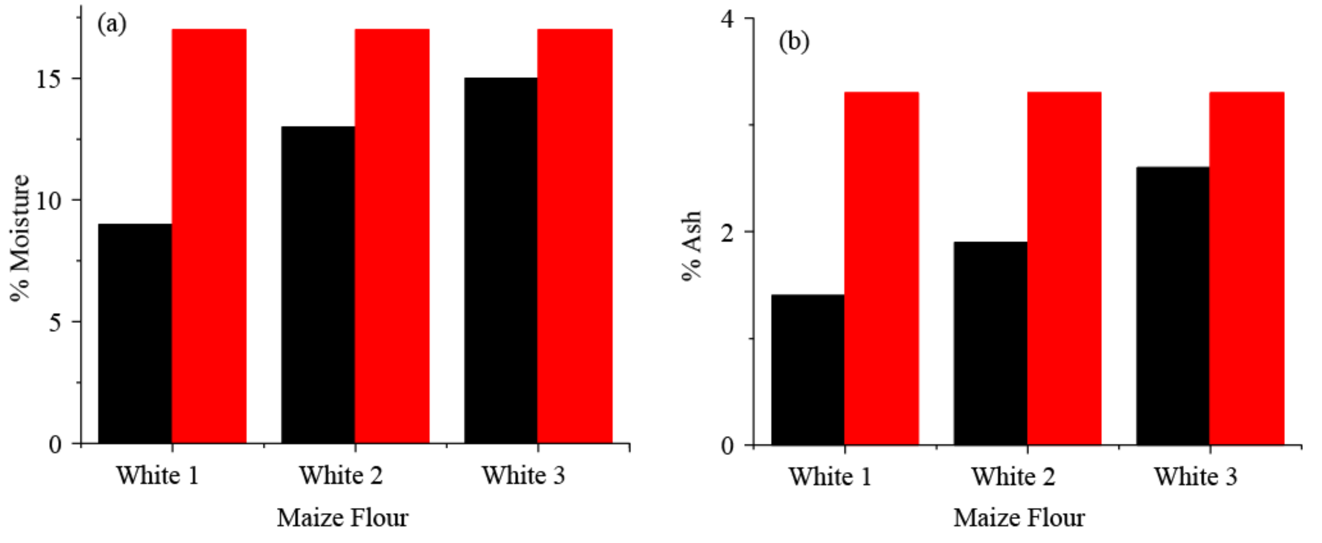

Fig. 1. The proximate chemical composition (a) Moisture content of commercially available white maize flours and noncommercial yellow maize flour (b) Ash content of commercially available white maize flours and noncommercial yellow maize flour.

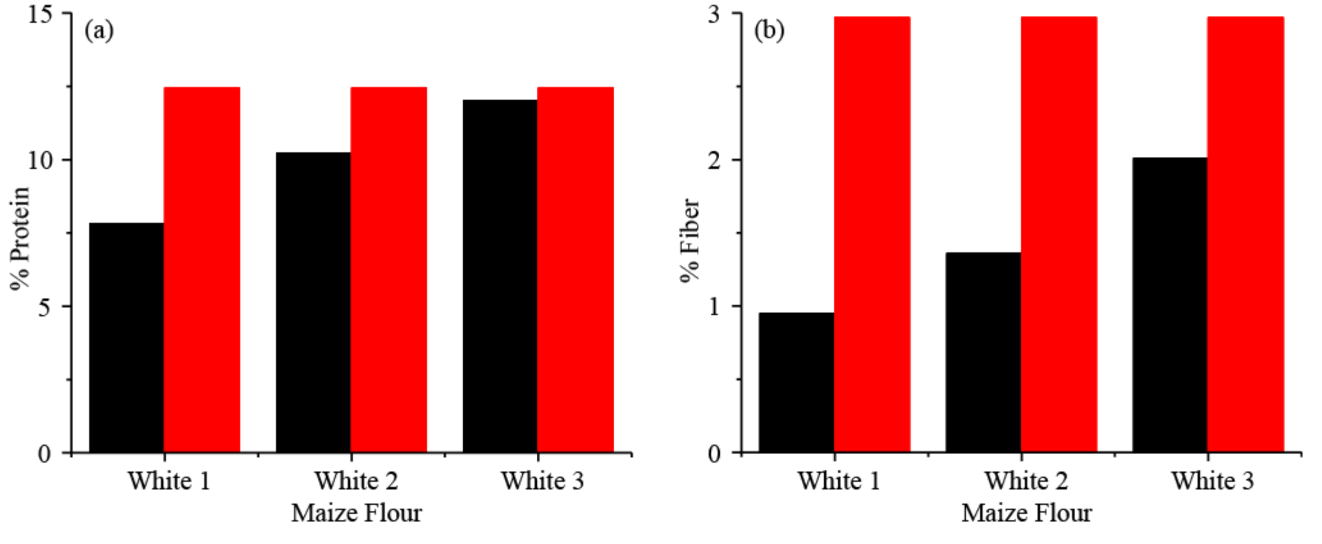

Fig. 2. The proximate chemical composition (a) Protein content of commercially available white maize flours and noncommercial yellow maize flour (b) Fiber content of commercially available white maize flours and noncommercial yellow maize flour.

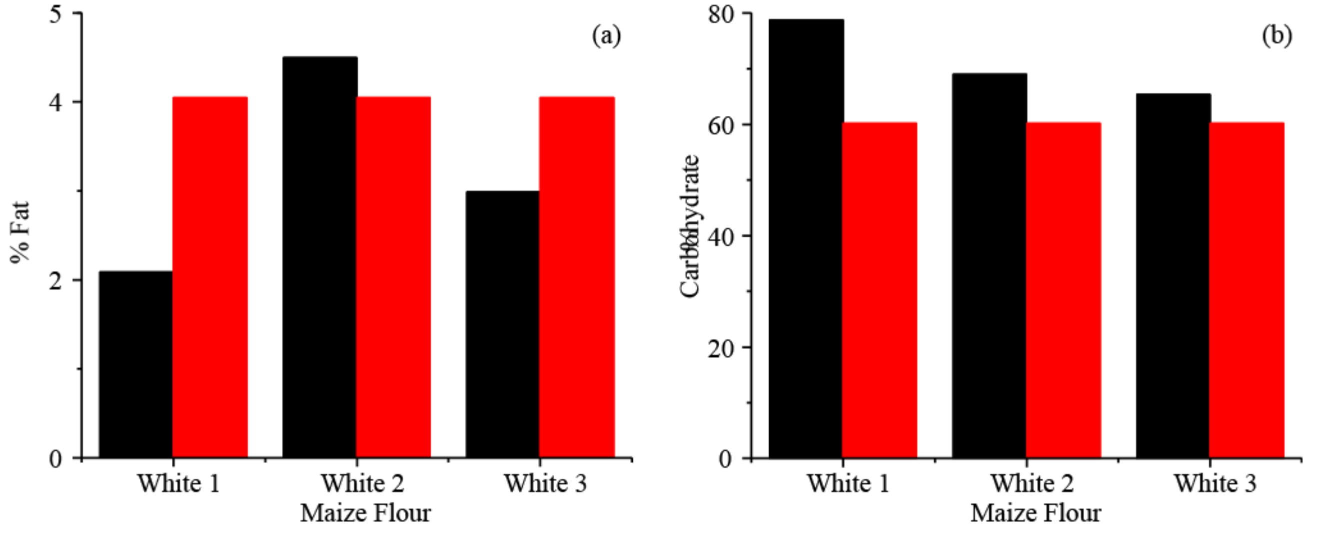

Fig. 3. The proximate chemical composition (a) Fat content of commercially available white maize flours and noncommercial yellow maize flour (b) Carbohydrate content of commercially available white maize flours and noncommercial yellow maize flour.

Table 1. The inorganic nutrients determined by ICP-MS in commercial white and noncommercial yellow maize flour powder grown at research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.

Maize Flour	Magnesium (Mg)	Potassium (K)	Sodium (Na)	Calcium (Ca)	Manganese (Mn)	Zinc (Zn)	Iron (Fe)	Copper (Cu)
White 1	98.16(1.1)	33.09(0.3)	95.18(1.3)	1319.78(1.0)	2.79(2.3)	6.1(1.2)	81.78(1.1)	5.39(1.3)
White 2	96.79(1.0)	32.80(0.2)	94.37(1.4)	1315.56(1.2)	2.68(2.2)	6.3(1.5)	80.73(1.0)	5.22(1.1)
White 3	99.61(1.2)	34.90(0.3)	96.08(1.4)	1327.56(1.1)	2.82(2.4)	6.4(1.6)	82.03(1.2)	5.43(1.3)
Yellow	1594.13(0.7)	914.98(0.9)	63.88(0.2)	1290.27(1.0)	21.48(1.9)	33.89(0.6)	115.13(1.2)	11.46(0.7)

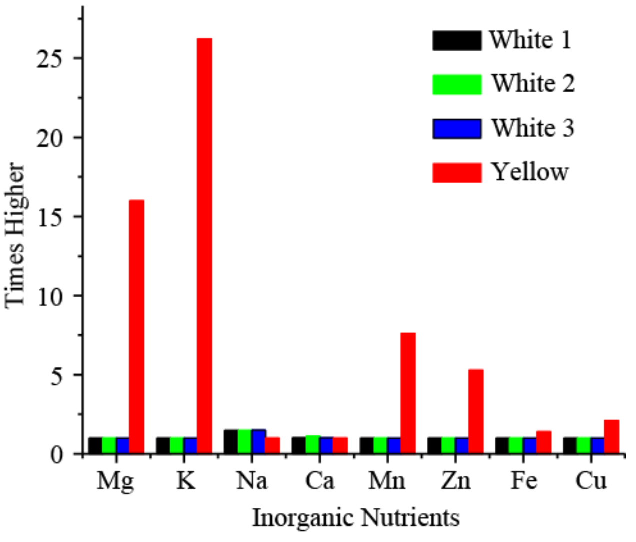

Fig. 4. Comparison of inorganic nutrients compositions of commercially available white maize flours and noncommercial yellow maize flour.

From the results of inorganic nutrients (Mg, K, Na, Ca, Mn, Zn, Fe, Cu) shows that the yellow maize flour contains 16, 26.21, 7.43, 5.29, 1.40, 2.11 times higher value of Mg, K Mn, Zn, Fe and Cu as compared to white maize flours, where as white maize flours contains 1.50, 1.02 times higher value of Na and Ca as compared to yellow maize flour obtained from the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan as shown in Fig. 4. The maize grown at UAF shows better nutritional compositions as compared to the commercially available mainly due to various genetic and environmental factors like irrigation rate, soil configuration and nourishment used (Ullah *et al*., 2010). Most of the nutritionally important minerals are higher in yellow maize flour as compared to commercially available white maize flour. Therefore, eating whole maize or yellow maize flour will be more advantageous as compared to white maize flour, as the exclusion of bran to make commercial available white flour resulted in eradicating the various vital component of maize.

Conclusion

The nutritional analysis of the commercially available white maize flours and noncommercial yellow maize flour obtained from the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan showed that both flours contain valuable crude fiber, protein, and required carbohydrates in the flour. In the present study, yellow maize flour obtained from the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan showed higher contents of protein, crude fiber and carbohydrates. From the results of inorganic nutrients (Mg, K, Na, Ca, Mn, Zn, Fe, Cu) the yellow maize flour contains 16, 26.21, 7.43, 5.29, 1.40, 2.11 times higher value of Mg, K Mn, Zn, Fe and Cu as compared to white maize flours, where as white maize flours contains 1.50, 1.02 times higher value of Na and Ca as compared to yellow maize flour obtained from the grains of the maize grown at University of Agriculture, Faisalabad, Pakistan.

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