ORIGINAL ARTICLE

CHEMICAL COMPOSITION OF LOCAL AND IMPROVED FINGER MILLET [*ELEUSINE COROCANA* (L.) GAETRTIN] VARIETIES GROWN IN ETHIOPIA

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ABSTRACT

BACKGROUND: ***Millet is stable food crop in the West, East and Great Lakes Regions of Africa. Finger millet (Eleusine corocana) is indigenous to Ethiopia and has good drought tolerance. The chemical composition of different finger millet varieties plays an important role in identifying those with high nutritional value. However, the chemical composition of the crop is not investigated in Ethiopia. Thus, this study evaluates the chemical composition of different varieties of finger millets grown in Ethiopia.***

METHODS*: The finger millet research materials were collected from Arsi Negele, Bako and Pawe research centers, and the study was conducted at Melkassa Agricultural Research Center in 2007. Comprehensive analyses of minerals such as Calcium, Iron, Zinc, Copper, Chromium, Magnesium and Manganese were determined using the atomic absorption spectrophotometer method. Proximate chemical composition analysis of the seed flour including moisture, total ash and crude protein were performed according Association of Official Analytical Chemists (AOAC) methods.*

RESULTS*: Nine millet varieties with 3-kg portions of each finger millet seeds were collected and used for this study. Mean values for protein content and mineral composition of finger millet varieties were ranged from 6.26* g/100 g *to 10.5* g/100g*; calcium 50.66 mg/100g to 319 mg/ 100g; iron 4.59 mg /100g to 53.39 mg/100g; zinc 0.97mg/100g to 2.56 mg/100g; magnesium 78 mg/100g to 201mg/100g; manganese 17.61 mg/100g to 48.43 mg/100g; phosphorus 3.46 mg/100g to 147mg/100g; chromium 0.12 mg/100g to 3.47 mg/100g and copper 0.18 mg/100g to 0.79 mg /100g. The protein content for improved Boneya and local PBL-1 varieties were 10.50 g 100 g^{-1} and 6.26 g 100 g^{-1} on dry basis, respectively. The proximate composition data analyses of improved and local finger millet varieties were also show significance variations within the varieties.*

CONCLUSION: ***This study reveled that finger millet are enriched with diverse macro and micronutrients even though there were significant differences among varieties in their composition. It was evident that from the composition analyses, the improved varieties from agricultural research centers were not superior in their composition except for protein content than the local ones. Further research into phytochemical composition, antioxidant activity of millet polyphenols, amino acid profile, digestibility and functional properties of these varieties need further investigation to select the best varieties with acceptable level of processing quality in order to develop alternative added-value food products.***

KEY WORDS*: Chemical composition, finger millet, nutritional quality, Ethiopia*

INTRODUCTION

Millet is one of the oldest foods known to humans and possibly the first cereal grain used for domestic purposes. Its use in making bread is mentioned in the Bible. *Eleusine* grain is most nutritious among the major cereal grains, its protein content is not only high, but of exceptionally good quality. Further more, it was reported that it has good amounts of phosphorus, iron, thiamine, riboflavin and nicotinic acid (1). It is mainly produced in West, East and Great Lakes Regions of Africa and still the principal sources of energy, protein, vitamins and minerals for millions of the resource poor people (2). China, Japan, Ethiopia, Egypt, Manchuria, India, Niger, Nigeria and the former Soviet Union are estimated to account for about 80 % of global millet utilization. Of the 30 million tones of millet produced in the world about 90% is utilized in developing countries and only a tiny volume is used in the developed countries outside the former Soviet Union (2).

Millet is most important cereal after rice, sorghum and wheat; and is a staple food for thousand of years in many parts of Africa and India. It can be grown on poor sandy soil in low rainfall areas (3). This crop is an important annual pasture and forage grass, highly drought resistant giving economically profitable yields on exhausted and nutrient poor soil. It is particularly high in the minerals iron, magnesium, phosphorous, and potassium. The seeds are also rich in phytochemicals, including phytic acid, believed to lower cholesterol which is associated with reduced cancer.(4-6). It was reported that millet grains has equal or superior in protein content as compared to wheat, rice, maize and sorghum grains (7).

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Finger millet, *Eleusine coracana* L., is also known as African millet, koracan, ragi (India), wimbi (Swahili), bulo (Uganda) and telebun (the Sudan). The colour of grains may vary from white through orange-red deep brown and purple, to almost black. It is an important staple food in parts of eastern and central Africa and India (7). Finger millet (*Dagussa)* is indigenous food crop to Ethiopia and occupies on average 5% (228,000 ha) of the total area devoted to cereal production and accounts for 4% of total cereal yield annually. It is important crop in areas of Gojjam, Gonder, Wollega, Iluababora, Gamo-Gofa, Eastern Hararghe and Tigray. This also becomes very important crop in the central rift valley of the country including Arsi Negele, Shashemene and Siraro Woredas (8). After the recent release of high yielding varieties for these areas, currently millet has become popular due to its advantages on agronomic practice (drought tolerant, storability of seeds and traditional food making quality) (9). The average millet production and utilization has been increasing and the estimated per capita consumption was 27.70 kg/year in Africa (10).

The search for high quality but cheap sources of protein and energy has continued to be a major concern of governments and organizations charged with the responsibility for food and nutrition in many parts of the world. Deficiencies of macro and micronutrients can lead to nutritional diseases. Hence knowledge about the chemical composition of food is vital to the health, well-being and safety of the consumer.

The present study was carried out to determine the chemical composition of finger millet including some important constituents of this cereal in order to identify varieties with high nutritional value that can be used for further development of new value-added food products.

MATERIALS AND METHODS

The experiment materials for the study were the three improved finger millet varieties (Tadesse, Padet, Boneya) and six local varieties which were collected from major finger millet producing areas of the country, Pawe and Bako. The local varieties included in the study were labeled PBR (Pawe Brown)-1, PBR-2, PBR-3; PBL(Pawe Black)-1, PBL- 2 and PBL-3. For each local variety 3-kg portions of finger millet seeds, were collected from Pawe and Bako agricultural research centers. The samples were collected in plastic bags and transported to the Food Science and Post-harvest Technology Research Program of Melkassa Agricultural Research Center for analyses in 2006.

The three improved finger millet varieties used in this study were grown at Arsi Negele Agricultural Research substation and Bako Agricultural Research Center. The varieties of (*Eleusine corocana* (L.) Gaetrin) that were used for the study were Tadesse (KNE #1098), Padet (KNE #409) and Boneya (KNE # 411). All varieties were released from national millet research centers (Arsi Negele, Pawe and Bako).

Tadesse variety was released in 1998 after the late Tadesse Mulatu, sorghum and millet breeder, who first selected this line as a potential variety. It was released for Arsi Negele, Adet, Pawe, Bako and similar areas. Padet variety was released for the Pawe and Adet areas where it has been repeatedly tested and shown better performance. Furthermore, Boneya (KNE # 411) variety was released by Bako Agricultural Research Center in 2002 for Western Ethiopia. It has been given superior yield and acquired resistant to blast disease and lodging.

All the test samples were clean, free from abnormal odors, broken seeds, dust and other foreign materials including living or dead insects before testing commenced. The finger millet varieties were ground in analytical mill to a fine powder that is able to pass through an 80-mesh screen. The finger millet powder obtained was placed in plastic containers and stored at room temperature (20 ^{0}C) prior to analyses. All chemicals and reagents used were either analytical or reagent grade from Fischer, Sigma and BDH Companies.

Proximate chemical composition analyses of the seed flour including moisture, total ash and crude protein (N x 6.25) were performed according to the Official Methods of Analysis of AOAC (2000) International 925.09, 923.03 and 979.09, respectively (21). Crude protein was analyzed using Kjeldahl block digestion and steam distillation (2200 Kjeltec auto distillation, Foss Tecator, Sweden). Analyses of Ca, Fe, Zn, Cu, Cr, Mg and Mn were done by the method reported by Issac and Johnson (22) using atomic absorption spectrophotometer. Phosphorus content was determined colorimetrically as described by Dickman and Bray (23) using UV/Visible spectrophotometer (Model 6405, Jenway Ltd. UK, 1999).

The experiment was laid out using complete randomized design (CRD) and data were scrutinized by analysis of variance (ANOVA). In order to determine homogenous groups of varieties *Schefe* test was employed. Statistical analyses were performed using SPSS for Windows version 12 .0.1 and significance was accepted at $P < 0.05$. All values were presented as means of triplicates ± standard deviation.

RESULTS

Result of the analyses revealed that there were statistically significant differences in the chemical and mineral composition of among the different finger millet varieties. Homogenous groups of finger millet varieties by composition were elaborated to reveal their significance difference within the varieties in each group (Table 1).

Contents of moisture, ash, protein and minerals of improved and local varieties of finger millets were analyzed. The protein content of PBL-1 and Boneya finger millet varieties were 6.26 and 10.50 g/100g; respectively. Relatively high quantity of protein was also observed in the improved variety Padet-1.

Table 1. Homogenous groups of finger millet varieties by composition

Composition		Homogenous groups of finger millet varieties			
		1	2	3	4
Protein	Subgroup	PBL-1, PBR-3, PBL-3, PBL-2, PBR-2, PBR-1, Tadesse	Tadesse, Padet-1	Padet-1, Boneya	
	Significance	0.55	0.05	0.99	
Moisture	Subgroup	Boneya, Tadesse	Tadesse, Padet-1, PBR-3, PBR-2, PBR-1, PBL-2	Padet-1, PBR-3, PBR-2, PBR-1, PBL-2, PBL-1	PBR-3, PBR-2, PBR-1, PBL-2, PBL-1, PBL-3
	Significance	0.17	0.09	0.13	0.61
Ash	Subgroup	Boneya	Padet-1, Tadesse	PBL-3, PBR-3, PBL-1, PBR-1, PBL-2	PBR-2
	Significance	1.00	1.00	1.00	1.00

Note: The first group with lower content and last group with higher content of nutrients respectively

Table 1. Continued

Composition		Homogenous groups of finger millet varieties								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ca	Subgroup	Boneya	Padet-1, Tadesse	PBR-3, PBR-2	PBR-1, PBL-2	PBL2, PBL-3	PBL-1			
	Significance	1.00	1.00	1.00	0.74	0.15	1.00			
Fe	Subgroup	Padet-1	Boneya	Tadesse	PBL--2	PBL-3	PBR-3	PBL-1	PBR-1	PBR-2
	Significance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Zn	Subgroup	PBR-1	Boneya	PBL-2	PBL-3, PBR-3, PBR-2	PBL-1	Tadesse	Padet-1		
	Significance	1.00	1.00	1.00	0.09	1.00	1.00	1.00		
Cu	Subgroup	Boneya	PBR-3, PBL-3 PBL_2, PBL-1	PBL-3 PBL-2, PBL-1 Tadesse PBR-1, Padet-1	PBL-1 Tadesse PBR-1, Padet-1 PBR-2					
	Significance	1.00	0.162	0.059	0.059					
Mg	Subgroup	Boneya	Tadesse, Padet-1, PBR-1	PBR-1, PBR-2, PBR-3	PBR-2, PBR-3, PBL-2	PBL-2, PBL-3	PBL-3, PBL-1			
	Significance	1.00	0.17	0.83	0.20	0.61	0.37			
Mn	Subgroup	Padet-1	PBR-1	Boneya	PBR-2	PBR-3	Tadesse	PBL-2	PBL-3	PBL-1
	Significance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P	Subgroup	Boneya	PBR-3, PBR-1	PBL-3, Padet-1	Padet-1, PBR-2	PBR-2, PBL-1	PBL-1, Tadesse	Tadesse, PBL-2,		
	Significance	1.00	1.00	0.93	0.08	1.00	0.08	1.00		

Note: The first group with lower content and last group with higher content of nutrients respectively; Significance represents the significance level at which significant difference could be observed within the varieties in each group

Table 2. Chemical composition of nine finger millet varieties of whole seed sample (mean ± SD, n=3)

Variety	Indicator	g 100 g^{-1} DM[a]			mg 100 g^{-1} of edible portion							
		Protein	Moisture	Ash	Ca	Fe	Zn	Cu	Cr	Mg	Mn	P
Boneya	Mean	10.50	6.00	1.80	50.66	6.01	0.97	0.18	ND	78.00	18.87	3.46
	SD	0.50	1.00	0.15	0.03	0.04	0.02	0.04	ND	58.03	0.03	0.04
Padet-1	Mean	9.86	9.39	2.41	248.00	4.59	2.56	0.73	0.18	165.00	17.61	135.00
	SD	0.84	0.04	0.01	3.00	0.02	0.03	0.02	0.03	1.00	0.02	0.00
PBL-1	Mean	6.26	12.25	2.85	319.00	34.15	1.91	0.66	0.19	201.00	48.43	141.00
	SD	0.02	0.23	0.02	1.00	0.05	0.01	0.00	0.00	0.00	0.03	0.00
PBL-2	Mean	6.71	11.75	2.89	299.00	26.62	1.57	0.61	0.19	186.33	45.39	147.00
	SD	0.30	0.00	0.09	4.00	0.00	0.01	0.01	0.06	6.43	0.01	3.00
PBL-3	Mean	6.64	12.73	2.84	307.00	27.31	1.69	0.60	1.02	193.00	48.08	133.00
	SD	0.10	0.01	0.00	2.00	0.01	0.00	0.00	0.01	1.00	0.00	1.00
PBR-1	Mean	6.70	11.48	2.89	289.00	53.13	1.72	0.73	3.47	174.00	17.80	126.00
	SD	0.03	1.18	0.02	1.00	0.03	0.02	0.01	0.00	6.00	0.01	0.00
PBR-2	Mean	6.80	11.30	3.32	277.00	53.39	1.75	0.79	0.12	179.33	18.98	140.00
	SD	1.20	1.30	0.03	7.00	0.00	0.03	0.09	0.02	6.81	0.00	2.00
PBR-3	Mean	6.36	10.87	2.85	271.00	30.66	1.71	0.55	0.18	179.33	19.86	125.00
	SD	0.96	0.36	0.01	0.00	0.01	0.00	0.04	0.01	1.53	0.01	1.00
Tadesse	Mean	7.61	9.71	2.45	248.00	6.25	2.31	0.72	0.15	163.00	20.17	146.00
	SD	0.11	0.02	0.01	4.00	0.00	0.01	0.00	0.03	2.00	0.01	2.00
Total	Mean	7.49	10.61	2.70	256.52	26.90	1.80	0.62	0.69	168.78	28.35	121.83
	SD	1.60	2.04	0.42	77.85	18.03	0.43	0.18	1.11	38.44	13.70	43.32
F-Values		19.22	16.59	152.99	1844.42	1697884	1886.15	74.79	5413.69	10.10	2110869	2886.71
Significance level		***	***	***	***	***	***	***	***	***	***	***
Eta Squared		0.90	0.92	0.99	1.00	1.00	1.00	0.97	1.00	0.82	1.00	1.00

Note: *** indicates significance difference among varieties at 5% significance level, SD represents standard deviations. Eta squared represents the proportion of variation accounted for by the differences among the groups, ND-Not detected, DM[a] - Each values expressed on dry matter (weight) basis.

The lowest calcium content was seen for Boneya variety (50.66 mg/100g) whereas, for the others it ranged from 248.00 to 319.00 mg/100g; the higher Ca content being observed in the local black finger varieties. The improved varieties Boneya, Padet-1 and Tadesse had lower content of Ca as compared to both the brown and black local varieties. The lowest Iron content was for Boneya (4.59 mg/100g) and the highest for PBR-2 (53.39 mg/100g). Zinc content ranged from 0.97 to 2.56 mg/100g with higher content for the improved varieties of Padet-1 and Tadesse. Low content of magnesium (78.00 mg/100g) was for Boneya and the highest was (201.00 mg/100g) for PBL-1. Manganese content was low (17.61 mg/100g) for Padet- 1 and highest (48.43 mg/100g) for PBL-1. The highest Phosphorus content (147.00 mg/100g) was seen for PBL-2. Moisture, ash, Cu and Cr were all low or undetectable on Boneya variety (Table 2).

DISCUSSION

Contents of moisture, ash, protein and minerals of improved and local varieties of finger millets studied are presented in Table 2. For all varieties, significant differences ($P < 0.05$) were observed in the nutrient contents.

The protein content of these cultivars was varied from 6.26 (PBL-1) to 10.50 g $100g^{-1}$. The chemical composition values found in the three improved and six local finger millet varieties considered in this study were similar to or slightly greater than concentrations reported by many investigators for different varieties (10-17). Ca, Fe, Zn, Cu, Cr, Mg, Mn and P concentrations of the grains were varied and found to be greater than concentrations given by the Indian and Saudi cultivars (1). Concentration of phosphorus in this study was lower while, that of Ca and Fe were higher than those observed for the millet cultivars of Saudi Arabia, India and other parts of Africa (1). The iron content of local finger millet varieties is better than improved dry bean varieties grown in Ethiopia (19) and other cereals (wheat, maize, sorghum). Furthermore, the calcium content was 5-30 times more than that of many cereals including sorghum 30 mg/100g, *tef* 140 mg/ 100g, barley 47 mg/100g, maize 6 mg/ 100g and wheat 49 mg/ 100g; respectively (18). Zinc is an essential trace element (micronutrient) involved in the immune function, in the activation of many enzymes, healthy growth and reproduction (20). Zinc concentration in the nine analyzed samples varied from a low of 0.97 g/100gm (Boneya) to 2.56 g/100gm (Padet-1). Zinc deficiency is common in Africa and Asian continents. Thus, zinco-protein supplementation of plant based foods can reduce protein energy malnutrition disease in general (20). By and large millet grains contained good amounts of minerals and consequently consumption of alternative value-added finger millet food products can be recommended to prevent calcium deficiency and other related nutritional disorders.

In conclusion, the results of this study reveled that finger millets can be good sources of macro and micronutrients. It was evident that from the composition analyses, the improved varieties from agricultural research centers were superior in their protein content but the local varieties were better in other nutritional components. This in turn shows that the National breeding program of finger millet had focused mainly on agronomic traits such as yields, drought tolerance and disease resistance but never on nutritional quality. It is recommended to focus and conduct breeding activities on the enhancement of local varieties which are superior in their compositions. In general, this work shows that millet grains contained good amount of minerals especially calcium which can be used as a raw material for weaning food processing industries. Further investigation focusing on amino acid profile of finger millet proteins quality, phytochemical composition, digestibility, antioxidant activity, polyphenols and functional property of these varieties is recommended.

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