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Determining the Physicochemical Compositions of Recently Improved and Released Sorghum Varieties of Ethiopia

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Abstract: Sorghum is an important cereal crop used as human a staple food grain in many semi-arid and tro pical areas of the world, notably is Sub-Saharan Africa and Asian continents by approximately 500 million people due to its good agronomic properties in harsh environment. It is known that sorghum is a gluten-free cereal used as ground flour and it is a source of energy, protein, vitamins, minerals, and as antioxidant phenolics and cholesterol- lowering waxes. The Physicochemical characteristics of sorghum flour were determined for ten recently improved and released sorghum varieties cultivated in Ethiopia were analyzed for proximate composition. Results revealed that proximate composion i.e. moisture, 1000- kernel weight, crude protein, crude fat, ash, crude fiber and total carbohydrates of sorghum varieties differed significantly ($P<0.01$) and the results of the crude protein ranged from 9.333-16.030%, crude fat 2.602 to 4.627%, crude fiber 4.850-8.963%, ash 1.241-1.883, moisture content 6.767-12.839, 1000 kernel seed weight 22.263-42.626, and total carbohydrate 66.834 to 78.744%. This study showed that the physicochemical composition of the 10 selected sorghum varieties of Ethiopia was significantly different from one variety to another variety and different varieties are different in physicochemical profile.

Keywords: Ethiopian Sorghum, Physico-Chemical Properties, Improved and Released Varieties

1. Introduction

Sorghum (*Sorghum Bicolor (L) Moench*), is an important cereal grain in the developing countries due to its drought resistance and relatively low input costs [1, 2]. It is one of the most important crops in Africa, Asia and Latin America. Sorghum while playing a crucial role in food security in Africa, it is also a source of income of house-hold [3]. More than 35% of sorghum is grown directly for human consumption. The rest is used primarily for animal feed, alcohol production and industrial products [4]. A part of Africa's yearly sorghum crop is allocated to opaque beer processing [5]. But as we know that the nutritional and chemical composition of sorghum varies from variety and at different agro ecology. In Ethiopia sorghum production is well established and has been practiced across communities for centuries. Furthermore it has been established that sorghum varieties differ substantially in their physical and chemical characteristics and therefore will produce products of varied qualities [6]. The yield and quality of sorghum produced worldwide is affected by a wide array of biotic and abiotic constraints [7-10]

Furthermore, very little data exist on the physicochemical composition of Ethiopian recently improved and released sorghum varieties. The objective of this study was to produce and to provide physicochemical characterization data for ten different sorghum varieties used for human diet in Ethiopia in order to make suggestions for their qualities improvement. This information could be used in assisting sorghum breeders and those adding value to sorghum, in producing products of specific sensory characteristics that are well accepted by consumers.

2. Materials and Methods

2.1. Sample Collection and Preparation

The ten recently improved and released sorghum varieties of Ethiopia used in this study were collected from Melkassa agricultural research center as this center coordinates the commodity at national level in Ethiopia. The test samples were cleaned manually to remove husks, damaged grains, stones, dust, light materials, glumes, stalks, undersized and immature grains and other extraneous materials. Cleaning was done by winnowing, hand sorting and passed through 1mm mesh size laboratory sieve.

Table 1. *The released year of sorghum variety, the agro ecology, and the seed color data.*

No	Variety Name	Year of Release	Agro Ecology	Seed Color
1	ESH-3	2014	Dry lowland	White
2	ESH-4	2016	Dry lowland	Red
3	MELKAM	2009	Dry lowland	White
4	DEKEBA	2012	Dry lowland	White
5	JIRU	2016	High land	Red
6	DIBABA	2015	High land	White
7	ADELE	2010	High land	White
8	ASSOSA-1	2015	Humid lowland	White
9	ADUKARA	2015	Humid lowland	White
10	TESHALE	2008	Dry lowland	White

The agro-ecology at which the sorghum varieties to be cultivated, the year when the improved sorghum varieties released and the color of each variety is enclosed in the table. As it is shown in the table 1 the agro ecology at which the varieties are (5 Dry lowland, 3 High land, 2 Humid lowland) and the seed color released sorghum varieties are (8 variety are white and 2 variety are red) which were improved and released at national level starting from 2008-2016 G.C.

2.2. Physico-Chemical Analysis Methods of Ten Sorghum Varieties

Official standard methods of analysis of Association of Official Analytical Chemists (AOAC, 2000) were used for proximate chemical analysis of sorghum.

2.2.1. Thousand Seed Kernel Weight

One thousand seed kernel weight of sorghum varieties was analyzed by electronic grain counter (wagtech international) and the results are expressed as the mean of triplicates observation.

2.2.2. Determination of Moisture Content

Empty dishes and their lids (made of porcelain) was dried using drying oven for 1h at 130°C, transferred to the desiccators (with granular silica gel), cooled for 30 min, and weighed. The prepared samples were mixed thoroughly and about 2.000g of fresh samples were transferred to the dried and weighed dishes. The dishes and their contents were placed in the drying oven and dried for 1h at 130°C. Then the dishes and their contents were cooled in desiccators to room temperature and reweighed and triplicates of each sample were determined. The amount of water present in a sample is considered to be equal to the loss of weight after drying the sample to constant weight at a temperature near the boiling point of water.

2.2.3. Determination of % Ash

Ash was determined by incineration of known weights of the samples in a muffle furnace at 550°C until a white ash was obtained. Organic matter was burned off and the inorganic material remaining is cooled and weighed. Heating was carried out in stages, first to derive the water, then to char the product thoroughly and finally to ash at 550°C in a muffle furnace. The ashing dishes (made of porcelain) were placed into a muffle furnace for 30 min at 550°C. The dishes were removed and cooled in desiccators for about 30 min at room temperature; each dish was weighed to the nearest g. About 4 g of flour sample was added into each dish. The dishes were placed on a hot plate under a fume-hood and the temperature was slowly increased until smoking ceases and the samples become thoroughly charred. The dishes were placed inside the muffle furnace at 550°C for 6 h, and removed from 30 the muffle and then placed in desiccators for 1h to cool. The ash was clean and which in appearance. When cooled to room temperature, each dish + ash was reweighed. Weight of total ash was calculated by difference and expressed as percentage of the fresh sample.

2.2.4. Crude Protein Determination

Protein (N*6.25) was determined by the Kjeldahl method. All nitrogen is converted to ammonia by digestion with a mixture of concentrated sulfuric acid and concentrated ortho-phosphoric acid containing potassium sulfate as a boiling point raising agent and selenium as a catalyst. The ammonia released after alkalinization with sodium hydroxide is steam distilled into boric acid and titrated with sulfuric acid.

2.2.5. Determination of Crude Fat Content

Crude fat was determined by exhaustively extracting a known weight of sample in petroleum ether (boiling point, 40 to 60°C) in a soxhlet extractor. The ether was evaporated from the extraction flask. The amount of fat was quantified gravimetrically and calculated from the difference in weight of the extraction flask before and after extraction as percentage.

2.2.6. Determination of Crude Fiber Content

Crude fiber was determined after digesting a known weight of sorghum flour by refluxing 1.25% boiling sulfuric acid and 28% boiling potassium hydroxide.

About 1.6g of sample was digested into a 600ml beaker, with addition of 200ml of 1.25% H_2SO_4, and boiled gently exactly for 30 min placing a watch glass over the mouth of the beaker. During boiling, the level of the sample solution was kept constant with hot distilled water. After 30 min boiling, 20ml of 28% KOH was added and boiled gently for a further 30 min, with occasional stirring. Then filtration and washing was performed. Drying and combustion: The crucible with its content was dries for 2 h in an electric drying oven at 130°C and cooled for 30 min in the desiccators (with granular silica gel), and then weighed (recorded as W1). The crucible was transferred to a small muffle furnace and incinerated for 30 min at 550°C. The crucible was cooled in the desiccators and weighed (recorded as W2).

Then the fiber was calculated as a residue after subtraction of the ash.

$$\text{Crude fiber g/100g} = \frac{(\text{w1} - \text{w2})}{\text{w2}} \times 100$$

Where: W1= weight of (Crucible + sample) after drying; W2= weight of (Crucible + sample) after ashing; W3= weight of fresh sample.

2.2.7. Determination of Total Carbohydrate

Total carbohydrate contents of sorghum varieties were calculated by the following equations

Total Carbohydrate (%) = 100-(% moisture+%protein+%fat +%ash).

3. Results and Discussion

Physical characteristics colour and 1000-kernel weight of sorghum varieties are presented in Table 1 and 3. Visual observations of sorghum genotypes revealed that sorghum were creamy white in colour and red. The 1000 kernel weight of sorghum varieties varied widely and ranged from 22.263-42.626 g (Table 2). The highest 1000- kernel weight (42.626 g) and the lowest 1000-kernel weight (22.263g) were observed by electronic grain counter (wagtech international). Table 2 reveals the proximate composition of sorghum varieties. Moisture content varied widely among the different sorghum varieties and ranged between 6.767-12.839 per cent. The highest moisture content was in ESH-3 followed by ESH-4 (11.740%). The crude protein content of sorghum varieties varied from 9.333-16.030 percent. The highest protein content was found in ESH-3 (16.030) followed by ESH-4 (15.467%) and least value was observed in JIRU (9.333%). The crude Fat content in the sorghum varieties ranged between 2.602 to 4.627 percent. The fat content was highest (4.627%) in the variety TESHALE followed by ADELE (4.010%) and the least value was noticed in DEKEBA (2.602%). Ash content of different sorghum varieties varied widely and ranged from 1.241-1.883 percent. The crude fiber content of different sorghum varieties varied widely, and ranged from 4.850-8.963% percent. The content of total carbohydrates of different sorghum varieties varied widely. The highest content of total carbohydrates (78.744%.%) was in MELKAM, followed by DEKEBA (76.802%) and the least (66.834%) was noticed in ESH-3. The difference observed in moisture content, crude protein content, and crude fat content and carbohydrates were statistically significant. A significant variation in chemical composition was also observed as reported in [12, 13)].

3.1. Physico-Chemical Analysis of Ten Sorghum Varieties

The ten recently improved and released sorghum verities such as ESH-3, ESH-4, Melkam, Dekeba, Jiru, Dibaba, Adele, Assosa-1, Adukara, Teshale were used for this study. Color of the whole sorghum grains were observed visually and recorded. One thousand seed kernels of sorghum varieties were counted by electronic grain counter (wagtech international) and the results are expressed as the mean of triplicates observation. The moisture content, crude protein, crude fat, ash, crude fiber and total, carbohydrates analysis of ten varieties of recently improved and released sorghum verities were analyzed by using standard methods. The results of each parameter were reported in the following table and data's were mean of triplicate analysis.

Table 2. *Physico-chemical analysis of ten sorghum varieties.*

No	Variety name	1000 seed kernel weight (g)	Moisture content	% Ash	Crude fat	Crude fiber	Crude protein	% of Total carbohydrate
1	ESH-3	33.020	12.839	1.783	3.066667	7.047	16.033	66.8327
2	ESH-4	32.850	11.740	1.758	3.302533	7.360	15.467	67.7325
3	MELKAM	33.691	6.767	1.607	3.015367	6.260	9.867	78.7437
4	DEKEBA	29.242	7.264	1.732	2.602433	6.583	11.600	76.8016
5	JIRU	42.626	11.652	1.479	3.233933	4.850	9.333	74.3021
6	DIBABA	32.191	10.763	1.700	2.9747	8.614	10.933	73.6293
7	ADELE	32.217	11.163	1.437	4.0101	5.938	10.717	72.6729
8	ASSOSA-1	22.263	10.443	1.241	3.534767	8.100	10.300	74.4813
9	ADUKARA	28.327	10.529	1.883	3.2585	8.963	11.483	66.8327
10	TESHALE	28.883	7.014	1.532	4.627333	5.776	12.300	67.7325

3.2. Thousand Seed Kernel Weight

Table 3. *Thousand seed kernel weight data for ten selected sorghum varieties.*

No	Variety name	1000 seed kernel weight(g)
1	ESH-3	33.020
2	ESH-4	32.850
3	MELKAM	33.691
4	DEKEBA	29.242
5	JIRU	42.626
6	DIBABA	32.191
7	ADELE	32.217
8	ASSOSA-1	22.263
9	ADUKARA	28.327
10	TESHALE	28.883

One thousand seed kernel weight of sorghum varieties was analyzed by electronic grain counter (wagtech international) and the results are expressed as the mean of triplicates observation.

3.3. Determination of Total Carbohydrate

Table 4. *Total Carbohydrate (%) data for ten selected sorghum varieties.*

No	Variety name	Mean value of CP	Mean value of C Fat	Mean value of MC	Mean value of% ash	Total Carbohydrate (%)
1	ESH-3	16.033	3.066667	12.839	1.783	66.8327
2	ESH-4	15.467	3.302533	11.740	1.758	67.7325
3	MELKAM	9.867	3.015367	6.767	1.607	78.7437
4	DEKEBA	11.600	2.602433	7.264	1.732	76.8016
5	JIRU	9.333	3.233933	11.652	1.479	74.3021
6	DIBABA	10.933	2.9747	10.763	1.700	73.6293
7	ADELE	10.717	4.0101	11.163	1.437	72.6729
8	ASSOSA-1	10.300	3.534767	10.443	1.241	74.4813
9	ADUKARA	11.483	3.2585	10.529	1.883	72.8465
10	TESHALE	12.300	4.627333	7.014	1.532	74.5267

Total carbohydrate contents of sorghum varieties were calculated by the following equations

Total Carbohydrate (%) = 100- (% moisture + %protein + %fat + %ash). As it seen from in the table 4 the highest total carbohydrate% is melkam which is 78.7437 and the lowest one ESH-3 which is 66.8327.

4. Conclusion

The present work aimed to profile the physic-chemical properties of recently improved and released sorghum varieties used for food in Ethiopia. It focused on the physico-chemical characterization of white and red varieties of sorghum samples which were improved for different agro-ecology as compared to varieties. The sorghum varieties were collected from sorghum improvement program in Ethiopia and the physico-chemical parameters of 10 sorghum varieties flour were performed. The results obtained from the analysis indicated that the crude protein ranged from 9.333-16.030%, crude fat 3.58 to 4.47%, crude fiber 4.850-8.963%, ash 1.241-1.883, moisture content 6.767-12.839, 1000 kernel seed weight 22.263-42.626, and carbohydrate 66.834 to 78.7437%. Therefore the results reveals that there were a significant difference on the physicochemical composition of sorghum varieties obtained from Ethiopian agro-ecology. For instance this study showed that variety difference has significance difference on physicochemical composition sorghum varieties at different agro-ecology and even if within the same agro-ecology. To conclude that different 10 recently improved and released sorghum varieties physicochemical composition is significantly different from one variety to another variety. The researcher recommends that to study micro-nutrient, functional property and anti-nutritional factors analysis to finalize the profiling of the selected varieties and to help the sorghum breeders for further improvement of varieties.

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