Investigation of Quality Traits In 30 Sudanese Pearl Millet (Pennisetum glaucum [L.] R. Br.) Genotypes

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Abstract

30 Sudanese pearl millet (Pennisetum glaucum [L.] R. Br.) genotypes were investigated to determine their chemical compositions, mineral contents and physical properties. Randomized complete design with three replications was used for laying out the laboratory experiments. The results showed that there were significant differences (P ≥ 0.5) between the 30 pearl millet genotypes for all the quality studied traits. The means of the chemical compositions showed that, the highest values of protein (16.21%), carbohydrates (68.63%), fiber (15.37%), moisture (7.05%), fats (5.21%) and ash (1.70%) were obtained by the genotypes Dembi millet, HSD55555, Sudan II, Dembi Shangal Toby, HSD10294 and HSD10294, respectively. The means of the minerals in (mg/kg) showed that, the highest values of Ca (125.7), P (972.33), Fe (100.82), K (5742.3), Mg (1588.3), Na (45.00), Zn (50.68) were obtained by the genotypes Dembi Sea, SADC (Long), Dembi Shangal Toby, Dembi Millet, HSD10293, HSD10292 and HSD10354, respectively. The highest granule size (11.9) and weight of 100 seeds (1.36 gm) were obtained by the genotypes Dembi kabkabia and HSD10294, respectively. Most of the 30 millet genotypes were characterized with yellow and/or different ranges of yellow color mixed with other colors. 27 millet genotypes included 7 local, released and improved varieties exhibited desirable and normal tastes. The considerable variability and the millet genotypes scored high values of quality traits could be of a great value in any millet breeding program and/or for Sudanese millet consumers.

Key words: Pearl millet; Genotypes; Chemical composition; Physical properties; Minerals contents.

I. INTRODUCTION

Pearl millet (Pennisetum glaucum [L.] R. Br.) is a cereal crop belongs to the family Poaceae (Gramineae) and believed to be originated in west Africa. It is an annual summer crop, cross pollinated and has a chromosome number of 2n =14. The term millet is brooding applied over 140 species belonging to the Genus ‘Pennisetum’ [17]. In terms of annual production, pearl millet is the sixth most important cereal crop in the world following wheat, rice, maize, barely and sorghum [35]. In general, pearl millet is grown in the dry areas of temperate tropics and sub tropics in Africa and Asia under the most difficult environmental conditions, including those in drought – stricken areas where soil fertility is low and food supplies are dependent on rainfall [17]. Today millet is considered as the food needs for more than 500 million people. The areas cultivated with millet are estimated annually as 15 million hectares in Africa and 14 million hectares in Asia, the world production is around 33.4 million metric/tons with an average grain yield of 699.0 Kg ha⁻¹ [16]. Bibliography [3] reported that, in the Sudan and among the cereals, millet comes second to sorghum in area and total production and consumption and it is preferred staple food for the most of inhabitants in Western Sudan (Kordofan and Darfur states). It is mainly grown under traditional farming methods, where the rainfall is between 200 – 800 mm [5] and the average yield fluctuates between 185 to 618 kg/ha [7]. Recently millet is cultivated in small areas of the irrigated projects of the Sudan [36]. The grains of
pearl millet is comparatively highly nutritive value more than the grains of other cereals, especially in carbohydrates, fats and minerals contents. Recently, high nutritive value of millet grains were reported by many authors, e.g. [33] and [37]. More over many millet investigators e.g [20] illustrated that multi health benefits could be obtained from millet grains. Most of millet improvement programs in the Sudan were focused on obtaining millet varieties or hybrids characterized with high yield, early maturity prevailing pests and disease …etc., [4]. On the other hand, meager studies were conducted to investigate or compare the differences between the Sudanese grain millet genotypes in quality traits (protein , carbohydrates, minerals, vitamins ..etc. [36]. Therefore, the present study was conducted to investigate some quality traits (chemical compositions, mineral contents and physical properties) in 30 Sudanese grain pearl millet genotypes.

II. MATERIALS AND METHODS:

I. Materials

A total of 30 Sudanese grain pearl millet (Pennisetum glaucum [L.] R. Br.) genotypes obtained from Plant Genetic Resource Unit(PGR), Agricultural Research Corporation (ARC) and North and East Darfur States, Sudan, were used in this study to determine their Chemical composition, Physical Properties and Mineral Contents (Table, 1).

<table>
<thead>
<tr>
<th>Millet Genotypes</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HSD7131</td>
<td>PGR Unit, Gene Bank, ARC, Sudan.</td>
</tr>
<tr>
<td>2. HSD7132</td>
<td>PGR Unit, Gene Bank, ARC, Sudan.</td>
</tr>
<tr>
<td>3. HSD7133</td>
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<td>11. HSD10309</td>
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<td>12. HSD10313</td>
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<tr>
<td>13. HSD10318</td>
<td>PGR Unit, Gene Bank, ARC, Sudan.</td>
</tr>
</tbody>
</table>
14. HSD10319 PGR Unit, Gene Bank, ARC, Sudan.
15. HSD10331 PGR Unit, Gene Bank, ARC, Sudan.
16. HSD10354 PGR Unit, Gene Bank, ARC, Sudan.
17. HSD10362 PGR Unit, Gene Bank, ARC, Sudan.
18. HSD10376 PGR Unit, Gene Bank, ARC, Sudan.
19. HSD10392 PGR Unit, Gene Bank, ARC, Sudan.
20. HSD55555 PGR Unit, Gene Bank, ARC, Sudan.
21. Ashana Released variety by ARC, Sudan.
22. SADC (Long) Released variety by ARC, Sudan.
23. SADC (Togo) Released variety by ARC, Sudan.
24. Ugandi Released variety by ARC, Sudan.
25. Sudan II Improved variety, ARC, Sudan.
26. MCNELC Released variety by ARC, Sudan.
27. Dembi Millet Local variety, E. Darfur State, Sudan.
28. Dembi Shangal Toby Local variety, N. Darfur State Sudan.
29. Dembi Kabkabia Local variety, N. Darfur State Sudan.
30. Dembi Sea Local variety, N. Darfur State Sudan.

PGR= Plant Genetic Resources.
ARC= Agricultural Research Corporation, Wad-Madani, Sudan.

III. Laboratory experiments

The laboratory experiments were carried out at the laboratory of National Food Research Center, Khartoum North, Shambat, Sudan. The seeds of the 30 millet genotypes were manually and separately cleaned to remove dust, broken seeds and other extraneous materials, then the dry samples were later milled and the processing of the samples was carried out in a randomized complete design (RCD) with 3 replicates for the following procedures:

A. Chemical analysis (Proximate composition analysis):

The Chemical analyses in this study Included moisture content%, Crude protein%, Crude fiber%, Crude fats%, ash content%, carbohydrates%, they were carried out according to the official methods described in [6].
**B. The mineral contents:**

The mineral contents (in mg/kg) in the seeds of the 30 pearl millet genotypes included Calcium (Ca), Phosphor (P), Iron (Fe), Potassium (K) Magnesium (Mg), Sodium (Na) and Zinc (Zn). These minerals were determined according to the official method of [6].

**C. Physical properties:**

The physical properties in this study included seed colour, grain (seed) size (mm), 100 seed weight (g) and Taste. The granules size of the 30 pearl millet seeds were recorded using Vernier Caliper.

**IV. STATISTICAL ANALYSIS:**

The statistical analysis of variance for the collected data of the chemical analysis, mineral contents and physical properties was carried out for a randomized complete design according to [18]. The means were separated according to Duncan Multiple Range Test at 5% level of probability [14].

**V. RESULT AND DISCUSSION**

**I. Statistical analysis**

The statistical analysis of variance for the chemical composition, mineral contents and physical properties of the 30 pearl millet genotypes showed that there were significant differences (P ≥ 0.5) between the 30 millet genotypes in these characters. This existing variability could be attributed to the genetic variability between them, which could be of a great potential in the improvement of Sudanese pearl millet genotypes (through selection or hybridization). Variability between millet genotypes in quality characters could also be attributed to the effect of different environmental factors as reported by [12], [21] and [38]. Variability between millet genotypes in quality characters was reported by many investigators, e.g. [13], [9], [10], [32], [19], and in other characters (growth, yield and yield components) was also reported by [3], [36], [35] and [29].

**II. Chemical composition of the 30 pearl millet genotypes**

In this study, the means of chemical compositions of the 30 pearl millet genotypes were shown in Table 2.

**A. Protein content:**

The means of protein percentage in the 30 pearl millets ranged from 14.57% to 16.21%, obtained by the genotypes Ashana and Dembi millet, respectively. These results reflect the high percentage of protein in these genotypes and indicate the high nutritive value of them. Similar findings were also revealed by [8], [2] and [28] in their studies in different millet genotypes. The Bibliography [11] found that millet has a higher protein content (8.8 to 20.9%) than other cereals grown under similar conditions. The results of [27] and [31] indicated that millet protein was similar to corn (*Zea mays* L.) rather than that of grain sorghum in the distribution and lysine content. In general, millet is low in lysine, tryptophan, threonine and sulfur containing amino acids, than other cereal crops [31] and [26]. Recently, high nutritive value and several health benefits of millet grains were reported by many authors. e.g. [15], [26], [20], [33] and [37].

**B. Carbohydrates and Fiber contents:**

The means of carbohydrates contents in the 30 pearl millet genotypes ranged from 62.53 to 68.63 obtained by the genotypes Sudan II and HSD55555, respectively. The means of the fiber contents ranged from 9.63 to 15.37 obtained by the genotypes HSD10294 and Sudan II, respectively. The high levels of carbohydrates and fiber obtained in the studied 30 grain millet genotypes could be
of a great nutritive value and human health benefits. These results agreed with [14] who found that the fiber content of pearl millet was 12-13% and it helps the body to get rid of stomach fats, supply the human body with sufficient energy and protect it from heart attack. The Bibliography [37] reported that millet contains 18% dietary fiber. In addition [33] reported that, millet is considered as a great source of starch, carbohydrates and fibers making it a high-energy food.

C. Moisture content, Fats content and Ash content:
In the 30 millet genotypes, the moisture content means ranged from 6.16 obtained for Dembi Millet to 7.05 obtained by the genotypes HSD55555 and Dembi Shangal Toby. Fats content means ranged from 4.24 to 5.21 obtained by the genotypes Ugandi and HSD10294, respectively. Ash content means ranged from 1.25 obtained for HSD10376 to 1.70 obtained for HSD10294 and HSD10318, respectively. Similar findings for Ash and Fats in different pearl millet genotypes were reported by [10] and [2]. The Bibliography [26] reported that the energy of millet is greater than sorghum and nearly equal to that of brown rice. In addition [22] reported that millet exceeded wheat, brown rice, maize and sorghum in total fats.

III. Minerals contents:
In this study, the means of minerals contents of the 30 pearl millet genotypes measured in mg/kg were shown in Table, 3. The Ca ranged from 60.7 to 125.7 obtained by HSD10292 and Dembi Sea, respectively. The P ranged from 529.33 to 972.33 obtained by HSD10309 and SADC (Long), respectively. The Fe ranged from 60.50 to 100.82 obtained by HSD10291 and Dembi Shangal Toby, respectively. The K ranged from 3212.0 to 5742.3 obtained by HSD10294 and Dembi Shangal Toby, respectively. The Mg ranged from 375.3 to 1588.3 obtained by HSD10294 and HSD10293, respectively. The Na ranged from 13.67 to 45.00 obtained by SADC (Togo) and HSD10292, respectively. The Zn ranged from 21.68 to 50.68 obtained by Sudan II and HSD10354, respectively. These results illustrate that three millet genotypes from Darfur states (Dembi Sea, Dembi Shangal Toby and Dembi Millet) scored the highest values of Ca, P and K, respectively. In addition, the released genotype SADC (Long) scored the highest value of P, these genotypes could be of a great nutritive value for the consumers of millet at the productive areas of Darfur and Kordofan states, Sudan. Similar findings for Ca, Mg, Fe, Na, and K were observed in eight finger millet genotypes as explained by [34] Shashi, et al (2007). The Bibliography [2] and [20] found that millet is rich of macro-minerals specially P and trace elements specially Fe. Many investigators e.g. [25] explained that pearl millet exceeded wheat, sorghum and rice in total contents of minerals, fibers and calcium.

IV. Physical properties of the 30 millet genotype:
In this study, the means of Physical properties of the 30 pearl millet genotypes were shown in Table, 4.

A. Granule size
The granule size of the 30 pearl millet genotypes ranged between 3.7 to 11.9 obtained by SADAC Togo and Dembi kabbabia, respectively. In addition to millet granules high nutritive value for human and animals, small millet granules could be of a benefit for birds feeding especially ornamental birds. The variation in millet granule size was studied by many authors, e.g. [23] and [24].

B. Grain colour of the 30 millet genotypes:
Among the 30 millet genotypes, 9 genotypes shown yellow grain colour, 5 genotypes shown dark yellow grain colour, 4 genotypes shown yellowish black grain colour, 4 genotypes shown bright yellow grain colour, 3 genotypes shown greenish yellow grain colour, 2 genotypes shown white grain colour and the three remaining genotypes shown brown, black yellow and yellowish brown grain colour. The Bibliography [36] indicated the yellow colour is favourite for the millet farmers and consumers in the Sudan. In India [30] explained that various colours were existed in different
millet types, e.g. light brown, brown copper and purple colours in finger millet; brown and golden colours in Kodo millet; little grey, dark grey, brown and dark brown colours in little millet.

C. Weight of 100 seeds (gm):
The weight of 100 seeds of the 30 millet genotypes ranged from 0.48 to 1.36 gm obtained by the genotypes HSD10362 and HSD10294, respectively. Among yield components of pearl millet, 100 seed weight is considered as the most important yield component [3] and [36]. Similar findings in different pearl millet genotypes were reported by [35].

D. Taste estimation:
The taste estimation of the 30 millet genotypes seeds was divided in this study to three ranges of numbers: 5 represent desirable taste, 3-4 represent normal taste and 1-2 represent bitterness taste. 12 millet genotypes included 7 local, released and improved varieties exhibited desirable taste, 15 millet genotypes exhibited normal taste and the remaining 3 millet genotypes exhibited bitterness taste. In the Sudan, the consumption of millet depends principally on its taste but few studies were conducted to estimate the taste of pearl millet genotypes [36].

VI. CONCLUSIONS
It could be concluded that, significant and considerable variability was detected among the 30 Sudanese pearl millet genotypes for chemical compositions, mineral contents and physical properties, this variability would be useful in any millet breeding program aiming for improving quality traits in millet. However, the millet genotypes scored high values of quality traits could be used by Sudanese millet consumers and/or millet breeders by selection or hybridization in order to produce improved millet genotypes or hybrids characterized with high and good quality traits .

VII. ACKNOWLEDGMENTS
The authors are grateful to Dr. Altahir Ibrahim Mohamed, (Plant Genetic Resources Unit), Agricultural Research Corporation, Wad Madani, Sudan, for providing part of the millet genotypes used in the study. Thanks also extended to college of Agricultural Studies (CAS), Sudan University of Science and Technology (SUSTECH) for supporting part of this research.

Table 2. Means of Chemical compositions of the 30 pearl millet genotypes

<table>
<thead>
<tr>
<th>Protein</th>
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<th>Fiber</th>
<th>Fats</th>
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For each character (nutrient), different letters indicate means are significantly different (P <0.05).

### Table 3. Means of minerals (mg/kg) of the 30 pearl millet genotypes

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Ca</th>
<th>P</th>
<th>Fe</th>
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<th>Mg</th>
<th>Na</th>
<th>Zn</th>
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<td>14.57&lt;sup&gt;10&lt;/sup&gt;</td>
<td>6.69&lt;sup&gt;1&lt;/sup&gt;</td>
<td>11.72&lt;sup&gt;D&lt;/sup&gt;</td>
<td>4.54&lt;sup&gt;10&lt;/sup&gt;</td>
<td>1.543&lt;sup&gt;Y&lt;/sup&gt;</td>
<td>67.63&lt;sup&gt;HJ&lt;/sup&gt;</td>
<td>67.63&lt;sup&gt;HJ&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

For each character (nutrient), different letters indicate means are significantly different (P <0.05).

### Table 4. Physical properties of the 30 pearl millet genotypes

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Colour</th>
<th>Granule size* (mm)</th>
<th>Weight of 100 seeds (g)</th>
<th>Taste**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1..HSD7131</td>
<td>Yellowish black</td>
<td>3.4x2.0x1.5</td>
<td>0.94</td>
<td>4</td>
</tr>
<tr>
<td>2..HSD7132</td>
<td>Dark yellow</td>
<td>3.2x2.0x1.0</td>
<td>0.56</td>
<td>4</td>
</tr>
<tr>
<td>3..HSD7133</td>
<td>Bright Yellow</td>
<td>3.4x2.0x1.0</td>
<td>1.23</td>
<td>4</td>
</tr>
<tr>
<td>4..HSD7134</td>
<td>Yellow</td>
<td>2.8x2.0x1.8</td>
<td>0.66</td>
<td>4</td>
</tr>
<tr>
<td>5..HSD7135</td>
<td>Yellow</td>
<td>3.0x2.0x0.8</td>
<td>0.56</td>
<td>1</td>
</tr>
<tr>
<td>6..HSD10291</td>
<td>Bright Yellow</td>
<td>3.2x2.0x1.4</td>
<td>1.19</td>
<td>3</td>
</tr>
</tbody>
</table>
7. HSD10292  Yellow  3.0x2.0x1.0  0.95  4
8. HSD10293  Dark yellow  3.0x1.8x1.2  0.93  4
9. HSD10294  Yellow  3.2x2.0x1.5  1.37  5
10. HSD10303  Dark yellow  3.0x2.0x1.0  0.94  3
11. HSD10309  Yellow  3.0x1.8x1.0  0.52  1
12. HSD10313  Black yellow  3.2x2.0x1.2  0.92  4
13. HSD10318  Dark yellow  3.0x1.8x1.0  0.68  4
14. HSD10319  Yellow  3.2x2.0x1.0  0.69  5
15. HSD10331  Dark yellow  3.4x2.0x1.2  1.02  5
16. HSD10354  Yellow  3.0x2.2x1.8  0.86  4
17. HSD10362  Yellow  3.0x2.0x1.2  0.48  1
18. HSD10376  Yellow  2.8x1.8x1.0  0.68  4
19. HSD10392  Brown  3.0x1.8x1.2  1.02  5
20. HSD55555  White  3.2x2.0x1.0  0.76  5
21. Ashana  Greenish yellow  3.4x2.2x1.4  1.05  5
22. SADC (Long)  Bright yellow  3.2x2.0x1.2  0.71  5
23. SADC (Togo)  White  2.6x1.8x0.8  0.65  5
24. Ugandi  Greenish yellow  3.0x2.2x1.2  0.93  5
25. Sudan II  Greenish yellow  3.4x2.4x1.0  1.27  5
26. MCNELC  Yellowish black  3.2x2.2x1.2  0.82  4
27. Dembi Millet  Yellowish black  3.0x2.2x1.2  0.98  5
28. Dembi Shangal  Yellowish brown  3.2x2.4x1.4  1.13  5
29. Dembi Kabbabia  Yellowish black  3.4x2.2x1.6  1.25  4
30. Dembi Sea  Bright yellow  3.4x2.2x1.4  0.70  4

* LengthXwidthXthickness
** 5: Desirable, 4-3: Normal, 2-1: bitterness (Off taste).

**BIBLIOGRAPHY**


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[28] Obilanla, A.O. 2013 Nutritional, Physico-Chemical and Sensory Characteristics of pearl millet based on instant beverage powder. Dtech Degree in Food Technology, Faculty of Applied Sciences, Durban University of Technology, South Africa.


