International Journal of African and Asian Studies www.iiste.org
ISSN 2409-6938 An International Peer-reviewed Journal
Vol.15, 2015

Evaluation of Sweet Potato [Ipomoea Batatas (L.) Lam.] Accessions for their Physicochemical Attributes in Ethiopia

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Abstract
The productivity of sweet potato [Ipomoea batatas (L.) Lam.] Is mainly dependant on the acquisition accessions which posses desirable traits and development of high yielding varieties with desired quality attributes. We collected 116 sweet potato accessions from International and National sources to develop varieties for Ethiopia; however, the accessions characterization and documentation were not exhaustively done to support the improvement program. Therefore, this study was conducted during 2012/2013 cropping season to characterize, evaluate, and documenting of physicochemical attributes of sweet potato accessions in Ethiopia. Augmented design consisting of 114 entries and two checks were used. Number of accessions recorded significantly higher values than the mean of the checks for reducing sugar, total sugar, and total starch content, pH, dry matter content, total soluble solid, specific gravity and peel content. CN-1752-14, CN-2056-8 and Tis-80/043-1 for reducing sugar, pH and total soluble solid, respectively, exhibited significantly highest values, while CN-1752-15 recorded the highest total sugar and total starch content. Korojo had significantly highest values for specific gravity, dry matter. Tis-82/0602 were exhibited that the lowest in peel content. study showed that presence of variations among accessions for traits studied and the possibility of selecting accessions for further testing for different breeding objectives.
Keywords: Sweet potatoes, proximate analysis, reducing sugar, total starch content, dry matter.

INTRODUCTION

The sweet potato [*Ipomoea batatas* (L.) Lam.] Is a dicotyledonous plant which belongs to the family *Convolvulaceae*. It is a tuberous root crop important for food security and cultivated in over 100 developing countries and ranks among the five most important food crops in over than 50 of those countries (FAOSTAT, 2012). Over 95% of the global sweet potato production is in developing countries. In Ethiopia, sweet potato has been cultivated for the last several years and over 95 percent of the crop is produced in the Southwest, eastern and southern parts, where it has remained for many years as one of the major subsistence crops especially in the periods of drought (Adhanom *et al*., 1985 and Endale *et al.,* 1992).

Sweet potato is cultivated in Ethiopia mostly for human consumption. It ranks third after Enset [*Ensete ventricosum* (Wele) Cheesman] and Potato (*Solanum tuberosum* L.) as the most important root crops produced in the countries. Sweet potato covers about 81000 hectares of land in Ethiopia with an average national yield of about < 9 t/ha on farm and 25-36 t/ha on research centers (CSA, 2011). Selection for good cultivar performance under drought conditions is thus considered to be of major importance. Conservation of genetic diversity within a crop species is the basis of all variety improvement. However, if the improved variety replaces traditional farmers' varieties, as it often does, the result may still be genetic erosion. Therefore, collecting and conserving farmers' varieties is an essential activity as equal to improving and disseminating new varieties. Haramaya University has released and made recommendation for cultivation two sweet potato varieties namely; Barkume and Adu for eastern part of the country. Moreover, there were 114 accession was maintained in Ethiopia and the two released varieties were also maintained for years which were obtained from International and local sources. However, extensive physicochemical attributes has not been carried out to identify which accession(s) attributed what and potentially used for which purpose(s). This necessitates studying and documenting the physicochemical attributes of these accessions. Therefore, this research was initiated with the objective of characterization, evaluation and documenting of physicochemical attributes of sweet potato accessions in Ethiopia.

MATERIALS AND METHODS

Sweet potato accessions were grown using unreplicated plot under rainfed conditions during the year 2012/2013 main cropping season at Haramaya, Ethiopia research field.

Description of the Experimental Materials

One hundred fourteen (114) sweet potato accessions and two released varieties (Adu and Barkume) were used in this study. The accessions were collected from eastern Ethiopia, other regions of the country and International Research Canters. The two varieties, Adu and Barkume were released for eastern Ethiopia for cultivation by

Haramaya University in 2007 after fulfilling the requirements set by the National Variety Release Committee. The accessions were planted at Haramaya University research field using augmented design in 2012/13 main growing season.

Note: Accessions started with Tis and CN were obtained from Nigeria and Asian Vegetable Center, respectively, and Cuba 1 was obtained from Cuba. The remaining are categorized as Alamaya collection, which were collected from eastern Ethiopia (Abadiro, Alemaya-local-2, Alemaya-local-3,) and other regions of the country such as central Ethiopia (Koka-26, Koka-9, Koka-12, Wondogenet), southern Ethiopia (Arbaminch, Awassa-83) and the last two varieties are released by Haramaya University.

Experimental Design and Procedure

The Accessions were tested in augmented block design with 19 replications. Each replication contained 6 accessions and 2 checks. Each check was appearing once in each block. The checks were replicated 19 times and 114 entries/tests were not replicated. Hundred cm and 30 cm was maintained between rows and plant, respectively. Twelve holes per plot were prepared and one vine cutting was planted in each hole of the ridge and the size of each plot was 3.3 m x 7 m (23.1m^2).

Physicochemical attributes of storage roots

Physicochemical attributes of sweet potato accessions storage roots were measured through the following parameters and procedures. Sugar analysis, reducing sugar, total starch content, pH , total soluble solid, specific gravity, moisture content, peel content and dry matter were determined using a standard format

Statistical Analysis

The data were subjected to analysis of variance using the Statistical package for augmented design (SPAD) software (Abhishek *et al.*, 2010). Means that differ significantly were separated using critical difference in each category.

RESULTS AND DISCUSSION

Analysis of variance was computed for 9 physical and chemical attributes of sweet potato accessions and is presented in Table 2. The result revealed that the presence of highly significant differences ($P<0.01$) among accessions for reducing sugar, total sugar, total starch content, pH, total soluble solid and specific gravity while significant differences ($P<0.5$) was observed for dry matter content and peel content. However, non-significant differences among accessions were observed for moisture content.

As the results are presented in Table 2, there were highly significant ($P<0.01$) differences between the control (check) varieties for peel content, reducing sugar, total sugar, total starch content and total soluble solid while significant ($P<0.5$) differences were observed for dry matter content. However, non-significant differences between the check varieties were observed for pH, moisture content and specific gravity.

Analysis of variance also exhibited highly significant ($P<0.01$) differences among tests for reducing sugar, total sugar, total starch content, pH and specific gravity. Likewise significant ($P<0.5$) differences were exhibited among test entries for dry matter content, peel content and total soluble solid. However, moisture content were found to be non significant. The result in Table 2 revealed that the presence of highly significant ($P<0.01$) differences among test versus control for total starch content, pH and moisture content while significant differences ($P<0.5$) was observed for reducing sugar and total sugar. However, non-significant differences among test versus control were observed for dry matter content, peel content, total soluble solid and specific gravity.

Generally, it was observed significant differences among entries, among test versus control/check varieties, betwee check varieties of sweet potato studied for considerable number of traits which can be exploited in breeding program or that will allow breeders to select entries for desirable trait(s) that they wish to improve. Donald (1968) describes two basic principles for plant breeding, 'selection for yield' and 'defect elimination'. Therefore, the basic philosophies behind plant breeding programme are to develop cultivars with better yield potential and quality attributes as well as to develop cultivars that have genetic resistance against production hazards that can prevent a cultivar from expressing its yield potential (Acquaah , 2007). Based on these philosophies the sweet potato breeding programme may relies on improvement of the quality of the storage roots as per the end use and the observed differences among entries may allow the breeders to use accessions for different objectives.

Variation is the occurrence of difference among individuals due to difference in their genetic composition and/or the environment in which they are raised (Falconer, 1990; Allard, 1960). If the character expression of two individuals could be measured in an environment exactly identical for both, difference in expression would result from genetic control and hence such variation is called genetic variation (Falconer, 1990). The presence of variation in the germplasm for the trait of interest is, therefore, very important. Therefore, information generated in this study on variation of accessions can be utilized by the breeders since the observed variability greatly helps in formulating sound crop breeding and improvement program (Welsh, 1990)

Table 1 List of Sweet potato accessions and cultivars

No	Accession	No	Accession	No	Accession	No	Accession
1	Tis-8441-11	30	Tis-8441-4	59	CEMSA	88	CN-1753-16
2	Tis-8441-3	31	Tis-9465-2	60	Bacariso	89	CN-1752-14
3	Tis-82/0602-12	32	Tis-80/043-3	61	Awassa-83	90	CN-2065-18
4	Tis-70357-7	33	Tis-9465-10	62	Nefissie	91	CN-2059-9
5	Tis-9465-7	34	Tis-9068-8	63	CN-2065-5A	92	CN-2065-16
6	Tis-8250-9	35	Tis-70357-5	64	CN-2065-11	93	CN-2065-15
7	Tis-9065-5	36	Tis-9465-8	65	CN-2065-1	94	CN-1753-5
8	Tis-82/0602-2	37	Becale type-3	66	CN-2065-10	95	CN-1775-4
9	Tis-80/043-1	38	Koka-26	67	CN-2065-7	96	CN-1775-3
10	Tis-9068-6	39	Wondogenet	68	CN-2065-8	97	CN-1753-1
11	Tis-82/0602-6	40	Tis-9068-2	69	CN-2065-12	98	CN-1753-7
12	Tis-82/0602-A	41	Koka-9	70	CN-2065-5B	99	CN-1753-8
13	Tis-70357-4	42	Guracha	71	CN-2065-6	100	CN-1754-6
14	Tis-8250-4	43	Arbaminch	72	CN-2066-4	101	CN-1754-5
15	Tis-9465-1	44	Abadiro	73	CN-2066-2	102	CN-1754-3
16	Tis-9465-8	45	Koka-14	74	CN-1752-8	103	CN-1753-11
17	Tis-9065-1	46	Cuba-1	75	CN-1752-9	104	CN-1753-12
18	Tis-8441-1	47	Koka-12	76	CN-1752-15	105	CN-1753-13
19	Tis-9468-7	48	Becale	77	CN-2059-4	106	CN-1753-14
20	Tis-80/043-2	49	Becale type-1	78	CN-2059-3	107	CN-1753-17
21	Tis-82/062-11	50	Alemayalocal-2	79	CN-2059-20	108	CN-1753-18
22	Tis-8250-7	51	Alamaylocal-3	80	CN-2059-5	109	CN-1754-12
23	Tis-9465-9	52	Becale-type-2	81	CN-2059-8	110	CN-2054-5
24	Tis-9068-3	53	Lesh type—1	82	CN-1752-5	111	CN-2054-7
25	Tis-8250-8A	54	Korojo-1	83	CN-1752-6	112	CN-1754-11
26	Tis-8250-2	55	Becale-B	84	CN-2054-1	113	CN-1753-20
27	Tis-8250-1	56	Korojo	85	CN-2054-2	114	CN-1753-19
28	Tis-70357-2	57	Becale-1B	86	CN-1754-9	115	Adu
29	Tis-82/0602-1B	58	Korojo-2	87	CN-1753-15	116	Barkume

Table 2. Mean squares for 9 traits of sweet potato [*Ipomoea batatas* (L.) Lam.] Collections on the basis of adjusted means

	Mean squares					-
Trait	**Replication (18)**	**Accession (115)**	**Error (18)**	**Among control (1)**	**Among tests (109)**	**Tests vs control (1)**
DM	13.01	21.61^{*}	6.16	23.1^{*}	16.83^{*}	16.47^{ns}
PC	61.77	95.2^{*}	37.86	212^{**}	80.84^{*}	1.68^{ns}
RS	0.42	2.18^{**}	0.23	2.6^{**}	2.12^{**}	2.22^{*}
TS	1.29	2.72^{**}	0.55	5.7^{**}	2.25^{**}	0.94^{ns}
TSC	1.16	3.55^{**}	0.49	11.9^{**}	2.02^{**}	5.8^{*}
pH	0.04	2933.79^{**}	0.04	0.05^{ns}	3204.2^{**}	117.35^{**}
TSS	0.75	2.85^{**}	0.9	5.6^{**}	2.27^{*}	0.22^{ns}
MC	1.71	2.71^{ns}	1.95	1.6^{ns}	2.27^{ns}	14.36^{**}
SG	0.73	15.26^{**}	0.8	0.50^{ns}	18.63^{**}	2.67^{ns}

*, ** and ns = Significant at P<0.05, P<0.01 and non significant, respectively.

DM- dry matter, PC-peel content, RS- reducing sugar, TS-total sugar, TSC- total starch content, TSS-total soluble solid, MC-moisture content, SG-specific gravity

Dry matter and moisture content

Analysis of variance showed that significant (P < 0.05) differences among accessions, tests and control but there was non-significant difference among tests versus control for dry matter content while for moisture content it was observed highly significant (P < 0.01) differences among test versus control but difference among accessions and control and tests were not significant (Table 2).. the mean of accessions were 24.878 % and 8.85 %, respectively, while the mean of checks were 28.42 % and 8.8 %, for dry matter content and moisture content, respectively. Dry matter content was ranged from 13.275 % to 40.215 % likewise the range of moisture content was between 1.003 % and 16.698 %.

CN-1753-18 (40.215 %) and CN-1753-11 (39.535 %) had the highest dry matter content among test accessions including checks. On the other hand, Abadiro and Tis-9468-7 had the lowest dry matter content. Tis-9468-7 and Tis-82/0602-6 were the first in moisture content. On contrary, Becale-B and Tis-8250-2 found to be the first from the last.

The observed differences of dry matter content and moisture content among accessions as well as checks may be mainly due to genetic constitution of the new entries as well as check varieties since all accessions were tested in one location with similar management. This suggestion might be supported by Dominguaz (1976) who reported that dry matter content is genetically controlled trait in sweet potato. Catherine *et al.*, (2012) and Scott *et al.*, (2000) reported that the dry matter percentage of different sweet potato varieties were between 13.4 and 29.2 %, 25.23 and 41.11 %, respectively. Tsakama *et al.*, (2010): Fred *et al.*, (2008): Bonsi *et al.*, (1994); and Loretan *et al.*, (1989) also found that the dry matter in storage roots were ranged from 12.5 to 30.2, 29 to 39.07, 25 to 42 and 25.5 to 31.7%, respectively. As reported by Chan *et al.* (2006) the dry matter percentages of Xushu18, Sushu2 and Sushu8 were 31.9%, 36.7% and 18.6%, respectively. The dry matter of Beauregard, White Star and skin of White Star variety were 17.54 %, 17.89 % and 18.97 %, respectively (Surayia *et al.*, 2006).

Physicochemical Attributes

Specific gravity and peel content

As it was presented in Table 2, highly significant ($P<0.01$) differences was observed among tests for specific gravity and there was no significant differences among control and tests versus control. Differences among control was highly significant ($P<0.01$) and for accessions and tests were significant ($P < 0.05$), but it was non-significant among accession and tests (Table 2) for peel content. The mean of accessions for specific gravity and peel content were 2.194 and 34.709, respectively while the mean of checks was 1.75 for specific gravity and 37.225 for peel content. The result showed that the range for specific gravity was between 0.046 and 42.334 and for peel content was 14.41 and 78.04. The result showed that specific gravity of CN-2054-1 and CN-1753-16 was the highest values among test entries and checks. Tis-70557-2 and Tis-8250-2 had the smallest among test accessions as well as checks. The difference observed between checks, accessions and checks and accession was due to differences in genetic constitution. This statement might be supported by Ruinard (1976).

Accession Korojo and Tis-82/0602-12 registered for peel content was the highest from most of accession including checks. Whereas accession Tis-82/0602-6 and Tis-9465-9 were the least from all new entries as well as checks. The difference observed between checks, accessions and checks and accession may be due to differences in genetic constitution. This statement might be supported by Surayia *et al.*, (2006) who reported that genetic constitution of each accession contributed for difference of peel content.

Reducing Sugar

Highly significant ($P<0.01$) differences among accession, tests and control and significant ($P < 0.05$) differences were observed among tests versus control for reducing sugar (Table 2). the mean of accession those registered for reducing sugar was 6.143 mg $100g^{-1}$ while mean of check was 6.346 mg 100 g^{-1} and reducing sugar content was ranged from 2.576 to 10.331 mg 100 g^{-1}.CN-1752-14 and CN-1752-9 was exhibited that the highest reducing sugar content from most of accession. Whereas Neffsie and Korojo-1 were registered the lowest reducing sugar which is consider as desirable. The difference here between accession, checks and check and accessions may be due to genetic differences for the trait which this statement was in agreement with Frankin *et al.*, (1988) who reported that reported that reducing sugar of storage root was genetically controlled traits. Hacineza *et al.*, (2010) and Picha (1985) stated that the total reducing sugar in fresh sweet potato was 6.94 mg 100 g^{-1} and, 7.84 mg 100 g^{-1}, respectively. Walter *et al.*, (1986) reported that the concentration of reducing sugar of fresh fry type sweet potato ranges from 5.88 to 6.31 mg g^{-1} similar result were also found by Loretan *et al.*, (1989). This work is in agreement with the findings of Ruinard (1976), who reported that the reducing sugar concentration of four varieties was between 2.9 and 5.8 mg 100 g^{-1}.

Total sugar

Analysis of variance in Table 2 showed that there was highly significance difference ($P < 0.01$) among accessions, tests and control but among tests versus control the difference was statistically non-significant for total sugar content. The mean of accessions was 13.305 mg 100 g^{-1} while the mean of checks was 13.603 mg 100 g^{-1}. The range for total sugar concentration was between 9.533 and 17.258 mg 100 g^{-1}. Total sugar concentration of CN-1752-15 and CN-2059-7 was found to be the highest among accessions. However, accession Tis-80/063-3 and Tis-9465-2 were exhibited the lowest. The observed differences of total sugar content among accessions as well as checks and accessions may be mainly attributed to the genetic differences of the entries as well as check varieties since all accessions were tested in one location with similar management. This suggestion might be supported by Frankin *et al.*, (1988) who reported that total sugar concentration is genetically controlled trait in sweet potato. Andrade *et al.*, (2009) reported that the concentration of total sugar of five sub Saharan Africa sweet potato collection was laid between 1.7 mg $100g^{-1}$ to 27 mg 100^{-1} which this result was strongly agree with the present result. According to Onwueme (1978) the range of recommended total sugar concentration was between 6.98 to 14.59 g 100 g^{-1} and this result strongly agree with the present finding. Average (11.2 mg 100 g^{-1}) total sugar concentration of four sweet potato varieties was recorded by Hamed *et al.*, (1973).

Total starch content

There was highly significant (P<0.01) differences among accessions, tests and control and there was significant (P < 0.05) differences among tests versus control for total starch content (Table 2).The mean of accessions for total starch content was 12.569 mg 100g $^{-1}$ while the mean of check was 12.923 mg 100g $^{-1}$.

Total starch content concentration was ranged from 1.167 to 16.402 mg 100g $^{-1}$(Table 9). CN-1752-15 and CN-2059-7 had the highest concentration of total starch content among accessions and checks. Whereas Tis-7035-7 and Tis-80/043-3 had the lowest total starch content. There was a difference in total starch concentration between accession, checks and checks and accession. The observed differences may be due to genetic differences among accessions. This suggestion is in agreement with Tsakama *et al.*, (2010).

The present study results agrees with Ruinard (1976) report that the total starch content of four sweet potato varieties was laid in the range between 13 mg 100 g^{-1} and 21 mg g $^{-1}$. Similar results were also reported for Xushu18**,** Sushu2 and Sushu8 varieties by Chan *et al*., (2006).

pH value and total soluble solid

There was highly significant (P < 0.01) differences among accessions, tests and tests versus control but non-significance differences was observed between check varieties/among control for pH (Table 2). Likewise, highly significant (P < 0.01) differences were exhibited among accession and tests and difference among tests were significantly (P < 0.05) different for TSS but there was non-significant difference among tests versus control (Table 2). The mean of accessions for pH and TSS was 6.203 and 12.138^{0} brix, respectively, while the mean of checks was 6.06 (pH) and 12.637 ^{0} brix (TSS). The pH and TSS values were ranged from 5.044 to 7.264 and 7.132 to 7.132 ^{0} brix, respectively. The pH value of CN-2065-8 and Tis-9465-8 were found to be the highest. However, Tis-82/0602-1A and Becale-1 had the lowest pH values. Kure *et al.*, (2012) reported that the pH value of seven sweet potato varieties was ranged from 5.5 to 7.1. Aina *et al.*, (2009) and Woolfe *et al.*, (1992) reported that the range of pH in sweet potato varieties were ranged from 5 to 6.9 and 5.5 to 6.7. These findings are strongly agreed with the present findings.

SUMMARY AND CONCLUSION

Sweet potato *[Ipomoea batatas* (L.) Lam] is cultivated in Ethiopia mostly for human consumption and it ranks third after Enset [*Ensete ventricosum* (Wele) Cheesman] and Potato (*Solanum tuberosum* L.) as the most important root crops produced in the country.

The genetic diversity in the germplasm collections is critical to the world's and the country's fight against hunger. They are the raw material for breeding new plant varieties and are a reservoir of genetic diversity. Haramaya University has released and made recommendation for cultivation two sweet potato varieties namely; Berkume and Adu for Eastern part of the country. Moreover, we maintained 114 accessions and two released varieties for years. These collections are obtained from International and local sources. However, extensive physicochemical attributes of collections has not been carried out to identify which accession(s) attributed what and potentially used for which purpose(s). Therefore, documenting the physicochemical attributes of accessions is necessary. The is research was conducted to evaluate, characterized and document physical and chemical attributes of sweet potato collection obtained from international as well as local sources.

An experiment was conducted during the main rainy season of 2012/13 at Haramaya University, eastern Ethiopia. The collections were tested in augmented block design with 19 replications or blocks. Each replication/block contained 6 entries/tests and 2 checks. Each check was appearing once in each block. The checks were replicated 19 times and 114 entries/tests were not replicated. The experiment consisted of a total of 114 entries/tests and two checks; Adu and Berkume.

The results of the study are summarized as below

CN-1852-14 and Neffissie had the highest and the lowest content of reducing sugar, respectively. Concentration of total sugar was highest in CN-1752-15 and lowest in Tis-80/043-3. CN-1752-15 and Tis-70357-7 exhibited the highest and the lowest content of total starch concentration, respectively. CN-2065-8 and Tis-80/043-1 had the highest pH and TSS, respectively, whereas Tis-82/0602-1A and CN-1752-8 were found to be posses the lowest pH and TSS, respectively. CN-2054-1, CN-1753-18 and Korojo had the highest specific gravity, dry matter and peel content, respectively. Tis-8250-2, Tis- 9468-7 and Tis-82/0602-6 registered the lowest specific gravity, dry matter and peel content, respectively.

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