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AGRONOMY

Studies on Physico-Chemical Constituents in Different Cultivars of Sweet Potato under West Bengal Condition

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Abstract

Sweet potato (*Ipomoea batatas* (L.) Lam.) is a low-input crop that can produce stable yields under suboptimal conditions. It is a nutritious and ample food source for humans and animals as well as a raw material for manufacturing. The experiment was carried out at the Horticulture Research Stationand AICRP Tuber Crops laboratory of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India from 2012-2014 to study the variability existing among the tubers after harvest. It has been found that the different cultivars had plant length (79.26-130.36 cm.), number of shoots/plant (7-13.67), number of leaves/plant (56.33-120), and number of tubers/plant (2.67-7), tuber weight (80.23-175.87 gm.), length (17.07-24.05 cm.), girth (3.42-5.28 cm.), yield/plant (2.97-10.78 kg/plant)and these varied significantly among the cultivars. The cultivars were observed to have good biochemical properties with moisture content (74.74-150.74 %), dry matter (18.42-31.62 %), TSS (6.43-11.25 °Brix), ascorbic acid (12.84-25.91 mg/100gm), total sugars (2.17-3.68 %), carbohydrate (15.67-28.42 mg/100g), protein (1.09-3.08 %)and starch (8.23-15.56%).They have also high sensory scores (7.20-8.55) based on the results obtained from overall acceptability. Cultivar IGSP-15, S-61 and ST-14 were identified to be superior considering all qualitative aspects like morphological characteristics, overall acceptability, biochemical compositions like good nutritional value, antioxidant property and suitable for processing purposes which can be selected for further improvement and can be promoted for cultivation. Results show that these sweet potato varieties have potentials of biological properties and could have wide utility in food, alcohol and sugar industries. In addition, it could serve as a promising source of protein and its consumption could be utilized in the management of diseases that implicate free radicals.

Highlights

- The study was undertaken to investigate the physical and biochemical characteristics of different sweet potato cultivars which represents the qualitative characteristics of corms.
- IGSP-15, S-61 and ST-14 have highest organoleptic score and good physico-chemical properties, they can be adopted for commercialization in the food industry.

Keywords: Sweet potato, cultivars, physical characters, biochemical properties

Sweet potato (*Ipomoea batatas* (L.) Lam.), a member of the Convolvulaceae family, is grown for its starchy roots and immature leaves, which are used for human consumption (Hazra *et al.*, 2011), animal feed (Lebot, 2009) and, to some extent, for industrial purposes (Woolfe 1992). It is a major economical and healthy food crop in developing countries. According to the United Nations Food and Agriculture Organization data, the sweet potato is cultivated in 114 countries (FAOSTAT, 2012). The sweet potato crop is highly adaptable and tolerates high temperatures, low soil fertility, and drought. It is a short season crop, provides food on marginal soils and degraded. The vine tips and leaves are used as vegetables. The vines are also used for planting material and so do not compete with the root tubers for human food, in addition to the fact that they are easy to handle and transport to the field (Antiaobong and Bassey, 2008). It is highly nutritious, easily digestible and grown in most parts of the world, especially in the tropics where the bulk of the crop is cultivated and consumed which confers nutritional advantage to people living in these regions.

Although sweet potato is cheaper than other crops, this abundant resource is still poorly utilized. Sweet potatoes are high in energy, dietary fiber, potassium and vitamin C, low in fat and are important sources of the dietary antioxidant β-carotene (Hagenimana *et al*., 1993). In many food-deficit countries, the need to fully utilize all existing foodstuffs with a view to alleviating poverty and hunger is now receiving considerable attention.

Recognizing the great potential of the crop of sweet potatoes in combating malnutrition and food security has resulted in intensified research efforts in recent decades to improve their production and processing (Laurie *et al.,* 2013) mainly as flour for use in beverage, alcohol, dye and bakery products, such as cookies, biscuits, muffins, noodles, breakfast foods and pies production (Huang *et al*., 2013).

Starch, the main industrial product of sweet potatoes is used in the manufacture of noodles (Chen *et al*., 2003), syrup, glucose and isomerized glucose, bakery and snack foods (Woolfe, 1992). The carbohydrate composition in sweet potato roots greatly affects the eating quality and processing traits. Moreover, the use of sweet potato and products is primarily determined by its physico-chemical properties.

Materials and Methods

Experimental Site: The experiment was conducted during *rabi* season of 2012-13 at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya. The experimental field was situated at about 23° 5′ N latitude and 89° E longitude, with an average altitude of 9.75 m above mean sea level. The climatic condition is subtropical sub humid. Laboratory of AICRP Tuber Crops, Directorate of Research, BCKV, Nadia, West Bengal was used for bio-chemical analysis.

Soil Characteristics: Soil samples were collected from different locations of the entire experimental field. Soil samples were collected and dried, ground and analyzed to assess various mechanical and chemical compositions.

Table 1: The texture and properties of the soil of Experimental field

Component	Contents
Texture	**Sandy loamy soil**
Soil pH	6.9
Organic carbon (%)	0.41
Total nitrogen (%)	0.05
Available phosphorus (kg/ha.)	21.11
Available potassium (kg/ha.)	78.80

The physicochemical properties of experimental soil have been presented in Table 1. The table revealed that the soil of the experimental site was sandy loamy in texture, well drained with moderate amount soil fertility status

Field Practices: The field was prepared thoroughly by repeated ploughing to get a fine tilth. The plot size was 3 m × 2.4 m. Fine and fully decomposed Farm Yard Manures (FYM) @ 25 t/ha was mixed well 10 days before sowing. The recommended fertilizer dose was 20:40:60 kg NPK/ha as basal and 20:40:60 kg NPK/ha after 30 days whereas urea, single super phosphate and muriate of potash were used as a source of nitrogen, phosphorus and potassium respectively. Vine cuttings were sown during middle of November at a spacing of 60×20 cm. and irrigation was given immediately after planting. Further, the crop was grown with necessary cultural operations and finally harvesting was done. Sweet potato was harvested 120 days after planting when leaves are turned yellow and shed. Irrigation is given 4-6 days prior to harvest to facilitate harvesting.

Observations Taken

The pH is a measure of the hydrogen or hydroxyl ion activity of the soil-water system. The soil pH was determined using combined electrode suggested by Jackson (1973). Soil organic matter is the seat of nitrogen in soil and its determination is often carried out as index of nitrogen availability. The organic carbon was estimated using titration method (Walkley and Black 1934). Total nitrogen is estimated by modified Kjeldhal's method (Jackson, 1973). The determination of available phosphorous in soil was estimated using Bray's P-1 method (Bray and Kurtz 1945) and potassium by Ammonium acetate method of K determination (Hanway and Heidel 1952).

Vine length was measured from the base of the plant to the top by measuring tape. For count the number of shoots per plant, the primary shoots arising from the main vine were counted and the mean number is calculated. The number of fully grown, green and photosynthetically active leaves and tubers produced from every plant were counted and their mean was calculated. Tuber weight was weighed individually and the average was calculated. The length and girth of tubers were measured by Vernire caliper. The tubers harvested from each plant were weighed and then, yield per plant was computed.

Biochemical characteristics of tubers viz., moisture content was determined by drying a known weight of the sample at 50-60°C to a constant weight (Ranganna, 1997) and after drying the dry matter was recorded. Total soluble solids (TSS) were estimated by hand refractometer (0-32°B). The readings obtained were calibrated against a standard temperature at 20°C as per the International Temperature Correction Table and expressed as °Brix. Ascorbic acid was determined by standard method (AOAC, 1990) and results were expressed as percentage citric acid of juice respectively. Total sugars were estimated by the Lane and Eynon volumetric methods (AOAC, 1990) and carbohydrate content by spectrophotometer (Sadasivam and Balasubramaniam, 1987). Protein contents were determined by the method of Bradford (1976) using bovine serum albumin (BSA; Sigma Chemical Corp., St. Louis, MO, USA) as a standard. The starch content was determined by the anthrone method (Sadasivam and Manickam, 2008).

Sensory evaluation: The cultivars were cooked and judged by a panel of judges of different age groups for appearance, colour, flavour, texture, odour and taste for overall acceptability, based on a 9 point hedonic scale rating (Amerine *et al.*, 1965). A score of 5.5 and above was considered acceptable.

Statistics: The analysis was carried out in three replicates for all determinations. The mean and standard deviation of means were calculated. The data were analyzed by one-way analysis of variance (ANOVA). The field experiment was laid out in randomized block design (RBD). Observations under each biochemical experiment were tabulated and analyzed statistically in a completely randomized design (CRD). Data were analyzed statistically with one factor analysis using OPSTAT software on CCS HAU website. All the comparisons were made at 5% level of significance.

Results and Discussion

Physical characteristics

Analysis of the physical parameters revealed that the maximum average plant height (130.36 cm.) was recorded in cv. X-24 followed by IGSP-15 (118.13 cm.), S-61 (110.19 cm.) and ST-14 (95.31 cm.) whereas, minimum was recorded in cv. SV-98 (79.26 cm.). It is apparent from the Table 2 that the number of shoots of different sweet potato cultivars was observed ranged from 7 to 13.67 shoots where highest number of shoots was noticed in cv. S-61 and cv. CIPSWA-2 recorded minimum shoots/ plant. Cultivar X-24 showed highest number of leaves/plant (120) and number of tubers /plant was in S-61(7) as compared to all other investigated cultivars and the difference among the cultivars were statistically significant while lowest was recorded in cv. IGSP-15 (56.33) and SV-98 (2.67) respectively. A good range of variation (80.23 to 175.87 gm.) in tuber weight was noticed among different cultivars. Among the cultivars, S-61 (175.87 gm.) produced maximum tuber weight through the growing period which was statistically on par with ST-14 (158.28 gm.), X-24 (140.83 gm.), IGSP-15 (132.23 gm.) and minimum in cv. DOPMIX 94-38 (80.23 gm.). Maximum tuber length of 24.05 cm. was found in cv. IGSP-15 and the lowest was in cv. DOPMIX 94-38 (17.07 cm.). S-61 had the superiority in terms of tuber girth (5.28 cm.) followed by X-24 (4.98 cm.), ST-14 (4.65 cm.) and the cv. CIPSWA-2 (3.42 cm.) had the lowest value. The maximum yield/plant was observed in cv. S-61(10.78 kg/plant) and lowest was found in cv. SV-98 (2.97 kg/plant).

Biochemical constituents

Moisture: Considerable cultivar specific difference in moisture content of tubers was recorded. The highest content was present in cv. CIPSWA-2 (150.74 %). Minimum Moisture content (74.74 %) was found in the cv. S-61 which was statistically on par with

Table 2: Physical characteristics of different sweet potato cultivars

Cultivars	Plant length (cm.)	No. of shoots/plant	No. of leaves/plant	No. of tubers/plant	Tuber weight (gm.)	Tuber length (cm.)	Tuber girth (cm.)	Yield/plant (kg/plant)
IGSP-15	118.13	13.33	56.33	6.00	132.23	24.05	3.92	8.95
CIPSWA-2	83.62	7.00	65.00	3.00	95.75	18.17	3.42	4.68
CROSS 4	82.61	11.67	68.33	4.00	111.17	18.27	3.96	5.21
SV-98	79.26	10.00	80.33	2.67	102.28	20.43	3.56	2.97
X-24	130.36	11.67	120.00	6.00	140.83	17.55	4.98	9.86
S-61	110.19	13.67	75.33	7.00	175.87	21.07	5.28	10.78
ST-14	95.31	8.67	64.33	5.67	158.28	23.20	4.65	8.93
DOPMIX 94-38	88.52	10.00	71.00	3.00	80.23	17.07	3.47	3.30
C.D. (0.05)	2.496	0.830	2.375	0.473	2.604	1.287	0.109	0.125
S.Em(±)	0.815	0.271	0.775	0.154	0.850	0.420	0.036	0.041
SE(d)	1.152	0.383	1.097	0.218	1.203	0.594	0.050	0.058
C.V. (%)	1.433	4.366	1.789	5.727	1.182	3.644	1.486	1.032

DOPMIX 94-38 (77.32 %), CROSS 4 (78.22 %) and IGSP-15 (80.25 %). Bradbury and Holloway (1988) indicated that differences in moisture contents of sweet potato cultivars are due to such factors such as cultivar, location, climate, soil type, incidence of pests and diseases, and cultivation practices. High moisture content indicates poor shelf life characteristics and high chances of deterioration from microbes. This study shows that they cannot possibly be stored for a long time to avoid spoilage. However, where there is need for storage, it has to be processed to flour and dried properly.

Dry matter: Dry matter content of sweet potato cv. IGSP-15 was the highest (31.62 %) as compared to all others, followed by S-61(30.22 %), DOPMIX 94-38(29.41%) and ST-14 (28.81%). The cv. CIPSWA-2 (18.42 %) was recorded with lowest content. This result corroborated with the findings of Akkamahadevi *et al.* (1996). Low dry matter content might be due to presence of high moisture in the tuber. Ingabire and Vasanthakaalam (2011) observed in sweet potato that the average dry matter content is 30%, but varies according to cultivar, climate and soil conditions and agronomic practices.

Total soluble solid (TSS): TSS is an important quality parameter which determines the quality of the processed food product. The data presented in Table 3 indicated that the cultivars differed considerably in TSS content of tubers. Maximum TSS value (11.25 °Brix) was recorded in cv. S-61 which was on par with the cv. IGSP-15 (10.85 °Brix), ST-14 (9.68 °Brix) where lowest was noticed in cv. X-24 (6.43 °Brix).

Ascorbic acid content: Mapson (1970) reported that as the tuber matures there was reduction of ascorbic acid content. But Takebe and Yoneyama (1992) recorded steady increase in ascorbic acid concentration in tuber during the growth period. Maximum ascorbic acid content of 25.91 mg/100gm was found in cv. SV-98 followed by ST-14 (18.73 mg/100gm.), S-61 (15.02 mg/100gm), IGSP-15 (14.13 mg/100gm) and the cv. X-24 (12.84 mg/100gm) was recorded with lowest value. Higher ascorbic acid content at initial stage of harvest might be attributed toadequate supply of hexose sugar via photosynthetic activity and reduction in ascorbic acid at later stages might be related to enzymatic loss of ascorbic acid through oxidation (Mapson,1970).

Total sugar: It has been reported that sucrose is the most abundant sugar in raw sweet potatoes with smaller amount of glucose and fructose (Bouwkamp, 1985). Among all the cultivars, ST-14 scored the highest values (3.68 %), which was on par with the cv. IGSP-15 (2.81 %), CIPSWA-2 (2.48 %) and S-61 (2.46 %). The cv. with lowest sugar content was X-24 (2.17 %). These results correlate with the findings by Chattopadhyay *et al.* (2006).

Carbohydrate: The data presented in Table 3 indicated that the carbohydrate content of tubers was in the range of 15.67 to 28.42 mg/100g where highest was found in cv. IGSP-15 and lowest in

Table 3: Biochemical attributes of different sweet potato cultivars

Cultivars	Moisture (%)	Dry Matter (%)	TSS (°Brix)	Ascorbic Acid (mg/100g)	Total sugar (%)	Carbohydrate (mg/100g)	Protein (%)	Starch (%)
IGSP-15	80.25	31.62	10.85	14.13	2.81	28.42	2.11	10.68
CIPSWA-2	150.74	18.42	8.22	13.94	2.48	19.26	1.16	9.64
CROSS 4	78.22	27.58	8.58	14.11	2.26	24.13	1.38	15.56
SV-98	108.19	24.10	9.13	25.91	2.39	20.25	1.84	9.82
X-24	123.58	18.87	6.43	12.84	2.17	15.67	2.12	8.23
S-61	74.74	30.22	11.25	15.02	2.46	26.20	2.34	10.03
ST-14	82.46	28.81	9.68	18.73	3.68	21.15	3.08	9.13
DOPMIX 94-38	77.32	29.41	8.83	13.70	2.23	25.68	1.09	8.92
C.D. (0.05)	2.753	1.824	0.401	0.287	0.037	1.658	0.055	0.218
S.Em(±)	0.910	0.603	0.132	0.095	0.012	0.548	0.018	0.072
SE(d)	1.288	0.853	0.187	0.134	0.017	0.775	0.026	0.102
C.V. (%)	1.627	3.998	2.515	1.023	0.817	4.203	1.676	1.217

X-24. It correlates with the findings of Omodamiro *et al.* (2013). The carbohydrate composition in sweet potato roots greatly affects the eating quality and processing traits (Walter and Palma, 1996). The high carbohydrate values obtained in this study suggest that tuber crops could be utilized as a reliable food and energy security crop; especially owing to their content of some of the most desirable nutritional compounds like carbohydrate, starch and protein.

Protein: There is existed significant difference among the sweet potato cultivars regarding protein content. The result revealed that cv. ST-14 had the highest protein content (3.08 %) followed by S-61 (2.34 %), X-24 (2.12%), IGSP-15 (2.11 %) and the lowest content (1.09%) was observed in the cv. DOPMIX 94-38. Result shows that the cultivars could be a promising source of plant protein and its consumption could contribute to the formation of hormones which control a variety of body functions such as growth, repair and maintenance of body. Variability in protein content is due to production practices (Constantine *et al*., 1974), environmental condition and genetic factors (Collins *et al*., 1982). Most dominant protein in sweet potato is to be a globulin, 'Ipomein' (Jones and Gersdorff, 1931).

Starch: In the present study starch was foundin the range of 8.23 to 15.56 % among the eight cultivars which is in line with the findings of Chattopadhyay *et al*. (2002). The cv. CROSS 4 recorded highest starch (15.56%) which is on par with the cv. IGSP-15 (10.68 %), S-61 (10.03%), SV-98 (9.82 %) and significantly different from all other treatments whereas lowest starch (8.23%) was recorded in cv. X-24. Cultivars containing low starch can be considerable suitable for table purpose (Mitra *et al.*, 2010). Sweet potato tuber is highly rich in starch. It is reported that the cultivar with the highest starch content is best for the processing. In food industry, it is applied to enhance functional properties, as in soups, meat sauces, as builders in candies, etc. (Stracke *et al.*, 2009).

Sensory evaluation: Based on the results obtained from overall acceptabilityof sweet potato, best cultivars were selected. Among all the treatments, ST-14 scored the highest value (8.55) which was on par with the cv. SV-98 which had a score of 8.30. IGSP-15 and S-61 also resulted in higher scores for sensory properties. X-24 was found inferior, based on scores (7.20) observed in the organoleptic evaluation.

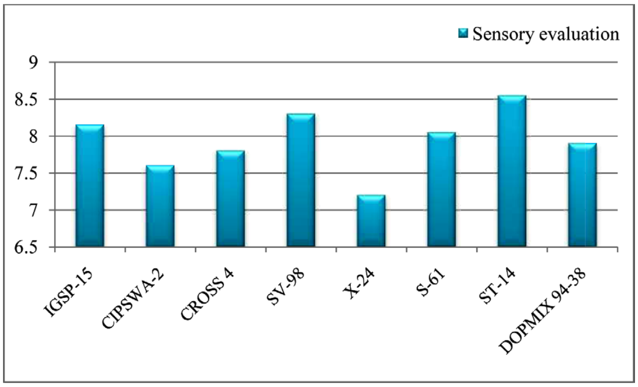

Fig. 1: Mean sensory scores of sweet potato cultivars

Conclusion

A wide variation in some physico-chemical properties of sweet potato from eight cultivars was recorded, indicating that they may be suitable for diverse applications. Among the cultivars of sweet potato studied IGSP-15, S-61 and ST-14 cultivars were identified to be superior based on their suitable morphological characteristics, overall acceptability, biochemical compositions like good nutritional value, antioxidant property and suitable for processing purposes which can be selected for further improvement and can be promoted for cultivation. Result indicated that sweet potato has appreciably high amount of nutrients. High TSS, total sugar and starch content can be recommended for production of high value-added (alcohol, noodles, snacks, flour) and processed products such as jam, candies, biscuits etc. In addition, they were found to be a rich source of protein which can be promoted among the malnourished areas.

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