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Research Article
Sensory Properties and Profiling of Tops and Storage Roots of Sweetpotato Genotypes

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Abstract

Background and Objective: Sweetpotato tops (tender vines with leaves) and storage roots are nutritious. Sensory properties of some local indigenous and exotic genotypes are not explored. The present study was conducted to determine sensory properties namely latex content, anthocyanin pigmentation, flesh colour, boiling time, peeling quality, stickiness and flesh compactness of storage roots and to establish sensor profile of tops and storage roots of nine sweetpotato genotypes. **Materials and Methods:** Physical appearance, sweetness of fresh and boiled storage roots, texture, fibre content, ingestion quality and consumer preference were evaluated for establishing of sensory profile. Sensory properties of tops and storage roots were evaluated by a panelist of ten respondents. Medians of the sensory scores were analyzed by non-parametric test of Kruskal-Wallis through Minitab 17 software. **Results:** Sensory properties revealed that Local-2, Local-1and Local-8 had very few latex and Exotic-2 and Exotic-3 had high content of latexin storage roots. Anthocyanin appeared in the cortex of Local-8, Exotic-2, Exotic-3 and BARI SP-4; epidermis of Local-1, Local-2; centre of the flesh of Local-5, Exotic-4 and the entire flesh of Exotic-1. Flesh colour of the storage roots were white in Local-1, Local-2 and Local-5; yellow in Local-8, Exotic-1 and Exotic-2, Exotic-4;orange in BARI SP-4 and deep orange in Exotic-3.Peeling quality of storage roots of all local genotypes, Exotic-1 and Exotic-2 were found good and easy. Flesh compactness of storage roots of Local-2, Exotic-3 and BARI SP-4 were soft at fresh and became very soft after boiling. Storage roots having compact flesh were needed more time to boil their storage roots. Stickiness of boiled storage roots of Local-2, Exotic-3 and BARI SP-4 were found low to very low compared to other genotypes. Tops of Local-1, Local-8 and Local-5 and storage roots of Local-1, Local-2, Exotic-3 and Local-8 were good at sensory test. **Conclusion:** It can be concluded that tops of Local-1, Local-8 and Local-5 may be suitable for vegetables and storage roots of Local-1, Local-2, Exotic-3 and Local-8 for boiling purpose.

Key words: Sensory properties, sensory profiling, tops, flesh, peeling quality

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sweetpotato [*Ipomoea batatas* L. (Lam.)] is a starchy root crop. It is a very efficient food crop and produces more dry matter, protein and minerals per unit area in comparison to cereals[1]. It has multifarious uses. Its storage roots are consumed by human as boiling, burning or as processed foods. Its tops (leaves with tender vines) are using as vegetables. Its vines are good feed of livestock. Storage roots of some varieties contain coloured pigments such as β-carotene, anthocyanin and unidentified flavoniods[2]. These pigments are regarded as anti-oxidants having several physiological attributes such as anti-oxidation, anti-cancer, anti-immunodilation, protection against cataract, aging and liver injury[3]. Despites its various uses, it is a neglected crop in Bangladesh.

Sensory evaluation produces a description of the physical appearance, sweetness/taste, texture, fibre content, ingestion quality, consumer acceptability of a food and quantifies the intensity of each. Besides, shape, skin and flesh colour, peeling quality, stickiness, flesh crunchiness at fresh and after boiling are important organoleptic characters that influence consumer acceptance. Factors which differentiate consumer preference of sweet potato varieties include gender, age (adults or children) and cultural affiliation. Consumer preference of varieties can differ for sweetpotatoes produced at different environments.

Food acceptability generally refers to liking, preference and selection of a food[4]. Food acceptability depends on a complex set of attributes which are mostly difficult to assay. The taste and gustatory perception of a food crop plays a vital role in increasing chances of its acceptance and utilization. Taste is an important consideration in varietal choice in sweetpotato. Laurie and Magoro[5] and Kulembeka *et al.*[6] reported that taste of sweetpotato storage roots was an important characteristic that influenced acceptability of new varieties. The success of any new sweetpotato variety will depend not only on production traits but also on sensory and utilization acceptability[7]. Unlike other staple crops, the sweetpotato has a dominant taste which greatly minimizes the variation achievable in the final flavor of the cooked product[8]. The sweet taste modulates the overall flavor through direct impact on taste as well as through the role of monosaccharides as precursors in the synthesis of key aromatic compounds[9]. The taste of cooked storage roots was therefore one of the selection criteria used in the local sweetpotato breeding program during development of improved varieties aimed at resource-poor farmers.

There are many local genotypes of sweetpotato available in different locations of Bangladesh. Breeders suggested that local indigenous genotypes have genetic potentials. The uses of tops and storage roots of the local genotypes need to be explored for consumer acceptability. Therefore, the study was taken for the following objectives:

- Characterize the sensory properties of storage roots
- Establishing a sensory profile of tops and storage roots of nine sweetpotato genotypes

MATERIALS AND METHODS

An experiment was conducted at Dashpara village of Sylhet Sadar Upazila, Bangladesh during November 2016 to April 2017 to evaluate sensory analysis of nine local and exotic genotypes of sweetpotato namely Local-1, Local-2, Local-5, Local-8, Exotic-1, Exotic-2, Exotic-3, Exotic-4 and BARI SP-4 in Randomized Complete Block Design with 3 replications. Soil samples were collected from field before ploughing and then tested of the sample and fertilizer recommendations were made using Soil Resource Development Institute (SRDI) developed technique[10]. Cowdung, Urea, TSP, MoP, gypsum, zinc sulfate (Hepta), solubor, magnesium sulfate and dolomite were applied at 5000, 224, 186, 200, 70, 10, 3, 85 and 988 kg ha^{-1}, respectively. Sixty days old vine cuttings were planted on a well prepared land. After 120 days of planting, soft and succulent tops (tender vines with leaves) were collected and evaluated the sensory properties by a panel of 10 members consisting of advanced farmers. At final harvest storage roots of sweetpotato were collected and evaluated at laboratory by a panel of expert members consisting of MS students of Sylhet Agricultural University.

Establishing sensory profile of sweetpotato tops (leaves and tender vines): Ten participants (advanced farmers) were gathered at farmer's house. About 1000 g of tops of each genotype was fried with equal amount of oil and spices. Each of the cooked tops was placed on a separate plate and clearly identified by number as well as name tag. At first, researcher explained the trial objectives and evaluation procedure to the participant using simple words. Then individual opinion was taken to select the best genotype(s) for tops. Each participant tested the dish (genotype) one after one and placed tick mark against dish following a scale ranged from 1-5. Participants evaluated physical appearance, texture and taste of cooked tops of each genotype.

Characterization and profiling of sensory properties of storage roots: After harvesting, fresh storage roots were carried to Abdus Samad Azad Hall, Sylhet Agricultural University (SAU) and washed them clearly. Ten participants (MS students) were invited at Dining room of the Hall. Fresh storage roots were cut in transverse position and evaluated flesh colour, latex content and anthocyanin pigmentation as per guidance of Huaman[11]. Another 2000 g of sun dried uniform storage roots were selected from each genotype. Storage roots of each genotype were boiled with a few amounts of salts. Boiled storage roots were cooled at room temperature. Boiled storage roots of each genotype was placed on a separate plate and clearly identified by number as well as name tag. Prior to evaluation, the author briefed the trial objectives and the procedure. Then individual opinion was taken to select the best genotype(s). Each participant tested the dish of storage roots one after one and placed tick mark against dish using a five point Hedonic scale ranged from 1-5. Participants provided vote for physical appearance, sweetness, texture, fibre content, ingestion quality and preferences of each genotype. In case of testing of sweetness at fresh, storage roots of each genotype were sliced with knife. Then they were placed to the panelists with proper tagging for evaluation in the same procedure.

Procedure of evaluation: A 5-point hedonic scale was used with some modifications[12].

In case of tops:

- **Physical appearance:** The appearance refers to the visual aspect: how the fried tops of sweetpotatoes of each genotype look like when presented on plates (Scale: 5: Excellent, 4: Good, 3: Fair, 2: Inferior/Bad and 1: Most inferior/very bad)
- **Taste:** Taste is a very complex trait. When a food is consumed, a variety of sensory stimuli is received[4]. It is very personal criterion (Scale: 5: Excellent, 4: Good, 3: Medium, 2: Mild and 1: Tasteless
- **Texture:** The texture refers to the stickiness that the sweetpotatoes leaves possess (Scale: 5: Mealy/floury, 4: Less mealy/floury, 3: Fair/intermediate, 2: Watery/soggy and 1: More watery/soggy)

In case of storage roots:

- **Physical appearance:** The appearance refers to the visual aspect: how the boiled storage roots of sweetpotatoes of each genotype look like when presented on plates (Scale: 5: Excellent, good, 4: Good, 3: Fair, 2: Bad and 1: Very bad)
- **Sweetness (at boiled):** The sweetness refers how much sugars are present in boiled storage roots (Scale: 5: Excellent, 4: Good, 3: Medium, 2: Mild and 1:Sweetless)
- **Sweetness (at fresh):** The sweetness refers how much sugars are present in fresh storage roots (Scale: 5: Excellent, 4: Good, 3: Medium, 2: Mild and 1: Sweetless)
- **Texture:** The texture refers to the dry matter of storage roots that the sweetpotatoes possess (Scale: 5: Mealy/floury, 4: Less mealy/floury, 3: Fair/intermediate, 2: Watery/soggy and 1: More watery/soggy)
- **Fiber:** The fiber refers to the presence of fiber in boiled sweetpotato flesh (Scale: 5: No fiber present, 4: Less fiber, 3: Moderate fiber, 2: Bad/high fiber and 1: Fibrous roots)
- **Preference:** It refers to the personal preference (Scale: 5: Superior/very good, 4: Good, 3: Medium, 2: Inferior/bad and 1: Not preferable)

Statistical analysis: Sensory scores of 10 participants were evaluated by non-parametric test of Kruskal-Wallis through Minitab 17 software. Medians of the sensory properties were summarized and made ranking of nine genotypes.

RESULTS

Characterization of sensory properties of sweetpotato

Latex content (at fresh): The latex drops were produced when the storage roots were cut and they darkened very quickly due to the oxidation. It was comparatively higher in exotic genotypes than local genotypes (Table 1, Fig. 1). There was no latex or very few latex in Local-2 and Local-1 and Local-8, whereas Local-5, Exotic-1, Exotic-4, BARI SP-4 had medium and Exotic-2 and Exotic-3 had high content of latex.

Anthocyanin pigmentation in storage roots (at fresh): Pigmentation of anthocyanin in the storage roots appeared as narrow rings, broad rings and dots or scattered in the flesh (Fig. 1, Table 1). Anthocyanin pigmentations appeared as narrow ring in the cortex of fresh storage roots of Local-8, Exotic-2, Exotic-3 and BARI SP-4. Anthocyanin appeared as broad ring in the cortex and in the centre of the flesh of storage roots of local-5 and Exotic-4. Anthocyanin appeared in the epidermis of Local-1 and Local-2 and entire flesh of Exotic-1.

Flesh colour: Colour of flesh of the boiled storage roots became fade from their natural colour (Table 1). Flesh colour of Local-1, Local-2 and Local-5 became cream from white; Local-8, Exotic-1 and Exotic-2, Exotic-4 became light yellow from yellow, Exotic-3 became orange from deep orange and BARI SP-4 became light orange from orange.

Fig. 1: Pictorial presentation of flesh colour and anthocyanin pigmentation in the flesh of storage roots of sweetpotato genotypes

Table 1: Variation on latex content, anthocyanin pigmentation and flesh colour of storage roots of 9 sweetpotato genotypes

Genotypes	Latex content (at fresh)	Anthocyanin pigmentation (at fresh)	Flesh colour	
			At fresh	After boiling
Local-1	Very low	Narrow ring in the epidermis	White	Cream
Local-2	Very low	Very narrow ring in the epidermis	White	Cream
Local-5	Medium	Broad ring in the cortex and center in the flesh	Cream	Cream
Local-8	Low	Narrow ring in the cortex and in the flesh	Yellow	Light yellow
Exotic-1	Medium	Covering middle of the flesh	Yellow	Yellow
Exotic-2	High	Narrow ring in the cortex	Yellow	Light yellow
Exotic-3	High	Narrow ring in the cortex	Deep orange	Orange
Exotic-4	Medium	Broad ring in the cortex and covering of the flesh	Yellow	Cream
BARI SP-4	Medium	Narrow ring in the cortex	Light orange	Light orange

Boiling time: Exotic-1, Exotic-2 and Exotic-4 required the highest boiling time (40 min) and Local-2 needed the shortest time 28 min (Table 2). The rest of the genotypes took 30-35 min to boil the storage roots. Exotic genotypes need more time than local genotypes to boil their storage roots.

Thickness of peel and its quality: Thickness of peel of Local-1, Local-2, Local-5 and Exotic-4 was medium and peel of the rest of genotypes was thin (Table 2). Peeling quality of storage roots of Exotic-1 and Exotic-2 was poor and troublesome, whereas peeling quality of rest of the genotypes was good

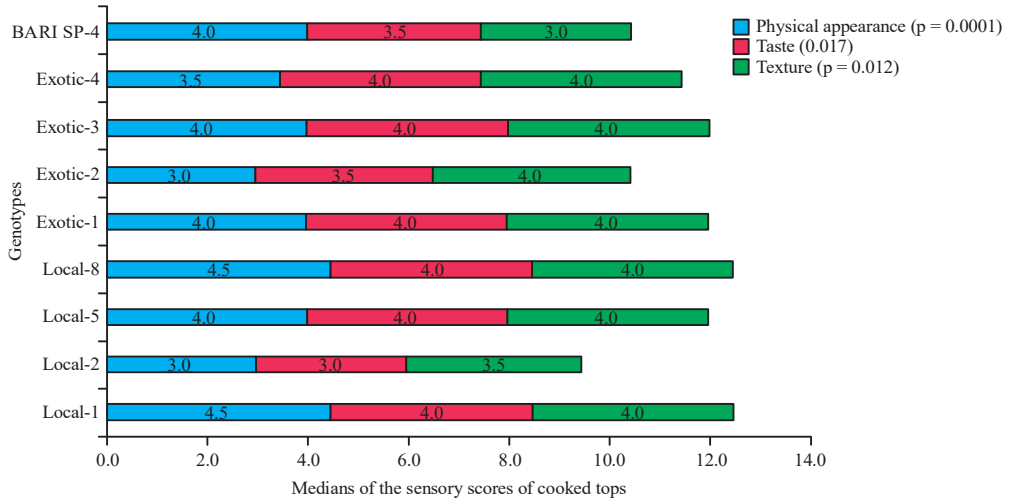

Fig. 2: Median of sensory scores of the characters of the cooked leaves of sweetpotato genotypes

Table 2: Variation in boiling time, peel thickness and its quality, stickiness and flesh compactness of storage roots of sweetpotato genotypes

Genotypes	Boiling time (min)	Thickness of peel (after boiling)	Peeling quality (after boiling)	Stickiness (boiled roots)	Flesh compactness	
					At fresh	After boiling
Local-1	35	Medium	Good, easy	Medium	Very compact	Compact
Local-2	28	Medium	Good, easy	Low	Soft compact	Very soft
Local-5	35	Medium	Good, easy	Medium	Very compact	Medium compact
Local-8	30	Thin	Good, easy	Medium	Compact	Medium compact
Exotic-1	40	Thin	Poor, troublesome	Medium	Compact	Medium compact
Exotic-2	40	Thin	Poor, troublesome	Medium	Very compact	Compact
Exotic-3	30	Thin	Good, easy	Low	Soft compact	Soft compact
Exotic-4	40	Medium	Good, easy	Medium	Very compact	Very compact
BARI SP-4	30	Thin	Good, easy	Low	Soft compact	Soft compact

and easy. Thickness of peel of storage roots of local genotypes and Exotic-4 are comparatively thicker than check variety.

Stickiness of storage roots: Stickiness of storage roots of Local-1, Local-5, Exotic-1, Exotic-2 and Exotic-4 were medium. Local-2, Exotic-3 and BARI SP-4 had stickiness from low to very low and Local-8 had good stickiness (Table 2).

Flesh compactness: At fresh storage roots, very compact flesh was observed in Local-1, Local-5, Exotic-2 and Exotic-4, whereas Local-2, Exotic-3 and BARI SP-4 had soft compact flesh (Table 2). Rest of the genotypes had compact storage roots. On the other hand, flesh of Exotic-5 became very compact and Local-2, Exotic-3 and BARI SP-4 became soft flesh after boiling of storage roots. Local-1 and Exotic-2 became compact flesh, whereas the rest of the genotypes became medium compactness.

Sensory profiling of tops: Result of the sensory profile for physical appearance, taste and texture of the cooked sweetpotato tops are shown in Fig. 2. The highest median of the score of physical appearance was 4.5 in Local-1 and Local-8 whereas the lowest median was 3 in Local-2 and Exotic-2. The highest median score of taste was 4 in Local-1, Local-5, Local-8, Exotic-1 and Exotic-4 whereas the lowest median was 3 in Local-2. The highest median of the score of texture was 4 in all of the genotypes except BARI SP-4 which score was 3.

The cumulative median bar of the genotypes Local-1 and Local-8 was 12.5 followed by cumulative bar of Local-5, Exotic-1 and Exotic-3. The lowest cumulative bar was 9.5 in Local-2. Thus the better genotypes were Local-1 and Local-8, as indicated by the sensory panel which is an indication of the consumers' preference.

Sensory profiling of storage roots: Results of the sensory profile for physical appearance, sweetness, fiber content, texture, ingestion quality and consumer's preference of the storage roots of sweetpotato are shown in Fig. 3. The highest median of the score of physical appearance was 4 in Local-1, Exotic-3 and BARI SP-4, whereas 3.5 was recorded in Exotic-1 and 3 in the rest of the genotypes. The highest median score

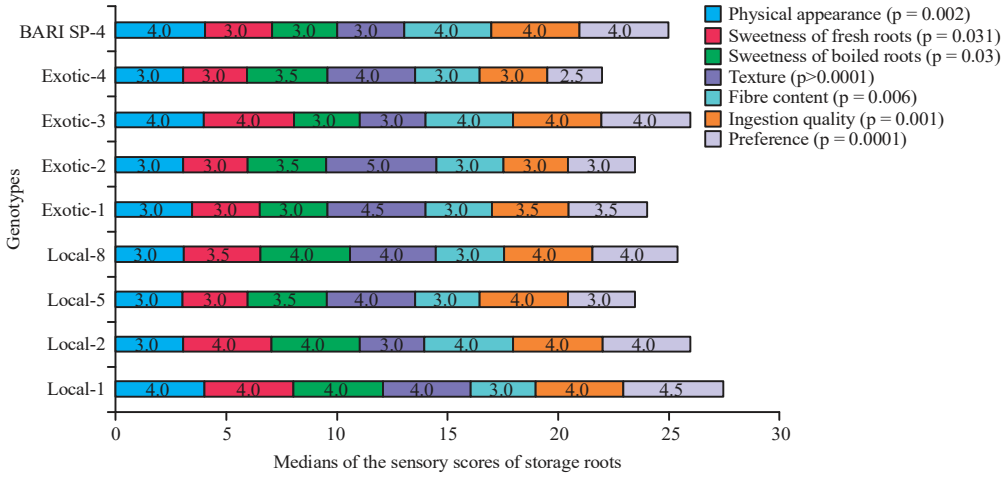

Fig. 3: Median of sensory scores of the characters of the storage roots of sweetpotato genotypes

of sweetness of fresh storage roots was 4 in Local-1, Local-2 and Exotic-3 whereas 3.5 in Local-8 and 3 in the rest of the genotypes.

The highest median of the score of sweetness of boiled storage roots was 4 in Local-1, Local-2 and Local-8 and 3.5 in Local-5, Exotic-2 and Exotic-4. The highest median score of texture of boiled storage roots was 5 in Exotic-2 followed by Exotic-1 (4.5) and the lowest median score was 3.0 in Local-2, Exotic-3 and BARI SP-4. The highest median score of fiber content of storage roots was 4 in Local-2, Exptic-3 and BARI SP-4. The median score of rest of the genotypes was 3.

Median scores of ingestion quality of Local-1, Local-2, Local-5, Local-8 and BARI SP-4 were statistically similar (4.0), whereas median score 3.5 was in Exotic-1 and 3 was in Exotic-2 and Exotic-4. The maximum median score of consumer's preference of boiled storage roots was 4.5 in Local-1 followed by Local-2, Local-8, Exotic-3 and BARI SP-4; the lowest score was 2.5 in Exotic-4.

The cumulative median bar was 27.5 in Local-1 followed by Local-2, Exotic-3 and Local-8. The lowest cumulative bar was 22 in Exotic-4. Genotypes Local-1, Local-2, Exotic-3 and Local-8 performed better in sensory evaluation than check variety BARI SP-4. Thus the better genotypes were Local-1 and Local-8 as indicated by the sensory panel.

Sensory profiling revealed that cooked tops of Local-1, Local-8, Local-5, Exotic-1 and Exotic-3 and boiled storage roots of Local-1, Local-2, Exotic-3 and Local-8 performed better than check variety BARI SP-4.

DISCUSSION

Latex content characterizes the acceptance of storage roots by the consumer. It varies from genotype to genotype. Huaman[11] stated that the amount of the latex formed depends on the maturity of the storage root, the cultivar and the soil moisture during the growing period.

Stevenson *et al.*[13] identified hydroxycinnamic acid (HCA) esters in the storage roots latex of sweetpotato resistant to sweetpotato weevil (SPW). These compounds reduced development of SPW larvae. Anyanga *et al.*[14] reported that HCA's might be useful as markers for resistance in sweetpotato breeding programs.

Flesh colour of Local-1, Local-2 and Local-5 were white; Local-8, Exotic-1 and Exotic-2, Exotic-4 was yellow, Exotic-3 was deep orange and BARI SP-4 was orange. Anthocyanin pigmentation appeared asring in the cortex of local-8, Exotic-2, Exotic-3, BARI SP-4, local-5 and Exotic-4 in the epidermis of Local-1 and Local-2 and entire flesh of Exotic-1. The result agreed with the findings of Huaman[11]. It added that the intensity of the flesh color depends on the environmental conditions where the plant is grown.

Anthocyanins are the most common pigmented flavonoids that are responsible for most of the brilliant colors (orange, red, pink, purple and blue) observed in most fruits, flowers, leaves and cereal grains[15]. Color directly affects the appearance and the consumer acceptability of the fruits and their derived products. In recent years, various important biological activities, such as anti-oxidant, anti-mutagenic, anti-cancer, anti-inflammatory and anti-obesity properties of anthocyanins have been reported[16]. Anthocyanins specifically are associated with a reduced risk of cardiac events, type-2 diabetes and cognitive decline in free-living population[17].

Boiling time, peeling quality and stickiness of storage roots varied with genotypes. It is perhaps due to variations of dry matter content and flesh compactness. Flesh compactness of storage roots probably depends on dry matter content.

Sensory profile of tops indicated that cooked tops of Local-1 and Local-8 were good in physical appearance; Local-1, Local-5, Local-8, Exotic-1 and Exotic-4 were good in taste whereas all of the genotypes were good in texture except BARI SP-4. Overall assessment may be concluded that tops of Local-1, Local-8 and Local-5 are suitable for vegetable.

Sensory profile of storage roots revealed that Local-1, Exotic-3 and BARI SP-4 were better in physical appearance; Local-1, Local-2 and Exotic-3 were most sweetness at fresh and Local-1, Local-2 and Local-8 were best sweetness after boiling. Exotic-2 and Exotic-1 appeared as best in texture; Local-2, Exotic-3 and BARI SP-4 were highest in fiber content; Local-1, Local-2, Local-5, Local-8 and BARI SP-4 were best in ingestion quality; Local-1, Local-2, Local-8, Exotic-3 and BARI SP-4 had more acceptance in consumer's preference of boiled storage roots.

The cooked tops of Local-1, Local-8, Local-5, Exotic-1 and Exotic-3 and boiled storage roots of Local-1, Local-2, Exotic-3 and Local-8 were more acceptable than check variety BARI SP-4.

A consumer survey in Tanzania showed that high starch, good taste, cooking quality and flesh colour were all major drivers in consumer acceptance of sweetpotatoes[18]. Essilfie *et al.*[19] found a significant difference between Apomuden and Okumkom in terms of taste, texture, colour, palatability and overall acceptability at harvest and after cooking. Okumkom was the most preferred and Apomuden was the least accepted in overall acceptability.

Clear differences were observed by Laurie[20] in the sensory traits of the ten cream to yellow-orange sweetpotato varieties studied. In another South African study by Leighton *et al.*[21] stated that Blesbok was mostly associated with the typical sweetpotato aroma and flavor, moist texture attributes and higher fiber content. Fibrousness is related to the size/age/maturity of sweetpotatoes and is an undesirable varietal trait[1].

CONCLUSION

It can be concluded that tops of Local-1, Local-8 and Local-5 may be used as vegetables, whereas storage roots of Local-1 and Local-8 may be consumed as boiling purpose and Local-2 and Exotic-3 as fresh chewing.

SIGNIFICANCE STATEMENT

The study discovered the potentials of local indigenous genotypes of sweetpotato as vegetables of tops and boiling purpose of storage roots that can be benefitted for the disadvantaged people of Bangladesh as well as remedy of malnutrition. This study will help the researchers to uncover the critical areas of sensory properties like flesh colour and compactness, latex content, anthocyanin pigmentation, taste, texture, sweetness, fibre content, ingestion quality and consumer preferences of tops and storage roots of local and exotic genotypes of sweetpotato that many researchers were not able to explore. Flesh colour of Local-8, Exotic-1, Exotic-2, Exotic-3, Exotic-4 and BARI SP-4 are light orange to deep orange colour that indicates availability of β-carotene. Tops of Local-1, Local-5 and Local-8 are excellent in frying whereas storage roots of Local-1, Local-2, local-8 and exotic-3 are excellent in boiling. Therefore a sensory evaluation of tops and storage roots of local and exotic genotypes of sweetpotato are arrived.

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