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Sensory quality of orange-fleshed sweetpotato cultivars as affected by curing and household-level storage methods

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A 2×2×3 factorial design was used to investigate the effect of two orange-fleshed sweetpotato cultivars, three curing treatments and two homestead storage methods on the general appearance, finger-feel firmness, sweetness and overall acceptability of boiled roots. The cultivars were Apomuden and Nane, and the two homestead storage methods were the sand box and the heap storage. In-ground curing (dehaulming) and field-piled curing, for seven days and then uncured treatment were the curing options investigated. A hedonic scale ranging from 1 = extremely dislike to 5 = like extremely was used. For cultivars, the sensory scores ranged from 3.20 to 3.84 (farming season I) and 3.32 to 3.93 (farming season II), indicating good consumer preference. Curing type significantly ($p<0.05$) influenced the sensory properties of roots in the second farming season. Storage type showed no significant difference ($p > 0.05$) in all sensory attributes in both farming seasons except for sweetness and the heap storage had significantly higher (3.84 *vs.* 3.47, $p<0.0001$; respectively) score relative to sand box in the first year. Apart from general appearance (3.64 *vs.* 3.32, $p = 0.002$) and finger-feel firmness (3.51 *vs.* 3.25; $p = 0.006$) in which females had a significantly higher score than males in the first farming season, all the other sensory attributes were similarly ranked by males and females for both years. In-ground and field-piled curing methods, there is increased consumer acceptability and it should be encouraged.

Key words: Curing, Field-piled, Gender, Sensory, in-ground, orange-fleshed sweetpotato.

INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L) Lam.) is an important food security crop in sub-Saharan Africa (van Oirschot et al., 2003). In Ghana, the traditional sweetpotato cultivars are either white or cream-fleshed devoid of β-carotene, a vitamin A precursor. However, the orange-fleshed sweetpotato (OFSP) have been reported to contain

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significant amount of β-carotene; one variety in Ghana has concentration ranging from 2100 to 5500 µg/100 g on fresh weight basis (Tumwegamire et al., 2014). OFSP is gradually gaining attention in developing countries because of its potentials in ameliorating vitamin A deficiency (VAD) (Agbemafle et al., 2014; Laurie and Van Heerden, 2012). VAD is a public health concern in low income countries including Ghana (World Health Organization, 2009) and requires a multi-sectorial approach in addressing it. Food-based approaches through biofortification of indigenous crops have been shown to be a promising and sustainable means to address VAD (Birol et al., 2015; Low et al., 2007). Therefore, sweetpotato, particularly OFSP, is a very good candidate because; it is high in β-carotene and able to do well on marginal soils characterized by soils in low income countries.

Curing, a pre-or post-harvest treatment of sweetpotato could be achieved by either field-piled (Ravi et al., 1996) or/and dehaulming (Tomlins et al., 2002). Field-piled is a form of curing where roots are heaped on the field and covered with fresh vines for seven days before storage. Dehaulming which is a preharvest curing method, entails pruning the vines of sweetpotato plants seven days before harvest (Tomlins et al., 2002). This has been reported to improve the postharvest qualities of the roots (Tomlins et al., 2002). However, some changes may occur during these pre and post-harvest processes and could significantly influence consumer acceptability.

In Ghana, efforts are on-going in the release of more OFSP varieties. However, successful introduction of new varieties, not only depends on production characteristics but the sensory and utilization characteristics as have been found elsewhere (Tomlins et al., 2004, 2007). Therefore, a study that focuses on the changes in sensory quality with postharvest practices such as curing and storage is worth investigating.

During curing and storage, certain biochemical changes occur and may either be desirable or undesirable (van Oirschot et al., 2003). For instance, the sensory attributes of roots could be affected by location and sweetpotato management practices (Tomlins et al., 2007b). Moreover, curing seem to promote the synthesis of α and β amylase-important enzymes in the hydrolysis of starch during processing and the formation of monosaccharides that acts as precursors for vital flavour components (Wang et al., 1998).

Storage effect on sensory quality of sweetpotato roots has been contradictory. George and Kamara (1988) reported that storage of sweetpotato roots in baskets or on earthen floor had a little effect on the sensory qualities of boiled or fried roots of some cultivars. Furthermore, the sensory property of sweetpotato cultivars was not greatly affected by storage under tropical conditions (van Oirschot et al., 2003), but Mpagalile et al. (2007) reported that storage in traditional pit affected the sensory qualities of sweetpotato roots.

In this study, storage in sand and sprouting, denoted as the triple-S system that was designed for production of planting material (Namanda et al., 2013), was modified and investigated as a homestead storage method of roots for consumption. The objective was to assess the effect of curing and household-level storage methods on the sensory qualities of two orange-fleshed sweetpotato cultivars: Apomuden (19% dry matter content) and Nane (27% dry matter content).

MATERIALS AND METHODS

Experimental design

The experimental design used was a 2×2×3 factorial design. The treatment factors were two cultivars of orange-fleshed sweetpotato (Apomuden and Nane), two household-level storage methods (heap and sand box) and three curing treatments (field-piled, dehaulming and uncured).

Cultivars

Apomuden and Nane were planted in two successive farming seasons (August 2014 during the first season and July 2015 in the second season) at Bontanga in the Kumbungu district, Tamale, Ghana. All good agronomic practices were adhered until they were harvested at optimum maturity (Apomuden- 3.5 months and Nane- 4 months). Apomuden is an officially released variety by the Crops Research Institute of the Council for Scientific and Industrial Research, Ghana. Nane is a cultivar being evaluated for release as a variety in Ghana.

Curing and storage

In-ground curing (dehaulming) was done by removing part of the canopies and leaving about 30 cm of the vines from the base seven days prior to harvest. In the field-piled curing treatment, roots were carefully harvested, sorted and heaped on the field and then covered with fresh sweetpotato vines for seven days. During the seven-day curing period, no rains were recorded. Freshly harvested roots, the uncured treatment, together with roots from the two curing treatments stated above were stored in either sand box or under a moistened straw heap for nine and eight weeks, respectively in two successive farming seasons.

Sample preparation and sensory analysis

Wholesome roots (about 1 kg) of both Apomuden and Nane from each curing option in the two homestead storage methods were selected into labelled net bags. The roots were then washed, and wet cooked for (20 min) to become soft. The peels of the cooked roots were removed using a knife and sliced to thumb sizes for the consumer preference test. Three figure-coded disposable plates were used to serve the samples for scoring by the panelist. The consumer acceptability test took place at a dining room of Alimento catering service, University for Development Studies, Tamale. The boiled roots were evaluated by 121 untrained panelist (female = 76, male = 45) for farming season I and 91 untrained panelist (Male = 14, Female = 77) for farming season II. The ages of the recruited untrained panelist ranged from 17 to 37 years for both farming seasons. A five point hedonic scale: 1 = extremely dislike; 2 = dislike; 3 = neither like nor dislike; 4 = like; and 5 = like extremely

Table 1. Sensory scores of boiled OFSP roots after being cured/uncured and stored using two household-level storage methods (heap *vs*. sand box).

Cultivar*	Season I (*n*=121; Male=45, Female=76)				Season II (*n*=91; Male=14, Female=77)			
	Sensory attributes				Sensory Attributes			
	Gen. appearance	Finger-feel firmness	Sweetness	Overall acceptability	Gen. appearance	Finger-feel firmness	Sweetness	Overall acceptability
Apomuden	3.49±1.26[a]	3.26±1.16[a]	3.30±1.16[a]	3.44±1.15[a]	3.53±1.07[a]	3.35±1.11[a]	3.54±1.11[a]	3.63±1.15[a]
Nane	3.39±1.13[a]	3.39±1.15[a]	3.83±1.03[b]	3.76±0.98[b]	3.66±1.18[b]	3.63±1.12[b]	3.66±1.09[a]	3.75±1.13[a]
P-value	0.149	0.116	<0.0001	0.000	0.094	0.003	0.210	0.224
Curing#								
Field-piled	271.48[a]	304.94[a]	288.61[a]	288.62[a]	266.10[b]	298.93[b]	296.29[b]	288.99[b]
In-ground	329.58[b]	309.40[a]	312.42[a]	317.07[a]	278.98[b]	243.80[a]	238.49[a]	255.57[ab]
Uncured	307.97[ab]	297.98[a]	306.54[a]	304.49[a]	233.69[a]	233.69[a]	241.03[a]	229.59[a]
P-value	0.004	0.779	0.335	0.261	0.000	<0.0001	0.000	0.001
Storage type*								
Heap	3.40±1.14[a]	3.32±1.13[a]	3.84±1.04[a]	3.69±1.01[a]	3.63±1.16[a]	3.51±1.12[a]	3.54±1.13[a]	3.63±1.15[a]
Sand box	3.45±1.21[a]	3.35±1.17[a]	3.47±1.13[b]	3.60±1.10[a]	3.58±1.12[a]	3.49±1.13[a]	3.70±1.06[a]	3.75±1.13[a]
P-value	0.491	0.569	<0.0001	0.397	0.539	0.903	0.157	0.224

Means in the same category in a column with the same letter are not significantly different (P > 0.05); *Values are means ± standard deviation; #values are mean of ranks.

was used to assess the sensory qualities of boiled roots. The sensory attributes evaluated were: General appearance, finger-feel firmness, sweetness and overall acceptability. The attribute sweetness was explained to panelist to mean desired taste as described by other researchers (Kapinga et al., 2003). Consumers rinsed their mouth with water before and in-between samples' tasting.

Statistical analysis

The statistical analysis was performed using Microsoft® Excel 2010/XLSTAT©-Pro (Version 2016.02, Addinsoft, Inc., Brooklyn, NY, USA. The Mann-Whitney test was used to analyze treatments cultivar and storage type factors. Kruskal-Wallis non-parametric test procedure was employed to analyze the curing treatment. Multiple pairwise comparisons was done using the Steel-Dwass-Critchlow-Fligner procedure/Two-tailed test when p<0.05. Comparison of scores on the basis of gender was done using the two sample t-test procedure. Minitab.v16.2.4.4™ (Minitab Inc., State College, PA, USA) software was used for this data analysis.

RESULTS AND DISCUSSION

All the sensory attributes had a sensory score ranging between 3.20 to 3.84 and 3.32 to 3.93 during the first and second farming seasons, respectively, indicating good consumer preference for both cultivars. However, in the first farming season, Apomuden had significantly lower score for sweetness (3.30 vs. 3.83, p < 0.0001) and overall acceptability (3.44 vs. 3.76, p = 0.000) when compared with Nane (Table 1). Recently, Owusu-Mensah et al. (2016) reported on the variability in the sweetness of cooked sweetpotato cultivars. The differences in the cultivars' overall acceptability could be attributed to desired taste (sweetness) as it was among other factors that largely influenced overall acceptability of sweetpotato cultivars (Kwach et al., 2010). In the second farming season, cultivars did not differ (p > 0.05) in all sensory attributes except for finger-feel firmness and Nane had a significantly higher score (3.63 vs. 3.35, p = 0.003). This could be attributed to the high dry matter content, averagely, 27% for Nane. The finding support the works of Kapinga et al. (2003) that showed firmness is an indicator of high dry matter content, a preferred sweetpotato root quality.

The OFSP cultivars have often been rated poorly regarding finger-feel firmness (Leksrisompong et al., 2012) probably due to their generally, low dry matter (20 to 24%) contents (Tomlins et al., 2012; Vimala et al., 2013).

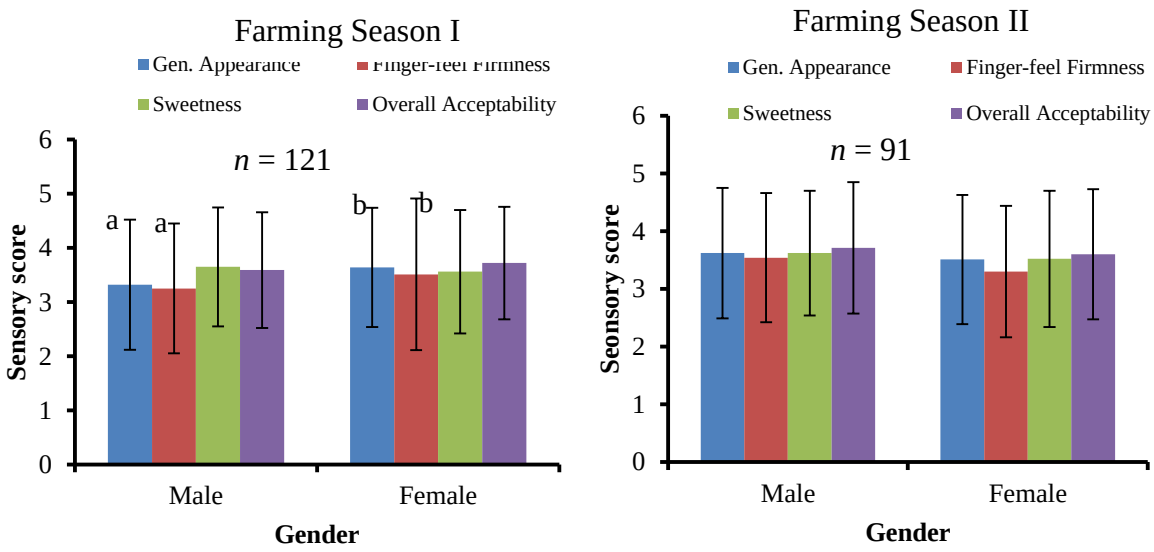

Figure 1. Sensory attributes of boiled OFSP roots as affected by respondent's gender. Bars represent means; and error bars are standard deviation. Comparison is between males and females with respect to the sensory attributes; bars with different alphabets are significantly different ($p < 0.05$).

However, Nane is relatively high in dry matter (27%) and it is reported that, African consumers prefer high dry matter cultivars (Tomlins et al., 2004).Thus, Nane, the cultivar under evaluation for release in Ghana could have high consumer acceptability. In the two successive farming seasons, in-ground curing consistently had higher mean rank for general appearance ranging from 278.98 to 329.58 ($p < 0.05$) when compared with field-piled (266.10 - 271.48) and uncured (233.69 - 307.97) as shown in Table 1. This implies that root that were cured in-ground and stored in sand box or under moistened straw heap were more preferred by consumers. Kuttappan and co-workers (2012) opined that the visual appearance among other factors is a very important criterion for assessing the quality of processed food product. Field-piled curing had significantly higher ($p < 0.05$) mean rank for all sensory attributes assessed for the second farming season except for general appearance. The curing method could have promoted the synthesis of α- and β-amylase enzymes that hydrolyses starch during cooking, leading to the formation of monosaccharides, precursors for vital flavour components as reported elsewhere (Wang et al., 1998). Both curing methods generally resulted in roots with better sensory quality than uncured treatment because the increased enzyme activity and sugars concentration make the boiled-cured roots become sweet and moist (Walter, 1987). Taste (sweetness) among other factors has been reported to be the main driver of overall acceptability of sweetpotato cultivars (Kwach et al., 2010).

Storage type showed no significant difference ($p > 0.05$) in all sensory attributes in both farming seasons. This is an indication that cultivars stored either in sand box or under moistened straw heap for a maximum of nine weeks will be equally accepted by Ghanaian consumers. The findings agree with van Oirschot and co-workers (2003) who reported that apart from fibrousness, storage had no significant effect on all the sensory qualities of sweetpotato roots. Mpagalile et al. (2007) also reported that improved open pit, improved house pit and raised woven structure had no significant influence on the acceptability of sweetpotato except for the traditional pit storage.

Gender is a major factor that determines the success and sustainability of any intervention including OFSP dissemination. In both farming seasons, males and females similarly ranked all the sensory attributes ($p > 0.05$) with the exception of general appearance and finger-feel firmness for farming season I (Figure 1). This is an indication that both cultivars could be equally accepted by both male and female. Because the men preferred the OFSP cultivars, and they are usually household heads, these β-carotene-rich food crops are likely to be prepared and consumed at the household-level. However, the finding in this study contradicts earlier studies by Tomlins et al. (2004) who reported that female consumers preferred some sweetpotato cultivars more than their male consumers.

The females scored the boiled roots higher when compared with ranking by the male participants for general appearance (3.64 *vs.* 3.32; $p = 0.002$) and finger-feel firmness (3.51 *vs*. 3.25; $p = 0.006$) in the first year. This probably could be attributed to the fact that females are more particular about the appearance of the food they consume, relative to their male counterparts. The preference of women is very important in determining

children preference of any food product. Reports have shown a significant but moderate direct relationship between preference of mothers and children (Skinner et al., 2002) since foods not preferred by mothers are not normally offered to children.

Generally, the sensory data from the two farming seasons suggest high consumer (males and females) preference after two months of storage. Therefore, in Ghana, and particularly in the rural communities where VAD prevalence is usually high, OFSP has the potential to be a dietary source of vitamin A for at least two months in a year.

Conclusion

The high sensory score for Nane is an indication that it possesses desirable sensory qualities that could be acceptable to Ghanaian consumers. Therefore, its evaluation process should be intensified for its release. In-ground and field-piled curing methods increased consumer acceptability and should be encouraged. The cceptance of the boiled OFSP cultivars by both males and females further suggest both cultivars could easily be accepted as part of the Ghanaian diet. Therefore, it is recommended that nutritional campaign should be intensified to increase its consumption as it could help in efforts target at reducing VAD.

Conflict of interests

The authors have not declared any conflict of interests.

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