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Delayed Harvesting Effects on the Cooking Qualities and Sensory Properties of Trifoliate Yam (*Dioscorea dumetorum*) Tubers

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Abstract

Cooking qualities and sensory attributes of trifoliate yam tubers harvested at different periods were evaluated at the Department of Food Technology, University of Ibadan, Oyo State, Nigeria, during 2010-2013 planting seasons. The tubers from two cultivars of trifoliate yam (white and yellow cultivars) were planted and harvested monthly from 7 to 11 months after vine establishment. The cooking qualities (water uptake ratio, cooking time and cooking loss, dry matter) and sensory properties of the boiled yam were determined. Water uptake ranged from 0.83 to 1.13, cooking time ranged from 49-97 min, cooking loss ranged from 0.87-2.38% and dry matter ranged from 31.85-45.34%. The yellow cultivar harvested at 11 months had higher water uptake and cooking time values of 1.13 and 97 min respectively, but there was no significant difference in the values recorded for white trifoliate yam at 11 months. White trifoliate yam tubers took lesser cooking time than the yellow tubers at all harvesting periods. The soluble losses decreased with delayed harvesting periods and the loss was prominent at the earlier harvesting periods due to mealiness of the tubers. The sensory evaluation conducted on the boiled yam revealed that the yam tubers were very mealy and soft at 7 to 9 months but became soggy at 10-11 months. Delayed harvesting of the tubers influenced the quality of the tubers. Harvesting of tubers at 7-9 months reduced postharvest losses and produced high quality food.

Key words: Delayed harvesting, cooking qualities, cultivars, sensory attributes, trifoliate yam

Introduction

Trifoliate yam (*Dioscorea dumetorum*) is a lesser known yam and is underutilized. Trifoliate yam tubers are known as three leaved yam, bitter yam and cluster yam. The plant is easily identifiable by its trifoliate compound leaf, which twines in anti-clockwise direction. The tubers are eaten during the time of famine or scarcity and are usually boiled with peel and eaten as boiled yam. The yam is highly nutritious than some other *Dioscorea* species with higher yield. The tuber grows on the surface of the soil thereby reducing work load and facilitate mechanization (Brillouet et al., 1981). According to Treche (1996) staking does not affect its yield but postharvest hardening limit their production and commercialization outside production zones thereby hampering their economic and nutritious value as food (Afoakwa and Sefa-Dedeh, 2001). Therefore, only freshly collected tubers can be consumed locally and technological transformation of *D. dumetorum* was reported to be carried out promptly after harvest (Brillouet et al., 1981). Due to these reasons, the tubers are left in the soil and harvested when needed for food. Several workers have studied the biochemical changes, anti-nutritional properties and changes in chemical composition during growth and after

harvest (Afoakwa and Sefa-Dede, 2001; 2002; Medoua et al., 2005;2007; Treche and Agbor-Egbe, 1996). There is dearth of information on the effect of underground storage of tubers on the properties of the yam after maturity. Therefore, the objective was to study the effect of delayed harvesting on the cooking and sensory properties of tubers of two cultivars of trifoliate yams.

Materials and Methods

The trifoliate yams of two cultivars (white and yellow) were collected from Esa-Oke farm settlements, Osun State, Nigeria.

Trifoliate yam setts weighing 850-900 g were planted in mounds with 10 per row and spacing of 1m x1m. Thirty samples were planted per cultivar. The planting was done on 20 March 2010 and sprouting of some of the yam setts occurred within a month. These trifoliate yam setts were marked and used for the study. After sprouting and establishment of vines, the yams were staked. The land was kept weed-free manually at monthly intervals after planting. Chemicals of any kind either as fertilizer, pesticide or herbicides were not applied. The yam tubers were harvested at monthly intervals starting from 26 November 2010 to 26 March 2011. The experiment was repeated in November 2011 to March 2012 and November 2012 to March 2013. Dry matter was determined using standard procedure (AOAC, 2006). Modified method of Singh (2005) was used for the determination of cooking properties. Sensory analysis of boiled trifoliate yam was done using the method of Eze et al. (2009).

All procedures were carried out in triplicates. The mean and standard deviation of the replicate data were calculated. The data were evaluated for significant differences in their means using Analysis of Variance (ANOVA) ($p \leq 0.05$). Differences between the means were separated by Tukey's test using SPSS software (17.0).

Results and Discussion

Effect of delayed harvesting on the dry matter of trifoliate yam tubers

The dry matter contents are presented in Fig. 1. It ranged from 31.85-45.34%. The white trifoliate yam tuber had higher dry matter than the yellow cultivar. Dry matter was high which was contrary to the report of Treche and Agbo-Egbe (1996) and Afoakwa and Sefa-Dede (2001) for trifoliate yam tubers. Dry matter increased till 10 months and then declined. The reduction in the dry matter at 11 months for both cultivars may be due to sprouting of the tubers due to rainfall. Dry matter contents reported by Kouakou et al. (2010) and Dje et al. (2010) for two species of yam ranged from 38.28 to 45.59% before storage. Adeyeye et al. (2000) observed lower dry matter (25.7%) in both yellow and white trifoliate yam tubers. Reduction in dry matter at 11 months may be due to depletion of the tuber carbohydrate as a result of sprouting and vine growth (Onwueme and Charles, 1994). Dry matter is an important food quality parameter in root and tuber crops and relates positively with good eating qualities and good textural properties of yam (Lebot et al., 2006; Wireko-Manu et al., 2011).

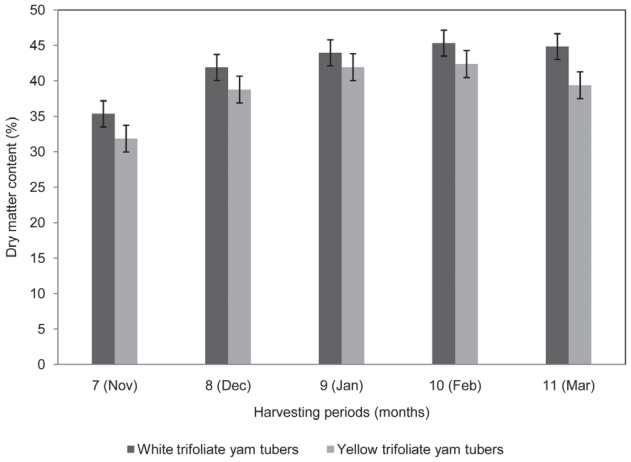

Fig. 1. Effect of harvesting periods on the dry matter contents of trifoliate yam tubers

Effect of harvesting periods on the cooking qualities of trifoliate yam

Water uptake ratio and cooking time increased with harvesting periods in both cultivars (Table 1). Although, the yellow cultivar harvested at 11 months had higher water and cooking time values of 1.13 and 97 min respectively, there was no significant difference with that for white trifoliate yam at 11 months. The weight of the cooked white trifoliate yam tubers harvested at 7-10 months and yellow tubers harvested at 7-8 months were reduced after cooking due to loss of soluble solids into the cooking medium and evaporation of volatiles through steam. These led to low water uptake ratio in the boiled yam tubers.

Table 1. Cooking properties of trifoliate yam tubers

Cultivar	Harvesting periods (months)	Water uptake ratio	Cooking time (min)	Cooking loss (%)
White	7	0.83 ± 0.011^{f}	49.00 ± 1.41^{g}	2.38 ± 0.04^{a}
	8	$0.89 \pm 0.0.1^{ef}$	57.00 ± 2.83^{fg}	2.33 ± 0.02^{a}
	9	0.97 ± 0.01^{cd}	68.00 ± 1.41^{de}	1.08 ± 0.01^{bc}
	10	0.99 ± 0.01^{cd}	74.50 ± 3.54^{cd}	1.01 ± 0.01^{cd}
	11	1.09 ± 0.02^{ab}	90.00 ± 1.14^{ab}	0.92 ± 0.02^{de}
Yellow	7	0.84 ± 0.01^{f}	63.50 ± 2.12^{ef}	1.13 ± 0.02^{b}
	8	0.93 ± 0.04^{de}	71.00 ± 2.82^{de}	1.05 ± 0.02^{bc}
	9	1.00 ± 0.01^{cd}	82.00 ± 1.14^{bc}	0.99 ± 0.04^{cd}
	10	1.03 ± 0.01^{bc}	86.00 ± 2.83^{b}	0.95 ± 0.04^{de}
	11	1.13 ± 0.03^{a}	97.00 ± 1.21^{a}	0.87 ± 0.01^{e}

Values with the same superscript in a column are not significantly different

But the white trifoliate yam harvested at 11 months and yellow trifoliate yam tubers harvested at 9-11 months absorbed more water therefore leading to higher water uptake ratio and reduced losses in soluble solid. Increase in cooking time observed may be due to gradual lignifications of the cell wall resulting in hard to cook process in the yam tubers (Afoakwa and Sefa-Dedeh, 2002; Medoua et al., 2007). White trifoliate yam tubers had lesser cooking time than the yellow tubers at all harvesting periods. The earlier the harvesting periods, cooking was faster and the energy consumption also was less. Rapid cooking of instant and pre-cooked foods has been reported to result in faster rate of digestion and absorption (Brand-Miller et al., 2008).

The soluble losses decreased with harvesting periods and the loss was prominent at the earlier harvesting periods due to mealiness of the tubers. This corroborates with the report of Kouadioa et al. (2011) that mealy cooking type yam absorbs less water (6.6%) during cooking but lost more soluble dry matter (9.5%) during the same process than hard cooking cultivars.

Low soluble loss at the latter harvesting period may be due to partial conversion of water soluble chemical components of the tubers into alcohol soluble components as a result of hardening process in the tubers (Degras, 1993). The swollen starch granules may be leaching to the cooking medium easily from the mealy tubers. However, in late harvested tubers, starch may not be swelling to the same extent as in the early harvested tubers, possibly due to the barrier created by lignin in the hard cell wall. Brunnschweiler et al. (2005) attributed low soluble losses as a result of high structural rigidity of the swollen granules and/or to an increased aggregation rate of amylose. The cooking losses were low when compared to the values reported by Kouadioa et al. (2011) for *D. alata* cultivars and cassava tubers. High cooking loss in rice was reported to be undesirable as it indicated the high solubility of starch, resulting in turbid cooking water, low cooking and sticky mouth feel (Bhattacharya et al., 1999; Fari et al., 2011).

Effect of harvesting periods on the sensory evaluation of boiled trifoliate yam tubers

The colour of the boiled white trifoliate yam tended towards whitish-yellowish at 7-9 months. At 9-11 months, they became creamy-light brown in colour (Table 2). The boiled yellow trifoliate yam at all harvesting periods were yellowish in colour. There was no significant difference in the colour of white trifoliate yam harvested at 8 and 9 months. Also, there was no significant difference in the colour of yellow trifoliate yam at all harvesting periods. Colour is a very important sensory attribute of most foods since it influences the consumers' first judgement and provides sensory information, which may interact with the gustatory olfactory and textural cues to determine the overall acceptability (DuBose et al., 1980; Eze et al., 2009). Francis (1980) also remarked that when the colour was unappealing, consumers were unlikely to judge the flavour or texture as favourable.

Texture and mealiness varied significantly among the cultivars and contributed most to overall quality and acceptability of food yam. The boiled white trifoliate yams

Table 2. Sensory evaluation of boiled trifoliate yam tubers

Cultivar	Harvesting periods (months)	Colour	Texture	Mealiness	Taste
White	7	1.22 ± 0.04^{e}	2.00 ± 0.00^{cd}	3.00 ± 0.00^{b}	3.99 ± 0.00^{a}
	8	1.30 ± 0.04^{d}	2.00 ± 0.00^{cd}	3.00 ± 0.00^{b}	4.00 ± 0.00^{a}
	9	1.35 ± 0.11^{d}	2.00 ± 0.00^{cd}	3.00 ± 0.00^{b}	3.90 ± 0.00^{a}
	10	2.77 ± 0.07^{b}	1.50 ± 0.71^{cd}	1.00 ± 0.00^{d}	4.00 ± 0.00^{a}
	11	3.21 ± 0.14^{a}	3.23 ± 0.04^{ab}	3.88 ± 0.04^{a}	4.00 ± 0.00^{a}
Yellow	7	2.00 ± 0.00^{c}	1.90 ± 0.14^{cd}	2.00 ± 0.00^{c}	4.00 ± 0.00^{a}
	8	2.00 ± 0.00^{c}	1.95 ± 0.21^{cd}	2.00 ± 0.00^{c}	4.00 ± 0.00^{a}
	9	2.00 ± 0.00^{c}	1.85 ± 0.07^{cd}	1.00 ± 0.00^{d}	4.00 ± 0.00^{a}
	10	2.00 ± 0.00^{c}	2.50 ± 0.14^{bc}	4.00 ± 0.00^{a}	4.00 ± 0.00^{a}
	11	2.00 ± 0.00^{c}	4.00 ± 0.00^{a}	4.00 ± 0.00^{a}	4.00 ± 0.00^{a}

Values with the same superscript in a column are not significantly different. Colour: 1 = white, 2 = yellowish, 3 = cream, 4 = light brown; Texture: 1 = slightly soft, 2 = soft, 3 = slightly hard, 4 = hard; Mealiness: 1 = slightly mealy, 2 = mealy, 3 = very mealy, 4 = waxy; Taste: 1 = sweet, 2 = slightly sweet, 3 = bland, 4 = slightly bitter

harvested at 7-9 months were very soft but the textural quality changed at 10 months. In the yellow cultivar, the boiled yams were soft to slightly soft at the early harvesting periods (7-8 months) and at 10-11 months, the boiled yams became slightly hard and hard. The yellow trifoliate yam tubers hardened on time than the white cultivar. The boiled white trifoliate yams at 7-9 months were very mealy, slightly mealy at 10 months and waxy at 11 months especially resulting from the decrease in dry matter and starch. The yellow cultivar was mealy at 7-8 months, slightly mealy at 9 months and waxy at 10-11 months. Taste attributes of boiled yams for the two cultivars at different harvesting periods were slightly bitter due to the presence of alkaloids in the tuber. Harvesting periods influenced the sensory attributes of the boiled tubers.

Conclusion

Harvesting of trifoliate yam, white cultivar at 7-9 months and yellow cultivar at 7-8 months was found to be ideal to produce yams with high sensory quality attributes. Sprouting of the tubers at 10 -11 months caused reduction in the dry matter at these periods. The boiled trifoliate yam tubers were soft and mealy at 7-9 months but became slightly hard at the later stages.

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