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Research article

Assessment of biochemical, cooking, sensory and textural properties of the boiled food product of white yam (*D. rotundata*) genotypes grown at different locations

Emmanuel Oladeji Alamu [a,b,*], Michael Adesokan [b], Wasiu Awoyale [b], Hakeem Oyedele [b], Según Fawole [b], Asrat Asfaw [c], Busie Maziya-Dixon [b]

[a] Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture, Southern Africa Research and Administration Hub (SARAH) Campus, Ngwerere Road, Kabangwe, Lusaka, Zambia
[b] Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture (IITA), Oyo Road, Moniya, Ibadan, Nigeria
[c] Yam Breeding Unit, International Institute of Tropical Agriculture (IITA), Oyo Road, Moniya, Ibadan, Nigeria

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ABSTRACT

Specific biochemical properties and textural attributes determine the final quality and acceptability of yam food products. This study assessed the flour and cooking qualities (boiled yam) of sixteen elite white yam genotypes (*D. rotundata*) grown in three locations. Fresh yam samples were cut into regular-shaped pieces and boiled using the standard procedure. Sub-samples were oven-dried at 65 °C for 72 h and milled to flour. The biochemical profiling for the yam flour showed, on average, 61.35 ± 5.15% starch, 5.35 ± 0.15% sugar, 1.55 ± 0.24% crude fiber, 1.91 ± 0.31% ash, 5.65 ± 0.66% protein, 0.33 ± 0.02% fat and 34.87 ± 1.94% amylose content. The boiled yam's water absorption and cooking time ranged from 0.35 to 5.17% and 7.00–18 min, with an average of 2.74% and 10.64 min, respectively. The hardness of boiled yam from the sensory assay correlated positively with the hardness of instrumental texture analysis ($p < 0.001$, $r = 0.47$). In contrast, the hardness of instrumental texture had a significant negative correlation with the chewiness of sensory profile analysis ($p < 0.05$, $r = 0.37$). Likewise, water absorption correlated positively and significantly ($p < 0.05$, $r = 0.43$) with the chewiness of the sensory analysis. The study shows that the sensory attributes that determine the acceptability of boiled yam could be determined using instrumental measurements to save time and cost.

1. Introduction

Yam (*Dioscorea* spp.) is an economically important staple throughout humid and semi-humid tropical Asia, the Americas, and several African countries (Otegbayo et al., 2011). Yam is of immense sociocultural importance for about 300 million people worldwide (Abiodun and Akinoso, 2014). It serves as a source of dietary calories and nutrients and contributes to household income (Honfozo et al., 2020), especially in the yam zone of West Africa, spanning Côte d'Ivoire, Togo, Benin, Ghana, Nigeria, and Cameroon (Honfozo et al., 2020; Oben et al., 2016). Yam tubers have specific bioactive components such as polyphenols, diosgenin, vitamins, carotenoids, and tocopherols (Alamu et al., 2020). With over 600 species, the family *Dioscoreaceae* is the most well-known and has a wide geographic distribution in tropical and temperate climates (WCSP, 2020).

However, only eight – *D. rotundata* Poir (White yam), *D. cayenensis* Lam (Yellow yam), *D. alata* Linn (Water yam), *D. dumetorum* (Kunth) Pax (Trifoliate yam), *D. bulbifera* Linn. (Aerial yam), *D. esculenta* (Lour) Burk (Chinese yam), *D. abyssinica*, and *D. praehensilis* are grown as staple foods in Africa (Otegbayo, 2018; Bekele and Bekele, 2020). In 2017, West and Central Africa accounted for 97.2% of yam's world production with 73.02 million tons, while Nigeria alone accounted for 65.5% (47.59 million tons) of the global output (FAOSTAT, 2019). Yam can be consumed with sauces in various forms, including boiling, frying, roasting, pounding after boiling, or processing into flour to prepare yam flour dough (; Adegunwa et al., 2011). Boiled yam is considered an important food product for all meals and as a snack. Boiled yam is prepared by peeling, washing, slicing, and cooking in boiling water or steaming (Honfozo et al., 2020).

* Corresponding author.
E-mail address: o.alamu@cgiar.org (E.O. Alamu).

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According to Polycarp (2017), food texture is an essential quality index in many food products. The texture is a multidimensional attribute that encompasses the structural and mechanical properties of the food and its sensory perception in the hand and the mouth (Delali, 2017). For boiled yam, mealiness, waxiness, sogginess, stickiness, and hardness are essential textural parameters. Mealiness is the ease of disintegration of the boiled yam, and processors reported it as an indicator of pounded yam quality (Otegbayo et al., 2021). It has been reported in several studies that the textural qualities of boiled yams are important parameters that determine the overall acceptability of farmers, processors, and consumers. These textural qualities have also been significantly different due to varietal effects (Oke et al., 2013; Ezeocha et al., 2015; Polycarp, 2017; Honfozo et al., 2020). Consumers prefer yam that cooks faster or disintegrates during cooking, which will require less energy to cook yam varieties. Therefore, the mealiness and texture of boiled roots are very high-priority traits for breeders. Boiled yam is one of the most common forms of yam consumption in Côte d'Ivoire, Nigeria, and other parts of West Africa.

The quality and acceptability of boiled yam are affected by variations in species, clones, and planting environment. Yam breeding programs have relied on a sensory analysis to screen new breeding lines for their quality attributes. Such assessment is necessary to ensure the high acceptability of new varieties. However, the sensory analysis seems to be a cumbersome assessment method, especially when a larger population of yam clones is to be evaluated. Therefore, there is a need to develop an indirect method of assessing these sensory qualities. This study aimed to evaluate the biochemical properties of elite yam clones and then establish the relationship between sensory textural attributes (STPA) and instrumental textural attributes (ITPA) of boiled yam. Thus, the attributes that drive the qualities and acceptability of the yam food product can be measured faster using instruments. This will, in turn, help breeders with a good and more efficient method to screen yam genotypes for cooking qualities.

2. Materials and methods

2.1. Yam materials and growth site characteristics

For this evaluation, fresh yam tubers from 16 *D. rotundata* clones grown in three places of Nigeria's International Institute of Tropical Agriculture (IITA) experimental fields, namely Abuja (9°04′N, 7°29′E), Ibadan (7°30′N, 3°54′E), and Oyo North (7°84′N, 3°94′E) were used. The locations vary in their agroecological conditions, such as rainfall patterns and temperature. The annual rainfall ranges from 1558 to 1682 mm at Abuja and a daily average temperature of 33.88 °C during the dry season, while the average annual rainfall for Ibadan and Oyo is 1250 and 1467 mm, respectively, with the average daily temperature ranging from 21 to 31 °C. The yam tubers were sampled from the 16 clones grown in an alpha lattice design with two replications. The clone selection represented variations in cooking and textural qualities, from good to poor.

2.1.1. Sampling and sample preparations

Three representative tubers (big, medium, and small) were sampled for each yam clone grown in replicated plots at three locations. The tuber samples were labeled and transported to the laboratory a day after harvest. The sampled fresh yam tubers were washed to remove dirt and adhered soil particles and dried at room temperature. The yam samples were prepared with different sample presentations for laboratory analysis: fresh blended, dried ground flour, and fresh yam for boiling. Three yam tubers were cut for each genotype into proximal, central, and axial sections. Then, using a stainless-steel cutter, a cuboid-shaped yam piece was removed from each section for boiling experiments. The sample pieces were cut into 6 cm × 2 cm using stainless steel cuter to have a consistent shape and size. At the same time, the remaining part of the yam samples was blended for dry matter analysis. Another portion was chopped into smaller pieces, dried in the oven for 72 h at 55 °C, and pulverized to obtain yam flour (Alamu et al., 2019).

2.2. Laboratory analysis

2.2.1. Biochemical analysis

The nutritional composition of the yam flour samples was determined in the laboratory using standard analytical methods. The protein content was determined by weighing 0.02 g of the dried yam flour into a digestion tube with the addition of concentrated sulphuric acid and copper sulfate tablets as the catalyst and placed on a digester at 420 °C for 1 h. It was allowed to cool and followed by steam distillation and titration using Kjectec 8400 (AOAC, 2000 method 990.03).

Crude fat was determined by the AOAC (2000 method 954.02) method using an Automated FOSS Soxtec System 8000, while ash content was determined according to AOAC, 2000 method 923.03. About 3 g of cassava flour was weighed in a pre-weighed crucible and, after carbonization, ignited in a Muffle furnace at 500 °C for 6 h.

The dry matter content of fresh yam tubers was calculated by weighing 10 g of the sample in a pre-weighed aluminum can and putting it in an oven (Memmert UN 55, GmbH) for 16 h at 105 °C until a consistent weight was reached (AOAC, 2000 method 930.15).

According to Alamu et al. (2019), the colorimetric assay method was used to measure the starch content of yam flour. 20 mg of the sample was weighed into a clean centrifuge tube, to which 1 mL of ethanol, 2 mL of distilled water, and 10 mL of boiling ethanol were added. The mixture underwent a vortex and 10-minute centrifugation at 2000 rpm. The starch content of the residue was assessed using perchloric acid hydrolysis, and the amount of soluble sugar in the supernatant was calculated. A calibration curve for quantification was created using the glucose standard and a phenol-sulphuric acid reagent for color development. A Genesys 101S UV–Vis Spectrophotometer was used to measure absorbance at 490 nm.

Amylose content was determined by the iodine binding method reported by Alamu et al. (2019). A sample of 0.1 g was weighed into a 100 L conical flask and dissolved with 1 mL of 95% ethanol. 9 mL of 1 N NaOH was added to hydrolyze the starch. The flask was transferred to a water bath to boil for 10 min, and distilled water was added to make up to 100 mL. Five ml was taken from the 100 mL into another conical flask, 1 mL of acetic acid was pipetted into the tube, and a 2 mL iodine solution was added for color development. Distilled water was added to make up to 100 mL, and the absorbance was read at 620 nm on *Genesys G10S* (USA) spectrophotometer.

The phytic acid was determined by extracting with 3% Trichloroacetic acid (TCA) by shaking at room temperature and centrifuge for 15 min, as reported by Ndidi et al. (2014). The suspension was precipitated by adding ferric chloride and boiling it in a water bath for 45 min and then centrifuging for 15 min at 2000 rpm. The ferric phytate was converted to ferric hydroxide with 2 mL of water and 3 mL of 1.5 N NaOH. Then the Iron content was estimated by reading on a UV/Vis spectrophotometer. The amount of phytate phosphorus was multiplied by a factor of 3.55 based on the empirical formula $C_6P_6O_{24}H_{18}$ to calculate the phytic acid concentration.

2.2.2. Water absorption (WAb) and cooking time (CT)

Wab and CT of yam samples were conducted using a standard operating procedure developed in the RTBfoods project (RTBFood_K. 2.18_SOP-https://doi.org/10.18167/agritrop/00603) with a few modifications. We removed 1/10 cm from the proximal and distal ends and then collected a cuboid-shaped size yam from each proximal, middle, and axial section using an adapted stainless-steel plunger of dimension 6 cm × 3 cm (Figure 1). In a strainer, six cuboid-shaped yam pieces per genotype and dimensions of 6 cm × 3 cm were weighed and immersed in water (1 g–8 ml of water) (Figure 2). The weight difference between the sample before and after boiling served as a measure of water absorption,

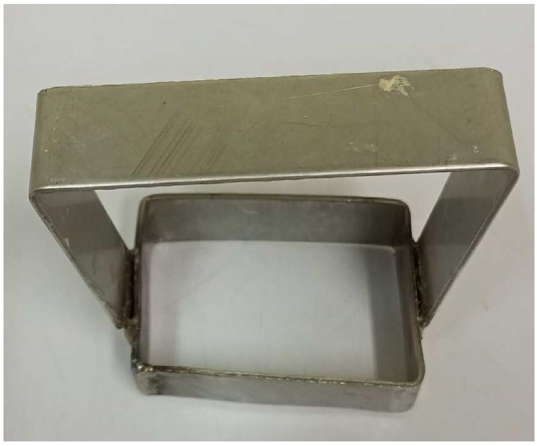


Figure 1. Image of the stainless-steel cutter for yam samples.

whereas the point at which the sample of boiled yam becomes soft and acceptable for consumption is during cooking.

2.2.3. Instrumental texture profile analysis of boiled yam

The yam samples consisted of clones with contrasting cooking and textural qualities and were characterized by their textural attributes. Each yam sample was divided into three sections (proximal, middle, and axial). Each section was cut into a regular shape using a 6 × 3 cm stainless-steel plunger. A compression/extrusion test was conducted on each sample using a five-blade Ottawa cell plunger mounted on the TA. XT texture analyzer. The texture attributes measured were hardness and the energy expended during extrusion.

2.2.3.1. Sensory texture profile analysis. The yam clones were evaluated for sensory texture profile analysis using a 0–10 point hedonic scale developed in the RTBfoods Project (RTBFoods_E.6.3_SOP, Adinsi and Akissoe, 2021) and 14 trained panelists. Boiled yam samples were collected into a warmer until ready for evaluation. The serving temperature was 45 °C and the sensory descriptors evaluated were hardness or softness, color, and ease of chewing. The sensory evaluation was conducted in a standard sensory booth with adequate illumination. Panelists were trained during three sessions to understand the sensory descriptors better. Each sample was assessed in two sessions to check the repeatability of the panelist using statistical analysis tools.

2.2.3.2. Ethical statement. No ethical approval is required for the experiment. However, informed consent was obtained from the participants

2.3. Statistical analysis

The results of the biochemical analysis of yam clones were subjected to statistical analyses using the XLSTAT (Addinsoft, NY, USA) tools. An ANOVA was used to calculate the least square mean to estimate the differences among the means of the proximate composition and phytate content for yam clones at 5% of the probability level.

3. Results and discussion

3.1. Biochemical properties of the yam genotypes

Table 1 shows the overall summary of the biochemical composition of the dried ground yam flour across the three locations. The dry matter content of the fresh yam ranged from 29.32 to 33.71% (FWB). The mean ± SD for starch, amylose, fat, and ash content were 61.35 ± 5.51%, 34.87 ± 1.94, 0.33 ± 0.02, and 1.91 ± 0.31, respectively. TDr1401220, TDr0900135, and TDr1400359 had the highest average dry matter composition, ash content, starch, and crude fiber. Proximate components obtained are comparable to previously reported results for white yam (Omohimi et al., 2019; Alamu et al., 2020; Matsumoto et al., 2021). The mean biochemical compositions show significant differences ($p < 0.01$) among the yam clones except for ash content, which had no significant difference ($p > 0.05$). Among the yam genotypes, TDr1401220, TDr0900295, TDr1000021, and TDr1100180 had no significant difference in their starch, ash and soluble sugar content compared with Meccakusa, which is a landrace variety and used a reference check. Protein content which ranged from 4.83 to 6.45%, is higher than values reported by Djeri et al. (2015) (3.5–5.7%), Abioye (2012) (2.6–2.9%), and Adejumo et al. (2013) (2.4–2.6%) for yam flour. However, similar values to those obtained in this study were reported for yam flour from *Dioscorea alata* by Polycarp et al. (2012); and Ayodele et al. (2013). High protein content in the yam clones is desirable due to their essential role in body tissue development. They help the body maintain body tissue and sustain



1: *Three tubers per genotype* **2:** *Washing tuber* **3:** *Tuber cut into 3 sections* **4:** *Each section cut into a piece of 6 cm × 2 cm* **5:** *Six pieces placed on strainers and weighed* **6:** *Immersed into boiling water* **7:** *Cooking checked using a fork*

Figure 2. Flow chart of sample preparations.

Table 1. Mean of the biochemical composition of yam flour across different locations (Dry weight basis).

	% DM	%Starch	%Sugar	%Crude Fibre	%Ash	%Protein	%Amylose	% Fat	%Phytate
TDr 1400537	30.147 ab	62.294 bc	5.388 abc	1.995 a	2.029 a	6.987 a	33.919 cde	0.366 a	0.914 b
TDr 0900135	32.713 ab	70.334 a	5.410 ab	1.458 bcde	2.428 a	5.980 abc	32.942 e	0.337 abcde	0.917 b
TDr Mecca kusa	31.179 ab	57.455 cde	5.313 abcd	1.747 ab	2.129 a	5.710 bcd	36.557 abcd	0.345 abc	0.947 ab
TDr 1400766	32.385 ab	53.508 e	5.060 cd	1.610 bc	2.022 a	6.450 ab	34.969 abcde	0.346 abc	1.057 a
TDr 1400359	32.532 ab	54.860 de	5.266 abcd	1.692 ab	1.978 a	5.508 bcd	35.350 abcde	0.362 a	0.950 ab
TDr 0900295	29.559 ab	60.748 cde	5.226 abcd	1.713 ab	2.164 a	6.013 abc	33.382 de	0.358 ab	0.983 ab
TDr 8902665	31.099 ab	64.634 abc	5.348 abcd	1.504 bcde	1.370 a	5.689 bcd	37.621 ab	0.308 ef	0.973 ab
TDr 1400158	30.129 ab	62.594 bc	5.243 abcd	1.430 bcde	1.501 a	5.777 bcd	38.120 a	0.309 def	1.017 ab
TDr 1401220	33.714 a	59.314 cde	5.165 abcd	1.603 bcd	1.940 a	4.968 cd	33.798 cde	0.336 abcde	1.027 ab
TDr 1000021	31.454 ab	59.695 cde	5.020 d	1.595 bcd	2.192 a	5.257 cd	33.216 de	0.321 cdef	1.054 a
TDr 1401419	29.391 b	61.995 bcd	5.253 abcd	1.457 bcde	1.666 a	5.784 bcd	34.316 bcde	0.340 abcd	0.987 ab
TDr 1401161	32.140 ab	64.080 abc	5.492 a	1.163 e	1.696 a	4.834 d	37.042 abc	0.307 ef	0.924 b
TDr 1100055	29.740 ab	57.300 cde	5.180 abcd	1.676 ab	1.863 a	5.011 cd	34.176 bcde	0.330 bcdef	0.992 ab
TDr 1100180	29.909 ab	60.990 cd	5.086 bcd	1.284 cde	1.906 a	4.910 d	35.172 abcde	0.300 f	1.062 a
TDr 1401593	29.323 b	69.358 ab	5.433 ab	1.253 de	1.783 a	5.421 bcd	32.025 e	0.322 cdef	0.938 ab
min	29.32	53.51	5.02	1.16	1.37	4.83	32.03	0.30	0.91
max	33.71	70.33	5.49	1.99	2.43	6.99	38.12	0.36	1.06
mean	31.09	61.35	5.26	1.55	1.91	5.65	34.87	0.33	0.98
SD	1.49	5.15	0.15	0.24	0.31	0.66	1.94	0.02	0.05

Mean values with the same alphabet are not significantly different at p<=0.05; SD: Standard deviation.

Table 2. Analysis of Variance of the biochemical composition of yam flour across different locations.

		DM	Starch	Sugar	Crude Fibre	Ash	Protein	Amylose	Fat	Phytate
Source	DF	MS	MS	MS	MS	MS	MS	MS	MS	MS
Clone Name	14	23.86*	264.34***	0.23***	0.55***	0.92^{ns}	4.29***	39.09***	0.03***	0.031***
Location	2	78.35***	4344.33***	15.98***	1.427***	3.65*	18.52***	252.18***	0.188***	2.79***
Clone Name*Location	28	27.18***	98.57***	0.142***	0.444***	1.20*	1.811***	17.49***	0.002***	0.019***

MS = Mean squares; ***Significant at p ≤0.0001; * Significant at p ≤ 0.05 and ns = Not significant at p > 0.05.

growth and health (Abeshu et al., 2016). Yam flour produced from all the yam clones had considerable low-fat content below 1%. This agrees with previous studies showing low-fat content in the different yam clones (Polycarp et al., 2012; Ferraro et al., 2016). The crude fiber in this study ranged from 1.09 to 1.88%, with an average of 1.49%. Fiber aids digestion by providing roughage, and dietary fiber is essential in human nutrition, removing cholesterol and other chemicals that cause chronic diseases. The crude fiber in this study is lower than the previously reported values of 2.0–2.1% reported by Abioye (2012). Consumption of adequate dietary fiber reduces cardiovascular disease and diabetes (Dahl and Stewart, 2015).

Table 2 presents the analysis of variance (ANOVA) in which yam clones and location showed a highly significant effect ($p \leq 0.0001$) on the biochemical components except for ash content. The observation in this study agrees with the work reported by Matsumoto et al. (2021). They reported that the genotypic factor significantly affected the dry matter composition of Guinea yam. Variations in the biochemical components of white yam may be caused by environmental factors in the growing area, such as the climate and soil nutrients (Rosero et al., 2020). The analysis of variance for the biochemical composition also shows that both clones and location showed a highly significant effect ($p \leq 0.001$) on the biochemical composition except ash content which is slightly significant at $p \leq 0.05$. This observation is in line with other authors' findings, who found significant geographical and genotype impacts on the proximate composition of yam flour (Tortoe et al., 2017). The location's impact on the yam flour's biochemical composition shows that the location affected fat, phytate, and soluble sugar content. There was a highly significant ($p \leq 0.0001$) difference in their values across the three studied locations. However, there was no significant difference between Abuja and Ibadan locations for protein and dry matter content. Similarly, there was no significant difference in the crude fiber and amylose content in Ibadan and Oyo locations, respectively (Table 3).

3.2. Cooking time and water absorption of boiled yam

The yam clones were evaluated for their cooking time (CT) and Water absorption (WAb) during cooking, which are essential criteria for the acceptability of boiled yams. WAb was measured by the increase in the

Table 3. Effects of locations on the biochemical composition of yam flour.

	% DM	% Starch	%Sugar	% Crude Fibre	%Ash	%Protein	%Amylose	% Fat	%Phytate
Abuja	31.432 a	62.444 b	5.296 b	1.367 b	1.771 b	5.386 b	37.207 a	0.316 b	0.959 b
Ibadan	31.913 a	52.245 c	4.725 c	1.640 a	2.196 a	5.220 b	33.720 b	0.286 c	1.209 a
Oyo	29.738 b	69.143 a	5.755 a	1.629 a	1.766 b	6.254 a	33.595 b	0.395 a	0.780 c
Mean	31.028	61.277	5.259	1.545	1.911	5.620	34.841	0.332	0.983
SD	0.933	6.948	0.421	0.126	0.202	0.453	1.674	0.046	0.176

Mean values with the same alphabet are not significantly different at $p \leq 0.05$. SD: Standard deviation.

Table 4. Summary of Water Absorption and Cooking time for boiled yam.

Clone ID	WAb	CT (min)
TDr 1400537	2.64	11.00
TDr 0900135	2.05	11.00
TDr Mecca kusa	4.61	18.00
TDr 1400766	4.10	12.00
TDr 1400359	3.51	12.00
TDr Ojuiyawo	2.18	7.00
TDr 8902665	0.54	8.00
TDr 1400158	3.46	13.00
TDr 1401220	2.16	8.00
TDr 1000021	3.33	13.00
TDr 1401419	0.35	9.00
TDr 1401161	2.43	9.00
TDr 1100055	2.18	9.00
TDr 1100180	4.12	10.00
TDr 1401593	5.17	11.50
TDr 1400537	2.34	10.00
TDr 0900295	1.29	9.00
Min	0.35	7.00
Max	5.17	18.00
Mean	2.73	10.62
SD	1.35	2.61

WAb: Water absorption; CT: Cooking time, SD: Standard deviation.

weight of the yam pieces after being cooked. At the same time, cooking time was determined by the method previously reported by Tran et al. (2020). A trained operator monitored the softness of the yam during boiling using a fork, observed the appearance, and checked when the fork could penetrate half of the yam piece for each genotype. The cooking time procedure was adjudged to have a precision of between 1 and 2 min and accuracy of ± 5 min (Tran et al., 2020). The water absorption ranged from 0.35 to 5.17%, with a mean of 2.74 ± 1.35%, while cooking time ranged from 7 min for the easy-to-cook to 18 min for the hard-to-cook yam clones, with a mean of 10.64 ± 2.61 min (Table 4). Water absorbed in the present study is lower than in a previous study on water absorbed by boiled yam, ranging from 6.51 to 8.20% (Bakare et al., 2018). It was observed generally that water absorption increases with cooking time. Consumers prefer yams that cook quickly and require minimum energy to cook and save time. Water absorption has been linked with ease of chewing. Tortoe et al. (2017) also reported that water absorption increased with boiling time for all 38 cassava genotypes evaluated in their study. It was also reported that variation in the cooking time roots is linked to genetic and environmental factors Sajeev et al. (2010). Water absorbed indicates a critical quality that affects the texture attributes of boiled yam (Kouadio et al., 2011).

3.3. Sensory texture profile analysis

The key descriptors for the sensory texture profile for the boiled yam samples were hardness and ease of chewing. Figure 3 shows the principal component analysis of the sensory descriptors and different yam clones. According to the sensory descriptors, PC1 and PC2 accounted for 68.67% of the variation in the cooked yam samples. The yam clones, TDr1400359, TDr1401419, TDr1400159, and TDr1100180, occupied the positive quadrant of the score plot in PC1 and were characterized by taste, color, and stickiness to the hand. Also, ease of chewing was the descriptor that explains the classification of TDr1100128, TDr1100055, TDr1000021, and TDr0900135 and occupies the left of the score plots. TDr1401220 was grouped with TDr Meccakusa and TDr Ojuiyawo, used as landraces in this study. Hardness is another sensory descriptor that describes the classification of yam clones, namely, TDr1400158 and TDr1401161.

3.4. Correlations of cooking qualities of the boiled yam with its sensory texture profiles

The relationship between cooking time and water absorption with the sensory textural profile was established (Table 5). The findings revealed a strong positive correlation between the chewiness from sensory texture profiling analysis (STPA) and WAb of boiled yam at $p < 0.05$. Cooking

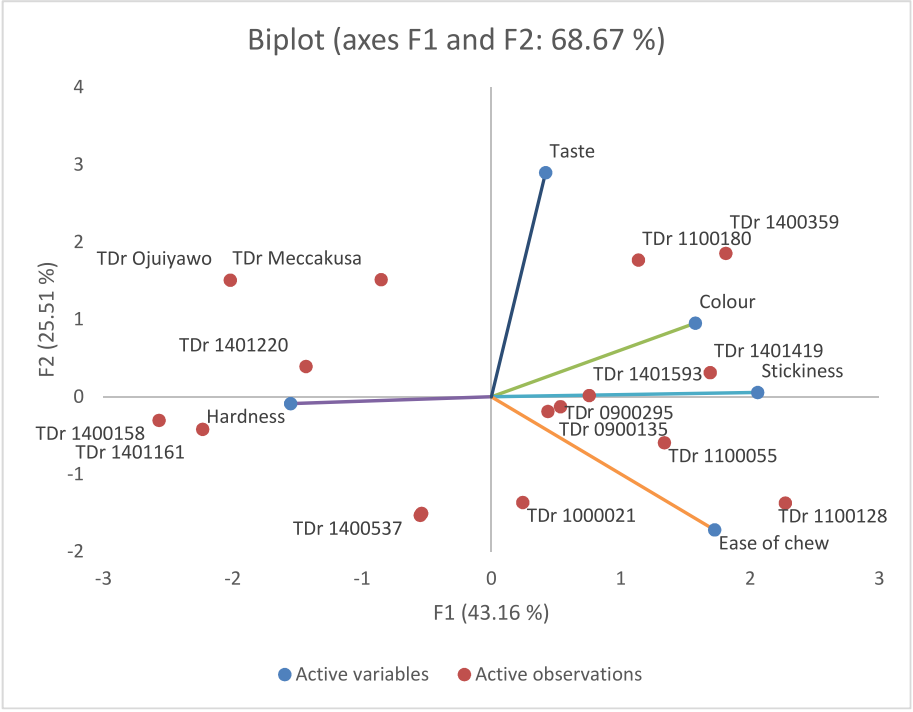


Figure 3. Principal component Analysis (PCA) of sensory analysis of the boiled yam from 16 varieties of *D. rotundata* tubers.

Table 5. Pearson correlations of cooking time, water absorption and sensory analysis of boiled yam.

	Cooking time	S-Hardness	S-Chewiness
Cooking time			
S-Hardness	–0.167		
S-Chewiness	–0.172	0.186	
Water absorption	0.276	0.144	0.432*

* Significant at p<= 0.05, S-hardness: sensory hardness, S-chewiness: sensory chewiness.

Table 6. Pearson correlation of STPA and ITPA of boiled yam.

	I-hardness	S-hardness
S-hardness	0.470**	
S-chewiness	–0.370*	–0.373*

**, * Significant at $p \leq 0.01$ and $p \leq 0.05$ respectively.
I-Hardness (Instrumental hardness); S-Hardness: (sensory hardness).
S-Chewiness (Sensory chewiness).

time negatively correlates with the yam's hardness as evaluated by the trained panelists though not significant. The previous study has established significant correlations between appearance, sensory texture, and taste, indicating that sensory properties played essential roles as the determinant of the culinary quality of boiled yam (Bakare et al., 2018). The finding shows that water absorption could be a good indicator of ease of chewing in boiled yam, an essential quality index for the acceptability of boiled yam. A previous study showed that hard cooking clones absorb less water and have lower water absorption (Kouadio et al., 2011).

3.5. Correlations of instrumental and sensory textural properties of the boiled yam

The Pearson correlations between the sensory descriptors and instrumental texture analysis are presented in Table 6. The correlation was significant and positive between the hardness of the sensory texture profile analysis and the instrumental texture profile analysis at ($p \leq 0.001$, $r = 0.47$). In contrast, a negative and significant correlation ($r = –0.37$, $p \leq 0.05$.) was observed between the instrumental hardness and ease of chewing from the sensory analysis (Table 6). Instrumental hardness is the peak force during the extrusion test, while chewiness measures the energy required to masticate the boiled yam in the mouth. Boiled yam texture influences consumers' perception of its culinary quality during chewing or mastication (Jahan et al., 2020).

4. Conclusion

The study shows that planting location has a highly significant effect ($p \leq 0.0001$) on the biochemical composition of the yam clones evaluated in this study. Also, the quality indicators of boiled yam that are likely to impact the acceptability of new yam clones have been identified as cooking time and ease of chewing linked with water absorption during cooking. There is a positive correlation between water absorption and chewiness of sensory texture and a negative correlation (albeit not statistically significant) between cooking time and sensory hardness. Significantly, there was a favourable link between the hardness of the sensory texture profile analysis and the instrumental texture profile analysis. In contrast, a negative correlation exists between the sensory analysis's instrumental hardness and ease of chewing. Therefore, predicting the sensory attributes of boiled yam by its relationship with water absorption and instrumental method may be possible, thus reducing the time required to screen a large yam population to select clones that would meet consumer expectations.

Declarations

Author contribution statement

Emmanuel Oladeji Alamu: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Michael Adesokan: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Wasiu Awoyale: Analyzed and interpreted the data.

Hakeem Oyedele; Según Fawole, MSc: Performed the experiments.

Asrat Asfaw: Contributed reagents, materials, analysis tools or data.

Busie Maziya-Dixon: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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