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FOOD SCIENCE & TECHNOLOGY | REVIEW ARTICLE

End-user quality characteristics and preferences for cassava, yam and banana products in rural and urban areas -A review

Adebowale Oluwaseun Osunbade[1,2], Emmanuel Oladeji Alamu[1,3]*, Wasiu Awoyale[1,4], Aishat Bolanle Akinwande[2], Johnson Akinwumi Adejuyitan[2,5] and Busie Maziya-Dixon[1]

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*Corresponding author: Emmanuel Oladeji Alamu, Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture, Research and Administration Hub (SARAH) Campus, P.O. Box 310142, Lusaka, Chelstone 10101, Zambia
E-mail:b.maziya-dixon@cgiar.org. oalamu@cgiar.org

Reviewing editor:
María Luisa Escudero Gilete, Nutrition and Bromatology, Universidad de Sevilla, Spain

Additional information is available at the end of the article

Abstract: The review attempted to evaluate the quality attributes and the preferred selected roots, tubers, and bananas (RTB) items (gari/eba, lafun, yam flour, pounded yam, boiled yam, and plantain flour) among the end-users in Nigeria's rural, peri-urban, and urban segments. The results showed that depending on location, consumers' preferred quality attributes of gari in the rural area are dry, bright/shiny, white, sweet, dense, fine, cooked aroma and sour/sweet gari. Cooked yam attributes include white or cream colour, soft, sticky to the touch, non-fibrous texture, easy chewing, crumbly/friable texture, sweet taste, and pleasant odor. Stretchy, moldable, non-sticky, smooth, moderately soft/hard, and pleasant aroma is a high-quality pounded yam. Plantains fingers of medium to large size, light yellow pulp, no black marks on the peel, firm texture, a medium intensity aroma and flavor, medium sweet fruits, and a shelf-life of 7–9 days under room temperature were preferred by consumers. Consumers also prefer plantain amala which is mouldable, smooth, and stretchable. This review provides preliminary details on consumer desired attributes of the selected RTB products in rural and urban areas with a shortage of data on the peri-urban consumer preference. Thus, detailed information on peri-urban consumer preferences should be studied further and correlated with the rural-urban consumer preferences for RTB products.

ABOUT THE AUTHORS

Adebowale Oluwaseun Osunbade (Mr) is a PhD student research fellow at the International Institute of Tropical Agriculture (IITA), Oyo Road, Ibadan, Nigeria.

Emmanuel Oladeji Alamu(PhD) is a Scientist/Food Science and Technology at the International Institute of Tropical Agriculture(IITA), Southern Africa, Research and Administration Hub (SARAH) Campus, Lusaka, Zambia.

Wasiu Awoyale (PhD) is a Lecturer at the Department of Food Science and Technology, Kwara State University Malete, Ilorin, Nigeria

Aishat Bolanle Akinwande (PhD) is a Professor at the Department of Food Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Johnson Akinwumi Adejuyitan (PhD) is a Lecturer at the Department of Food Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria Michael Adesokan (Mr) is a Laboratory Manager/ Food and Nutrition Sciences Laboratory at the International Institute of Tropical Agriculture (IITA), Oyo Road, Ibadan, Nigeria.

Busie Maziya-Dixon (PhD) is a Senior Scientist/Food and Nutrition Sciences at the International Institute of Tropical Agriculture (IITA), Oyo Road, Ibadan, Nigeria.

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1. Introduction

The Roots, Tubers, and Bananas (RTB) program aims to boost the adoption and impact of improved root and tuber varieties in Africa's Sub-Saharan (SSA) by assisting in deploying varieties that match user-preferred quality attributes. Users in the food chain, such as farmers, processors, retailers, and consumers, determine varietal preferences. Users' varietal selections are influenced by their preferences for specific crop qualities (preferred attributes) that can be connected to traits (Forsythe et al., 2021). The items, the alterations that users make, and the reason they have used all impact attribute preferences (e.g., urban or rural markets, household consumption). Users frequently have many preferences or "non-negotiable" qualities, while producers, for example, seek high-yielding or disease-resistant crops. Cassava and yam are important root and tuber crops grown worldwide in tropical and subtropical regions (Ikuemonisan et al., 2020). They provide carbohydrate, which is an integral part of the human diet. Cassava, for example, is typical food for nearly 500 million people globally due to its high carbohydrate content (Blagbrough et al., 2010). Yam is a tuber crop high in starch, and it is significant in West Africa due to its high nourishing constituents and cultural values (Alamu et al., 2014). Previous work on improving RTB crops has focused on farmers' choices at the expense of other users' desires (Abass et al., 2012). Specific quality parameters such as color and textural quality have been identified as the essential user-preferred characteristics for pounded yam in two different socio-cultural zones in Nigeria, according to 2020). Taste and scent, which are less essential attributes, are the least important.

2020) also discussed end-user preferences for boiled yams and their implications for trait evaluation. Boiled yam with high qualities, according to the authors, should be white or yellowish, non-sticky to the touch, non-fibrous, easy to chew, friable, sweet-tasting, and smell wonderful. 2020) assessed boiled and pounded yam end-user preferences in villages and small towns in Nigeria. To assess the RTB types' acceptance level in the peri-urban segments, it is necessary to determine discrepancies between consumer preferences for selected RTB by individuals in the peri-urban and urban segments. As a result, the qualitative features and consumer preferences of selected RTB food products (*gari/eba, lafun amala, yam amala*, plantain *amala*, pounded yam, and cooked yam) both in rural and urban consumers' diets were investigated. The findings could aid breeders in developing new, enhanced RTB food crop types acceptable to end-users in the rural and urban segments.

1.1. Processing and quality traits of cassava, yam and plantain-based products

Few studies have reported the processing quality characteristics of the finished products made from different RTB crops. Tekeen *et al*. (2020) worked on some RTB products and revealed that cassava roots' quality characteristics that give quality *gari* are non-woody, non-decaying white-flesh roots, white mash with low moisture and less chaff. They further described that the high-quality attributes of cassava roots during processing that gives good quality products are white-flesh roots, mash with the high dry matter, and non-coarse *gari* that gelatinized faster. The researchers established the quality traits of cassava roots and the finished product (*gari*) from the respondents in rural and small-town segments in Nigeria.

2020) reported that the quality characteristics that indicate good processing-ability of yam into pounded yam, according to the respondents in villages and small towns in Nigeria, are a white-flesh tuber, big tuber size, pounded yam that is clean, soft, smooth, stretchable, white, sweet and neat. Good yams will be soft during boiling, not too hard, white or creamy-white and easy to chew. Table 1 shows that good yam during processing has white flesh color (unless it is yellow yam (D. cayenensis)), is easy to peel, does not change color after peeling, has a short boiling time, absorbs less water during cooking and pounding, and produces smooth dough rapidly. Meanwhile,

Table 1. Pounded yam product profile (preferred/good quality)

Product Description*
Raw material (tubers)
✓ Big healthy tuber
✓ Low water content tuber
✓ Brown skin colour
✓ Regular form
Processing
✓ Unless it's a yellow yam, the flesh is white (D. cayenensis)
✓ Simple peeling
✓ No color change while peeling
✓ Short cooking time
✓ Heating and pounding, it absorbs less water.
✓ Easy to make a smooth dough
Final product
Southeast
✓ Appearance: Dough is white
✓ Textural quality: Stretchable, mouldable, non-sticky, smooth, somewhat soft/hard texture
✓ Taste: Sweet flavor
✓ Aromatic Appealing
Southwest
✓ Textural quality: Stretchable, mouldable, not sticky, smooth, moderately soft/hard texture
✓ Appearance: Unless the yam is yellow, the dough is white (*D. cayenensis*)
✓ Taste: sweet flavour
✓ Appealing aroma

Note: * The attributes are listed in order of preference.

Source: B. O. Otegbayo et al. (2020)

southeast Nigeria's essential textural quality that makes an excellent pounded yam should be stretchable, mouldable, not sticky, smooth, and moderately soft/hard. Similarly, the textural quality in southwest Nigeria is stretchable, mouldable, not sticky, smooth, and relatively soft/hard (B. O. Otegbayo et al., 2020). In the southwest region, color ranked as a top quality characteristic for pounded yam for male and female participants, while textural quality was the second most crucial component (Table 1). They emphasized that an excellent pounded yam should be stretchable, mouldable, and form a smooth dough without lumps. Participants from southwest Nigeria agreed that a yam specie used for pounded yam should produce a stretchable dough that does not stick to the fingers, is smooth (not lumpy), mouldable, soft, white in color, and has a pleasant taste and aroma. Stretchability, mouldability, softness but firm, smoothness, and adhesiveness are among the textural properties examined in pounded yam, according to 2018). Pounded yam with good textural attributes is supposed to have the characteristics listed above, whereas lumpy, not stretchy, too firm or soft, not cohesive (not moldable), and very sticky are the poor textural qualities of pounded yam. Plantains have three qualities: matured bunches or fingers,

finger-filling level, and pulp color. According to Ayinde et al. (2010), plantain quality features include the number of fingers, fruit size, appearance, texture, color, aroma, flavor, and shelf-life. Meanwhile, moldable, smooth, and stretchy *amala* is a property characteristic of plantain amala (Karim et al., 2013).

1.2. Consumer preferences for cassava, yam and plantain-based products

Different ethnocentric regions of the country have other preferences for cassava products like *gari*. Cassava mash is blended with the addition of palm oil in the Igbo-dominated southeast of Nigeria, resulting in yellow *gari*. In contrast, most *gari* consumed in the Yoruba-dominated southwest is white. *Gari* is a food commodity with specific attributes and preferred characteristics among consumers. These characteristic factors, such as color, texture, and taste, influence the behavior of economic actors and consumers (Osunbade & Adejuyitan, 2020). The most preferred quality characteristics of *gari* by consumers in the rural area of Benue State, Nigeria, are dry, bright/shiny, white, sweet, dense, fine, cooked aroma, and sour *gari*.

Consumer preferences for *gari* in rural areas of Osun State, Nigeria, are dry, white, dense, sour, and fine (Ndjouenkeu et al., 2020). Rural areas are classified based on high population density and infrastructural development, such as access to a good road network and social amenities. In contrast, rural areas have low population density and poor social amenities (Ospina-Patino & Ezedinma, 2015). The cooked *gari* food product (*eba*) is defined by its textural properties, while the dark color of *eba* is one of the most prominent low-quality characteristics of *eba*. The favored qualities of *eba*, according to 2020), are related to its texture, which communicates both its starch behavior and the grade of root utilized in processing *gari*. The textural qualities of *eba* are related to the density and granule structure, according to the terminologies used by stakeholders. *Eba* is chosen as soft, slightly sticky, smooth, stretchable, or firm, not sticky, less smooth, and less stretchable, according to him. This differential appears to rely on location and cooking techniques, as noted by Teeken et al. (2019). It is supported by the enjoyment of eba when eating, which is appreciated in the mouth for its strong or weak texture behavior.

Urban consumers in Ibadan, Nigeria, found bio-fortified processed items (*gari, fufu*, and *eba*) generally satisfactory in color and texture. Customers were eager to eat them regardless of their lack of gelatin because of their nutritional benefits. The flesh's taste, texture, and color were the most common consumption criteria for boiled yam (Honfozo et al., 2020). The texture of cooked root and tuber crops is critical in customer acceptance of new cultivars, though the yam-producing industry is being challenged by changing consumer demand.

On the other hand, the taste was deemed more essential than the other criterion (Goddard et al., 2015). Taste preferences (sweet, bitter, neutral), taste perceptions (refined, wild), an external aspect of the tuber free of damage, and tiny or medium tuber size are all sensory and visual aspects that consumers use to determine the quality of yams (depending on family size). A perfect and consumer-preferred boiled yam should be white or yellowish in color, sticky to the touch, non-fibrous, simple to chew, friable, sweet-tasting, and pleasing in aroma (Honfozo et al., 2020. 2020) also noted that too dark color, hard to the touch, no sweetness, and not friable when eaten detract from the overall like of boiled yam. Sensory (appearance, texture) and emotional (e.g. appealing, disagreeable odor, pleasing aroma/odor, excellent taste) quality aspects of boiled yam indicated by respondents during surveys on "boiled yam end-user preferences as well as the consequences for trait assessment" were categorized (Honfozo et al., 2020). Poor-quality boiled yam had a discoloration (red/purple/black spot) after cooking, a firm texture (hard in the mouth/difficult to chew), and a foul taste/bitter taste. The appearance, texture in the touch and tongue, and the flavor of yams that have been cooked are all high grade qualities. 2010) found that the best-cooked yam has a pleasant aroma, a good flavor (a little sweet/sugary) and is easy to chew. These findings corroborated prior research that identified texture, color, taste, and aroma as essential factors in consumers' choice of boiled yam. The textural qualities important in boiled yam are mealiness, waxiness, sogginess, stickiness and hardness (B. O. Otegbayo, 2018). A consumer of

pounded yam will typically want to feel the food to find out if the feel or touch is acceptable before considering the taste or aroma of the product. Otegbayo *et al*. (2018) reported that hand feel is more important than mouth feel in pounded yam.

Stretchable, mouldable, not sticky, smooth, and moderately soft/hard are the most preferred features of pounded yam, according to B. O. Otegbayo et al. (2020). According to research, the age of the bunch or fingers, the level of filling of the fingers, and the pulp color are the essential quality parameters for selecting quality plantain. Consumer preferences for plantain/banana were assessed in a large urban market in Nigeria's Kwara State by 2010). The quality aspects of the number of fingers, size, look, color, texture, scent, flavor, and shelf-life were investigated. Consumers liked medium or large fingers, bunches with 9–12 fingers, light yellow pulp, no black spots on the peel, firm texture, medium intensity aroma and flavor, medium sweet fruits, and a shelf-life of 7–9 days at room temperature, according to the findings. Taste, size, and the number of fingers on each hand of the fruit were deemed essential while purchasing, whereas appearance, color, and shelf life were deemed less necessary. According to 2010), diversity is the most critical characteristic of plantain in rural areas, followed by bunch size. Unlike in the city, consumers in rural areas prefer the status quo, i.e. conventional variations (Kikulwe, 2010. Karim et al. (2013) also confirmed that unripe plantains could be dried, ground into flour, and cooked to form a nice stiff dough known as "*amala*" in southwest Nigeria. It can be boiled and served with sauce, roasted and served with peanuts, or fried as "plantain chips." However, semi-ripe or ripe plantain can be fried to make "*dodo*." Customers prefer plantain amala because it is moldable, smooth, and flexible (Karim et al., 2013).

1.3. Consumption trends of cassava, yam and banana-based products

The consumption of RTB foods in Nigeria varies depending on the rural, peri-urban and urban (Tables 2 and 3). *Gari*, a roasted granule, is the most popular product in rural and urban places. *Gari* can be eaten plain or with other ingredients such as sugar, peanuts, fish, pork, and stew. *Fufu* and *Akpu*, fermented cassava wet paste, are also popular, particularly in the southern zones. However, most processors say that the *fufu* in a moist paste and *fufu* that is ready to consume currently on the market have a relatively short shelf life (Abass et al., 2012). Table 3 shows the daily

Table 2. Cassava product consumption patterns in rural, peri-urban and urban segments in Nigeria

Segments	Order of Consumption
Urban	*Gari, Lafun, Fufu/Akpu*
Peri-urban	*Gari, Akpu,Lafun, Pupuru*
Rural	*Gari, Fufu/Akpu, Lafun boiled cassava*

Source: McNulty and Oparinde (2015)

Table 3. Cassava consumption per capita daily

Zone	Grams per person per day
National zone	226.93
Dry savannah	131.16
Moist savannah	192.37
Humid Forest	284.42
Rural zone	239.74
Peri-urban segment	220.53
Urban segment	213.76

Source: FAOSTAT (2019)

consumption of cassava per capita, according to geographic region. Surprisingly, consumption differs across urban and rural areas, indicating cassava is a true national staple for city dwellers (Oparinde et al., 2014). Consumption of cassava is high in both urban and rural areas, but the consumption pattern differs. The crop's rapid quality loss after harvest restricts urban consumers' access to fresh cassava. Therefore, urban consumers prefer convenient, easy-to-prepare, long shelf-life products like *gari*, *fufu*, and *lafun* (Nweke et al., 2004). Rural consumers can supplement these products with fresh cassava. Despite the availability of various meal options in metropolitan settings, cassava looks to be a popular meal. Each year, rural micro, small, and medium food processors produce 4 million metric tons of processed cassava, assuming urban consumption per capita is 213.76 grams of cassava per day. This equates to 6.6 million metric tons of cassava root.

Yam is consumed in different forms, mainly boiled, fried, or roasted. Boiled yam could also be pounded and eaten with sauce. Yam can be fried or roasted as a snack. Another processed product is pottage which is usually prepared with other ingredients such as onions, pepper, a protein source, oil, and so on (B. O. Otegbayo, 2018). Boiled yam, pounded yam, and "amala" are the forms in which yam is primarily consumed in West Africa, especially in Nigeria. Boiled yam is considered an important all-time (breakfast, lunch or dinner) food product made by peeling the yam, slicing and boiling the pieces in water until the cores are soft. Regions have different yam consumption trends and patterns. Pounded yam, porridge, fried yam, boiled yam, "*ojojo*","*ikokore*", and "*amala*" are the most common yam dishes in Southwest Nigeria (Nweke et al., 2013). Consumers in Southeast Nigeria prefer boiled yam, roasted, fried, and porridge. The most common yam types in the north are boiled and pounded yams. However, amala usage in the north is relatively low compared to the Southwest of Nigeria. The General Household Survey Panel (GHS-Panel) was undertaken by the National Bureau of Statistics (NBS) in collaboration with the World Bank in 2010/2011 to investigate yam production and consumption trends in Nigeria. According to the GHS Panel, 46 percent of families in the post-planting season and 53 percent of households in the post-harvest season consumed yams weekly in urban areas and daily in rural parts of Nigeria. Different households consume different varieties of bananas and plantain in the country. Nigeria's most consumed (banana or plantain) variety is "landrace Agbagba" (Honfo et al., 2011). Various recipes were used for processing plantain at different ripening stages, and the main predominant dishes are presented in Table 4. In Nigeria, boiled ripe or unripe plantain, fried and roasted ripe plantain represented the most important consumption forms preferred by households because these forms could be quickly accompanied by many other complements foods such as stew, vegetable sauces, fried kidney beans, roasted fish or meat. Bananas and plantain processed into porridge and ripe bananas were also more preferred in the plantain chip seemed to be a popular snack in Nigeria. Depending on the household's income, these dishes were generally accompanied by stew or vegetable sauces with fish or meat.

Table 4. Forms of plantain (% of N respondents) preferred in the household

Forms of meal	Nigeria (*N* = 240)
Boiled ripe or unripe plantain	100
Fried plantain	100
Plantain chips	100
Plantain flour paste	79
Roasted plantain	100
Banana/plantain porridge	66
Pounded banana/plantain	76
Ripe banana	100

Source: Honfo et al. (2011)

2017) found that ripe plantain/banana was primarily consumed as a dessert fruit or snack between meals in a recent study on the frequency of consumption of plantain-based dishes in households. In rural and urban Nigeria, most respondents (60%) snacked on plantain chips in the afternoon for lunch and for dinner, pounded banana/plantain and plantain flour paste was preferred (43 percent of respondents). Rural and urban regions are affected, and the plantain paste food showed the same trend (Rosegrant et al., 2017). The respondents ate boiled ripe and unripe plantain throughout the day. Ripe bananas, boiled plantain, plantain porridge, and fried plantain were consumed regularly (2–3 times per week) by 15, 25, 5, and 31 percent of children and mothers, respectively. The widespread consumption of boiled and fried plantains revealed their overall appeal in rural and urban settings. Compared to urban consumers, rural consumers appeared to consume less pounded cooked banana and plantain flour paste (Rosegrant et al., 2017).

2. Conclusion

This review showed that studies have established that the quality features of cooked yam (boiled and pounded) influence the end-users varietal choices and decisions for adoption. Textural attributes of pounded yam were the essential food quality parameters that drive its preferences by consumers. Consumers from rural and urban areas liked the textural qualities of pounded yam in this order: stretchability> moldability>stickiness> smoothness > fairly hard/soft. Whereas, according to the studies, dry, dense, sour/sweet, and brightened/white gari are the quality attributes of cassava products. Meanwhile, the quality characteristics of plantains are matured bunch or fingers, the level of filling of the fingers and the pulp color. The researchers established the quality traits of the selected cassava, yam and bananas products from the respondents in Nigeria's rural and urban areas. This information, with an in-depth laboratory characterization of the uncooked root, tuber, and banana (RTB) products, will help develop varieties of RTB crops that will meet the good quality characteristics of the products as preferred by multi-end-users.

3. Recommendation

Detailed information on consumer preferences for the selected banana, tubers, and root products may be identified in peri-urban segments. Also, compare the differences between the peri-urban and urban consumer preferences, disaggregated by age, income, and gender in Nigeria and determine the features of selected RTB foods that constitute a good quality product in peri-urban and urban areas that are favorable and less desired.

Author details
Adebowale Oluwaseun Osunbade[1,2]
Emmanuel Oladeji Alamu[1,3]
E-mail: b.maziya-dixon@cgiar.org
ORCID ID: http://orcid.org/0000-0001-6263-1359
Wasiu Awoyale[1,4]
Aishat Bolanle Akinwande[2]
Johnson Akinwumi Adejuyitan[2,5]
Busie Maziya-Dixon[1]
[1] Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture (IITA), Ibadan, Oyo, Nigeria.
[2] Department of Food Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
[3] International Institute of Tropical Agriculture, Southern Africa, Research and Administration Hub (SARAH), Lusaka, Zambia.
[4] Department of Food Science and Technology, Kwara State University Malete, Ilorin, Nigeria.
[5] Department of Food Science and Microbiology, Land Mark University, Omu-Aran, Nigeria.

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No potential conflict of interest was reported by the authors.

Data availability statement
Because no data sets were collected, data sharing does not apply to this paper.

Ethical guidelines
This study does not require ethical approval.

Author Contribution
Adebowale Oluwaseun Osunbade: Conceptualization (equal); Writing-original draft (supporting); Writing, review and editing (lead). Emmanuel Oladeji Alamu: conceptualization (Lead); initial draft writing (lead); writing, review and editing (lead). Wasiu Awoyale: Conceptualization (equal); Original Draft Writing (supportive); Writing, Review and Editing (supporting). Aishat Bolanle Akinwande: Conceptualization (helpful); Writing-first draft (helpful); Writing-review and editing (supporting). Johnson Akinwumi Adejuyitan: Conceptualization (assistance); Writing-review and editing (supporting). Michael Adesokan: Conceptualization (assistance); Writing-review and editing (supporting). Busie Maziya-Dixon: Conceptualization (assistance); Writing, review and editing (supporting).

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