2026

Target Food Product Profile

Boiled Plantain



RTB Breeding

RTB foods

Gates Foundation

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Breeding Root, Tuber, and Banana (RTB) varieties that better serve user and consumer preferences will lead to greater varietal adoption in RTB value chains. This will help to further boost RTB-linked livelihoods and food and nutrition security, and reduce drudgery.

The RTB*foods* project designed and implemented a participatory gendered interdisciplinary methodology with RTB researchers and regional stakeholders. This has contributed to **identifying key traits and characteristics required for RTB food products, in terms of processing and consumption**. **New high-throughput phenotyping tools** for assessing RTB food product quality and preferences have been developed and deployed for use by breeders and food scientists. These validated new traits are already being incorporated into breeding programmes. The project has developed product profiles covering the complete range of RTB food products. Furthermore, the previously unknown and often stereotyped African gastronomy is emerging as an 'African nouvelle cuisine' which will benefit from RTB varietal quality improvements. The RTB*foods* project was supported by the Bill & Melinda Gates Foundation, and ended in 2023, and the work is now embedded within the RTB Breeding Initiative.

This Target Food Product Profile (TFPP) for **Boiled Plantain** is being translated into market-driven breeding initiatives to develop new, end-user-focused plantain varieties, which is significantly boosting their adoption.

Product Identity

Boiled Plantain is a nutritious food made from plantains, a type of cooking banana (*Musa* spp., AAB). It has a different flavor and culinary uses from desert bananas. Plantains are usually larger than bananas, and have a thicker skin, more starch and less sugar. Plantain is a delicious, nutritious food product with high energy potential as it is rich in carbohydrates. Africa is the primary supplier of plantain followed by Latin America. Plantain use spread to Latin America through the slave trade. It is a component of traditional and contemporary West African cuisine. It is widely used in Latin American, African, and Caribbean cuisine, usually as a culinary vegetable in savory dishes. The preparation method for plantain fruits depends on what they will be accompanying (sauce, meat, fish, or vegetables) and the stage of ripeness. **Boiled plantain can be cooked by boiling peeled or unpeeled fruits in water.** In general, when the fruit is unripe (green) it is peeled, and the pulp is prepared by full immersion in boiling water. The color of raw plantain flesh varies from orange to cream to ivory depending on the variety. Cooking normally lasts between 35 and 40 minutes, and is complete when the plantains turn an intense yellow and emit the characteristic plantain aroma. Cooking unpeeled fruit involves washing it thoroughly and immersing it in boiling water for almost an hour. Cooking is complete when, in addition to their appealing odor, the initially green fruit peel turns brown. When fruits are ripe, cooking time is decreased, and unpeeled cooking is recommended to prevent excessive water absorption. Boiled plantains can be easily prepared by anyone, and can be served as a side dish or paired with stews or meat. Boiled plantain is eaten in all regions worldwide, wherever it is grown and in the locations where it is marketed.



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Exploration of good quality traits for Boiled Plantain



Consumer testing of boiled plantain
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In order to obtain the best product quality and to rank traits in order of importance, a gendered map of characteristics demanded by food-chain actors was achieved through a multidisciplinary methodology. These actors included plantain farmers, processors/cooks and consumers. By including boiled-plantain processors in a participatory diagnosis of processing, and consumers in rural and urban areas in consumer testing, a more appropriate gendered food-product profile for boiled plantain has been developed. Several key end-user preferences relating to boiled-plantain quality traits have been identified in Cameroon[1,2] and Nigeria[3]. Men and women stated similar preferred characteristics for raw or boiled plantain. Raw plantain that is of high quality should have a physiologically **mature form with large fingers and a dark-green peel color. The pulp color should be yellow or orange.** Immature fruits with a light-green peel that are soft on touching are usually considered low-quality raw plantains. The appearance of plantain after boiling should be **soft and well-cooked**, with a **yellow or brown skin**. Boiled plantain should be attractive in both appearance and taste. The plantain's attractiveness is a result of thorough cooking and scraping before or after cooking. A good boiled plantain should not be too soft in the mouth or when forked. It must retain its original shape after cooking. The texture should be **firm but soft in the mouth**, and it should have a **sweet flavor when ripe**, with a **good plantain aroma**.

A trait evaluation toolbox to support breeding superior plantain varieties for enhanced adoption of Boiled Plantain





Color evaluation by chromameter (left) and textural analysis (right) of boiled plantain © Dominique Dufour - CIRAD

For the first time, food technologists and social scientists are able to assist breeders with quantifiable thresholds in terms of biophysical and sensory scores for overall preference for each measured trait. A toolbox of standard operating procedures (SOPs) for sampling, and textural and sensory analyses for boiled plantain has been developed. The textural attributes of boiled plantain pulp, including hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness, can be assessed by penetration and double compression using a texture analyzer. Physicochemical characteristics such as dry matter content (DMC); total soluble solids (TSS) using a hand-held refractometer; and total titratable acidity (TTA), have been measured in cooked plantain pulp. Methods for measuring starch and sugar content, amylose content, and cell wall polysaccharides have been developed for raw and boiled plantains. The protocols for characterizing water absorption and cooking time for boiled plantain have been adapted from those of boiled cassava.

Consumer testing, sensory quantitative descriptive analysis (QDA), instrumental texture profile analysis (TPA), and penetrometry, have been evaluated and correlated[4]. Untrained consumers described the preferred plantains by characteristics such as **smooth on sight, attractive, mealy, firm, plantain taste and yellow**. The panelists highlighted **color and firmness**. Penetrometry is superior to TPA in discriminating genotypes. The **TPA can distinguish hardness, gumminess, resilience, and chewiness** attributes, while the **penetrometry can distinguish hardness** of plantains. The TPA and the sensory texture of boiled plantain were highly correlated. The acceptable threshold values of boiled plantain quality traits have been identified including DMC, TPA hardness and resilience, TSS, and QDA firmness and color. Firmness and chewiness has been well-predicted by instrumental force and hardness, and by TSS and DMC[5]. Cooking methods (boiling plantain with or without peel) had an effect on DMC, firmness, and soluble solids, at all ripening stages (unripe, semi-ripe, and ripe)[6]. Pulp from plantains cooked with the peel displayed higher values than those cooked without peel.

For a medium-throughput screening of pulp color for raw plantains, a protocol using a chromameter has been developed. High-throughput screening using hyperspectral imaging has been calibrated for starch-grain size and shape of fresh plantains, and for color change during cooking boiled plantains. Developing molecular markers for identifying genes of interest can be achieved through our approaches based on the preferences of boiled plantain users and consumers. Identifying and assessing candidate genes controlling desirable plantain quality traits can enhance plantain selection and efficiency through genomic-assisted breeding. **By combining sensorial QDA and instrumental texture measurements, mid- and high-throughput screenings of fresh and cooked plantain, plantain hybrid selection will be more effective and new varieties can be adopted more effectively.** This will comprehensively accommodate stakeholder preferences across the entire boiled-plantain value chain. The work will significantly boost adoption rates of new varieties and make them more attractive in the market.

Key Publications

[1] Ngoh Newilah et al., 2021. Analysis of consumer-oriented quality characteristics of raw and boiled plantains in Cameroon: implication for breeding. *Int. J. Food Sci. Technol.*, 56(3), 1135–1147. https://doi.org/10.1111/ijfs.14812

[2] Ngoh Newilah et al., 2024. User preferences and consumer acceptability of boiled plantain in rural and urban localities in Cameroon. *J. Sci. Food Agric.*, 104(8), 4838–4850. https://doi.org/10.1002/jsfa.13090

[3] Amah et al., 2021. End-user preferences for plantain food products in Nigeria and implications for genetic improvement. *Int. J. Food Sci. Technol.*, 56(3), 1148–1160. https://doi.org/10.1111/ijfs.14780

[4] Ngoh Newilah et al., 2024. Relation between quantitative descriptive analysis and textural analysis of boiled plantain. *J. Sci. Food Agric.*, 104(8), 4540–4550. https://doi.org/10.1002/jsfa.12977

[5] Kouassi et al., 2021. Textural and physicochemical predictors of sensory texture and sweetness of boiled plantain. *Int. J. Food Sci. Technol.*, 56(3), 1160–1170. https://doi.org/10.1111/ijfs.14765

[6] Vepowo et al., 2024. Cooking mode and ripening stage influence physicochemical and nutritional properties of boiled plantain pulps. *J. Sci. Food Agric.*, 104(8), 4818–4828. https://doi.org/10.1002/jsfa.12785

Anajekwu et al., 2023. Influence of processing methods on the sensory acceptability of products from selected hybrid plantains (*Musa* species AAB) cultivars. *Afr. J. Food Sci.*, 17(2), 49-58. https://doi.org/10.5897/AJFS2022.2248



Target Food Product Profile of Boiled Plantain

Along with bananas, plantain is a key RTB food security crop in Africa, Asia, and Latin America.

139.5
million tons

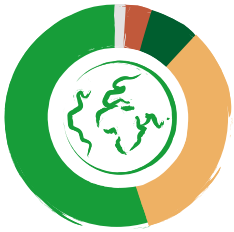


Global annual banana production

Cooking bananas = 42.4 Mt
- Plantain (AAB group)
- Highland banana + ABB group

Dessert banana = 97.1 Mt
- Cavendish
- Gros michel + others

21.0
million tons

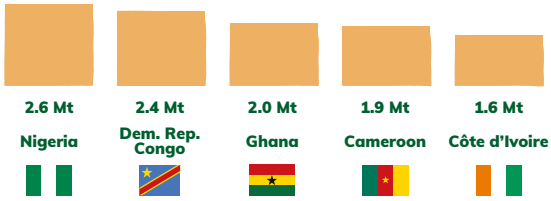


Global annual plantain (AAB group) production

- 55% West and Central Africa
- 33% Latin America
- 7% Asia
- 4% East Africa
- 1% Others

Top 5 plantain (AAB group) producers in Africa





Source: Lescot (2020)

The ripening stage of plantains determines how they are prepared for food



Water-based cooking

- Boiled with ingredients (porridge/pottage)
- Milled and reconstituted into dough (amala)

- Pounded plantain/cassava (foutou)

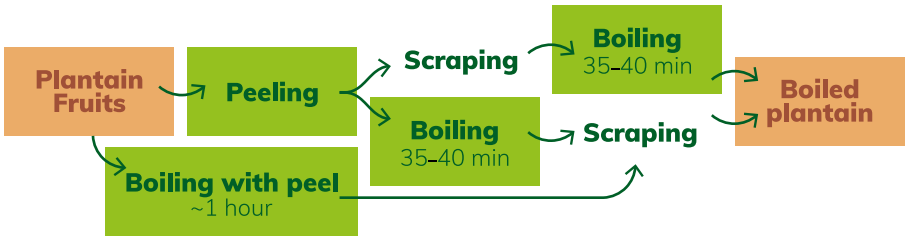
- Boiled plantain
- Boiled plantain with beans
- Milled and steamed (moin-moin)
- Pounded plantain (fufu)

- Pounded plantain/corn (akankele)

- Boiled plantain with corn dough (dokodoko)

Source:[1,5]; Dadzie & Wainwright, 1995 and Ogazi, 1996

Boiled Plantain Preparation



Preferences of farmers, producers, processors, and consumers of boiled plantain

Raw plantain
- Big plantain fruits
- Peel color (dark green)
- Mature plantain fruits
- Presence of a ripe finger
- Pulp color (yellow or orange)

During processing
- Easy to peel
- Short cooking time
- Short scaping time

Ready-to-eat boiled plantain
- Well cooked
- Soft in mouth
- Plantain taste
- Good plantain odor
- Attractive plantain
- Firmness

Key priority traits for development of plantain varieties for boiled plantain

- Fruit size
- Attractive pulp color
- Easy to peel
- Short cooking time
- Plantain aroma
- Firmness
- Sweetness

As a result of our work, new traits are being integrated into the plantain breeding pipeline. Moving forwards, this will significantly boost adoption rates and performance of new plantain varieties.

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For more information about Boiled Plantain, please see https://rtbfoods.cirad.fr/

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