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PHYSICOCHEMICAL PROPERTIES, PROCESSING SUITABILITY, AND PERCEIVED END-USE QUALITY OF *DIGITARIA EXILIS* (FONIO) CULTIVARS FROM NORTHERN BENIN

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ABSTRACT

Despite its economic, nutritional, and technological potential, *Digitaria exilis* (fonio) remains an underutilized cereal in West Africa, mainly due to limited knowledge of its cultivars, processing methods, and consumer preferences. This study aimed to fill these gaps by characterizing fonio cultivars, identifying derived products, and assessing technological and sensory-related consumption constraints. Data were collected through Focus Group Discussions (FGDs) with producers, processors, and consumers in Boukombé and Abomey-Calavi using a semi-structured discussion guide. Physicochemical analyses, including moisture, protein, lipid, starch, amylose contents, color parameters, and thousand-kernel weight, were performed using standard AOAC, ISO, AFNOR methods. From the results three cultivars were identified: *Iporapia*, *Iporawan* and *Ipooni*. *Iporapia* had the highest thousand-kernel weight (0.4±0.2 g). *Ipooni* exhibited the highest color indices (a* = 3.1±0.2 ; b* = 20.2±0.4) and the lowest protein (5.9±0.1%) and starch (79.8±3.4%) contents. Conversely, *Iporawan* had the highest starch content (87.3±1.9%). Amylose (29–31%) and lipid (0.5%) contents did not differ significantly among cultivars. Two main products were derived from cultivars: dehulled and precooked fonio, consumed as dough, porridge, or couscous-like dishes. Precooked fonio is processed using two methods: washing/desanding, precooking and drying; or washing/desanding, drying, precooking and final drying. Producers, who are the main fonio users, were able to distinguish between cultivars and adapt their processing practices accordingly, whereas consumers generally did not differentiate cultivars. Perceived sensory attributes reported by producers during FGDs indicated that *Iporapia* and *Ipooni* were preferred for whiter, smoother dough and porridge, whereas *Iporawan* was preferred for couscous. However, fonio couscous obtained from washed grains or precooked fonio has not yet met consumer expectations in terms of reduced preparation time and non-sticky grains. Diagnostic surveys revealed several major technological constraints, including the persistence of sand grains, long cooking times, high labor demand due to the small grain size, and difficulties in controlling final texture, particularly grain stickiness. These findings highlight the coexistence of rich empirical knowledge and persistent technological limitations. They underline the need for a better scientific understanding of fonio cooking and hydration mechanisms in order to improve product quality, enhance consumer acceptance, and support the sustainable development of the fonio value chain.

Key words: *Digitaria exilis*, fonio, physicochemical properties, processing method, couscous-like products, sensory quality, Benin

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INTRODUCTION

Digitaria exilis (fonio) is a small, ovoid-shaped traditional African cereal [1]. Its morphological traits and strong adaptability allow it to thrive in arid regions and poor soils [2]. It is a staple food in parts of West Africa and contributes to local food security.

It is predominantly composed of starch (approximately 70%) with a high energy value (374.3kcal/100g), surpassing that of maize and sorghum (321.8 and 308.8 kcal) [3–5]. Its protein content (8.1±1.1%) is moderate and lipid content very low (1.6 ±1.1%) compared to rice, maize and sorghum (3.7 to 8.4%) [6]. It also contains fibre and polyphenols [7], and a high methionine and cysteine levels, two sulfur containing amino acids typically deficient in wheat, rice, maize and sorghum [8]. Its low glycaemic index (42.7-58.3) and reduced sugar content (approximately 1% DM) make it suitable for individuals with diabetes or obesity [1].

Despite these nutritional and agronomic advantages, fonio remains underutilized in West African food systems and accounts for less than 1% of cereal production in the region [1]. Fonio represents the lowest cereal production among cereals in Benin (907 tons) and in the sub-region (689,223 tons). Its low production, combined with processing difficulties related to its tiny grain size and the limited documentation of its techno-functional (example: gelatinization, water absorption, cooking behaviour) and sensory properties (example: texture), contributes to its status as a neglected and underutilized cereal in West African agricultural and agrifood systems [9,10].

In Benin, few studies have simultaneously compared the physicochemical characteristics of local fonio cultivars, documented traditional processing methods, and assessed consumer expectations regarding end-product quality. Although processed fonio products (for example, blanched and precooked fonio) are increasingly available on the market, there is a lack of integrated baseline data on cultivar diversity, processing practices, and the sensory attributes that consumers value. Previous studies in Benin and West Africa have mainly focused on fonio biodiversity, nutritional composition, or agronomic aspects in isolation; thus, baseline data linking cultivar diversity, processing suitability, and consumer-valued sensory attributes remain limited.

This study therefore addresses these gaps by comparing the physicochemical characteristics of three fonio cultivars, documenting their processing methods and suitability, and assessing the perceived end-use quality attributes expected by consumers.

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MATERIALS AND METHODS

Study area

The study was conducted in Boukombé and Abomey-Calavi. Boukombé, the major fonio production area in Benin, contributes more than 74% of the national fonio production and is located in the north-western part of the country between 10° and 10°40' N latitude and 0°75' and 1°30' E longitude [11, 12]. The area is predominantly inhabited by the Otammari sociocultural group, for whom fonio holds important sociocultural and food significance.

Abomey-Calavi is a peri-urban area located in South of Benin between 6°19'20' and 6°42'51' north latitude and between 2°11'45' and 2°25'15' east longitude [13]. Its large population, sociocultural diversity, and proximity to Cotonou, the economic capital of Benin, make Abomey-Calavi a relevant area for exploring consumer perceptions and market opportunities for innovative convenient food products [13].

Selection of FGDs participants

Participants involved in the Focus Group Discussions (FGDs) included fonio producers, processors, and consumers. The size of fonio production of the village (large and small) and the age group (younger: < 40 years and older: ≥ 40 years) were combined to randomly select 4 FGDs in Boukombé. In each of the two fonio processing groups in Boukombé, a processor FGDs was formed, taking into account 2 to 3 people per processing station. In Boukombé, four consumer FGDs were selected by combining sociocultural origin (Otammari, non-Otammari) and gender (male, female). In Abomey-Calavi, 2 consumer FGDs were recruited on the university campus using network sampling. Each FGD included 10±2 participants.

Data collection

The discussion guide was pre-tested with a small group of participants outside the study sample to assess clarity, relevance, and comprehension of the questions before data collection. Socio-demographic characteristics, fonio cultivars' discrimination criteria, derivative products, as well as sensory attributes of end products were collected from all stakeholders. Technological and consumption constraints were collected from processors and consumers. Four FGDs were organized with producers, two with processors and six with consumers by a well-trained interviewer and translator. Processing methods and cultivar identification were documented through direct observations and FGDs conducted with processors. Discussions were conducted in the local language (Ditamari) in Boukombé and in French in Abomey-Calavi. They were recorded and transcribed afterwards.

Sample collection

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Three fonio cultivars harvested from the previous agricultural campaign were collected from producers in May 2023. Samples of each cultivar were taken from household granaries in 10 villages and mixed to obtain composite samples of approximately 36kg per cultivar.

Sample processing

The grains were dehulled using a GMBF huller (Engelberg type), then spread in thin layers and cooled at ambient temperature (30°C) in a dry environment for 24 hours. Dehulled grains were manually washed four times by sedimentation using calabashes and plain water. Wet grains were drained in jute bags for 45 minutes, then spread on fine-mesh cloth in trays of a CSec-T continuous flow drainer (Model CSec-T, France) and dried at 45°C for 5 hours. Finally, 4 to 6kg of dehulled dried grains of each cultivar were stored in vacuum-sealed bags at 4°C until analyses.

Physicochemical analyses

Colour

Grain colour was measured using a calibrated Minolta CR-400 chromameter (Konica Minolta, Japan) [14] under standard D65 illumination and a 10° observer angle. Four measurements were performed on 20g of grains uniformly distributed in a Petri dish (90 mm diameter, approximately 10 mm thickness). Mean L* (lightness), a* (red-green axis), and b* (yellow-blue axis) values were calculated.

Thousand-kernel weight

Thousand-kernel weight was determined according to AFNOR NF V03-702 standard method. Briefly, ten sets of 10 grains were manually counted and weighed using an analytical balance (± 0.01mg). The mass of 100 grains was calculated and multiplied by 10 to obtain the thousand-kernel weight.

Dry matter content

Dry matter content was determined according to the ISO 712 (2010) method. Approximately 5g of sample were dried at 132±2°C for 2 h, and dry matter content was calculated by differential weighing.

Protein content

Total nitrogen content was determined using the Kjeldahl method according to NF EN ISO 20483. Protein content was calculated using a nitrogen conversion factor of 6.25

Lipid content

Total lipid content was determined by acid hydrolysis using a Soxtec extraction system according to AOAC method 2005.03. Extraction was carried out using petroleum ether (40–60°C) until constant reflux was achieved.

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Total starch content

Total starch content was determined by enzymatic hydrolysis [15]. Finely ground samples (< 500 µm) were hydrolysed using thermostable α-amylase (Sigma-Aldrich, A3403-1MU) at 98°C for 15 min, followed by amyloglucosidase (Sigma-Aldrich, 10115, 70 U/mg) at 60°C for 30 min. Glucose concentration was determined using a glucose oxidase-peroxidase (GOD-POD) assay, and absorbance was measured at 510 nm using a spectrophotometer. Starch content was calculated from glucose concentration using a conversion factor of 0.9.

Amylose content

Amylose content was determined by differential scanning calorimetry (DSC) [16], based on the formation of an amylose–lysophosphatidylcholine inclusion complex. Approximately 3mg of fonio flour were mixed with 45µL of lysophosphatidylcholine solution in DSC pans, hermetically sealed, and equilibrated for 1 h at room temperature before analysis. Samples were heated from 25 to 160°C and cooled thereafter. Amylose content was calculated from the melting enthalpy of the amylose–lipid complex relative to a potato starch reference analysed under identical conditions.

All measurements were performed in triplicate and the results expressed per 100 g of dry matter (DM).

Analyses of qualitative data

Qualitative data were analyzed using content analysis [17]. Audio recordings from the Focus Group Discussions were transcribed verbatim into French. The transcripts were then carefully reviewed and segmented into meaningful units corresponding to sentences, ideas, or recurring statements related to the study objectives. Similar statements were grouped into thematic categories concerning cultivar identification, processing methods, sensory attributes, and technological or consumption constraints. An analysis grid was developed to organize and code the different categories and subcategories identified from the raw data. The frequency and recurrence of themes across participant groups were examined to support interpretation. Representative verbatim quotations were also selected to illustrate key findings. All data were processed anonymously.

Statistical analysis

All statistical analyses were performed using SPSS software version 20 (IBM Corp, 2011, New York). Participant socio-demographic characteristics and cultivar physicochemical data were expressed as means±standard deviation (SD) or proportions. Prior to analysis, normality and homogeneity of variance assumptions were checked using the Shapiro–Wilk and Levene's tests, respectively.

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Physicochemical differences were analyzed by ANOVA, followed by Tukey's post hoc test at a 5% significance level.

RESULTS AND DISCUSSION

Participant socio-demographic characteristics

Producers were mainly male (71%), aged 25 to 39, whereas processors were exclusively female (100%) mostly aged 40 to 60 (Table 1). This gender distribution reflects the traditional division of roles within value chains in West Africa, where men are generally involved in crop production while women predominantly handle post-harvest processing activities. It may also be explained by the fact that men generally have greater access to agricultural land and production resources than women in rural areas. Similar observations were reported in Benin by Ballogou *et al.* [18]

Participants in Boukombé were mostly Otammari, while those in Abomey-Calavi were mostly Fon. In Boukombé, 60% of consumers were uneducated unlike in Abomey-Calavi where 59% had reached higher education. These differences are consistent with the sociodemographic characteristics of the Beninese population [19] and may be explained by the urban and university environment in which participants from Abomey-Calavi were recruited.

Cultivars identification parameters and forms of consumption

Fonio cultivars were: *Iporapia*, *Iporawan*, and *Ipooni* (in Ditamari). These cultivars were previously reported by Sekloka *et al.* and Kanlidogbé *et al.* [20, 21]. According to producers, cultivars were mainly distinguished based on plant colour at maturity, maturation duration, grains' size and colour after dehulling.

As for processors, out of 26 participants, 77% identified cultivars solely based on grain size after dehulling. Among Otammari consumers (32 participants), 69% stated that only the husk colour differs between cultivars, while 31% attributed the difference in kernel size to soil fertility. Non-Otammari consumers from Boukombé and Abomey-Calavi (28 participants) did not mention any difference between cultivars (100% of respondents).

«After dehulling, the cultivars cannot be distinguished. «After dehulling, the grains have the same color and the same size. » (Source: male and female consumers from Boukombé)

Producers' ability to distinguish cultivars using plant and grain traits appears to be linked to their prolonged involvement with the crop throughout plant development, maturation, harvesting, and post-harvest operations, as reported during the FGDs. Maturation cycle was highlighted as a key criterion by Sekloka et *al.* and Kanlidogbé *et al.* [21, 22], while grain colour and size were mentioned byYerima *et al.* [23].

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Precooked and washed-dried fonio were identified as the main derived products by all processors (100%) in Boukombé. Other products, including whole grain flour, fortified flour enriched with baobab pulp or soy flour, and "aklui" (made from whole grain flour) were mentioned by 40% of processors. In Boukombé, all consumers (100%) reported dough and porridge as the main forms of fonio consumption, whereas in Abomey-Calavi porridge was mentioned by all consumers (100%). Dough and porridge are the most common forms of cereal consumption in West Africa [18]. Fonio couscous, obtained by steaming precooked or washed-dried fonio, was mentioned by 70% and 50% of consumers in Boukombé and Abomey-Calavi respectively, although its consumption remains limited because of the difficulty of obtaining a product with a soft texture. Given its similarity to wheat couscous, fonio couscous could become a convenience food in urban areas. Further research is needed to improve its processing and adapt its organoleptic qualities to the preferences of urban consumers, who represent an important market for ready-to-use products.

Physicochemical characteristics of cultivars

Among the cultivars, *Iporapia* has the lightest colour (L*=77.0±1.2), followed by *Iporawan* (L*=76.1±2.7) and *Ipooni* (L*=71.9±0.8), though differences are not significant (Table 2). *Ipooni* displays a yellow hue (b*=20.2±0.2) significantly higher ($p < 0.05$) than *Iporapia* (b*=18.0±0.6) and *Iporawan* (b*=18.5±0.7). Similarly, its red index (a*=3.1±0.2) is significantly higher than that of *Iporapia* (a*=0.3±0.1) and *Iporawan* (a*=0.3±0.2), both close to neutral. Ballogou *et al*. [18] reported much lower L*, a*, and b* values (11.80-14.64; -0.19-0.42; 6.87-8.71) in related ecotypes of *Iporawan* and *Ipooni*, likely due to differences in processing and cleaning [18]. Enhanced brightness obtained in the present study may be explained by more thorough grains dehulling, washing, and sorting. Variations in a* and b* indices could also stem from cultivar maturity, composition, and agroecological factors. Storage and drying conditions could further alter pigments responsible for red and yellow tones.

Thousand-kernel weight showed significant variation ($p < 0.05$): 0.45±0.18g for *Iporapia*, 0.40±0.27g for *Iporawan* and 0.39 ± 0.09g for *Ipooni*. These results are partly consistent with those of Jideani and Akingbala [24] who found 0.385 g in Nigerian ecotype, but contrast with higher values reported by Niaone *et al.* [25] in Burkina Faso (0.9g) and Senegal (0.6g), where fertilizer (NPK, urea) likely boosted grain size. No fertilizers were used by producers in our study. Maize (213-293g) and rice (14-32g) have much higher thousand-kernel weights [26, 27].

Moisture content ranged from 9.2% to 10.3% and are similar to those reported by Koreissi et al. and Bassey *et al*. [28, 29]. Other studies reported values between

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7.0% and 11.7% [3, 4], likely due to differences in harvest and post-harvest conditions.

Protein content varied from 5.9±0.1g/100g DM (*Ipooni*) to 6.6±0.4g/100g DM (*Iporawan*). These values are lower than those reported in Nigeria ecotype (7.9 - 9.1g/100g DM), probably due to differences in soil fertility, climatic conditions, cultivation practices, and genetic variability [3, 4]. Despite this, fonio's protein content remains comparable to other cereals.

Lipid content was low (0.5±0.02 g/100 g DM) and did not differ significantly between cultivars. Robet *et al.* and Koreissi *et al.* [4, 28] reported much higher values (1.6 - 1.9g/100g DM) probably due to differences in extraction methods. Indeed, present study used petroleum ether (apolar solvent) which extracts only free lipids, while the others used polar solvents (for example, chloroform-methanol, hexane), which extract both free and bound lipids. For large fonio consumers, a combination with lipid sources such as vegetable oils, oilseeds and dairy products may be necessary to prevent deficiencies in essential fatty acids and fat-soluble vitamins.

Starch content varied from 79.8 to 87.3g/100g and differed between cultivars (Table 2). These values are higher than those reported by Robet et *al.* and Bassey *et al.* [4, 29] probably due to methodological differences. The method used in this study quantifies total starch, including resistant fractions, while those used by Robet *et al.* and Bassey *et al.* [4, 29] may lead to underestimation due to their lower sensitivity. Additionally, finer particle size in the present study (<500µm) may have improved starch extraction. Fonio has starch content higher than wheat (51-60%), rice (66-78%) and maize (55-75%) [30, 31]. It's an excellent energy source especially in countries where cereals are the staple foods. Its resistant starch and dietary fiber contribute to a lower glycemic index, which is beneficial for individuals with diabetes and digestive disorders [32]. Moreover, this starch has potential applications in food and non-food industries (for example, instant flours, gluten-free products, bioplastics, paper mills) that require further exploration. These results open up interesting prospects for fonio promotion in the food and industrial sectors, while underlining the importance of further research into the functional and digestive properties of its starch.

Amylose ranged from 29.0±0.01 to 30.9±0.02 g/100 g (Table 2), indicating a very high content in the starch (Juliano, 1992). Lower values (21.4±0.02 g/100 g) were reported by Bassey *et al.* [29]. Amylose influences starch properties such as gelatinization, retrogradation, solubility and rheology, which are critical in food processing [33]. Although understudied, fonio*'s* starch is promising for industrial use and deserves further study [2, 34]

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Processing suitability and sensory attributes of end products

Fonio is primarily processed into dough, porridge and couscous. According to participants, dough is made by stirring dehulled grains into boiling water until a compact, homogeneous, elastic and smooth mass forms, whereas porridge involves boiling grains in water until they form a smooth, flowing and homogeneous texture. Couscous was described as being prepared either by steaming washed and dried (or non-dried) grains, or by boiling precooked grains, until a softened and non-sticky texture is achieved. Participants also clarified that the term “fonio couscous” refers to cooked *Digitaria exilis* grains rather than to wheat semolina couscous.

All producers (100%) reported that *Iporapia* and *Ipooni* are ideal for smooth and stretchy dough whereas *Iporawan* is better suited for couscous due to its lesser tendency to clump (Table 3).

Cultivar attributes described by producers partly contradicted laboratory results: *Iporapia*, described by producers as having small grains, exhibited the highest thousand-kernel weight (0.45 g), whereas *Ipooni*, perceived as whitish by producers, showed the highest yellow colour index (b* = 20.2).

These inconsistencies suggest the need for better cultivars characterization, selection and varietal purification. Consumers in Boukombé and Abomey-Calavi could not associate specific characteristic of end products with cultivars, but emphasized that ideal couscous should be bright, uniform, and non-sticky. The colour is also a determinant criterion for processors.

«Consumers are often attracted by the colour of products. As long as a product is not white, it doesn’t appeal to them, and they perceive it as dirty» (Source: consumers in Abomey-Calavi)

«*When the colour of couscous is too dark, consumers think it is unhealthy and do not buy it ».* (Source: processor in Boukombé)

Other studies confirmed that colour and texture are the primary evaluation criteria of traditional cereal-based foods [35]. Colour, in particular, strongly influences product acceptability. Therefore, it is crucial to develop processing methods that produce precooked fonio with a whitish colour and a couscous with a non-sticky texture.

Description of precooked fonio process

Precooked fonio is processed using two main methods (Figure 1). Both start with paddy dehulling and washing/desanding. Process A involves shorter draining (25 min), steam cooking (45 min), convective drying, and sorting. Process B includes longer draining (3 h 30 min), sun drying (5 h), sorting, rehydration, steam cooking (approximately 1 h), and convective drying. Cooking is done in a 50cm

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couscoussier-type lined with cotton cloth. Pre-moistened fonio is uniformly distributed over the cloth, forming a controlled layer with a thickness of 1 to 2cm. The edges of the cloth are folded over the grain bed to minimize steam loss and enhance steam transfer efficiency. Once the lid is in place, the basket is exposed to an upward steam flow that permeates the grain bed, ensuring a gradual and uniform heat supply. Steam condenses upon contact with the lid, and the resulting condensate contributes to the hydration of the grains. After a cooking time t, the grain bed is stirred to improve heat transfer homogeneity and promote uniform starch gelatinization. During the process, an additional 1 to 2kg of water is gradually introduced to maintain hydration and sustain the cooking process. Process A produced precooked fonio with X = 0.10 kg/kg db, whereas Process B produced precooked fonio with X = 0.15 kg/kg db. Understanding the effects of these operations can be useful for optimizing the processing.

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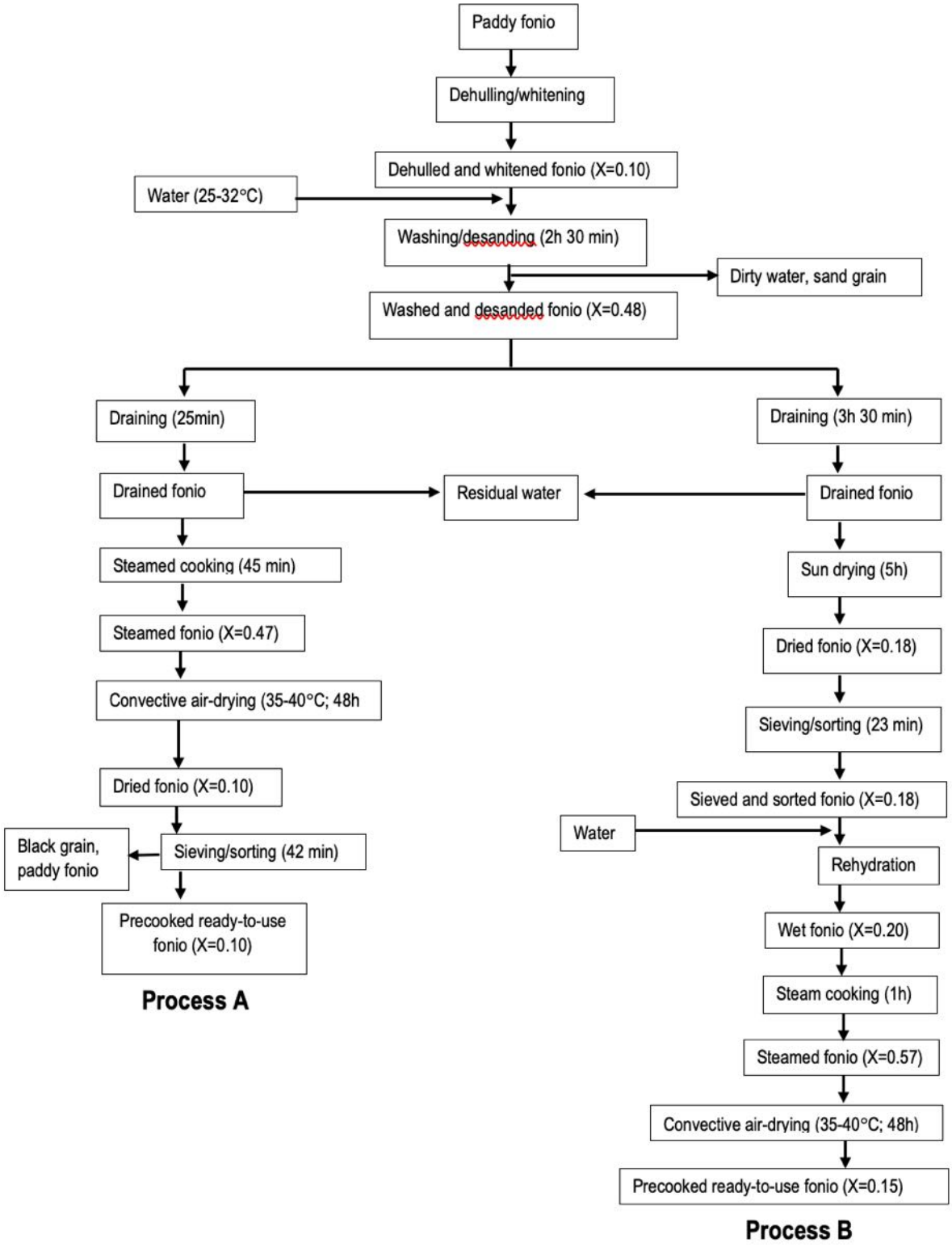


Figure 1: Flowchart of precooked fonio process (X is the water content in db)

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Technological and consumption constraints

Manual fonio processing was described by all participants (100%) as laborious and time-consuming because of the difficulty of dehulling and desanding operations associated with the small grain size [18]. Limited access to equipment is a constraint on the development of fonio sector. The process flow diagram of precooked fonio production (Figure 1) showed that steam-cooking lasted approximately 45 min in Process A and 1 h in Process B, while convective air-drying was performed at 35-40°C for 48 h in both processes. Draining duration also differed markedly between processes, ranging from 25 min in Process A to 3 h 30 min in Process B. According to processors, the sun-drying step included in Process B was intended to reduce grain agglomeration during cooking.

The main constraints reported by consumers were long cooking time, sticky texture, and residual sand. In Boukombé (n=43), long cooking time and residual sand were cited by all participants, while sticky texture was reported by 70%. In Abomey-Calavi, all three constraints were cited by 100% of consumers.

Sensory expectations reported during FGDs indicated that consumers preferred fonio couscous with bright colour, soft texture, and well-separated non-sticky grains.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Fonio cultivars exhibited largely similar physicochemical profiles, except for thousand-kernel weight, colour, starch, and protein contents. Producers relied on morphological traits to differentiate cultivars, although these criteria did not always agree with laboratory measurements. Fonio was processed into washed-dried or precooked grains, which were subsequently transformed into dough, porridge, or couscous, with quality attributes perceived to vary according to cultivar. Consumers preferred couscous with a bright, uniform colour and a non-sticky texture, but achieving these characteristics consistently remains a major challenge. Future efforts should focus on improving desanding efficiency, reducing cooking time, and standardizing precooking and drying operations to obtain products that better meet consumer expectations. In addition, further studies are needed to investigate the suitability of specific cultivars for different fonio-based products and to better elucidate the mechanisms governing fonio cooking and texture development, thereby supporting the development of evidence-based processing recommendations and high-quality fonio products for urban and emerging markets.

Author Contributions

Conceptualization, P.B., F.H., N.F., W.H., Ph.B. and C.M.; methodology, P.B., F.H., N.F., W.H., Ph.B. and C.M.; validation, Ph.B. and C.M.; formal analysis, P.B.; investigation, P.B.; resources, Ph.B.; data curation, P.B.; writing, original draft preparation, P.B.; writing, review and editing, F.H., N.F., Ph.B. and C.M.;

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visualization, P.B. and C.M.; supervision, Ph.B. and C.M.; project administration, Ph.B. All authors have read and agreed to the published version of the manuscript.

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Table 1: Socio-demographic characteristics of participants

Participants	Proportions												
	Gender		Socio-cultural group			Educational level				Marital status		Age group (year)	
	Male	Female	Otammari	Fon	Other	Primary	Secondary	Higher	None	Married	Single	25-39	40-60
Producers (n=42)	71	29	100	0	0	57	12	0	31	100	0	64	36
Processors (n= 26)	0	100	96	4	0	8	15	0	77	100	0	35	65
Consumers													
Boukombé (n= 43)	21	79	74	0	26	26	14	0	60	100	0	---	---
Abomey-Calavi (n=17)	35	65	0	76	24	24	18	59	0	76	24	47	53

--- missing data

Table 2: Physicochemical characterization of cultivars

Cultivars	Colour			Mass of 1000 kernel	Content per 100 g DM				
	L*	a*	b*		Moisture	Starch	Amylose	Lipid	Protein
Iporapia	$77.00^{a} \pm 1.17$	$0.31^{a} \pm 0.11$	$18.00^{a} \pm 0.56$	$0.447^{a} \pm 0.182$	$9.2^{a} \pm 0.02$	$86.0^{a} \pm 0.6$	$29.0^{a} \pm 0.01$	$0.5^{a} \pm 0.2$	$6.5^{a} \pm 0.1$
Iporawan	$76.10^{a} \pm 2.65$	$0.29^{a} \pm 0.17$	$18.45^{a} \pm 0.74$	$0.401^{b} \pm 0.271$	$10.3^{a} \pm 0.05$	$87.3^{a} \pm 1.9$	$30.9^{a} \pm 0.2$	$0.5^{a} \pm 0.1$	$6.6^{a} \pm 0.4$
Ipooni	$71.92^{a} \pm 0.81$	$3.10^{b} \pm 0.18$	$20.15^{b} \pm 0.38$	$0.394^{b} \pm 0.090$	$9.6^{a} \pm 0.01$	$79.8^{b} \pm 3.4$	$29.4^{a} \pm 0.01$	$0.5^{a} \pm 0.02$	$5.9^{b} \pm 0.1$

Values with the same letters (a, b, c) in the columns are not statistically different ($p > 0.05$)

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Table 3: Processing suitability and sensory attributes of end products

Food	Cultivars	Descriptors				
		Colour	Texture	Taste	Presence/absence of lumps	Swelling power
Dough	*Iporapia*	Very white	Smooth and stretchy	Slightly sweet	Absence	High
	Iporawan	Yellowish	Granular and stretchy	Slightly sweet	Presence	High
	Ipooni	Very white	Smooth and stretchy	Slightly sweet	Absence	Low
Porridge	*Iporapia*	Very white	Thick and viscous	Slightly sweet	---	---
	Iporawan	Yellowish	Thick and viscous	Slightly sweet	---	---
	Ipooni	Very white	Thick and viscous	Slightly sweet	---	---
	Iporapia	Very white	Sticky	---	Small grains	High
Couscous	*Iporawan*	Yellowish	Slightly sticky	---	Large grains	High
	Ipooni	Very white	Sticky	---	Small grains	Low

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