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Indigenous Knowledge on Landraces and Fonio-Based Food in Benin

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Fonio is a traditional cereal cultivated in many West African countries, where farmers are often the guardians of a rich diversity of landraces or traditional varieties. An investigation conducted in northwest of Benin on indigenous knowledge about fonio landraces and fonio-based traditional foods allowed us to inventory 35 landraces identified by the farmers. Ipormoa, Namba, Icantoni or Kopognakè or Icantoga and Iporhouwan landraces were good to cook paste and couscous and easy to dehusk. Besides, Ipormoa and Iporhouwan landraces had interesting agronomic characteristics. Paste, porridge, and couscous were the main fonio-based foods consumed by farmers in northwest of Benin.

KEYWORDS *Benin, ethnic group, fonio, food, landraces, quality*

Cereals are primary food sources for millions people in the semi-arid tropics of West Africa. Regionally important cereals include sorghum, maize, pearl

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millet, finger millet, and fonio. These grains, generally considered as subsistence food crops, play a fundamental role in agricultural dynamics, food security, and cultural identity of many poor farmers in marginal rural areas. They can easily be adapted to harsh environmental conditions and have a high tolerance to drought.

Fonio is a cereal belonging to the family *Poaceae* and the genus *Digitaria*. Two *Digitaria* species, *D. exilis* (white fonio) and *D. iburua* (black fonio), which provide many landraces, are domesticated and cultivated in West Africa (Dansi, Adoukonou-Sagbadja, and Vodouhe 2010). In the local agriculture of West Africa, hundreds of fonio landraces exist and derive from traditional selection (Adoukonou-Sagbadja et al. 2007). The fonio landraces have enabled humans to obtain sufficient food to survive for millennia and thereby are considered as a sacred staple crop in many poor rural communities. Landraces or local varieties, defined as variable plant populations adapted to local agro-climatic conditions, are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs (Teshome et al. 1997). According to these needs, farmers select the most appropriate landraces. In northern Benin, a large number of inventoried sorghum landraces were selected by farmers over the years and fulfilled relevant user criteria (Kayode et al. 2005). In contrast to other cereals, there is little information in the literature on diversity and traditional uses of the fonio landraces in spite of their cultural and nutritional importance in many sociocultural groups such as the Akposso and Lamba in Togo, the Peul and Malinké in Guinea, or the Dogon in Mali or Otamari in Benin (Dramé and Cruz 2002; Adoukonou-Sagbadja et al. 2006).

Fonio is the most tasty and nutritious of all grains (Vietmeyer et al. 1996; Temple and Bassa 1991). It is rich in the human-vital amino acids (methionine and cysteine), which are lacking in other cereals (Jideani 1990). The presence of high flavonoid content in the crude fonio grains with anti-thyroid properties has been reported (Sartelet et al. 1996). Fonio has also a number of folk medicinal values, for example, it is a useful diet for those suffering from diabetes or for delivering women (Jideani 1999; Adoukonou-Sagbadja et al. 2006). In addition to its nutritional and dietetic importance, fonio had a traditional and technological uses. Traditionally, fonio is routinely consumed as stiff or thin porridge, couscous, and can be used to brew local alcoholic or non-alcoholic drinks or mixed with other flours to make breads (Adoukonou-Sagbadja 2010).

In Benin, this cereal with multiple values is cultivated only in the department of Atacora, a local administrative unit. Atacora department is situated in a semi-arid agro-ecological zone characterized by unpredictable and irregular rainfalls with only one rainy season and a dry season lasting more than 5 months and the area is mountainous with poor sandy, rocky and encrusted soils and some shallows (Adam and Boko 1993; Dansi et al. 2010). Several ethnic groups live in this department and have a very long tradition in fonio

cultivation (Vodouhè, Zannou, and Achigan Dako 2003; Dansi et al. 2010). Outside the northern part of the country, fonio is not really known in Benin and it is non-existent in the urban markets or used by consumers.

This study was conducted through a survey in Atacora department on the endogenous data of the fonio landraces cultivated in Benin. It is mainly based on the production and processing constraints, landrace diversity, and agronomic and technological characteristics of fonio. The findings of this study could contribute to the pertinent research axes for promoting fonio in Benin.

METHOD

Data Collection

A survey was conducted in northwest of Benin (figure 1), precisely in the department of Atacora which is the only fonio production zone in the country. In this department, five municipalities: Boukoubé, Cobly, Tanguiéta, Natitingou, and Toucoutounan were selected on the basis of the importance of fonio production (maximal, average, minimal). Previous studies on fonio identified fifteen villages in the five surveyed municipalities (Dansi et al. 2010). Six of these villages (Dikokoré, Kouba, Kounadorgou, Nafayaoti, Perpoyakou, Touga) in Cobly, Tanguiéta, Natitingou and Toucoutounan municipalities, were no longer fonio producers. Therefore, we selected the nine villages still producing fonio. Thirteen other villages were chosen either randomly or with the advice of local agricultural officers at CeCPA (Communal Center for agricultural Promotion). In total, 22 villages were surveyed in the different municipalities. These villages are more concentrated in Boukoubé municipality, because the fonio production is very abundant there, average in Cobly and Natitingou, and scarce in Tanguiéta and Toucoutounan. Direct observation, a focus group and individual discussions by administration of questionnaires, which are Participatory Research Appraisal (PRA) tools and techniques, were used to collect the data. Data on landraces diversity and agronomic, technological and culinary characteristics were collected from this focus group. The survey was conducted in April 2011 by a team that had a good knowledge of the survey objectives; during the dry season when the farmers were readily available. The team was constituted of one researcher who was the supervisor and three agricultural engineers with skills in conducting surveys in the study zone. Interviews were performed in a language or dialect (Ditamari, M'bèlimè, Naténi, Wama) which was best understood by the respondents with translation if necessary. Therefore, in each of the surveyed sites, we have involved literate residents for translation purposes. The collected information was fonio production and processing constraints, landraces diversity and their agronomic and technological characteristics and importance of fonio-based food consumption.

Statistical Analysis

Descriptive statistics and the chi-square test were used for analysing data with SPSS software (version 16). The content analysis was the main method used to treat the qualitative data such as the stories and stakeholders points of view. The content analysis included three stages: pre-analysis, material exploitation as well as data treatment, inference and interpretation (Wanlin 2007). The recorded data were transformed into written text and the choice of the content was defined in relation to the survey objectives. The following stage involved exploring the properties and dimensions of categories, identifying the relationships between categories, uncovering patterns, and testing categories against the full range of data. Qualitative research is fundamentally interpretive, and interpretation represents personal and theoretical understanding of the studied phenomenon.

RESULTS AND DISCUSSION

Production and Processing Constraints

National fonio production in Benin remains low, in perpetual regression and varied from 4,164 tons in 1991 to 947 tons in 2010 (MAEP 2010). According to the surveyed farmers, this situation may be due to the reduction of the cultivated area to the profit of other crops, mainly maize, which is easier to produce and gives higher yield. In addition, fonio production and post-harvest processing were arduous and laborers were non-existent because of rural depopulation. From discussions with the farmers, it appeared that young people nowadays do not want to work in the village and move to urban areas in search of employment and increased access to money. These constraints were reported by Adoukonou-Sagbadja and colleagues (2006) and USAID (2008) in other producing countries of fonio such as Togo and Senegal. Depending on the economic importance of a crop, the degree of the national and local breeding efforts, and the introduction of exotic cultivars, landraces may disappear sooner or later (Zeven 1998).

Figure 2 presents the fonio production variation during the last twenty years. The production of fonio is more intensive in the Boukoumbé municipality (30725.98 T in 1991–2010) than in the others: Cobly (5273 T), Toucououtounan (2970 T), Tanguiéta (1229 T), and Natitingou (983 T) according to official statistics (MAEP 2010). Boukoumbé guarantees the most (more than 74%) of the national production because fonio has a sociocultural importance for Otamari, a preponderant ethnic group in the area (Dramé and Cruz 2002). In 2006, farmers (49.5%) reported that most Boukoumbé producers did not cultivate fonio and that elders of the municipality organized meetings to encourage farmers to restart production. Only 38.98 T of the fonio were produced in 2006 in Benin (MAEP 2010). Fonio is not the producer's main crop (99.4% of the respondents). The main crops for the

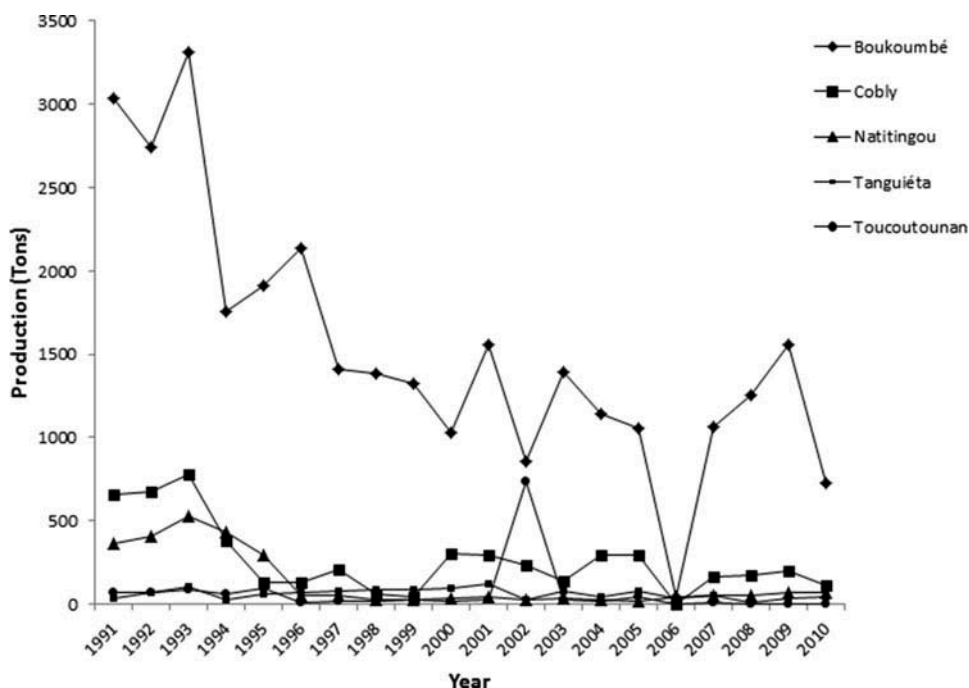


FIGURE 2 Fonio production during the last 20 years in five municipalities of Atacora Department in the North Benin.

Source: CountrySTAT (2014).

surveyed farmers were maize, rice, millet, or sometimes roots and tubers like yam and cassava. According to surveyed farmers (72% of the respondents), fonio was not grown in intercropping systems (i.e., in association with others crops) and occupied generally the first place in rotation cropping systems. Some cases of association were reported (Adoukonou-Sagbadja et al. 2006) with other crops such as Bambara groundnut, pigeon pea, pearl millet, sorghum, cassava, and okra but fonio remained the main crop. For most farmers (91.5% of responses), the production and post-harvest processing of the fonio were laborious.

The most difficult stage during production activities is harvest. It should be done not only under the sun to avoid morning dew but also in a short time to reduce the losses. To harvest, surveyed farmers (98% of responses) cut fonio stems with sharp knives and are often wounded in the process. Adoukonou-Sagbadja and colleagues (2006) reported that the harvesting methods vary in Togo by the producing zones and ethnicity. In the south, mature fonio plants are uprooted while in the north, traditional tools (home-made knives and sickles) are used by farmers to cut straw with mature panicles during harvesting. Fonio harvesting requires the participation of many people (93% responses). According to Jideani (1990), it is the most

labor consuming activity, involving the farmer and his family and friends. Harvesting is exclusively done by experienced men. Fonio harvesting is followed by several other operations with the most difficult being threshing and dehusking, according to farmers. However, drying fonio grains could become a constraint during the rainy season. Surveyed farmers reported that threshing is done by trampling and needs an abundant labour force. In Togo, the threshing method depended on the producing zones and is performed by beating (in the south) or tramping (in the north) of the fonio sheaves (Adoukonou-Sagbadja et al. 2006). Paddy fonio grains obtained after threshing are dehusked before their use in food preparation. The surveyed producers (67.5% of responses) rely on mutual assistance to carry out most operations mainly for small-sized households.

Fonio processing is still an artisanal activity done by women in Benin. The lack of modern equipment for post-harvest processing is the major constraint revealed by housewives. Some surveyed farmers (17.5% of responses) reported that women did not sleep with them when they constrained them to cook fonio paste, because it takes a long time to dehusk grains by pounding and the women are too tired. Dehusking is one of the most difficult post-harvest operations. Dehusking by pounding is done by women in holes (Otamari and M'bermè ethnic groups) dug directly in the ground with pestles which could weigh up to 10 kg or more, in mortars made of wood (Lamba). The dehusking method used by Otamari and M'bermè ethnic groups is scarcely reported in literature. The mortar and pestle are more used in fonio dehusking (Cruz 2004; USAID 2008). These traditional methods involved the introduction of sand into the husked grains, which affects their quality. Fonio is generally cultivated for self-consumption (83% of the respondents) and sometimes for both self-consumption and sale (17% of the respondents). Paddy fonio (64.7% of respondents) is more likely sold on indigenous market than dehusked fonio (35.3%).

Industrial fonio processing units do not exist in Benin. In the study area, there was only a dehuller. Women, gathered in groups, often bought paddy fonio when its price is very low (September–October) and dehusked it by pounding in order to resell it for a profit. Women's income-generating activities in developing countries often significantly contribute to the household income (Niehof 2004). According to some interviewed housewives (17%), the lack of knowledge about processing to diversify the range of fonio-based products was also a constraint.

Landraces Diversity and Agronomic, Technological, and Culinary Characteristics

Farmers have a good knowledge of fonio varieties in terms of classification, identification and uses. Therefore, their knowledge would be extremely useful to geneticists and breeders (Dansi et al. 2000; Dansi et al. 2010). Farmers

defined a folk taxonomic classification for the fonio traditional varieties or landraces cultivated in the investigation zones. This local taxonomy varied by ethnicity. In the investigated zone, fonio is called *Ipoaga* in Ditamari (spoken language by the Otamari), *Afé* in Lamba and *Ipouobi* in M'Bermè. Three principal criteria for identifying the various landraces of fonio in the study zone are gender, color (of shoot, leaves, panicles and seed), and growth cycle. Other criteria, such as the growth habit (height and vigor) of the plant, seed characteristics (size, form, brightness and hardness), and the organoleptic characters, are used and also reported in another work (Adoukonou-Sagbadja et al. 2006).

Of landrace varieties (tables 1 and 2), 35 were inventoried on the basis of the information given by farmers in the five studied municipalities in order to know their diversity in Benin. Adoukonou-Sagbadja and colleagues (2006) reported 42 fonio landraces in Togo. Fonio genetic diversity is unequally distributed with the essential part observed in the Upper Niger River basin, while a very low diversity is present in the Atacora mountain zone (Adoukonou-Sagbadja et al. 2007). Landrace diversity was higher within the Otamari ethnic group (19 landraces) than in the M'bermè (6 landraces), Lamba (5 landraces), Wama (3 landraces), and Natimba (2 landraces) ethnic groups. This situation can be explained by the fonio sociocultural importance for the Otamari, who use it for feeding and indigenous medicine. Moreover, the Ditamari included several dialects and the generic names given by the Boukoumbé farmers varied sometimes from one village to another. A fonio landrace could be indicated by many names within the same ethnic group and between the ethnic groups. As a consequence, fonio with different names could derive from the same landrace. Male fonio is called *Dapordana*, *Iporda* or *Iporpia*, and *Dèpordaté* in Ditamari; *Poualadji* in Natimba, and *Penii* in Wama. Dansi and colleagues (2010) reported a dendrogram that showed a similarity in the group of some landraces inventoried into five clusters, corresponding to the five morphotypes: *Yoro*, *Ipordapia*, *Ipoaga*, *Ipordawouan*, and *Iporni*, four of which are attributed to *D. exilis* and one to *D. iburua*. The landraces *Yoperi*, *Ipomondé*, *Dapornia*, *Ipormoa*, *Dapordana*, *Namba*, *Koponoudikou*, *Koporpango*, *Kotapoaga*, *Kotapola*, *Dèpordaté*, *Tchoboèm*, *Tchésèèm*, *Ipopiéni*, *Kèpognagè*, and *Ipobeti* were hardly mentioned in the literature. Fonio landrace diversity could imply a variability of its agronomic, technological, and culinary characteristics.

The investigated agronomic characteristics (table 1) of different varieties were: parasites resistance, drought resistance, growth cycle, yield, storage, and losses. For the growth cycle, early, semi-late and late landraces are most numerous in contrast to very early and intermediate ones. The very early and intermediate landraces were reported by surveyed farmers only in Otamari and Lamba ethnic groups. Very early landraces were *Kotapoaga*, *Kotapola*, and *Dèpordaté* in the Otamari ethnic group; and *Yoro* with Lamba; while intermediate landraces were *Iporbouwan* (Otamari) and *Thoboèm* (Lamba).

TABLE 1 Agronomic Characteristics of Fonio Landraces Listed by Farmers in Benin

Ethnic groups	Landrace name (N)	Significance of the name*	Parasites resistance*	Drought tolerance*	Maturity*	Yield*	Storage*	Losses*
Otamari	<i>Yopeti</i> or <i>Iguompéri</i> (7)	White fonio	High	High	Late	Medium	Easy	Medium
	<i>Ipomondé</i> (10)	Red fonio	High	High	Late	High	Easy	High
	<i>Iporni</i> (14)	Female fonio	High	High	Late	High	Easy	Low
	<i>Kuartinanfa</i> (6)	Fonio for the rich	High	Medium	Late	High	Very easy	Low
	<i>Dapornia</i> (6)	Female fonio	Low	High	Late	Medium	Easy	Low
	<i>Ipormoa</i> (6)	Fonio true	Medium	High	Late	High	Easy	Low
	<i>Inoura</i> (3)	Fonio for the rich	High	Low	Semi-late	High	Very easy	Medium
	<i>Dapordana</i> (3)	Male fonio	Low	High	Semi-late	Low	Easy	Medium
	<i>Namba</i> (8)	nd	High	Low	Semi-late	High	Easy	Low
	<i>Koponoudikou</i> (4)	White fonio	Low	Low	Semi-late	Medium	Easy	Low
	<i>Iporida</i> or <i>Iporpia</i> (36)	Male fonio	High	Medium	Early	Medium	Difficult	Medium
	<i>Iporhouwan</i> (41)	Female fonio	High	Medium	Intermediate	Medium	Easy	Medium
	<i>Depordawan</i> (4)	Red fonio	High	High	Early	Medium	Easy	High
	<i>Icantoni</i> (29)	Mature quickly	High	High	Early	Medium	Easy	High
	<i>Koporparigo</i> (4)	Female fonio	nd	High	Early	High	Difficult	High
	<i>Kotapoaga</i> (3)	Fonio for chicken	High	Very low	Very early	Very low	Very difficult	High
	<i>Tienttenga</i> (15)	Mature quickly	High	Medium	Early	Low	Difficult	Low
	<i>Kotapola</i> (4)	nd	Medium	Medium	Very early	Low	Very difficult	High
	<i>Dèporlaté</i> (4)	Male fonio	nd	Very low	Very early	Low	Difficult	High
	Lamba	<i>Yoro</i> (24)	Mature quickly	High	Low	Very early	Low	Very difficult
<i>Tchoboèm</i> (7)		White fonio	Medium	Medium	Intermediate	Medium	Difficult	Medium
<i>Tamaou</i> (22)		Fonio of white flower	High	High	Semi-late	High	Easy	Low
<i>Tintèka</i> (12)		Red fonio	High	Medium	Early	Medium	Difficult	Medium
<i>Ditenka</i> or <i>Tchèsèèm</i> (12)		Fonio of red flower	High	High	Semi-late	High	Easy	Low

Natimba	<i>Poualadji</i> (11) <i>Pouantidji</i> (11)	Male fonio Female fonio	High Low	Medium High	Early Late	High High	Difficult Easy	Medium Low
Wama	<i>Pèni</i> (15) <i>Pédai</i> (15) <i>Ipopiéni</i> (7)	Female fonio Male fonio White fonio	High Very High Low	High Very High High	Semi-late Early Late	High Very high Medium	Easy Easy Easy	Low Low Medium
M'bermé	<i>Kèpognagè</i> (9) <i>Ipoyè</i> or <i>Kuartinanfa</i> (21)	Mature quickly Fonio of rich	High Medium	High High	Early Late	High High	Difficult Easy	Low Medium
	<i>Iponi</i> (21) <i>Ipogninimè</i> (21) <i>Ipobeti</i> (4)	Mature lately Red fonio Fonio with small grains	High Low High	High Very high High	Semi-late Early Early	High Very high Low	Easy Very easy Very easy	Low Low Medium
	<i>Icantoni</i> or <i>Kopognakè</i> or <i>Icantoga</i> (28)	Mature quickly	High	Low	Early	Low	Easy	High

N = number of people who know the landrace; nd = not determined.

*Data on agronomic characteristics of fonio landraces collected with a focus group.

TABLE 2 Technological and Culinary Characteristics of Fonio Landraces Listed by Farmers in Benin

Ethnic groups	Landrace name (N)	Dehusking and milling*	Culinary quality	
			Couscous*	Paste*
Otamari	<i>Yoperi</i> or <i>Ignompéri</i> (7)	Difficult	Very fast cooking and swell well	Not extensible and difficult cooking
	<i>Iponondé</i> (10)	Easy	Fast cooking and swell a little	Not extensible and very difficult cooking
	<i>Iporni</i> (14)	Difficult	Fast cooking and swell a little	Extensible and easy cooking
	<i>Kuartinanfa</i> (6)	Very difficult	Very fast cooking and swell well	Extensible and easy cooking
	<i>Dapornia</i> (6)	Difficult	nd	nd
	<i>Ipormoa</i> (6)	Easy	Very fast cooking and swell well	Easy cooking
	<i>Incoura</i> (3)	Very difficult	nd	nd
	<i>Dapordana</i> (3)	Difficult	nd	nd
	<i>Namba</i> (8)	Easy	Very fast cooking and swell well	Very extensible and very easy cooking
	<i>Koponoudikou</i> (4)	Very difficult	Slow cooking and swell not	Extensible and easy cooking
	<i>Iporða</i> or <i>Iporpia</i> (36)	Easy	Fast cooking and swell a little	Extensible and very easy cooking
	<i>Iporbouwan</i> (41)	Easy	Fast cooking and swell well	Extensible and very easy cooking
	<i>Depordawan</i> (4)	Difficult	Fast cooking	Extensible and easy cooking
	<i>Icanitoni</i> (29)	Easy	Fast cooking and swell a little	Difficult cooking
Lamba	<i>Koporango</i> (4)	Very difficult	nd	nd
	<i>Kotapoaga</i> (3)	Very easy	nd	nd
	<i>Tientenga</i> (15)	Difficult	nd	nd
	<i>Kotapola</i> (4)	Difficult	Fast cooking and swell a little	Not extensible and difficult cooking
	<i>Dèpordaté</i> (4)	Easy	nd	nd
	<i>Yoro</i> (24)	Easy	Slow cooking and swell not	Not extensible and difficult cooking
	<i>Tchoboèm</i> (7)	Difficult	Fast cooking and swell a little	Extensible and easy cooking

Natimba	<i>Tamaou</i> (22)	Very difficult Difficult	Very fast cooking and swell well Fast cooking and swell a little	Extensible and easy cooking A little extensible and difficult cooking
	<i>Tintéka</i> (12)			
Wama	<i>Ditenka</i> or <i>tchéssém</i> (12)	Very difficult	Very fast cooking and swell well	Extensible and easy cooking
	<i>Poualadjji</i> (11)	Easy	Fast cooking and swell well	A little extensible and difficult cooking
	<i>Pouanidji</i> (11)	Difficult	Slow cooking and swell well	Extensible and difficult cooking
Wama	<i>Pénii</i> (15)	Difficult	Fast cooking and swell well	Extensible and easy cooking
	<i>Pédai</i> (15)	Easy	Slow cooking and swell a little	A little extensible and easy cooking
M'bermè	<i>Ipopiéni</i> (7)	Difficult	Slow cooking and swell not	Difficult cooking
	<i>Képognaqè</i> (9)	Easy	Very fast cooking and swell well	Extensible and easy cooking
	<i>Ipoye</i> or <i>Kuarinanifa</i> (21)	Difficult	Fast cooking and swell a little	A little extensible and difficult cooking
	<i>Iponi</i> (21)	Very difficult	Very fast cooking and swell well	Extensible and easy cooking
	<i>Ipoguinimè</i> (21)	Easy	Very fast cooking and swell well	Not extensible and very difficult cooking
M'bermè	<i>Ipobeti</i> (4)	Very difficult	Slow cooking and swell not	Extensible and easy cooking
	<i>Icantoni</i> or <i>Kopognakè</i> or <i>Icantoga</i> (28)	Easy	Very fast cooking and swell well	Extensible and easy cooking

N = number of people who know the landrace; nd = not determined.

*Data on technological and culinary characteristics of fonio landraces have collected with a focus group.

Dansi and colleagues (2010) reported that the early maturing landraces were preferred because they help farmers to bridge the food shortage period when no other crops are ready for harvest and consumption, and it also completes its growth cycle quickly to avoid a drastic yield loss due to drought. Landraces can reveal important differences in relation to the non-uniformity and variability of its different characteristics. Variations on landraces were found previously by scientists for traits such as disease resistance (Negassa 1986), morphology (Poiarkova and Blum 1983), yield improvement (Jaradat 1991), agronomic properties (Moghaddam, Ehdaie and Waines 1997), technology, and nutritional characteristics (Ereifej and Shibi 1993; Bhattacharya and Corke 1996; Bhattacharya et al. 1997; Black et al. 2000). Most local varieties of fonio have good resistance to drought according to all surveyed farmers. However, *Yoro* and *Icantoni* or *Kopognakè* or *Icantoga* landraces in Lamba ethnic group and *Inoura*, *Namba*, *Koponoudikou*, *Kotapoaga*, *Déportaté* landraces in the Otamari ethnic group were sensitive to drought (table 1). The results also show that the very early landraces were characterized by low resistance to drought. In contrast to fonio or “hungry rice,” drought is the most important abiotic stress factor in rice production, both in terms of degree and coverage worldwide (Odogoola 2006; Balasubramanian et al. 2007). The reduction of the fonio crops’ yield is more affected by loose grain attachment or shattering. Indeed, fonio is not an often parasitized crop, and the majority of landraces are parasite resistant, according to the farmers in the study. The current parasites reported by interviewed farmers were insects’ larvae, which consumed limbs during June drought, and insects called “fonio mosquitoes,” and “*difunte funi*” in Ditamari, which fed on spikelet involving a low-yield production. Traditional fonio varieties showing good agronomic characteristics for all interviewed farmers were: *Iponi*, *Pédai*, *Pénii*, *Iporni*, *Ditenka* or *Tchésèém*, *iporbouwan*, *Ipormoa*, *Kuartinanfa* and *Ipomondé*. Most of these landraces were mainly late and semi-late maturing varieties (table 1). The agronomic characteristics of these varieties are similar to the results obtained by Dansi and colleagues (2010). In terms of these agronomic characteristics, the landraces could have important technological and culinary qualities. Importance of the agronomic and technological characteristics in variety preference criteria were also reported for sorghum (Kayodé et al. 2006; Teshome et al. 2007). Therefore, in our study, the easiness of dehusking and milling of fonio grains as well as in their culinary qualities were also investigated (table 2). Fonio dehusking and milling was very difficult steps in post-harvest processing and traditionally done with pestle and mortar. After threshing, the paddy fonio grain is still surrounded by husks. Dehusking removed the first husk from paddy grains to get whole grains and milling removed the bran (pericarp and germ) from whole grains. Women took nearly one hour to mill just one or two kilograms of paddy fonio (Cruz 2004). Depending on housewives, the landraces *Ipomondé*, *Ipormoa*, *Namba*,

Iporda or *Iporpia*, *Iporhouwan*, *Icantoni*, *Dépordatè*, *Yoro*, *Poualadji*, *Pédai*, *Kèpognagè*, *Ipogninimè*, *Icantoni* or *Kopognakè* or *Icantoga*, *Kotapoaga* were easy to dehusk and to mill (table 2).

Swelling and fast cooking qualities of grains for couscous preparation and paste extensibility were the main culinary qualities required for the fonio. Extensibility was the most important attribute reported for other pastes such as yam-based pastes (pounded yam and *amala*) and sorghum-based paste (Hounhouigan et al. 2003; Kayodé et al. 2005). *Iporni*, *Kuartinanfa*, *Namba*, *Koponoudikou*, *Iporda* or *Iporpia*, *Iporhouwan* and *Depordawan* (Otamari ethnic group), *Tchoboèm*, *Tamaou*, *Ditenka* or *Tchésèèm* (Lamba), *Pouanidji* (Natimba), *Kèpognagè*, *Iponi*, *Ipobeti*, *Icantoni* or *Kopognakè* or *Icantoga* (M'bermè) and *Pénii* (Wama) landraces showed the extensible and easy cooking pastes (table 2). The quality of couscous quality is mainly associated by swelling and fastness the quick time it takes to cook the grains (Guezlane and Abecassis 1991). Grains of *Yoperi* or *Ignomperi*, *Kuartinanfa*, *Namba*, *Iporhouwan* and *Ipormoa* (Otamari ethnic group), *Tamaou* and *Ditenka* or *Tchésèèm* (Lamba), *Poualadji* (Natimba), *Kèpognagè*, *Iponi*, *Ipogninimè*, *Icantoni* or *Kopognakè* or *Icantoga* (M'bermè) and *Pénii* (Wama) landraces possessed quick cooking and good swell properties. On the 35 fonio landraces described, 14 varieties were easy to dehusk and 10 varieties had appreciable culinary characteristics (table 2). *Ipormoa*, *Namba*, *Icantoni* or *Kopognakè* or *Icantoga* and *Iporhouwan* were characterized at the same time by good paste cooking and couscous preparation and easy to dehusk.

Fonio-based Food and Their Importance

Fonio had a substantial place in the food habits of surveyed producers. According to Haq and Ogbe (1995), fonio can be consumed two to three times a day and is preferred to other cereals in many tribal areas of Guinea, Mali, Togo, and Nigeria. Major fonio-based foods reported by surveyed producers in the present study were: paste, porridge, and couscous (table 3). These meals are also appreciated by other traditional farmers, particularly in many tribes such as the Akposso and Lamba in Togo, the Peulh and Malinké in Guinea, or the Dogon in Mali (Adoukonou-Sagbadja et al. 2007). Paste and porridge are the current consumption forms of cereals in Africa. The indigenous crops are rarely transformed into couscous. However, in the most of Northern Africa, the granulated product (couscous) made from cereal flours is highly popular (Léder 2004). In contrast to other cereals such as sorghum, millet and corn, which must undergo several processes to have couscous aspect, fonio grains are very small and similar to imported couscous. Fonio-based foods are consumed at breakfast, lunch, in the afternoon and dinner.

Fonio paste is frequently consumed (90% of the respondents) in all the studied localities. The majority of interviewed producers preferred fonio

TABLE 3 Consumption of Fonio-based Foods (in % of Respondents, N = 200) in Five Municipalities in Northern Benin

Foods	Indigenous name (ethnic group)	Description of process	Frequently	Regularly	Occasionally	Rarely
Paste	<i>Moupotchia</i> (Otamari), <i>Afémouto</i> (Lamba), <i>Ipouotchia</i> (M'Bermè), <i>Téemanitchaabou</i> (Wàma), <i>Touoitcheabou</i> (Natimba)	Fonio paste is prepared with dehusked/milled grains or flour obtained after grinding grains. Flour or fonio grains are added to water and stirred until boiling. The mixture is stirred vigorously during the cooking to obtain a paste more or less hard depending on the flour or grains quantity. The paste is cooled and eaten with a sauce.	90	8.5	0.5	1
Porridge	<i>Moupotchoté</i> (Otamari), <i>Afèiérou</i> (Lamba), <i>Ipouotchiéti</i> (M'Bermè), <i>Téemanbèbou</i> (Wàma), <i>Touoitchiati</i> (Natimba)	To prepare porridge flour or dehusked/milled, grains are diluted into water. The solution is stirred and heated until boiling. Porridge obtained after cooking, which generally thin, is consumed slightly warm or cooled with sugar or honey.	9	71	9.5	10.5
Couscous	–	Dehusked or milled fonio grains are cooked with little water or using steamer. Cooked grains are eaten with sauce or oil. Sometimes, the ingredients (oil, salt, meat or fish) are directly cooked in water with fonio grains.	6	8.5	19.5	66

Note. Frequently = 4–7 times/wk; regularly = 2–3 times/wk; occasionally = 1 time/wk; rarely = less than 1 time/wk.

paste to corn paste because it is easier to digest. Quality criteria used to appreciate fonio-based traditional food (paste, porridges, and couscous) were: texture, taste, smell, and color. These different quality criteria are often used to appreciate traditional foods derived from cereals. Smell of fonio-based food was the most difficult quality attribute to be described by the interviewed respondents. However, they recognized that fonio-based food had a particular odor which, like other cereals, distinguished it. This smell was more agreeable and stiffer when the fonio grains are initially toasted before the preparation of the meals. According to the farmers, a good fonio paste should be extensible and firm (95% of the respondents), slightly sweet (87%), or neutral (12.6%) and of white color (97.5%). Similar characteristics were also reported by Kayodé et al. (2005) regarding sorghum paste, which in contrast to fonio paste, had a pink or red color related to the color of sorghum grains. Interviewed housewives considered fonio paste as more extensible or elastic than corn, millet, and sorghum pastes. In addition, they revealed that the fonio swelled more than other cereals. Fonio crops had high water absorption capacity (Fuanbial 1998; Jideani 1999), a property that could be linked to appreciable quantity of pentosans. Fonio pentosans content was about 33 g/kg (Lasekan 1994). This grain's property is very interesting and could have several applications in food industry. Fonio starch structure and physicochemical properties in relation to cooking were studied (Jideani and Akingbala 1993; Jideani, Takeda, and Hizukuri 1996) and the results revealed that the starches of fonio were similar to that of rice; hence some current applications of rice starch could apply to starches from this cereal. In most surveyed households, fonio paste is consumed more than porridges and couscous.

Fonio porridge (71% of the respondents) is regularly consumed while couscous (66% of the respondents) is rarely consumed. The most common and simplest food prepared from cereals is porridge. Fonio flour is used in Nigeria to prepare a thick unfermented porridge and fermented grains to make a thin porridge which are called respectively, *tuwo acha* and *kunu acha* (Vodouhè and Achigan Dako 2006). In the study area, fonio porridge is generally consumed at breakfast generally by children and women, mainly nurses. To be appreciated, fonio porridge should be a little viscous (81%), slightly sweet (90%) and of white color (100%). Sugar, honey, cow's milk, or baobab powder can be added to this porridge before consumption.

Couscous is the least most consumed food among fonio-based foods. In the majority of surveyed households, fonio couscous is eaten during festival occasions and its preparation requires dexterousness. Depending on the surveyed households, fonio couscous should be granulated (i.e. the grains should not be overcooked) and soft (59.5%), slightly sweet (52.5%) and of white color (46%). Couscous is often cooked with oil and other ingredients or accompanied by sauce.

CONCLUSION

Fonio is a traditional cereal very important for most surveyed farmers in this study. However, production and post-harvest processing methods were still traditional in Benin. A diversity of fonio landraces (35 species) was reported by farmers in 22 villages of Boukoumbé, Toucouounan, Coby, Natitingou, and Tanguiéta municipalities. Some landraces showed good agronomic, technological, and culinary characteristics. Fonio landraces having good agronomic characteristics were mainly late and semi-late maturing varieties.

Paste and porridge were the most consumed fonio-based foods by different ethnic groups surveyed in the study zone. Availability and accessibility of fonio-based foods to households could contribute to the alleviation of food insecurity. A comprehensive food security and vulnerability analysis conducted in 2008 by the World Food Program (WFP) estimated that nearly one million people in Benin were food insecure and more than one third of children under five years old suffered from chronic malnutrition. It is well known that communities in developing countries depend greatly on indigenous natural resources which not only act as buffers against hunger and poverty, but also ensure diversity in household diets. Further investigations on the physicochemical and technological characteristics of different cultivated fonio landraces in Benin will be interesting for diversified value added fonio-based foods.

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