Ecology of Food and Nutrition, 50:115–136, 2011

ISSN: 0367-0244 print/1543-5237 online
DOI: 10.1080/03670244.2011.552371

Routledge
Taylor & Francis Group

Preparation, Consumption, and Nutritional Composition of West African Cowpea Dishes

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In Africa, nutrient intake deficiencies are widespread. We, therefore, investigated the potential contribution of cowpea dishes to the ingestion of several macro- and micronutrients. Processors and consumers were interviewed and cowpea dishes analyzed. Energy, protein, iron, zinc, and calcium contents ranged from 1647 to 2570 kJ, 10 to 25 g, 1 to 35 mg, 1.5 to 3.0 mg, 38 to 380 mg per 100 g d.w., respectively. The iron and calcium contents were highest in dishes containing leaves. The consumption of these dishes should be promoted along with research on how to further decrease the associated antinutritional factors of traditional cowpea dishes.

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KEYWORDS Vigna unguiculata*, phytate, polyphenols, consumption patterns, Benin*

The international peasant movement "La Via Campesina" formulated the concept of food sovereignty during the World Food Summit in 1996, as the right of people to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems (La Via Campesina 2008). The concept of food sovereignty is meant to help overcome or reduce hunger, malnutrition and poverty. From this perspective, Windfuhr and Jonsen (2005) reported four core elements for this political concept: (1) the right to adequate food for each person, (2) access to productive resources, (3) mainstream agro-ecological production and (4) trade and local markets development. The right to safe food for all people is linked to the production and consumption of nutritious and culturally acceptable foods. Therefore, it is important to underline the strong linkage between food, culture and locality. Wahlqvist and Lee (2007) emphasize that locality matters; local conditions must be considered when a food is to be improved to achieve nutritional targets. Food sovereignty, as a baseline for achieving measurable food security (Quaye 2007) and as a potential solution for the actual food crisis (Rosset 2008), promotes development based on local or indigenous knowledge and practices. Information on such indigenous knowledge and local practices with respect to African food products is lacking in the literature, and may even disappear in actual practice due to increasing globalisation which is largely responsible for the invasion of convenience foods originating from elsewhere into developing country's markets (Heinrich et al. 2006). Indeed, Raschke et al. (2007) emphasized the critical need to gather information on traditional African food habits as a starting point to initiate research and education regarding food habits and health implications of food consumption.

In West Africa, traditional food habits of poor populations are associated with limited access to protein from animal sources and diets based on starchy products such as cereals, roots and tubers (Oniang'o, Mutuku, and Malaba 2003; Sodjinou et al. 2009). Consequently, the population faces protein-energy malnutrition and mineral deficiencies. In 2006, 43% of Beninese people were stunted and 78% of under-five year old children suffered from anaemia, and predominantly, iron deficiency anaemia (INSAE 2007). Simultaneously, several indigenous food products exist that have been poorly investigated for their potential to alleviate such deficiencies. This lack of information is also apparent in the fact that no national food composition table exist in Benin (Nago et al. 2010). As a result, foreign food composition tables are used. These tables provide data on unprocessed food ingredients, and occasionally, on the effects of single processing operations. Food

composition tables for locally processed and consumed foods are urgently needed (Sodjinou 2006).

This study investigated the diversity in and the nutrient and antinutrient contents of dishes prepared from an indigenous African legume crop, cowpea (*Vigna unguiculata* (L.) Walp). The purpose of this research is to identify cowpea dishes with valuable nutritional properties that can be promoted to improve the nutritional status of local people. Moreover, in this research, compositional data are produced on locally processed and consumed food products that can be used in nutrition research and intervention, public health information campaigns, and academic research.

MATERIAL AND METHODS

Basic Appraisal

A preliminary survey was conducted in six administrative regions of Benin. Fifteen to thirty cowpea households and/or commercial processors per region were individually interviewed using questionnaires with multiple choice and open-ended questions. Socio-demographic data, a listing of cowpea dishes produced locally and the processing techniques used to make these products were recorded.

Quantitative Surveys

The two cosmopolitan and most densely populated cities of Benin, Porto-novo and Cotonou, hosted the first stage of the surveys as areas where cowpea is not grown. The second stage was held in two rural communities, located in Savalou and Abomey regions, where cowpea is grown. Sample size was set according to Dagnelie (1998) as described by Chadare et al. (2008). In each community, the proportion of cowpea-dish consumers or processors was assessed through a random-check on 175 people, selected in the main market of the locality, on a market day. For the in-depth survey, respondents from each group were randomly selected. Consumers' questionnaires included food-consumption frequency of cowpea dishes that ranged from rarely (less than once a week), occasionally (once a week), regularly (2–3 times a week) to often (almost every day). The portion of total food expenses allocated to the regularly- or often-consumed dishes, the reasons for cowpea consumption, and the health disorders associated with cowpea consumption (i.e., bloating, flatulence) were also investigated. Processors' questionnaires included questions on the perception of the quality of raw materials, as well as on end-products, along with descriptions of processing techniques.

Food Composition Analysis

Sampling

For the purposes of this study, a dish was considered to be "a food prepared in a particular way as part of a meal." Approximately 300 g of ten popular cowpea dishes (marked † in table 1) were collected from five experienced processors throughout South and Central Benin, in regions where the dish is well known. These dishes were collected without the dishes that usually accompany them to make a full meal. Samples were dried in an oven at 60°C until constant weight was obtained, then blended and kept in a freezer at −20°C prior to analyses.

Dry matter, crude fat, crude protein, ash, crude fibre, and energy

Dry matter, crude fat, crude fibre and ash were determined according to AOAC methods 27.005, 27.006, 7.070 and 14.006, respectively (Association of Official Analytical Chemists 1984). Crude protein ($N \times 6.25$) was determined from nitrogen content quantified with Dumas method (Jung et al. 2003) by using a Flash EA 1112 N analyzer (Thermo Electron Corporation, Delft, The Netherlands) and D-methionine (Acros organics, New Jersey, USA) as nitrogen calibration standard. Metabolizable energy (ME) was calculated using the general Atwater factors (Wisker and Feldheim 1990).

Iron, zinc, and calcium

Iron, zinc, and calcium contents were determined by using an inductively coupled plasma optical emission spectrometer (ICP-OES; Elan 6000; Perkin Elmer, Wellesley, Massachusetts, USA) according to Temminghoff (1997).

Phytate

Phytate as IP6 (inositol hexaphosphate) was extracted and quantified in duplicate according to Bentsink and colleagues (2003) with minor changes: eluent and elution were set as follows: 0–15 min, 25–100 mM NaOH; 15–20 min, 500 mM NaOH to rinse the column; 20–35 min, 25 mM NaOH to equilibrate the column. DIONEX IonPac AS11-HC analytic column was used in combination with an IonPac AG11-HC Guard column.

Total phenolic compounds

Total phenolic compounds (TPC) were extracted in duplicate with HCl/methanol (1:100), measured following Singleton and Rossi (1965), and modified as follows: in 5 ml of water, 1 ml of extract, 1 ml of Folin–Ciocalteu's reagent (Merck, Germany) and 1 ml of saturated sodium carbonate solution were mixed. Volume was adjusted to 25 ml with Millipore

TABLE 1 Cowpea Dishes from Benin

Food			Plant part used			Main unit operations													
Names in Benin	Other names	Other ingredients	Beans	Leaves		Roasting	Milling /Grinding	Steeping in water	Wet dehulling	Partial dehulling	Whipping	Deep-frying	Steeping in oil	Slicing	Squeezing	Boiling	Steaming	Description
1. Abobo†	Sanzie or Tuya (Ghana); Ewa (Nigeria)	Salt; *Optional:* Potash, Sodium bicarbonate	X					O								B		Boiled beans
2. Ata†	Koose (Ghana); Akara (Nigeria)	Salt; *Optional:* Seasonings	X				M	SW	WD		W	F						Crispy fried-dumplings
3. Doco or Ata-doco†		Salt; *Optional:* Seasonings	X							PD	W	F						Fried-dumplings
4. Ataclè†		Salt	X				M				W	F	SO					Fritters
5. Adowè or Dovlo or Adovlo†		Salt; *Optional:* Oil	X					SW	WD							B		Puree
6. Fechuada		Salt; *Optional:* Seasonings	X							PD						B		Puree
7. Magni-magni or Olèlè or Lèlè†	Moinmoin (Nigeria) Koki (Cameroon)	Shrimps, Salt, Palm oil; *Optional:* Animal protein (fish, meat, etc)	X				M	SW	WD		W						S	Solid paste in banana leaves or tomato tin
8. Yoyoue		Seasonings	X			R	M					F						Oily flour
9. Akpada		Seasonings	X			O	M									B		Thick sauce

(*Continued*)

TABLE 1 (Continued)

Food		Plant part used			Main unit operations												
Names in Benin	Other names	Beans	Leaves	Other ingredients	Roasting	Milling /Grinding	Steeping in water	Wet dehulling	Partial dehulling	Whipping	Deep-frying	Steeping in oil	Slicing	Squeezing	Boiling	Steaming	Description
10. Atassi†	Waakye (Ghana)	X		Rice grains, Salt; *Optional:* Potash or Sodium bicarbonate or *Hibiscus sabdariffa'* red flowers			O								B		Mixture of boiled beans and rice
11. Abla† or Kowe		X		Maize flour; Palm oil or Crude fluid palm oil; Seasonings		M		WD								S	Steam-cooked dough
12. Atchonkouin or Kossibobo or Adalou or Aibli		X		Maize grains salt											B		Combined maize and beans

13. Djongoli or Zankpiti or Gnonmlin†		X		Maize flour, Palm oil or Crude fluid palm oil, Salt; *Optional:* Seasonings									B		Mixture of boiled beans and maize flour cooked with palm oil
14. Toubani		X		Salt; *Optional:* Yam or cassava flour, Seasonings, Bicarbonate	M		PD	W						S	Paste packed in tomato tin
15. Alounganta		X		Grated yam; *Optional:* Seasonings	M			W	F						Fritters
16. Tche		X		Yam, Salt									B		Boiled beans and yam
17. Aiman	Gora (Ghana)		X	Seasonings Palm oil									B		Vegetable sauce
18. Adjagbé or Amanmenou†		X	X	Potash, Crude fluid palm oil, Coarsely milled maize; *Optional:* Cowpea beans						L	Q			S	

Note. Main unit operations are related to beans or leaves processing. O = Optional Operation; R = Roasting; M = Milling; SW = Steeping in Water; WD = Wet Dehulling; PD = Partial Dehulling; W = Whipping; F = Deep-frying; SO = Steeping in Oil; L = Slicing; Q = Squeezing; B = Boiling in plenty of water; S = Steam-cooking.

†Popular cowpea dishes.

water (.22 μm) and the mixture was incubated for 15 min. Absorbance was then measured at 725 nm. Freshly prepared blanks and standard (Tannic acid, EC 215-753-2, Sigma Aldrich) were analyzed according to the same procedure.

Data Processing and Statistical Analysis

Survey data were entered in a database with Microsoft Access 2003 (Microsoft Corporation, Redmond, Washington, USA). Correspondence analysis (CA) was performed with SAS v.9 software (SAS Institute, Inc.) to cluster cowpea dishes according to their consumption frequency. SPSS 17.0 (SPSS, Chicago, Illinois, USA) was used to calculate mean values and standard deviations. Analytical data were compared using ANOVA test followed by a Student Newman and Keuls post hoc analysis to generate homogeneous subsets.

RESULTS AND DISCUSSION

Diversity of Cowpea Dishes

Cowpea processing leads to a variety of dishes (table 1) obtained from beans (90% of dishes) and/or leaves (10%). These dishes are mainly produced through a combination of techniques including steeping, dehulling, manual whipping, milling, and cooking. Beans are either prepared alone or in combination with cereals, roots and tubers, and/or cooking oils and seasonings such as salt, pepper, and roasted shrimp, while leaves are prepared by cooking and seasoning.

Cowpea Dishes Solely Based on Beans

Abobo and *Veyi* are boiled beans. Cleaned beans are boiled in a large amount of water and seasoned optionally. While water completely evaporates from *Veyi*, it remains with *Abobo*, resulting in a thick soup. *Abobo* is also known as *Sanzie* or *Tuya* in Northern Ghana (Quaye et al. 2009) and *Ewa* in Nigeria (Akinyele 1989). Cooking of beans is usually time - and fuel- consuming (Uzogara and Ofuya 1992). Therefore, strategies have been developed locally to shorten the cooking time. Cowpea beans can be steeped overnight prior to boiling or boiled in alkaline solutions of sodium bicarbonate or of *kanwu*, a kind of rock salt used as softener. *Kanwu*, also called *Kaun*, *Akaun*, *Kanwa* or *Trona* (Minka et al. 1999), is mainly a source of carbonate and bicarbonate of sodium and various minerals (Na, Ca, Fe) (Uzogara et al. 1988; Eyzaguirre et al. 2006). The use of *kanwu* as a softener is a common practice in Africa. Uzogara et al. (1988) showed that *Kanwu* contributes to a reduction of cooking time during open-pan boiling from 60 min (using tap water) to 35–45 min (in .05%–.1% tenderizing solutions).

The combination of pressure-cooking with a tenderizer further reduces the cooking time from 20 to 15 min as compared with pressure-cooking in tap water. In addition, mineral concentrations of boiled beans increase as a consequence of this practice, primarily for Na, but also for P, Ca, Mg, and Fe (Uzogara et al. 1988). Laurena et al. (1986) reported more efficient removal of polyphenols by leaching with the addition of dilute alkali during soaking of legumes. *Abobo* or *Veyi* is usually eaten with palm or groundnut oil, or a thick tomato sauce and fermented cassava flour (gari), bread or any type of boiled or fried root or tuber dish.

Ata (Benin), *Akara* (Nigeria), or *Koose* (Ghana) is a cowpea fritter, or snack dish. *Ata* is traditionally made by sorting, steeping, wet-dehulling (hand-rubbing only, or crushing on a millstone or milling in common maize mills followed by hand-rubbing and washing to release hulls), and grinding dehulled cowpea beans into a batter that is whipped to incorporate air. This dough can be seasoned prior to deep-fat frying. The wet-dehulling process is tedious and time consuming (we recorded 35–70 min for 1–1.2 kg of beans). A product similar to *Ata* is *Doco* or *Ata-doco*. Whole or dry-sieved cowpea flour, still containing fragments of hulls, is whipped and deep-fried. *Doco* can be cooled and fried a second time to obtain hard and dry fritters called *Ataclè*, which are immersed in oil (usually palm oil) for preservation. *Ata*, *Doco*, and *Ataclè* are commonly consumed as a side dish with porridges, yam (*Dioscorea* sp.), or sweet potato (*Ipomoea batatas*) fries, *Akassa* or *Lio* (cooked fermented maize dough), and also with mixed gari and oil.

Adowè and *Fechuada* are cowpea purees obtained from dehulled beans. For *Adowè*, beans are steeped and wet-dehulled as for *Ata* processing. Dehulled beans are boiled (with 1–2 g of bicarbonate for 1–1.2 kg of beans). Soft cowpeas are cooked to get a puree, which is salted, and oil is commonly added. For *Fechuada*, beans are parboiled, pounded, and sieved to remove seed coats. The resulting slurry is seasoned and cooked. Usually, white beans are used for *Adowè* and red ones for *Fechuada*. They are consumed after addition of palm, coconut or groundnut oil, or shrimp and thick tomato sauce and served with either gari or bread as desired.

Magni-magni, *Lèlè*, or *Alèlè* (Benin), *Moinmoin* (Nigeria), or *Koki* (Cameroon) is a kind of steam-cooked cowpea dough obtained from steeping, wet-dehulling, and washing of beans. Dehulled beans are ground with seasonings to taste, whipped, mixed with palm oil and salt, and finally wrapped in banana leaves or packed into recycled tins for steaming. Optionally, a source of animal protein (fish, boiled egg, etc.) is added before steaming. *Magni-magni* is usually consumed alone or with *Akassa* in Southern and Central Benin.

Yoyoue is a kind of oily flour. Cleaned beans are roasted, seasoned, ground, and finally deep-fried in cooking oil. *Akpada* is a very thick cowpea sauce. A thick tomato sauce is prepared, to which cowpea flour is added, mixed, and cooked together. *Yoyoue* and *Akpada* are usually consumed with *Akassa* or *Lio*.

Cowpea Dishes Prepared as Mixtures with Cereals

To prepare *Atassi* (Benin) *or Waakye* (Ghana), beans are parboiled in water (51% of processors), or in *kanwu* or bicarbonate solution (49% of processors), mixed with cleaned rice (.2–.3 as cowpea/rice ratio: 79% of processors) and cooked together. Another practice of commercial processors is to parboil beans and steep them in the cooking water overnight (38% of processors) before cleaned rice is added. The alkaline solution serves to soften the beans and, according to users, also darkens the color of the rice which is a desirable trait. The preferred colour is usually red, but certain types of potash result in a yellowish *Atassi,* which is appreciated in some regions. Red flowers of *Hibiscus sabdariffa* (2% of processors) are also used to reach the desired red colour. Uzogara et al. (1988) explained the change in colour obtained with *kanwu* by a browning process due to the Maillard reaction and oxidation of bean pigments. The type of additive used, according to preferences and localities, can affect iron availability in the end-product. Indeed, *Atassi* prepared with pure sodium bicarbonate will gain no additional mineral content (Fe, Ca, K, etc.), while the use of *kanwu* can improve the iron content. Eyzaguirre et al. (2006) showed that two samples of *kanwu* can vary drastically in mineral composition. Therefore, the source, and amount of *kanwu* used, affects the mineral content of the food product. *Atassi* is commonly consumed with a thick tomato sauce, and sometimes combined with spaghetti and animal protein.

Abla is a paste from maize (about 30%), cowpea (about 30%) and crude palm fruit extract (CPFE) or refined palm oil (RPO; about 40%). Beans are wet-dehulled, dried and milled. Fine maize flour is mixed carefully with fine cowpea flour and potash filtrate. This mixture is blended with palm oil to obtain a homogeneous dough, which is wrapped in banana (*Musa* spp.) leaves and steam-cooked. Dehulled cowpea flour can be replaced by dehulled beans to obtain *Kowe,* and this is especially done in the Abomey-Bohicon region. *Abla* and *Kowe* are consumed alone or in combination with *Akassa*/*Lio* or gari.

Atchonkouin, *Kossibobo*, *Adalou* or *Aibli* is a combination of cowpea with maize, mainly prepared in rural areas. Maize is parboiled and, later, boiled together with cowpea. The long cooking time of maize (we recorded 200 min for 1 kg of maize boiled on a charcoal fire) was reported by interviewees to be the main reason for its low consumption.

Djongoli, Gnonmlin or Zankpiti is obtained by preparing *Abobo,* which is mixed with fine maize flour and palm oil (CPFE or RPO) and cooked together. At the household level, the cowpea:maize:oil ratio is usually 3:3:1. However, *Djongoli* may contain far less cowpea at when sold commercially.

Cowpea Dishes Based on Mixtures with Roots or Tubers

Toubani is a kind of *Magni-magni* processed without oil and seasonings. Cowpea is partially dehulled, whipped, moulded in recycled tins or leaves and steam-cooked. Yam (*Dioscorea* sp.) or cassava (*Manihot esculenta*) flour is usually added during the whipping process of *Toubani* production (as a binder) along with sodium bicarbonate.

Cowpea can also be used to enhance the acceptability of water yam (*Dioscorea alata),* which is inappropriate for making pounded yam (i.e., a typical meal in Central and Northern Benin). An example is a fritter named *Alounganta*. *Dioscorea alata* tubers are grated, mixed with cowpea flour (5% of the grated yams' weight), whipped and deep-fried. The addition of cowpea flour is done to improve the nutritional value of the fritters, according to 50% of the processors interviewed.

Tche is a kind of *Abobo* obtained by boiling beans together with peeled and sliced yam. *Tche* is prepared in rural production areas, mainly for traditional ceremonies.

Cowpea Dishes Based on Leaves

Cowpea leaves are commonly boiled and sold in the market as *Aïman* (Benin) or *Gora* (Northern Ghana). Boiled leaves can be seasoned, combined with smoked or fried fish or meat and consumed as a vegetable sauce. Cowpea leaves are also processed into *Adjagbé or Amanmenou* (Benin). Leaves are cleaned, shredded and mixed with *kanwu* filtrate, CFPE, and coarsely milled maize, and optionally parboiled cowpea beans. The mixture is wrapped in *banana or teak (Tectona grandis) leaves for steam-cooking*. *The addition of kanwu filtrate is* done to tenderize the leaves. These leafy products are usually consumed alone, but may also be eaten with *Akassa* or *Lio*.

Importance of Cowpea-Based Dishes in the Beninese Diet

The importance of cowpea dishes in Beninese food consumption habits is analyzed on the basis of their consumption frequency and the fraction of total food expenses allocated to their consumption. Figure 1 shows the relationship between cowpea dishes and their consumption frequency through correspondence analysis. The first two axes explain 99.6% of the collected information, which allows adequate interpretation. All cowpea dishes are well represented on the first axis except *Adjagbé*, which is best represented on the second axis, according to correlations and partial contribution of modalities to each axis. Modalities of consumption frequency are all well represented on axis 1, except for the modality "occasionally,"

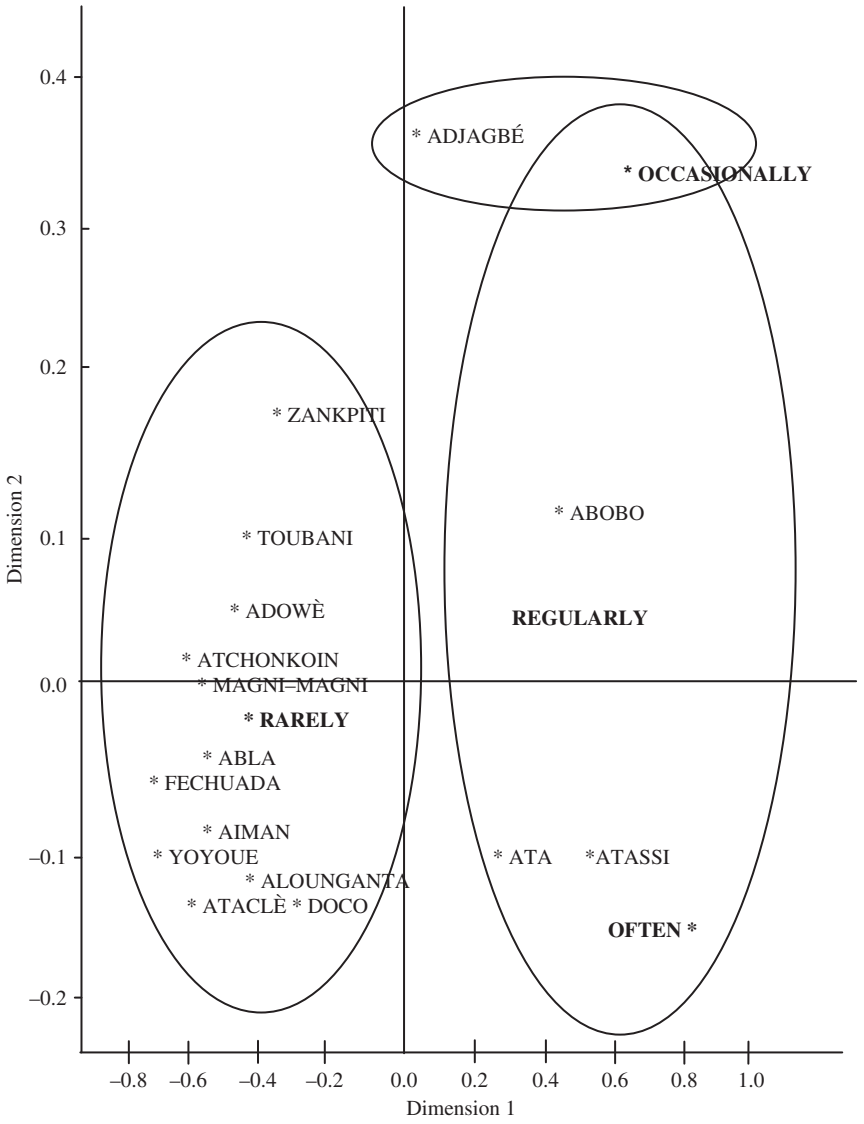

FIGURE 1 Consumption frequency of cowpea dishes from Benin.

which is best represented on axis 2. *Ata*, *Atassi*, and *Abobo* are strongly and positively correlated with axis one, as with "often" and "regularly." All the other dishes, except *Adjagbé*, as well as the frequency modality "rarely" are strongly and negatively correlated with axis one. Consequently, *Ata* and *Atassi* can be considered to be consumed "often" by interviewees. *Abobo* is "regularly" consumed and the other dishes, except *Adjagbé,* are consumed rarely. *Adjagbé* and "occasionally" are the modalities best represented on

axis 2, and they are positively correlated with this axis. Therefore, *Adjagbé* is considered to be consumed "occasionally" by interviewees.

Ata, *Atassi*, and *Abobo* are processed and consumed by all the socio-cultural groups in our surveys. The other dishes are associated with some regions and certain socio-cultural groups. *Ataclè*, *Zankpiti*, *Yoyoue*, *Akpada*, and *Abla* are generally prepared by Fon and Goun people, whereas *Alounganta* is consumed by Mahi people. *Adjagbé* as well as *Kowe* are restricted to Fon people and the Abomey-Bohicon region. *Magni-magni* is attached to Yoruba and Nago, while *Adowè* is a specialty of Mina people. Fon, Goun, Mahi, Yoruba, Nago and Mina are important socio-cultural groups in Benin. Irrespective of the relationship between consumption frequencies, socio-cultural group and cowpea dishes, consumers state that they eat cowpea dishes because of: (1) the nutritive character of cowpea (44% of interviewees); (2) the "stomach filling" and "energy provision" properties of cowpea dishes (22% of interviewees); and (3) the high accessibility of cowpea dishes as street foods (16% of interviewees). Indeed, Uzogara and Ofuya (1992) reported cowpea dishes as high energy foods for peasants and farmers.

Around 47% of the respondents allocate more than 10% of their food expenses to cowpea consumption (figure 2). A chi-square analysis revealed that the money spent on cowpea dishes is significantly related to location. Indeed, 60% of the urban respondents allocated less than 10% of food expenses to cowpea dishes as opposed to nearly 56% of rural respondents who spend more than 10% of food expenses to cowpea dishes. This distribution might be influenced by respondents' incomes. At present, about 42% of the population of Benin lives in urban areas (INSAE 2008), and presumably have higher incomes on average than people living in rural areas. People with higher incomes might consume more meat and less cowpea as a source of protein. In addition, the difference in the consumption of cowpea dishes between urban and rural areas may result from discomforts caused by cowpea consumption (22% of respondents). Seventy percent of these complaints, expressed in terms of bloating, constipation, and stomach pain, came from urban areas. Digestion problems also occur in rural areas, but certain effects, such as flatulence, are not perceived as significant problems in rural areas.

Bottlenecks in Cowpea Processing and Preservation

Traditional cowpea processing operations were reported to be tedious and time consuming. Processors complain about cleaning, whipping, kneading, and dehulling. To circumvent the constraints related to dehulling, processors in urban areas are accustomed to coarse grinding of cowpea (using cereal or tomato mills) prior to hull removal. Millers often refuse grinding because of the residual and undesired "beany odour" on products milled later. Mills

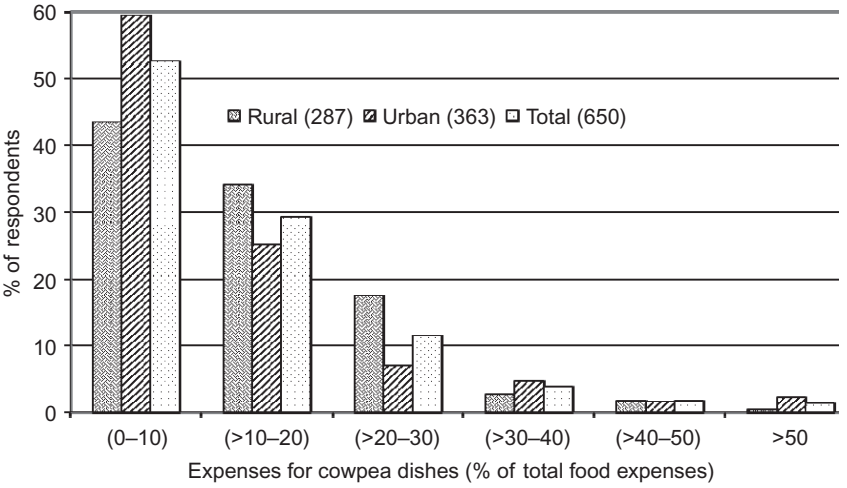

FIGURE 2 Expenses for cowpea dishes consumption in rural and urban areas of Benin.

need to be cleaned thoroughly after cowpea grinding, and so the millers who will grind cowpea tend charge extra to cover cleaning costs.

Cowpea processors also reported that cowpea dishes have short shelf lives. Most cowpea-based dishes have high moisture (from 18% in *Ataclè* to 74% in *Adjagbé*) and fat contents (13% in *Zankpiti* to 45% in *Ataclè*). Therefore, they are difficult to preserve for more than 24 hours at ambient temperature. Most cowpea dishes are either wrapped in local materials (leaves, recycled tomato tins, plastics, etc.) or not packaged at all. They are produced daily for immediate consumption. Multi-purpose intermediate products and/or adequate packaging would facilitate the trade of cowpea dishes enormously.

Proximate, Mineral, and Antinutrient Composition of Cowpea Dishes

Overall, a large variation in proximate composition exists between cowpea dishes and within a particular dish (table 2), which may be attributed to variations in processing techniques, and to type and amount of varieties and ingredients. Because the analyzed samples were not obtained from standardized recipes, they more accurately express the quality of these dishes as they are commonly offered for sale on the market.

Crude protein, crude fat and carbohydrate contents per 100 g d.w. ranged from 9.8 to 25.1, .3 to 44.6 and 38.0 to 86.6 g, respectively. Boiled cowpea (*Abobo*) and decorticated cowpea puree (*Adowè*) have high protein contents, comparable with whole cowpea (Kachare et al. 1988; Iqbal et al. 2006) and with *Ewa*, a similar home-made dish from Nigeria (Akinyele

TABLE 2 Proximate (g/100 g d.w.) and Mineral (mg/100 g d.w.) Composition of 10 Cowpea Dishes Consumed in Benin

Foods**	Ash	Crude fat	Crude fibre	Crude protein	Carbohydrate*	Metabolizable energy***	Calcium	Iron	Zinc
Abla	5.14 ± 1.0^{b}	26.19 ± 2.4^{c}	$2.00 \pm .3^{b,c}$	10.00 ± 1.0^{a}	58.67 ± 3.2^{d}	2162.7 ± 52.6^{c}	$94.0 \pm 6.0^{b,c}$	18.0 ± 7.5^{b}	$2.2 \pm .1^{b}$
Abobo	$6.95 \pm .8^{c}$	$1.80 \pm .2^{a}$	$3.25 \pm .7^{d}$	25.10 ± 2.2^{c}	65.35 ± 1.7^{e}	1623.4 ± 20.8^{a}	112.0 ± 3.7^{c}	$6.5 \pm 1.2^{a,b}$	$2.5 \pm .7^{b,c}$
Adjagbé	$2.62 \pm .4^{a}$	15.15 ± 4.4^{b}	$3.75 \pm .8^{e}$	10.30 ± 1.0^{a}	$71.93 \pm 3.5^{f,g}$	1973.6 ± 96.0^{b}	380.0 ± 30.3^{d}	35.3 ± 12.0^{c}	$2.6 \pm .3^{b,c}$
Adowè	$5.47 \pm .5^{b}$	$1.74 \pm .3^{a}$	$1.54 \pm .2^{a,b}$	$23.95 \pm .6^{c}$	$69.05 \pm .9^{e,f}$	1647.1 ± 10.6^{a}	$62.0 \pm 3.7^{a,b,c}$	$6.4 \pm 1.2^{a,b}$	$2.0 \pm .2^{b}$
Ata	$3.00 \pm .6^{a}$	40.28 ± 6.8^{e}	$1.35 \pm .2^{a}$	14.07 ± 1.9^{b}	42.65 ± 6.82^{b}	2494.8 ± 141.4^{e}	$67.5 \pm 7.5^{a,b,c}$	18.4 ± 15.5^{b}	$2.5 \pm .3^{b,c}$
Ataclè	$3.41 \pm .4^{a}$	44.62 ± 3.8^{f}	$1.03 \pm .2^{a}$	13.95 ± 1.5^{b}	38.02 ± 3.5^{a}	2579.1 ± 79.9^{e}	$62.5 \pm 2.5^{a,b,c}$	$13.4 \pm 3.8^{a,b}$	$2.5 \pm .2^{b,c}$
Atassi	2.38 ± 1.1^{a}	$.34 \pm .1^{a}$	$.91 \pm .5^{a}$	10.82 ± 1.0^{a}	86.63 ± 1.5^{h}	1669.6 ± 20.5^{a}	38.0 ± 13.6^{a}	1.3 ± 1.1^{a}	$1.5 \pm .3^{a}$
Doco	$2.93 \pm .5^{a}$	32.00 ± 6.1^{d}	$1.55 \pm .1^{a,b}$	15.75 ± 2.0^{b}	49.33 ± 4.7^{c}	2322.2 ± 128.3^{d}	$92.5 \pm 16.0^{b,c}$	$8.2 \pm 2.4^{a,b}$	$3.0 \pm .3^{c}$
Magni-magni	5.06 ± 2.5^{b}	24.04 ± 6.2^{c}	$1.03 \pm .3^{a}$	15.49 ± 4.8^{b}	55.41 ± 9.0^{d}	2118.9 ± 164.0^{c}	$57.5 \pm 10.3^{a,b}$	$10.9 \pm 2.9^{a,b}$	$2.9 \pm .2^{c}$
Zankpiti	3.06 ± 1.2^{a}	13.41 ± 6.7^{b}	$2.40 \pm .8^{c}$	9.78 ± 2.7^{a}	74.39 ± 6.0^{g}	1940.5 ± 132.3^{b}	$45.0 \pm 6.5^{a,b}$	$9.0 \pm 3.9^{a,b}$	$2.6 \pm .3^{b,c}$

Note. Values with the same letter in the same column are not significantly different ($p < .05$).

*Carbohydrate by difference (100 d.w. – (protein + fat + ash)).

**For each food, five samples were collected: one sample each from five different processors.

***Calculated metabolizable energy (protein*17 kJ + fat*38 kJ + carbohydrates*17kJ) expressed in kJ/100 g d.w.

1989). *Atassi*, *Adjagbé*, *Abla* and *Zankpiti* have the lowest protein contents. *Magni-magni* and *Ata* are less rich in protein, but have a higher fat contents than their Nigerian equivalents (*Moinmoin* and *Akara,* respectively) as reported in Nigeria by Akinyele (1989) and Patterson et al. (2004). The average recommended level of protein intake (RLPI) for 6–11 year-old children, as defined by World Health Organization/Food and Agriculture Organization/U.N. University (2002) is .9 g per kg body weight per day. So, a child weighing 26 kg requires 23.4 g of protein daily (World Health Organization 2007). Therefore, the main dish of a lunch of 322 g (w.b.), as given to school children in Eastern Ghana (Martens 2007), provides 98 and 88% of the recommended protein intake when it consists of *Abobo* or *Adowe*, respectively. *Adjagbe* (37% RLPI), *Atassi* or *Abla* (43–44% RLPI) and *Zankpiti* (49% RLPI) contribute the least to the daily protein intake as compared with other cowpea dishes. Furthermore, combinations of cowpea with cereals (as observed in these dishes) compensate for the amino acids deficiencies of both ingredients (Kononowicz et al. 1997). However, in this study, we did not investigate the protein quality of these dishes.

Except for *Abobo*, *Adowè* and *Atassi*, all cowpea dishes presented in this study are rich in fat. Indeed, Patterson et al. (2004) qualified *Akara* as a high fat food (about 31% d.w.). Deep-frying and the use of large amounts of fat in combination with the high oil absorption capacity of some varieties add to the high fat content of these dishes.

The metabolisable energy of 100 g cowpea dish ranged from 1623 to 2579 kJ. This is relatively high when compared to cereal porridges (1674–1704 kJ/100 g) (Akinrele and Edwards 1971; Ocheme and Chinma 2008). The crude fibre content per 100 g d.w. ranged from .9 to 3.8 g while the inorganic fraction of 100 g d.w. cowpea dish varied from 2.4 to 7.0 g. Calcium, iron and zinc contents in 100 g d.w. of cowpea dish vary between 38 and 380; 1.3 and 35.3; 1.5 and 3.0 mg, respectively. These products contain more calcium and iron than similar cowpea dishes analyzed in Nigeria. In fact, *Ewa*, *Gbegiri*, *Akara*, and *Moinmoin* were reported to contain 39.7–41.8 of calcium, 1.0–2.4 of iron and .9–5.7 of zinc mg/100 g d.w., respectively (Akinyele 1989). The lowest mineral contents were found in *Atassi*, while *Adjagbé* was the best calcium and iron provider among the analyzed dishes. The high mineral content of *Adjagbé* may be explained by the use of cowpea leaves. Greenhouse cowpea leaves boiled in water and drained, contained 1240 mg of calcium, 43.8 mg of iron and 19.7 mg of zinc per 100 g of solids (Imungi and Potter 1983). Moreover, a high amount of rock salt filtrate (known to be rich in minerals and salt) is used in Adjagbe processing, thus adding to the amount of minerals.

At a low bioavailability (i.e., 5% for iron and 15% for zinc), a 6- to 9-year-old child requires a daily intake of 12.6–17.8 mg of iron and 9.6–11.2 mg of zinc (Food and Agriculture Organization/World Health Organization 2004). Therefore, the main dish of a lunch of 322 g w.b. of *Adjagbe* or *Abla*

TABLE 3 Antinutrients in Cowpea Dishes from Benin (g / 100 g d.w.)

Foods	Polyphenols	Phytate
Abla	$.62 \pm .2^{c,d}$	$.42 \pm .1^{c,d,e}$
Abobo	$.26 \pm .1^{b}$	$.50 \pm .1^{e}$
Adjagbé	$.91 \pm .1^{e}$	$.18 \pm .1^{b}$
Adowè	$.18 \pm .1^{ab}$	$.36 \pm .1^{c,d,e}$
Ata	$.78 \pm .1^{c,d}$	$.36 \pm .1^{c,d,e}$
Ataclè	$.65 \pm .1^{c,d}$	$.28 \pm .1^{b,c}$
Atassi	$.07 \pm .0^{a}$	$.08 \pm .0^{a}$
Doco	$.57 \pm .2^{c}$	$.47 \pm .1^{d,e}$
Magni-magni	$.67 \pm .1^{c,d}$	$.34 \pm .2^{c,d}$
Zankpiti	$.65 \pm .1^{c,d}$	$.36 \pm .1^{c,d,e}$

Note. Values with the same letter in the same column are not significantly different ($p < .05$).

is enough to cover 100% and 20%–23% of the daily requirements for iron and zinc, respectively. Most of the other main dishes, namely *Adowe*, *Abobo*, *Magni-magni*, and *Zankpiti*, cover 31%–89% of iron, and 15%–31% of zinc intake requirements. However, the availability of these micronutrients will be less, depending on antinutritional factors present.

Table 3 gives an overview of antinutrients in cowpea dishes. IP6 and TPC in 100 g d.w. of cowpea dish ranged from .08 to .50 g and .07 to .91 g, respectively. Most cowpea dishes (9 and 7 over 10 dishes for IP6 and TPC, respectively) were rich in IP6 (.18–.50 g/100 g d.w.) and in TPC (.57–.91 g /100 g d.w.). *Atassi* contained the lowest amount of these antinutrients. *Doco, Ataclè, Abla* and *Abobo* had a particularly high content of IP6, while *Adjagbé* had the highest TPC concentration. The high TPC contents of these dishes are comparable with those reported by Preet and Punia (2000) for brown unprocessed cowpea beans in India (.8–.9 g/100 g d.w.), and higher than for white cowpea unprocessed beans (.5 ± 1.4 g/100 g d.w.) and processed ones (.2–.5 g/100 g d.w.) (Sinha and Kawatra 2003). Oluwatosin (1999) and Oboh (2006) also reported higher IP6 content in beans (1.4–2.9 g /100 g d.w.) as compared to dishes. Akinyele (1989) previously demonstrated a reduction of antinutrients in the same type of dish (*Ewa*, *Akara*, *Moinmoin*) due to processing. Frequently, an antinutrient reduction due to processing is accompanied by mineral losses (Khalil and Mansour 1995; Akaninwor and Essien 2005). Therefore, the ratio [antinutrient]:[mineral] is a better indicator of the mineral availability. In our study, the [IP6]:[Ca], [IP6]:[Fe] and [IP6]:[Zn] molar ratios range from .03 to .44; .37 to 6.16; and 4.93 to 19.14, respectively (figure 3).

Investigations of Morris and Ellis (1985) on adult men recorded an average 13%–21% apparent absorption of calcium at a [Phytate]:[Ca] molar ratio lower than .24. *Atassi* (molar ratio .17), and *Adjagbe* (molar ratio .03) can

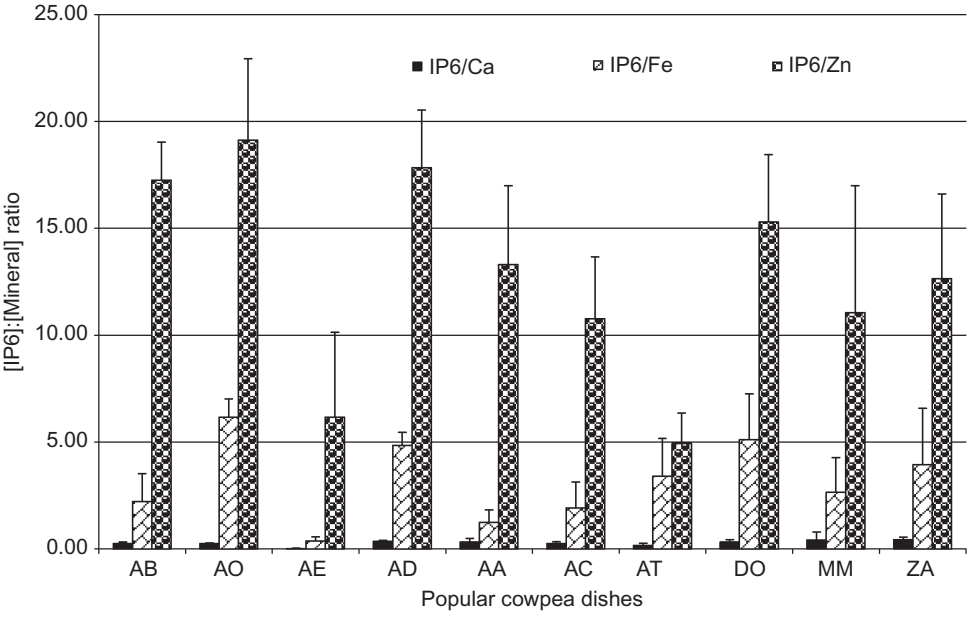

FIGURE 3 Mineral availability index ([IP6] / [Mineral]) of cowpea dishes.
Note. AB = Abla; AO = Abobo; AE = Adjagbé; AD = Adowè; AA = Ata; AC = Ataclè; AT = Atassi; DO = Doco; MM = Magni-magni: ZA = Zankpiti.

therefore, be considered dishes that have a moderate to high calcium availability, respectively. Hallberg et al. (1989) showed that 10% available iron could be reached when the [Phytate]:[Fe] molar ratio is equal to 1. Nout (2009) reported an adequate (>70% of Fe present) iron availability with a ratio ≤.3. Consequently, *Adjagbe* (molar ratio .37) is the only cowpea dish with expected adequate iron availability. A [Phytate]:[Zn] molar ratio ≤5 indicates a high zinc availability, while a ratio from 5 to 15 predicts moderate availability (World Health Organization 1996). Hence, zinc may be highly available in *Atassi* and poorly available in *Doco*, *Abla, Adowè* and *Abobo*.

Adjagbé is the cowpea dish in which all minerals were available, probably because cowpea leaves are an important ingredient and phytate levels are reduced. The use of cowpea leaves in cowpea dishes has potential to improve mineral intake. Dephytinisation and removal of phenolic compounds in cowpea dishes warrant additional research to make further improvement possible.

In conclusion, this article contributes to our understanding of indigenous knowledge on cowpea consumption, and also helps to quantify nutritional composition. Moreover, we provided data that can be used in national food composition tables. Our investigations demonstrate that *Ata*, *Atassi* and *Abobo* are the most popular of the 18 cowpea dishes consumed in Benin. They are primarily processed by the following unit operations: steeping, dehulling, milling, whipping, and cooking, whereas fermentation and

germination are not applied. Cowpea dishes, processed from beans as well as leaves, have also been established as highly nutritious foods. This is confirmed by analytical data with respect to energy supply and protein content. The mineral contents of dishes prepared with beans are low as compared with dishes that contain leaves as well. A lesser-known dish like *Adjagbe* has been identified as a highly nutritious dish with regard to mineral availability. Mineral binding compounds are present in significant amounts in dishes with beans, while phenolic compounds are the main concern in dishes with leaves. Therefore, strategies should be developed to increase mineral availability in cowpea dishes, especially the ones that contain leaves. Moreover, the consumption of these potentially healthy foods is challenged by the issues of bloating, a long cooking time and dehulling constraints; this issues should also be addressed in future research. Working to improve the nutritional value of cowpea dishes through the methods discussed in this article may help to increase access to adequate food and the development of trade and local markets—two essential goals of food sovereignty in Africa.

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