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Plant Foods of West Africa: A Call for Bioavailability Studies

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Populations in many regions of sub-Saharan Africa, especially those inhabiting rural areas, rely on plant foods, many of which are uncultivated, to supplement their largely cereal-based diets. These plant foods have been referred to variously as 'famine' foods, 'spontaneous' edible plants, 'wild' plant foods and 'uncultivated' plant foods. The term 'famine' food is misleading because it implies that the plant is consumed only when cultivated plants such as maize, millet, sorghum (guinea corn) and rice are unavailable due to poor harvests resulting from drought, flooding, war or political unrest. In fact, to the contrary, such plants have been consumed for centuries, if not millennia, and continue to be used to supplement human diets of people inhabiting all parts of Africa even when harvests are plentiful.

Plant foods are most often in the form of leaves, seeds, fruit and roots. The plants are prepared in a variety of ways including: cooked in sauces that are eaten at the evening meal; dried and eaten alone; or, cooked and eaten in combination with a mixture of other ingredients such as dried peanut extract, red pepper, salt and other spices in the form of a 'leaf bundle'. Most plant foods are only available for fresh specimen collection during the rainy season (May-September). However, many can be dried and stored for later consumption or sale in the market. Many of these plant foods play an important role in local diets and are often eaten throughout the year. However, during times of grain scarcity or non-availability, such plant foods take on added importance.

A good example of a plant food available in many regions of sub-Saharan Africa, including Madagascar, and which is consumed year-round is baobab leaf. In Hausa-speaking West Africa, baobab leaf is called *kuka* and the soup that is made there from is called *miyar kuka*. Baobab leaf is one of the most affordable plant foods you will find in African markets and, when thoroughly sun-dried, can be stored for months without need for refrigeration. Not infrequently, newcomers to Africa mistakenly assume that *kuka* is a food of the poor. *Kuka*, however, is eaten by all members of society.

If you consult the primary literature, you will find hundreds of publications that report on the content of various nutrients (and occasionally even the antinutrients) in the edible plants of Africa (Humphry *et al*. 1993; Smith *et al*. 1996; Glew *et al*. 1997; Freiberger *et al*. 1998; Sena *et al*. 1998; Cook *et al*. 2000; Fernandez *et al*. 2003). Moreover, the number of such publications appearing each year is growing, perhaps due to the continuing chronic shortages of cultivated plant foods such as maize and millet in some parts of the continent. Despite the vast body of knowledge that is accumulating about the content of essential nutrients including vitamins, protein and amino acids, fatty acids, and minerals and trace elements, much more research remains to be done before the full potential and value of these edible plants can be realized.

The purpose of this paper, which is more a position piece than a review of the literature, is to assess the state of research on the edible plant foods of sub-Saharan Africa and to offer recommendations regarding the kinds of research that ought to be undertaken if the large and diverse populations who inhabit this part of the world are to derive greater benefit from the large and expanding body of knowledge about the critical nutrients these indigenous edible plants contain.

The authors of this piece represent a collaborative research effort that has brought experts in the fields of nutrition and biochemistry together with social scientists. Much of their research has been aimed at quantifying particular nutrients essential for human health and which are contained in edible plants that are grow in the western Sahel, in particular in northern Nigeria, Niger, Cameroon, and Burkina Faso. The research, like much of the published studies on uncultivated edible plants of the Sahel, is by-and-large limited to reporting information about the content of particular nutrients. The main argument of this report is that there is a compelling need for research that goes beyond simply quantitative nutrient analyses of edible plants to research which addresses the question of how the results of such studies might be applied to improve the diets and overall well-being of the populations who have access to these plants. We argue below that attainment of these goals will require much greater emphasis on, and commitment to, the kinds of research that will complement the plethora of published analytical studies that inform us of the potential of hundreds if not thousands of wild plant foods to provide useful amounts of many different nutrients to populations in Africa, particularly those who live where food security is a recurring problem.

To support our argument that there is a need to expand the depth of plant food studies that are undertaken in the next decade or so, we have chosen to make our point by focusing on the example of one particular nutrient, namely calcium, which is required by humans at all stages of growth and development, from embryonic life to old age.

Calcium is the main mineral component of bone, thus inadequate calcium intake may cause bone disease. For example, in young children a lack of calcium results in rickets. If rickets is not treated soon after the disease is recognized, the probability is high that the rachitic child will carry his or her skeletal deformity into adulthood where stature and mobility will be compromised for a lifetime. In most regions in sub-Saharan Africa where rickets has been studied, the disease has been shown to be caused not by a lack of vitamin D or a defect in vitamin D metabolism, but by inadequate dietary calcium (Thacher *et al*. 1999a, 1999b).

In adults, a calcium-poor diet is a risk factor for osteopenia and osteoporosis, and ultimately bone fractures. Dietary calcium is a critical issue during pregnancy and post-partum, especially for lactating women. A major cause of fetal and maternal mortality in sub-Saharan Africa is cephalopelvic disproportionation, a condition in which the

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Research Note

Table 1 Calcium content of selected edible plant foods of the western Sahel.

Plant	Hausa name	Calcium content (mg/g)	Reference(s)
Eleusine corocana	tamba	407, 431	Fernandez *et al*. 2003; National Research Council 1996
Leptadenia hastada	yadiya	117, 21	Humphry *et al*. 1993; Freiberger *et al*. 1998
Tribulus terrestris	tsaido	44	Humphry *et al*. 1993
Maerua crassifolia	jiga	24, 17	Freiberger *et al*. 1998; Fernandez *et al*. 2003
Amaranthus hybridus	aleyahou	22	Humphry *et al*. 1993
Gynandropsis gynandra	gassaya	17	Humphry *et al*. 1993
Cassia occidentalis	redore	17	Humphry *et al*. 1993
Entada africana leaves	tawarsa	16	Cook *et al*. 2000
Commiphora africana	dashi	15	Humphry *et al*. 1993
Adansonia digitata leaves	kuka	15, 20	Sena *et al*. 1998; Glew *et al*. 1997
Moringa oleifera	zogali	14, 14, 19	Humphry *et al*. 1993; Freiberger *et al*. 1998; Sena *et al*. 1998
Crataeva religiosa	guodido	14	Humphry *et al*. 1993
Ipomoea coscinosperma	tarengida	14	Humphry *et al*. 1993
Hibiscus esculentus fruit	kubewa	10	Glew *et al*. 1997

pelvic canal of the mother is too narrow to allow passage of the fetus (Harrison 1989). Even today, obstructed labor in a rural setting far removed from a tertiary care center is virtually a death sentence for both the mother and the fetus. The calcium status of the growing female child is a factor in the adequate development of the pelvic bones. In addition, since exclusive breastfeeding for the first six months of life is common, the issue of maternal calcium nutrition is a critical one of great practical significance. The growth of the fetus and breastfeeding stress the calcium reserves of the mother.

Apart form serving as a structural component of bone, calcium plays a central role in regulating cellular metabolism. The function or proper regulation of the activity of numerous enzymes and proteins is calcium-dependent. For example, intracellular calcium regulates the activity of protein kinases which in turn control the flux of metabolites through various metabolic pathways. Extracellularly, calcium is a co-factor for many of the proteases involved in blood coagulation.

We and many other investigators have determined the calcium content of numerous plant foods that grow in the Sahel. **Table 1** summarizes the results of some of these studies and highlights those plants that have the potential of being useful sources of calcium. Interestingly, one of the richest sources of calcium is baobab leaf. Relative to 800 to 1300 mg of calcium that is recommended for humans under a variety of physiologic conditions (e.g., childhood, pregnancy, postmenopause), one serving of *kuka* containing the equivalent of 20 grams of dried baobab leaf would provide 400 mg of calcium, or about 50% percent of the daily requirement of most humans.

It is useful to point out, however, that the data in **Table 1** only indicates the potential a particular plant food has for contributing to satisfying a human's recommended intake of calcium. Before the calcium in *kuka* can be utilized to satisfy the kinds of functions described above, the mineral must be released from its bound form in the small intestine and then absorbed and transported through the blood circulation to the tissues that require calcium. There are several well-documented dietary factors that can compromise the absorption of calcium from the gastrointestinal tract. Prominent among these calcium antagonists are phytates and polyphosphates which chelate calcium and other divalent cations, thereby preventing them form being absorbed. Cereals such as millet and sorghum contain relatively large amounts of phytates.

The amounts and kinds of calcium (and other divalent-cation) chelators in *kuka* and several other calcium-rich plants listed in **Table 1** are largely unknown. However, knowledge of the calcium and phytate molar ratios would be useful for assessing the potential calcium availability from a particular food. In addition, methods for removing phytates and other chelators from plant foods should be examined for their ability to render the calcium in these plants more accessible. Several studies have reported on the effectiveness of removing phytate from beans and other grains, using leaching and fermentation processes (Hotz *et al*. 2001; Makokha *et al*. 2002). These methods, including some that are suitable for home use, could be applied to these uncultivated edible plants. Women could then be educated at the local level as to how to prepare the various plant foods so as to make the nutrients they contain more available. We therefore recommend that direct studies of the bioavailability of the calcium in *kuka* and other plants of the Sahel be undertaken. The availability of stable isotopes of calcium renders such studies doable even under conditions that prevail in developing countries. Classical calcium balance studies, too, ought to be feasible at many of the teaching hospitals in Africa.

In addition to trace metal chelators, other antinutrients such as protease inhibitors may be important in determining the nutritional value of the edible plants. Protease inhibitors prevent the complete breakdown and absorption of protein in foods and play an important role in determining the protein availability in the foods of populations consuming diets that are marginal in protein content. Although it is known that substantial quantities of these inhibitors are present in soybeans, millet and other beans and seeds there is not a large literature reporting the activity of protease inhibitors in uncultivated plants of the western Sahel (VanderJagt *et al*. 2000).

Ultimately, it is important to know how effective various plant foods are in treating nutritional deficiency conditions such as rickets in Africa. In this regard, epidemiological studies involving the introduction of plant foods into communities with recommendations for consumption where the incidence and prevalence of rickets are high would be especially useful.

In closing, the more general point we have tried to make using the example of calcium-dependent rickets is that there is both a need and an opportunity for studies of the bioavailability of nutrients in the numerous and diverse edible plants that grow in sub-Saharan Africa. Our hope is that the present paper will encourage such studies.

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