THE COMPOSITION OF SOME WILD PLANT FOODS USED BY EAST AFRICAN HUNTER-GATHERERS

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ABSTRACT

The composition of 134 specimens of plants commonly used by Tanzanian hunter-gatherers was determined by standard techniques. Hadza hunter-gatherers rely on tubers and to a lesser extent on fruits as dietary staples, as well as a variety of wild animal game and honey, as supplements. Season and food preparation affected the composition of the most important tuber, Vigna frutescens. However, all tubers are low in nutrient density. Baobab is an unusual fruit in potentially being a good source of dietary fat and protein.

KEY WORDS: proximate composition; plant foods; Tanzania; Hadza hunter-gatherers

Running headline: Composition of Wild Plant Foods

INTRODUCTION

Most African hunter-gatherers inhabit arid and semi-arid regions, marked by seasonality in spatial and temporal distribution of resources utilized for food [but, cf Bailey and Aunger (1989a,b) and Bailey and DeVore (1989) on the Efe hunter-gatherers of the Ituri Forest, Zaire]. The importance of wild foods, especially wild plants, to hunter-gatherer diets is well documented and the nutrient content of a few major wild plant foods is well known (Newman, 1975; Hitchcock, 1988; Hitchcock and Osborn, 1990; Lee, 1979). For example, wild fruits (followed by leaves and tubers) are reported to be the most important foods eaten by hunter-gatherer groups throughout eastern and southern Africa (Peters and O'Brien 1981, Hitchcock and Osborn 1990). In addition, it is widely understood that the famous mongongo nut (*Ricinodendron rautanenii*) is high in fat content and rich in protein (Lee, 1979). Furthermore, baobab (*Adansonia digitata*) fruit pulp is reported to have the highest vitamin C content of any natural fruit (FAO, 1988) and it has been recorded as part of the diet of many African populations (e.g., Newman, 1975; Lee, 1979). Despite their acknowledged importance as dietary staples, little information is available on the actual consumption of these plants or on the nutrient content of most of these wild foods (Fleuret, 1979). The effect of season on their composition is even less well known (see e.g., Galvin and Waweru, 1987).

Knowledge of the nutrient content of foods used by hunter and gatherers is important for at least two reasons. First, information on nutrient content of consumed foods is necessary to assess the general character of the diet. Second, in order to assess return rates for work effort in food acquistion, accurate information on energy content of the foods is required. Because seasonality, soils and temperature affect nutrient composition of plants, local plant food should be analyzed for nutrient content whenever possible.

This paper discusses the nutrient content of the native food plants collected and consumed by the Hadza hunter and gatherers of northern Tanzania. Food samples were collected and analyzed as part of a wider investigation of foraging patterns among modern hunter-gatherers designed to explore the ecological bases of human behavioral variation. The ultimate goal is to describe and explain patterns of behavior among modern hunter-gatherers along lines which can contribute to the interpretation of changes indicated in the archaeological record of the Pleistocene (Hawkes, 1987; Hill and Hawkes, 1983). Specific goals include the examination of subsistence patterns in terms of the costs and benefits of exploiting various resources. The Hadza are of interest both as an ethnographic example to add to the very small sample of cases on which quantitative observational data on foraging patterns are available, and more particularly because they inhabit an East African savannah environment, and so exploit resources which may have been of special importance to some Pleistocene hominids: large animals and tubers (see Hawkes, et al, in press, for references to other aspects of our work).

The Eastern Hadza occupy a 2500 km^2 area in the Eastern Rift Valley, southeast of Lake Eyasi (Woodburn, 1964; 1968a,b). This region has a warm, dry climate, with a marked 6-7 month rainy season (November-May). Mean annual rainfall is 300-600 mm (Schultz, 1971). Much of the country is rock strewn and hilly. Vegetation is primarily mixed sa~~n~~vanna woodland (Schultz, 1971); medium and large mammals are locally abundant (Smith, 1980). 200 -

The 600-800 Hadza who occupy this area divide the region into several loosely bounded units, including Mangola on the north, Sipunga on the east, and Tli'ika on the southwest (Woodburn, 1968b). At the time of European contact, around the beginning of this century, only the Hadza occupied the country (Obst, 1912). They apparently lived entirely by hunting and gathering. However, local incursions by non-Hadza pastoral and agricultural groups are recorded in historic times as early as the 1920's (Woodburn, 1964; McDowell, 1981). Non-Hadza settlement is now heaviest in Mangola and Sipunga.

During the past 50 years, various segments of the Hadza population have been subjected to a series of government- and mission-sponsored settlement schemes designed to encourage them to abandon foraging in favor of full time farming (McDowell, 1981; Ndagala, 1986). Most Hadza now support themselves by a combination of hunting and gathering, farming, and farm labor, the precise mix of strategies pursued varying locally. Some 200 Hadza are essentially full time subsistence foragers. We collected food samples from this latter group.

One hundred thirty four samples of plant components (for example, fruit, seed, quid) from 13 different plants were sampled for compositional analyses. Not analyzed were two major non-plant diet components, honey and meat as well as those foods eaten in negligible amounts. The two plant resources which are most important to the Hadza and used throughout the year, are the tuber Vigna frutescens, and the fruit of the baobab tree, Adansonia digitata.

METHODS

Field Collection Methods

The majority of the samples were collected in the field during two seasons. The first samples were collected from September 1985 through January 1986 which corresponds to the late-dry/early-wet season. All samples were weighed with hanging spring scales, then preserved with a measured amount of methanol. The second set of samples were collected between March and August 1986, which was the late-wet/early-dry season. These samples were weighed, then exposed to the sun for several days to dry, and weighed again. In addition, a few samples of fruits from the baobab, tamarind, Salvadora persica and Cordia trees were collected from September to November 1988. These samples were also preserved by sun drying. All plants were collected during times when the Hadza consume them.

Laboratory Analyses

Analyses of moisture, nitrogen, fat, carbohydrate, fiber, ash and energy were performed on each sample by the Food Research and Development Center, Department of Food Science and Human Nutrition, Colorado State University. All procedures used were from the AOAC (1984). To conduct the constituent analyses, the methanol was distilled off those samples preserved in it before performing the analyses. The moisture content of the field dried samples was determined by weighing an amount of each sample and drying it at 100°C for 24 hours, then cooling and reweighing the sample. Loss in weight was calculated as the residual water remaining after drying in the field. Fat was determined for most samples by extraction of lipids with cholorform in a soxhlet extractor for 16 hours. For the pigmented samples, chloroform extract was passed through activated charcoal to remove most of the pigment from the lipid phase. The nitrogen content of foods was determined by a standard micro-kjeldahl analysis. Protein was calculated from N x 6.25. Fiber was determined by treating the defatted sample with acid and base, and the remaining residue was calculated as fiber. Ash was ascertained by incinerating a weighed sample at 600°C and the residue calculated as ash. Carbohydrate was calculated as the difference between 100 and the sum of moisture, fat, protein, fiber, and ash percentages. Available energy contents were calculated using the commonly accepted energy conversion factors for fat, protein and carbohydrate as 9, 4 and 4 kcal/g, respectively.

The results are expressed on a wet weight (as is) basis. For those samples dried in the field, results were converted back to wet weight by multiplying each constituent by the dry weight fraction. Fat, protein, carbohydrates, fiber and ash were added together and the result was subtracted from 100 to derive wet weight moisture.

An SPSS ANOVA (analysis of variance) was used to look for the effect of treatment (raw vs. roasted) and season on the nutrient and energy content on the tuber Vigna frutescens.

RESULTS

The nutrient and energy contents of the analyzed foods are shown in Table 1 and Table 2. The foods are listed by food type, Latin name and by their Hadza name and plant part.

TABLE 1 HERE

TABLE 2 HERE

Tubers

The tuber, Vigna frutescens, is fibrous, usually leaving a residual quid. Although tubers are occasionally eaten raw, the bulk of the roots are roasted in a high flame fire, then peeled and eaten. Results show (Table 1) that whether raw or roasted, there are no significant differences in nutrient content between the quid and the edible root except for carbohydrate content of the roasted tuber (17.4 g/100 g roasted root, 26.1 g/100 g quid). This difference in carbohydrate content accounted for a significant difference in energy content of the roasted tuber and its quid (80 kcal/100 g vs. 115 kcal/100 g). The quids are not consumed. They remain as a fibrous mass in the mouth after chewing and swallowing the rest of the peeled tuber, and are then spat out. Since this portion is routinely expelled, its consistently higher carbohydrate value is surprising. Our analysis cannot account for rejection of the quid.

Season affected two nutrients (Table 2). Fat content of the fresh tuber is significantly greater in the late-dry/early-wet season (season 1)(2.6 g/100 g) relative to the late-wet/early-dry season (season 2)(0.9 g/100 g). Fiber content is also significantly higher in season 1 than in season 2 in all cases (fresh, fresh quid, roasted, roasted quid). Vincent (1984) analyzed early-dry season samples of roasted V. frutescens and reported a similar energy content (81 kcal/100g) to our season 2 samples (85 kcal/100g) (Table 2).

Whereas, carbohydrate content was almost identical in the two sets of samples (when Vincent's values are figured on a wet weight basis), Vincent's protein content was higher (1.9 g/100 g vs. 0.3 g/100 g this study), and fat content was much lower (0.009 g/100 g vs. 0.9 g/100 g this study).

Of the four other tubers sampled, Eminia antennulifera is the most important to the Hadza after the V. frutescens tuber. This tuber as well as Ipomoea transvaalensis, Coccinea aurentiaca, and Vatovaea pseudolablab are all processed like V. frutescens. As in V. frutescens, results show the tuber and its quid to be similar in composition (Table 1).

Fruit

Besides V. frutescens the other most important plant resource used by the Hadza is the fruit of the baobab, Adansonia digitata. Ripe baobab pods are about 15 cm long, 5 cm in diameter, although size is quite variable. The hard shell is mossy green with a velvety surface and it is sufficiently durable to serve as a water-tight container, or split in half, as a ladle or cup. Inside, the whitish fruit surrounds nuts which are bean shaped and about the size of pistachios. The ripe fruit is dry and powdery and adheres in tight clumps around the nuts. Commonly, the fruit and nut are processed by pounding them together, then winnowing out fragments of the nut's shells until the consistency of flour. Baboon-passed nuts are retrieved from the desiccated droppings left under trees where baboons have fed and slept. The practice is reminiscent of "the second harvest" described by Baegert (1952). Nuts can accumulate in thick carpets where they are collected, then rinsed, ground, and the shell fragments winnowed away. In April, green, unripe baobab pods are exploited by children. The pods are roasted and the fruit and nut are consumed.

Baobab "flour" is very high in fat content and baobab appears to be a *good source* of calories. The energy content of "flour" (fruit and nut) of 403 kcal/100 g is similar to that reported by Lee (1979) (388 kcal/100 g) for baobab. This fruit is second only to the mongongo as an important food plant for the !Kung San. However, baobab contains less than half the calorie content reported for mongongo nut (641 kcal/100 g) and fruit (312 kcal/100 g) (Lee, 1973, 1979).

ie 200g
7 oz

The results for baboon-passed nuts are lower in protein (19.3 g/100 g) and fat (3.1 g/100 g) than those reported for nuts (which were not processed by baboons) analyzed by Arnold et al. (1985) who report (protein 33.7 g/100 g; fat 30.6 g/100 g) for samples from the arid and semi-arid areas of Namibia, Botswana and Angola .

The two most important fruits, excluding baobab are Cordia spp. and Grewia spp. Grewia platycada fruits, besides being consumed fresh, are regularly mixed with water. The skinned berries are kneaded in water and the fruit and seeds discarded after preparation of the broth. G. bicolor fruits, on the other hand, are cooked in water. The berries in broth are usually sucked and spat out. Four other species of berries are analyzed: Vangueria acutiloba, Opilia campestris, Tamarindus indica, and Salvadora persica. Results show that the fruits were analyzed at various stages of moisture content. The Hadza consumed the different fruits most often when these fruits were somewhat dry.

DISCUSSION

The results indicate large standard deviations in nutrient content within some samples. A number of possibilities could account for this variation in nutrient content including seasonality and method of preservation. Methanol can solubilize some nutrients such as carbohydrates and protein which increases the fiber and ash component (Harris and Karmas, 1975). Seasonality can affect the water content and therefore the energy density in foods (Hudson et al., 1980; Norgan et al., 1979). In addition, other factors such as variation in maturity of plant, soil type and temperature can account for nutrient differences within food types.

It is unclear to us why the quids, that portion of the V. frutescens root spat out, is higher is carbohydrate than that portion of the root that is consumed. Perhaps an analysis which distinguished types of carbohydrate would show the quids to have a larger indigestible fraction. What happens to cellulose ... a CH

The results also show that the tubers and fruits available to the Hadza are generally low in nutrient density, the baobab fruit being the exception. High fat and relatively high protein content, make it potentially an important diet item for the Hadza.

These results should be useful for those interested in hunter-gatherer diets and foraging strategies. These analyses of consumed vs. not consumed portions of fresh and cooked foods should reduce error in estimating diet intake as well as return rates for people who consume these foods.

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REFERENCES

Arnold, T.H., M.J. Wells and A.S. Wehmeyer. (1985). Khoisan food plants: taxa with potential for future economic exploitation. In Plants for Arid Lands. George Allen and Unwin, Boston, pp. 69-86.

Association of Official Analytical Chemists. (1984). Official Methods of Analysis. 14th Edition. AOAC, Arlington, VA.

Baegert, J.J. (1952). Observations in Lower California. Translated from the original German with an Introduction and Notes by M.M. Brandenburg and C.L. Baumann, University of California Press, Berkeley.

Bailey, R.C. and R. Aunger, Jr. (1989a). Net hunters vs. archers: variation in women's subsistence strategies in the Ituri Forest. Human Ecol. **17**(3), 273-297.

Bailey, R.C. and R. Aunger, Jr. (1989b). Significance of the social relationships of Efe pygmy men in the Ituri Forest, Zaire. Amer J Physical Anthropology. **78**, 495-507.

Bailey, R.C. and I. DeVore. (1989). Research on the Efe and Lese populations of the Ituri Forest, Zaire. Amer J Physical Anthropology. **78**, 459-471.

FAO. (1988). Traditional Food Plants. A resource book for promoting the exploitation and consumption of food plants in arid, semi-arid and sub-humid lands of Eastern Africa. FAO Food and Nutrition Paper 42. FAO, Rome.

Fleuret, A. (1979). The role of wild foliage plants in the diet. A case study from Lushoto, Tanzania. Ecology of Food Nutr. 8, 87-93.

Galvin, K., and S.K. Waweru. (1987). Variation in the energy and protein content of milk consumed by nomadic pastoralists of northwest Kenya. In A.A.J. Jansen, H.T. Horelli and V.J. Quinn (Eds.), Food and Nutrition in Kenya. A historical review. UNICEF, Nairobi, pp. 129-138.

Harris, R.S., and E. Karmas. (1975). Nutritional Evaluation of Food Processing. 2nd Edition. AVI Publ, Westport, CT.

Hawkes, K. (1987). How much food do foragers need? In M. Harris and E.B.Ross (Eds.), Food and Evolution. Temple University Press, Philadelphia, pp. 341-356.

Hawkes, K, J.F. O'connell, N.G. Blurton Jones. Hunting income patterns among the Hadza: big game, common goods, foraging goals, and the evolution of the human diet. Philosophical Transactions of the Royal Society. (in press).

Hill, K. and K. Hawkes. (1983). Neotropical hunting among the Ache of Eastern Paraguay. In R.B. Hames and W.T. Vickers (Eds.), Adaptive Responses of Native Amazonians. Academic Press, New York, pp. 139-188.

Hitchcock, R.K. (1988). Settlement, seasonality, and subsistence stress among the Tyua of northern Botswana. In R. Huss-Ashmore, J.J. Curry and R.K. Hitchcock (Eds.), Coping with Seasonal Constraints. MASCA Research Papers in Science and Archaeology, Vol. 5. The University Museum, University of Pennsylvania, Philadelphia, pp. 65-85.

Hitchcock, R.K. and A. Osborn (1990). Nutritional and physiological impacts of subsistence strategy shifts among Kalahari San. Paper presented at the Sixth International Conference on Hunting and Gathering Societies. Fairbanks Alaska.

Hudson, G.J., P.M.V. John and A.A. Paul. (1980). Variation in the composition of Gambian foods; the importance of water in relation to energy and protein content. Ecology of Food Nutr. **10**, 9-17.

Lee, R.B. (1973). Mongongo: the ethnography of a major wild food resource. Ecol. Food and Nutrition. **2**, 307-321.

Lee, R.B. (1979). The !Kung San. Men, women, and work in a foraging society. Cambridge University Press, N.Y.

McDowell, W. (1981). A brief history of the Nangola Hadza. Unpublished manuscript prepared for the Rift Valley Project, Ministry of Information and Culture, Division of Research, Dar es Salaam, Tanzania.

Newman, J. (1975). Dimensions of Sandawe diet. Ecol. Food Nutr. **4**, 33-39.

Norgan, N.G., J.V.G.A. Durnin and A. Ferro-Luzzi. (1979). The composition of some New Guinea foods. The Papua New Guinea Agricultural J. **30**(1-3), 25-39.

Obst, E. (1912) Von Mkalama ins Land der Wakindiga. Mitteilungen der Geographischen Gesellschaft in Hamburg. **26**(1): 2-27.

Peters, C.R. and E.M. O'Brien. 1981. The early hominid plant-food niche: insights from an analysis of plant exploitation by Homo, Pan, and Papio in eastern and southern Africa. Current Anthropology, 22(2):127-140.

Schultz, J. (1971). Agrarlandschaftliche Veranderungen in Tanzania (Mbulu/Hanang Districts. Munich, Weltform Verlag.

Smith, L. (1980). Resource survey of Hadza hunter-gatherers. Unpublished manuscript on file, Department of Anthropology, University of Utah.

Vincent, A.S. (1984). Plant foods in savanna environments: a preliminary report of tubers eaten by the Hadza of northern Tanzania. World Archaeology. **17**(2), 131-148.

Woodburn, J.C. (1964). The Social Organisation of the Hadza of North Tanganyika. Unpublished PhD dissertation. University of Cambridge.

Woodburn, J.C. (1968a). An introduction to Hadza ecology. In Lee, R.B. and I. DeVore (Eds.), Man the Hunter. Aldine, Chicago. pp. 49-55.

Woodburn, J.C. (1968b). Stability and flexibility in Hadza residential groupings. In Lee, R.B. and I. DeVore (Eds.), Man the Hunter. Aldine, Chicago. pp. 103-110.

TABLE 1
The composition of northern Tazanian foods.
Values per 100 grams edible portion.

Name, local names and method of preparation	n	Moisture g/100g	Protein g/100g	Fat g/100g	Carbohydrate g/100g	Fiber g/100g	Ash g/100g	Energy kcal/100g
WILD VEGETABLE FOODS								
Tuber *(Vigna frutescens)*, //ekwa								
fresh[1]	6	71.4a*	0.4a	1.8a	17.8a,b	5.4a	3.2a	89a,b
		(6.1)+	(0.1)	(1.2)	(3.4)	(3.6)	(1.6)	(16)
fresh, quid[2]	6	66.8a	0.5a	1.7a	21.6a,b	5.8a	3.6a	104b
		(7.0)	(0.2)	(1.0)	(9.2)	(3.0)	(1.3)	(35)
roasted[3]	28	71.8a	0.4a	0.9b	17.4b	6.0a	3.4a	80b
		(10.2)	(0.2)	(0.4)	(3.5)	(4.0)	(1.8)	(15)
roasted, quid	24	69.3a	0.5a	0.9b	26.1a	6.7a	3.5a	115a
		(12.3)	(0.2)	(0.5)	(12.5)	(3.9)	(1.5)	(52)
Tuber *(Eminia antennulifera)*, makalidako								
fresh	2	69.6	0.3	1.5	14.6	2.6	4.0	73
		(20.3)	(0.0)	(1.4)	(1.3)	(2.4)	(4.7)	(18)
fresh, quid	2	64.8	0.4	1.7	19.5	2.5	4.3	95
		(5.5)	(0.2)	(1.2)	(10.3)	(2.5)	(4.2)	(31)
roasted	4	79.0	0.4	0.8	14.5	3.4	1.9	67
		(5.9)	(0.2)	(0.5)	(3.4)	(4.9)	(2.2)	(11)
roasted, quid	4	68.3	0.5	1.0	23.9	4.0	2.4	107
		(7.9)	(0.1)	(0.3)	(14.1)	(4.4)	(1.9)	(54)
Tuber *(Ipomoea transvaalensis)*, panjuako								
roasted	2	53.8	0.6	1.7	37.4	2.6	3.9	168
		(2.3)	(0.0)	(0.0)	(2.1)	(0.4)	(0.1)	(9)
Tuber *(Coccinea aurantiaca)*, matukwaiako								
roasted	1	55.2	0.3	8.1	31.7	2.4	2.3	201
Tuber *(Vatovaea pseudolablab)*, shumuaako								
fresh	1	55.2	0.19	0.8	41.7	1.2	0.9	175
fresh, quid	1	59.4	0.14	1.1	37.1	1.3	1.0	159
roasted	2	58.2	0.20	1.7	34.6	2.7	2.6	173
		(4.9)	(0.0)	(0.2)	(3.7)	(0.2)	(0.0)	(14)
Fruit, baobab *(Adansonia digitata)*, n//obabe								
dry fruit[4]	4	7.5	0.2	8.2	76.6	2.3	5.3	381
		(0.4)	(0.0)	(1.0)	(1.1)	(0.2)	(0.2)	(5)
"flour[5]"	1	18.3	2.4	29.1	32.7	6.2	11.2	403
baboon-passed[6] nuts	2	27.7	3.1	19.3	31.7	7.7	10.5	313
		(5.6)	(0.2)	(0.7)	(7.3)	(0.7)	(0.2)	(22)
green, unripe, roasted	2	44.7	0.1	7.9	41.7	2.8	2.8	238
		(1.7)	(0.1)	(5.1)	(8.3)	(1.7)	(1.7)	(17)

TABLE 1 (Continued)

Name, local names and method of preparation	n	Moisture g/100g	Protein g/100g	Fat g/100g	Carbohydrate g/100g	Fiber g/100g	Ash g/100g	Energy kcal/100g
Fruit *(Grewia platycada)*, embiribi								
whole fruit	1	10.4	0.3	0.6	81.4	4.4	3.0	332
fruit without seeds	1	16.0	0.2	0.1	76.8	4.1	2.8	309
seeds	1	21.5	0.2	1.0	72.0	2.9	2.4	297
fresh, in water[7]	2	72.4	0.0	0.4	22.9	2.3	2.0	95
fruit and seeds[8]	1	74.8	0.3	1.9	13.9	5.8	3.4	74
Seeds swallowed or not?								
Fruit *(Grewia bicolor)*, kongoro								
whole fruit	3	38.3	0.2	1.4	55.1	3.5	2.7	234
		(8.3)	(0.1)	(0.1)	(1.1)	(1.0)	(0.9)	(12)
fruit without seeds	1	7.0	0.2	0.2	81.0	4.7	5.4	327
seeds	1	28.4	0.1	1.7	60.7	5.2	4.2	259
broth, cooked[9]	1	50.2	0.3	0.0	44.9	2.0	2.5	181
Fruit *(Cordia species)*, ondishi								
whole fruit	5	50.4	0.5	5.3	23.8	4.5	3.2	145
		(5.6)	(0.3)	(2.0)	(11.2)	(1.5)	(1.3)	(27)
fruit and skins, without seeds	1	65.3	0.1	2.0	29.2	1.5	2.0	135
seeds	2	49.3	0.4	3.9	33.5	7.3	5.6	171
		(8.4)	(0.2)	(1.7)	(0.7)	(9.1)	(3.1)	(13)
Fruit *(Vangueria acutiloba)*, mattarobe								
whole fruit	1	16.8	0.3	0.1	74.6	5.0	3.2	301
seeds	1	13.8	0.4	0.4	77.3	5.0	3.2	314
Fruit *(Opilia campestris)*, karahaibi								
whole fruit with seeds[10]	1	59.9	0.8	2.5	24.0	7.4	5.3	122
Fruit (*Tamarindus indica*), muhibe								
fruit without skins and seeds	1	19.6	0.2	0.2	76.7	2.2	1.1	309
Fruit (*Salvadora persica*), tafabe								
fruit without skins and seeds	3	72.5	0.1	0.3	26.3	1.5	0.3	108
		(4.1)	(0.0)	(0.0)	(2.1)	(0.1)	(0.0)	(8)

[1]Peeled and consumed.
[2]Fibrous residue spit out as tuber is consumed.
[3]The tuber is roasted several minutes in a high flame fire, then peeled and eaten.
[4]The pod is cracked and the dry fruit is sucked out.
[5]Fresh fruit with nuts pounded into flour and nut shells removed.
[6]Baboon-passed nuts are those already passed through baboons, ground and the shells winnowed.
[7]Juice produced by kneading the skinned (a loose papery cover) fruit in water, then the fruit and seeds squeezed and discarded.
[8]Discarded fruit and seeds after being kneaded in water.
[9]Broth made from pitted fruit cooked in water. The cooked broth is drunk and the fruit is sucked and discarded.
[10]The skins are removed before consuming.

*Different letters in the same column indicate that the means differed significantly at the $p \leq 0.05$ level as determined by the Student-Newman-Keules procedure (SNK). An analysis of variance was conducted only for *Vigna frutescensens* as the sample sizes were sufficient for statistical analysis.
+Numbers in parentheses are standard deviations

TABLE 2
Composition of *Vigna frutescensens* (tuber).
Values per 100 grams edible portion.

Name, local names and method of preparation	n	Moisture g/100g	Protein g/100g	Fat g/100g	Carbohydrate g/100g	Fiber g/100g	Ash g/100g	Energy kcal/100g
Tuber *(Vigna frutescensens)*, //ekwa								
fresh								
Season 1[1]	3	67.0a*	0.5a	2.6a*	16.4a	8.6a	4.7a	91a
		(1.2)⁺	(0.0)	(1.1)	(0.7)	(0.3)	(0.1)	(13)
Season 2[2]	3	75.8a	0.4a	0.9b	19.1a	2.1b	1.7a	86a
		(5.8)	(0.2)	(0.3)	(4.8)	(0.3)	(0.4)	(22)
fresh, quid								
Season 1	3	69.0a	0.4a	2.3a	14.9a	8.5a	4.6a	82a
		(0.4)	(0.0)	(1.2)	(0.1)	(0.1)	(0.1)	(10)
Season 2	3	64.6a	0.5a	1.2a	28.2a	3.1b	2.5a	126a
		(10.4)	(0.2)	(0.4)	(8.8)	(0.4)	(0.6)	(39)
roasted								
Season 1	17	68.9a	0.5a	1.0a	16.4a	8.6a	4.6a	76a
		(11.2)	(0.2)	(0.5)	(1.2)	(2.7)	(1.0)	(6)
Season 2	11	76.4a	0.3a	0.9a	19.0a	1.8b	1.5a	85a
		(6.5)	(0.1)	(0.3)	(5.2)	(0.7)	(0.5)	(23)
roasted, quid								
Season 1	14	71.5a	0.5a	0.8a	25.3a	9.6a	4.5a	110a
		(12.1)	(0.2)	(0.5)	(14.3)	(2.1)	(0.9)	(58)
Season 2	10	66.3a	0.5a	1.1a	27.3a	2.7b	2.1a	121a
		(12.5)	(0.2)	(0.5)	(10.2)	(1.0)	(0.9)	(45)

*Different letters in the same column indicate the means differed significantly at the $p \leq 0.05$ level as determined by the Student-Newman-Keules procedure (SNK).

⁺Numbers in parentheses are standard deviations

[1]Season 1 is September 1985 through January 1986. This period corresponds to the late-dry/early-wet seasons.

[2]Season 2 is March 1986 through August 1986. This period is the late-wet/early-dry seasons.