Chemical Composition and Starch Hydrolysis of *Acacia colei* and *Acacia tumida* Seeds

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ABSTRACT

Acacia seed is a promising famine food due to its ability to thrive in dry zones of the world. In this study, some chemical compounds of nutritional importance as well as starch hydrolysis in three cultivars of *Acacia tumida* and *A. colei* were determined. The crude protein was 20.6–23.0%, while extractable protein was 11.5–17.5%. Total dietary fiber (TDF) (28.5–32.7%) and soluble dietary fiber (SDF) (2.2–5.8%) were higher than values reported for most legumes. Reducing sugar range was 31.0–54.5 mg/g, while total sugar range was 137–161 mg/g. The starch content of the seed was 25.6–32.3%. The samples did not contain any alkaloid but did contain saponins. Phytate and trypsin inhibitor contents were low; oxalate was fairly high (2.2–2.6 g/100 g), but tannin was on the high side (66.0–86.7 mg/g) compared with legumes. In vitro starch digestibility was highest in *A. tumida* (III). Using a first-order kinetic equation, *A. colei* showed the highest initial rate of starch hydrolysis ($t_{1/2}$ = 411.56 and 1,893.4 min), followed by *A. tumida* (III) (539.25 and 1,738.1 min); the lowest vales were for *A. tumida* (II) (1,764.99 and 4,249.8 min) for both methods of starch digestion.

Hunger, famine, malnutrition, and their attendant diseases are a major concern in the semi-arid Sahelian region of West Africa where rainfall is <600 mm per annum (FAO 1995). In a drought-free year, 150 million Africans are usually malnourished and go hungry, while more than 100 million Africans in this arid region live in a semi-permanent state of starvation (Rinaudo 1992). All this is happening on a continent where food production is going down but population growth is going up (Harrison 1987).

To prevent famine, most especially in the arid regions where crop failure is common, it is imperative to introduce novel foods that can be obtained from drought-resistant crops. Acacia is one of the well-known drought-resistant crops that reportedly thrives in the dry zones of Africa where other crops such as millet, corn, and sorghum have failed (Thomson 1989).

There are over 50 Australian dry-zone *Acacia* species identified as a significant seasonal component of traditional Australian Aboriginal diets (Devitt 1992). Thomson (1989) for example observed heavy seed production of acacia in several Sahelian countries and drew attention to their human food potential. Indeed between 1990 and 1995, over 100,000 *Acacia colei* trees had been planted around Maradi, Niger Republic, alone while *A. tumida* cultivars, supplied by the Australian Tree Seed Centre (ATSC), were tested for suitability of growth and seed yield in Maradi. In 1992, a three-year-old *A. colei* tree growing in a village compound in Maradi produced up to 10 kg of seed (*personal communication,* T. Rinaudo, Director of Maradi Integrated Development Project).

Preliminary studies in our laboratory revealed *A. colei* and *A. tumida* to be rich in protein, unsaturated fatty acids, and vitamins, and balanced in amino acids (Adewusi et al 2003). Insufficient studies before introduction of new foods in the past have caused problems of toxicity and nutritional imbalance (Liener 1980). Therefore it is imperative that a new food be subjected to a thorough investigation for the presence of all suspected toxic compounds before its promotion for human consumption. The present study was designed to investigate cultivar differences in the chemical composition and starch hydrolysis in acacia seeds. This will provide information on whether or not it is advisable to incorporate these seeds into the traditional diets of people living in famine-prone regions of Africa.

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MATERIALS AND METHODS

Seed-lots of *A. colei* and three cultivars of the desert shrub form of *A. tumida* v. kulpurn (Leguminoseae: Mimosoideae) (McDonald 2003) identified by native location of collection and accession number (Broome. 18653, Pt Hedland. 17964, and Tanami. 18646) were supplied by ATSC. The seeds were planted in Maradi, Niger Republic, and the produce harvested by T. Rinaudo, Director of Maradi Integrated Development Project (MIDP) of the Sudan Interior Mission International (SIM). The harvested seeds provided for these experiments were cleaned by removing stones, fragments of wood, and resinous matter by hand and then milled in a local mill.

The milled *A. colei* and *A. tumida* seeds were sieved to remove the coarser fragments of the seed coat as is the custom of Maradi people. The products obtained are referred to as sieved *A. colei* and *A. tumida* I, II, and III for Broome. 18653, Pt Hedland. 17964, and Tanami. 18646, respectively. All the samples were stored in plastic containers and refrigerated.

The moisture content and ether extract of triplicate seed samples were determined by the AOAC (1984) procedure. Nitrogen was determined on dry weight basis by the micro-Kjeldahl method, and crude protein was estimated as N × 6.25. Extractable protein was determined by both the colorimetric and precipitation methods.

Protein was extracted from 1.0-g samples as described by Murray and McGee (1986). The protein content of 0.1 mL of the extract was precipitated by 80% ethanol, and the precipitate was redissolved in 4.0 mL of 0.25*M* NaOH. Protein was then determined by the biuret method using 2.0 mg/mL of bovine serum albumin as a standard.

Precipitation was performed as described earlier (Adewusi et al 2003). Seed flour (10 g) was suspended in water in a 1:10 (w/v) ratio and adjusted to pH 8.0. The suspension was heated at 62°C for 1 hr in water bath with occasional shaking. This was cooled and centrifuged at 4,000 rpm for 30 min. The supernatant was adjusted to pH 4.0 and left overnight in the refrigerator to precipitate the protein. The isolated protein was centrifuged, dried at 50°C, milled, and used for nitrogen determination by the micro-Kjeldahl method.

Determination of Carbohydrate Components

Dietary fiber was determined by the gravimetric method of Lee et al (1992) using a combination of three enzymes (heat-stable α-amylase, protease solution, and amyloglucosidase solution) for the digestion. Soluble sugar was extracted three times from 2-g samples with 80% ethanol using a Soxhlet extractor and refluxed for 2 hr as described by Bainbridge et al (1996). Reducing sugar

was determined from the ethanolic extract by the ferricyanide method (Approved Method 80-60, AACC International 2000). Extract (2 mL) was added to 8.0 mL of the ferricyanide reagent and the absorbance read at 380 nm using glucose as the standard. Total sugar was estimated by the modified anthrone method (Cerning-Beroard 1975): 2.0 mL of extract was added to 0.5 mL of 2% (w/v) anthrone in ethyl acetate and the absorbance was read at 620 nm with glucose as the standard. The starch content of the samples was determined on 200 mg of residue of the ethanolic extract obtained above by refluxing the sample with 0.7*M* HCl for 2.5 hr (AOAC 1984). The acid hydrolysate was neutralized, made up to volume in a 500-mL standard flask with distilled water and then filtered through a Whatman no. 541 filter paper. The starch in the original sample was then determined as reducing sugar, using the ferricyanide method described above. The reducing sugar was then converted to starch content using the AOAC (1984) equation.

In vitro starch hydrolysis of the samples was conducted as described by Adewusi et al (1991a). Each sample (250 mg) was added to 10 mL of 0.2*M* phosphate buffer (pH 6.9), followed by 20 mg of pancreatic amylase (Sigma-type VIA) in 50 mL of the same phosphate buffer. The mixture was incubated at 37°C with shaking and allowed to settle for 3 min before 1.0-mL aliquots were withdrawn at intervals and added to 2.0 mL of dinitrosalicylic acid reagent (1% dinitrosalicylic acid reagent, 0.2% phenol, 0.1% sodium hydrosulphite, and 1% NaOH) (Miller 1959). The mixture was shaken and heated in boiling water for 5 min, diluted to 25 mL, and the absorbance was read at 550 nm against a blank containing buffer, enzyme, and dinitrosalicylic acid reagent.

In vitro starch hydrolysis of the samples was also determined as described by Bravo (1998) but with some modification. Sample (250 mg) was added to 20 mL of distilled water in a beaker and heated at 100°C for 20 min. The cooked sample was homogenized with 20 mL of HCl-KCl buffer (pH 1.5) using a basic homogenizer (Kika Labortechnik T25, Janke and Kunkel GmbH & Co., Staufen, Germany) at 9,500 rpm for 1 min. The homogenate was digested with 20 mg of pepsin (1.0 g of pepsin/10 mL of HCl-KCl buffer) for 2 hr. It was then adjusted to pH 6.9 after the addition of Tris maleate buffer and the suspension was transferred into a 50-mL standard flask with 2.6 IU of α-amylase in 5 mL of Tris maleate and then made up to the mark with distilled water. The samples were incubated at 37°C in a shaking water bath and 1.0-mL aliquots withdrawn at 30-min intervals, placed into a 25-mL standard flask, and shaken vigorously at 100°C for 5 min to inactivate the enzyme. The digested starch was then fully hydrolyzed with amyloglucosidase. Glucose was determined using dinitrosalicylic acid as described above. Distilled water was taken through the same process for the blank.

Phytochemical Screening for Alkaloids and Saponins

The methods of Odebiyi and Sofowora (1978) were used for the qualitative screening of samples for the presence of alkaloids and saponins. The presence of alkaloids was tested by Dragendorff's reagents, 10% (w/v) tannic acid, and saturated picric acid solution, while saponin was tested by the frothing method.

Antinutritional Factors

Trypsin inhibitor was determined by the method of Kakade et al (1974) as modified by Adewusi and Osuntogun (1991). Each sample (0.2 g) was extracted with 10 mL of 0.01*M* NaOH for 1 hr, centrifuged at 4,000 × *g* for 30 min and diluted 10-fold. Different aliquots of this extract were added to 5 mL of benzoyl-DL-arginine-*p*-nitroanilide hydrochloride (BAPNA) solution for hydrolysis with 2 mL of 0.2 mg of trypsin/mL (Sigma Type II) in 0.0001*M* HCl serving as the standard. The reaction was stopped after 10 min with 1.0 mL of 30% acetic acid; absorbance was read at 410 nm. The modified vanillin-hydrochloric acid (MV-HCl) method of Price et al (1978) was used for tannin determination using catechin as the standard. Phytate was determined by the anion-exchange method (Harland and Oberleas 1986). Each sample (2.0 g) was extracted with 2.4% HCl for 3 hr. Extract (1.0 mL) was added to Na_2EDTA-NaOH reagent and transferred onto an Ag 1–X 4, 100–200 mesh column. The column was eluted with 0.7*M* HCl after a preliminary clean up with lower concentrations of NaCl, collected into a Kjeldahl digestion flask, and digested with a mixture of 0.5 mL of conc. H_2SO_4 and 3.0 mL of conc. HNO_3 for 1 hr. The digestate was transferred into a 50-mL standard flask; reagents (2.0 mL of ammonium molybdate and 1.0 mL of sulfonic acid) were added and made up to volume with distilled water and absorbance read at 640 nm. KH_2PO_4 solution (80 μg/mL) was used as the standard. Oxalate was estimated by the method of Oke (1966) as modified by Falade et al (2004). Sample (2.0 g) was extracted with 190 mL of distilled water plus 10 mL of 6*M* HCl in boiling water for 2 hr, filtered, and made up to 250 mL with water. An aliquot (50 mL) with 10 mL of 6*M* HCl was filtered. The filtrate was titrated against NH_4OH until the salmon pink color of the methyl red indicator changed to a faint yellow. The solution was heated to 90°C and 10 mL of $CaCl_2$ solution was added to precipitate the oxalate overnight. The precipitate was washed free of calcium and then washed into a 100-mL conical flask with 10 mL of hot H_2SO_4 (25%, v/v) and then with 15 mL of distilled water. The final solution was heated to 90°C and titrated against a standardized 0.05*M* $KMnO_4$ until a faint purple color of the solution persisted for 30 sec. The oxalate was then calculated as the sodium oxalate equivalent.

Statistical Analysis

The results were expressed as a mean of three determinations. Data were subjected to one-way analysis of variance and the correlation analysis by using GraphPad InStat v. 3.06 for Windows 2003. The Graphpad InStat computer program was also used to compare the means of the two methods used for the analysis of total sugar and in vitro starch hydrolysis.

RESULTS AND DISCUSSION

The results presented in Table I revealed all the samples to be low in moisture content. This is similar to earlier reports (Harwood 1994), which could account for the high keeping quality of these seeds. Crude protein did not vary significantly between sieved *A. colei* and two of the cultivars of *A. tumida* (I and III). The value for crude protein obtained in this study was within 21–34% reported for cowpea (Adewusi and Falade 1996). This shows that acacia seeds can compete favorably and replace cowpea as a source of protein in the diets of the people of the arid zone of Africa. Crude protein for the three cultivars of *A. tumida* agreed favorably with 23.8% reported for *A. cowleana*, another closely related species, and *A. leucophloea*, a seed being assessed in India as human food (Vijayakumari et al 1994).

The crude protein of *A. tumida* seeds obtained directly from Australia reported earlier (Adewusi et al 2003) was, however, significantly higher than the values now reported for *A. tumida* samples, while the value (17.6%) reported by Brand and Maggiore (1992) for *A. tumida* samples also collected in Australia was lower than in the present report.

Extractable protein determined by the colorimetric method (11.5–12.6%) for the cultivars of *A. tumida* was lower than the value recorded for *A. tumida* obtained from Australia (Adewusi et al 2003). Because solubilization of the protein is a crucial step in its determination, any variation as a result of storage would definitely affect the result, but it is also possible that the variation could be due to cultivar differences. The lower extractable protein content of these acacia seeds compared with their crude protein content implies the presence of nonprotein nitrogen in these seeds. This is in agreement with the observation of Murray and McGee (1986) and our earlier results (Adewusi et al 2003).

Ether extract was 7.7–10.5% among the three cultivars of *A. tumida.* The values now reported for *A. tumida* (I) and (III) are not significantly different ($P < 0.05$) from the value reported earlier for *A. tumida* (Adewusi et al 2003) but were significantly different ($P < 0.05$) from *A. tumida* (II). The range of ether extract values obtained in this study was within the 7.8–10.2% values reported for different varieties of *A. coriacea* (Brand et al 1985) but higher than 6.4% reported for *A. tumida* (Brand and Maggiore 1992).

Total dietary fiber (TDF) content was 28.5–32.7% for *A. tumida* samples. This range was significantly different ($P < 0.05$) from the 41.2% reported earlier for *A. tumida* collected from Australia (Adewusi et al 2003) but higher than 12.2–19.9% reported for maize (Bressani et al 1989), which means that the inclusion of acacia into the diets prepared with maize will increase the level of the dietary fiber intake of Maradi people. No significant difference ($P < 0.05$) was observed in the insoluble dietary fiber (IDF) content of the three cultivars of *A. tumida* from Maradi. The value reported here for *A. tumida* (II) and (III) agreed favorably with 34.5% reported for *A. holosericea* (Brand and Maggiore 1992). The values of soluble dietary fiber (SDF) reported in this study for the three cultivars of *A. tumida* was higher than 1.4% and 1.14–1.64% reported for cowpea and maize, respectively (Bressani et al 1989; Adewusi and Falade 1996). This result indicates that the incorporation of acacia seeds into human diets would increase the level of soluble fiber intake. Soluble fiber decreases postprandial glucose and insulin concentrations (Mayer et al 2000), thus the incorporation of acacia seeds into the diets of diabetic patients could be of tremendous benefit.

The carbohydrate content of the acacia seeds is presented in Table II. The reducing sugar range was 31.0–54.5 mg/g. This is higher than the 17–24 mg/g range reported for some varieties of cowpea that were used as models in protein-reducing sugar interaction (Adewusi et al 1991b). The total sugar content determined by the ferricyanide method was 139.6–154.3 mg/g, while total sugar (anthrone method) was 137.5–161.4 mg/g. Both values fit within the range of 87–167 mg/g reported for legumes (Adewusi and Falade 1996) and the values now reported for *A. tumida* compared well with the 146 mg/g value reported earlier for A. *tumida* obtained from Australia (Adewusi et al 2003). Taste is partially determined by the amount of total sugar present thus replacing the traditional sources of carbohydrates with acacia may not drastically alter the taste of the modified diet of the people of the arid zone. Our findings during the human trial experiment (reported elsewhere) revealed that *A. colei* is sweet to taste and the indigenous people of Maradi were willing to include it in their local recipes. When the two methods for total sugar determination were compared by subjecting data to the *t*-test, there was no significant difference ($P = 0.36$) between the two methods. The starch content (Table II) was 281.8–323.4 mg/g for *A. colei* and *A. tumida*, respectively. This range is lower than the 695 mg/g reported for sorghum (Jambunathan and Subramanian 1988), which is one of the staple foods in Maradi.

The result of in vitro hydrolysis of the acacia starch is presented in Table III and Fig. 1 for the first method employing the pancreatic amylase without prior pepsin digestion, which is fast but suffers from the criticism that it may not represent the in vivo condition. The results presented in Table IV and Fig. 2 represent the second method with initial homogenization, pepsin, α-amylase, and finally amyloglucosidase digestion. The latter method was more cumbersome and expensive but gave better color intensity than the first method. However, both methods gave similar results though the quantitative results differed. When the mean values ($t_{1/2}$) of the two methods of starch hydrolysis were compared, there was no significant difference ($P = 0.64$) between the two methods. The highest reducing sugar level was recorded for *A. tumida* (III), followed by *A. colei*, and closely followed by *A.*

TABLE I
Chemical Composition of Acacia Seeds (% dwb)[a,b]

	A. colei Sieved	*A. tumida* (I)	*A. tumida* (II)	*A. tumida* (III)
Moisture	6.4 ± 0.3b	7.2 ± 0.1a	7.8 ± 0.4a	7.4 ± 0.5a
Crude protein	22.3 ± 0.2c	22.6 ± 0.4ac	20.6 ± 0.4c	23.0 ± 0.6a
True protein				
Colorimetric method	17.5 ± 0.3a	12.4 ± 1.2b	11.5 ± 0.9b	12.6 ± 0.7b
pH 8 (ppt)	4.8 ± 0.1a	5.1 ± 0.6a	4.9 ± 0.2a	5.2 ± 0.5a
pH 10 (ppt)	13.8 ± 0.2a	7.7 ± 0.5c	7.0 ± 0.1c	8.1 ± 0.9b
Ether extract	11.9 ± 0.5a	7.8 ± 0.1c	10.5 ± 0.5b	7.7 ± 0.06c
IDF[c]	23.7 ± 1.0a	26.9 ± 2.1b	26.3 ± 0.7b	26.1 ± 0.5b
SDF[c]	5.4 ± 0.9a	5.8 ± 0.6a	2.2 ± 0.4b	3.2 ± 0.4c
TDF[c] (as is)	29.5 ± 1.6a	32.7 ± 1.3be	28.5 ± 0.8a	29.2 ± 0.3a
Tannins[d] (mg/g)	86.7 ± 1.2a	80.3 ± 6.4b	83.0 ± 7.6b	66.0 ± 5.7c
Phytates[d] (mg/g)	0.09 ± 0.02a	0.03 ± 0.00b	0.03 ± 0.00b	0.04 ± 0.02b
Trypsin inhibitor[e] (TIU/g)	23	24.5	19	18
Oxalate[f] (g/100 g)	2.4 ± 0.2a	2.3 ± 0.1a	2.2 ± 0.2a	2.6 ± 0.2a

[a] Mean and standard deviation of 3–5 replicates. Values followed by the same letter in the same row are not significantly different ($P < 0.01$).
[b] *A. tumida* (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964 and *A. tumida* (III) = Tanami. 18646.
[c] IDF, insoluble dietary fiber; SDF, soluble dietary fiber; TDF, total dietary fiber.
[d] Mean ± SD of three determinations.
[e] Mean of two determinations.
[f] Mean ± SD of quadruplicate analysis.

TABLE II
Carbohydrate Content of Acacia Seeds (g/kg, dwb)[a,b]

		Total Sugar		
Sample[c]	Reducing Sugar	Ferricyanide Method	Anthrone Method	Starch
A. tumida (I)	54.5 ± 0.5a	148.4 ± 1.0ab	149.2 ± 0.1a–c	323.4 ± 5.6a
A. tumida (II)	38.7 ± 1.4ab	149.3 ± 1.3ab	155.3 ± 0.5a–c	304.6 ± 1.1ab
A. tumida (III)	31.0 ± 0.1b	154.3 ± 0.6a	161.4 ± 0.7a–c	281.8 ± 0.7ab
A. colei	34.1 ± 0.2ab	139.6 ± 0.8b	137.5 ± 2.0ab	255.9 ± 5.6b

[a] Values are mean ± SD of quadruplicate analysis.
[b] Values followed by the same letter in the same column are not significantly different ($P < 0.01$).
[c] *A. tumida* (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964, and *A. tumida* (III) = Tanami. 18646.

tumida (I); *A. tumida* (II) gave the least value during in vitro starch digestibility.

When first-order kinetics (Rosenthal and Nasset 1958) was applied to Figs. 1 and 2, the half-life of *A. colei* within the first 30 min was the lowest (411.56 and 1,893.4 min, for Figs. 1 and 2, respectively) showing the highest level of starch digestion, followed by *A. tumida* (III) (539.25 and 1,738.1 min). The sample with the highest half-life (1,764.99 and 4,249.8 min), hence the least digested, was *A. tumida* (II) (Tables III and IV). The reason for the difference in the observed α-amylolysis of these acacia seeds (Figs. 1 and 2) is not clear but it could be due in part to the content and nature of the dietary fiber. High negative correlation (r = –0.64, $P < 0.05$) was observed between soluble fiber and half-life, while a low correlation was observed between half-life and total and insoluble fiber (r = –0.33 and +0.33; $P < 0.05$), respectively. A low correlation factor (r = 0.38; $P < 0.05$) was obtained between tannin content and half-life, indicating that tannin may not significantly interfere with the rate of starch hydrolysis. Tannin was reported to bind to protein and hence impair protein digestibility (Adewusi and Osuntogun 1991), but its effect on carbohydrate digestive enzymes is yet to be documented. The rate of the release of maltose from all the acacia samples was lower than in cereals (Adewusi et al 1991a) and in wheat flour used as control in this study. This could be of advantage to diabetic patients because incorporating acacia seed into their diets could reduce the level of blood sugar. Fakoya et al (1997) observed a reduction in the glycemic response when soluble fiber (xanthan gum) was included in the diets of healthy subjects. This is in agreement with the high negative correlation observed between half-life and soluble fiber in this study.

The samples did not seem to contain alkaloids but were positive to the saponin test. Saponin has been reported to impair iron absorption (Price et al 1989) and to form complexes with cholesterol, which is then excreted from the body (Jacobberger 2001). Saponin also suppresses alcohol absorption by slowing gastric emptying and by inhibiting absorption across the cell membranes of the digestive tract (Tsukamoto 1993). Trypsin inhibitor activity was 18–24.5 TIU/g (Table I). One of the three cultivars of *Acacia tumida* was significantly higher than the remaining two samples, but it was not significantly different from sieved *A. colei*. Trypsin inhibitor in these acacia samples was low when compared with the 15,000–23,000 TIU/g and 6,700–23,300 TIU/g ranges reported for *Phaseolus vulgaris* and cowpea, respectively (Elias et al 1979; Adewusi and Osuntogun 1991), and is therefore not likely to pose any problem in their utilization for foods.

Tannin content for acacia (Table I) was 66.0–86.7 mg/g. *A. colei* seed is particularly small with a hard seed coat that represents ≈70% of the total seed mass. Thus milling was the only method of processing, and contamination of the final food product with high tannin seed coat was inevitable. *A. tumida* seeds were at least four times bigger than those of *A. colei* and with a lighter seed coat. The preference for *A. tumida* on this basis actually informed this

TABLE III
Rate Constant and Half-Life Values of Starch Hydrolysis in Acacia Seeds

Sample[a]	t_1 (min)	t_0 (min)	t (min)	K/10^4 min^{-1}	$t_{½}$ (min)
A. tumida (I)	30	0	30	3.118	2,222.7
	60	30	30	1.716	4,038.5
	90	30	60	0.313	22,125.9
	180	30	150	0.406	22,125.9
	210	30	180	0.314	22,084.3
A. tumida (II)	30	0	30	1.631	4,249.8
	90	30	60	1.021	6,787.5
	180	30	150	0.411	16,850.4
	210	30	180	0.323	21,488.1
A. tumida (III)	30	0	30	3.987	1,738.1
	90	30	60	2.486	2,787.6
	180	30	150	0.984	7,041.4
	210	30	180	0.769	9,007.2
A. colei	30	0	30	3.660	1,893.4
	90	30	60	1.401	4,946.1
	180	30	150	0.861	8,050.0
	210	30	180	0.359	19,306.1

[a] *A. tumida* (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964, and *A. tumida* (III) = Tanami. 18646.

TABLE IV
Rate Constant and Half-Life Values of Starch Hydrolysis (pepsin, α-amylase, and amyloglucosidase) in Acacia Seeds

Sample[a]	t_1 (min)	t_0 (min)	t (min)	K/10^4 min^{-1}	$t_{½}$ (min)
A. tumida (I)	30	0	30	7.402	936.3
	60	30	30	2.195	3,156.8
	90	30	60	1.046	6,624.1
	180	30	150	0.418	16,560.3
A. tumida (II)	30	0	30	3.926	1,764.9
	60	30	30	0.733	9,458.1
	120	60	60	0.355	19,504.4
	180	30	150	0.291	23,783.9
A. tumida (III)	30	0	30	12.851	5,39.3
	90	30	60	1.878	3,690.4
	180	30	150	0.993	6,976.6
A. colei	30	0	30	16.838	411.6
	60	30	30	1.036	6,689.9
	180	30	150	0.212	32,765.4
Wheat flour	30	0	30	25.188	275.1
	90	30	60	6.881	1007.2
	180	30	150	3.530	1963.1

[a] *A. tumida* (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964, and *A. tumida* (III) = Tanami. 18646.

investigation. Cultivar difference was noticed in the tannin content of the three *A. tumida* seeds (Maradi). Tannin content reported in this study was higher than the 0.9–3.9 mg/g reported for some Nigerian legumes (Adewusi and Falade 1996). Judging from the high levels of this antinutritional factor in acacia seeds, tannin is likely to play a vital role in the protein nutriture of these seeds.

The phytate content was very low in acacia samples (0.03–0.1 mg/g) with no significant cultivar difference (Table I); this was lower than the range reported for other acacia seeds thus far investigated (Aganga et al 1998, 2001) and may not likely play a significant role in the nutritive value of the acacia samples in this study. The level of phytate in acacia was also lower than the 1.7–3.8 mg/g value reported for sorghum (Doherty et al 1982), which acacia is targeted to replace.

The oxalate content (Table I) was fairly high (2.17–2.39 g/100 g) compared with some Nigerian vegetables (Falade et al 2004) and within the 0.67 and 3.5 g/100 g range reported for soybean, a corresponding legume (Massey et al 2001). Oxalate has been implicated as a source of kidney stones (Curhan et al 1997; Chai and Liebman 2004) but is not likely to pose any danger in acacia when compared with 10.2 g/100 g and 32.6 g/100 g levels reported for cabbage and sweet potato respectively (Santamaria et al 1999).

In conclusion, the chemical composition of these acacia seeds revealed the seeds to be nutritious. Incorporating these seeds into the diets of people from drought-stricken parts of Africa would go a long way to improve their nutrition status.

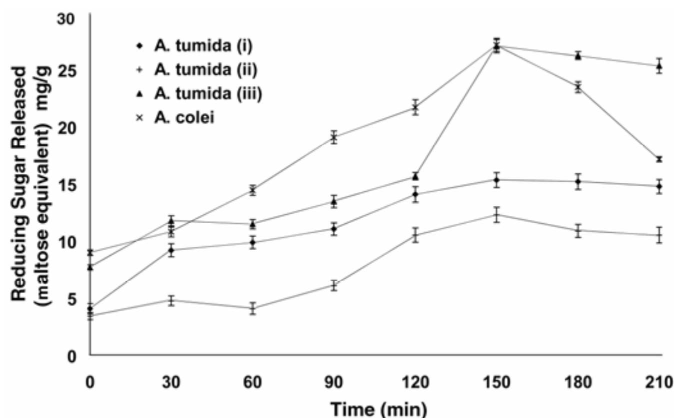

Fig. 1. In vitro starch digestibility of acacia seeds. *Acacia tumida* (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964, and *A. tumida* (III) = Tanami. 18646.

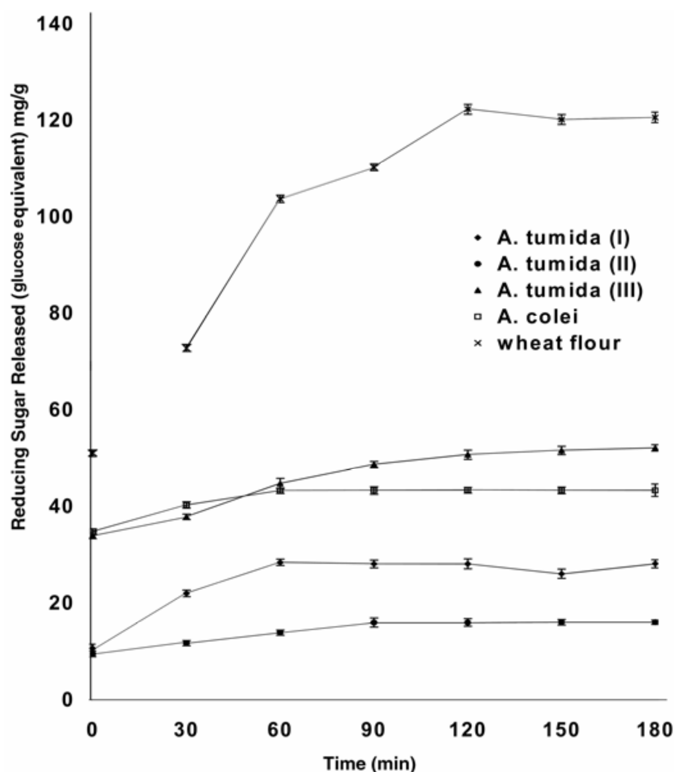

Fig. 2. In vitro starch digestibility (pepsin, α-amylase, and amyloglucosidase) of acacia seeds. *Acacia tumida* (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964, and *A. tumida* (III) = Tanami. 18646.

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