

PhytoTrade

SUMMARY REPORT:

**Nutritional Evaluation of Baobab Dried Fruit Pulp
and its Potential Health Benefits**

AFRICA

Prepared by Leatherhead Food Research for
PhytoTrade Africa

July 2009



Background

Notice to reader: The data presented in this report may be used to develop product marketing claims, but it should be noted that marketing claims need to fulfil specific claim requirements in each country where they are being made - for which neither Leatherhead Foods Research nor PhytoTrade Africa can be held responsible. For more information please contact info@phytotradeafrica.com.

Baobab (*Adansonia digitata*) is a deciduous tree, coming mainly from Africa . The name of Baobab is derived from the Arabic word *buhibab* meaning “fruit with multiple seeds” but it is also known as bottle tree, upside down tree, monkey bread and chemist tree.

The leaves, bark and fruit are used for food and medicinal purposes. The bark has astringent properties and has been used to alleviate colds, fevers, and influenza, The wood and the seeds of the tree are thought to have anti-inflammatory properties.. The leaves may be used as an antiperspirant, and have also been used in treating kidney and bladder diseases, asthma and diarrhoea ⁽¹⁻⁵⁾.

The nutrients are found mainly in the fruit. The pulp is found within a very hard outer capsule (epicarp). The internal fruit or endocarp, is divided into small floury, dehydrated slices that contain seeds and filaments, ⁽⁶⁾. The ripe fruit is naturally dry and powdery. It has a slightly acidic taste since it contains organic acids (citric, tartaric, malic and succinic) ⁽⁷⁾. Published research has shown that Baobab fruit pulp is an excellent source of vitamin C, calcium and also pectin. Based on its nutritional value and consequent potential health benefits, interest in applications of Baobab in food products has recently increased ⁽¹⁾.

Results

Nutritional Composition of Baobab Dried Fruit Pulp

Baobab dried fruit pulp provides a variety of important nutrients including vitamins, minerals and amino acids. The fruit pulp has been reported to contain sugars but no starch, to be rich in pectins and vitamin C ⁽¹⁾.

The dried Baobab fruit pulp contains levels of vitamin C ranging from 74 - 163mg/100g and pectins 23.4 - 33.8mg/100g ⁽⁸⁾ depending on varieties and geographical location. It is also regarded as a good source of calcium and a source of iron ⁽⁹⁾. Table 1 lists the major nutrients present in the dried fruit pulp of Baobab.

Table 1: Nutritional Composition of Baobab Dried Fruit Pulp*

Macronutrients (g/100g)	
Protein	2.04 - 3.24
Fat	0.4 - 0.70
Total carbohydrate	78.3 - 78.90
Total sugars (as glucose)	16.9 - 25.30
Total dietary fibre	45.8 - 53.90
Pectin	23.4 - 33.80
Ash	5.5 - 6.60
Micronutrients (mg/100g)	
Sodium	7.00 - 31.10
Potassium	2010.00 - 2390.00
Calcium	257.00 - 370.00
Magnesium	126.00 - 179.00
Phosphorus	56.10 - 73.30
Iron	3.95 - 9.13
Copper	0.53 - 0.75
Zinc	0.70 - 1.02
Manganese	0.65 - 1.30
Vitamins (mg/100g)	
Vitamin C	74.00 - 163.00
Thiamin	0.01 - 0.09
Riboflavin	0.01 - 0.03

• Data provided by PhytoTrade Africa

Nutritional Differentiation between Baobab and Selected Fruits

The nutritional value of Baobab has been compared with selected dehydrated fruits, as these are more appropriate comparison for Baobab than fresh fruits.

Macronutrients

Table 2 compares the macronutrient content of Baobab dried fruit pulp with other dehydrated fruits. The Baobab dried fruit pulp has very low calorific value compared to other selected dehydrated fruit pulps (^{8; 10}) and it contains the lowest level of fat and total carbohydrates on a g/100g basis.

Table 2: Comparison of Macronutrients of Baobab Dried Fruit Pulp with other Dehydrated Fruits

Fruit	Moisture Content	Energy (kcal/100g)	Protein (g/100g)	Fat (g/100g)	Carbohydrate (g/100g)	Fibre (g/100g)
Baobab ^{1,*}	12.4%	127	2.68	0.52	78.52	50.57
Apples ^{2,3,4,**}	3.0%	346	1.32	0.58	93.53	4.09
Apricots ^{2,3,4,**}	7.5%	320	4.90	0.62	82.89	3.96
Bananas ^{2,**}	3.0%	346	3.89	1.81	88.28	1.88
Peaches ^{2,3,4,**}	7.5%	325	4.89	1.03	83.18	3.97

¹dried pulp, ²dehydrated (low-moisture), ³sulphured, ⁴uncooked * (⁸), ** (¹⁰)

The Baobab fruit is relatively low in protein, when compared with other dehydrated fruits but data provided by PhytoTrade Africa showed that Baobab dried fruit pulp contains all essential and non-essential amino acids. Compared to other dehydrated fruits, Baobab contains slightly higher amounts of cystine and serine, although the amino acid composition of all fruits does not differ significantly (Tables 3 and 4) ⁽¹⁰⁾.

Table 3 : Essential Amino Acids of Baobab Dried Fruit Pulp and other Dehydrated Fruits

Fruit (g/100g)	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Tryptophan	Valine
Baobab ^{1,*}	0.086	0.160	0.128	0.033	0.145	0.150	0.040	0.117
Apples ^{2,3,4,**}	0.052	0.081	0.082	0.013	0.037	0.047	0.012	0.061
Apricots ^{2,3,4,**}	0.151	0.288	0.339	0.024	0.203	0.176	0.087	0.179
Bananas ^{2,**}	0.167	0.359	0.162	0.074	0.201	0.167	0.171	0.282
Peaches ^{2,3,4,**}	0.141	0.277	0.157	0.118	0.154	0.192	0.014	0.267

¹dried pulp, ²dehydrated (low-moisture), ³sulphured, ⁴uncooked * ⁽⁸⁾, ** ⁽¹⁰⁾

Table 4 : Non-essential Amino Acids of Baobab Dried Fruit Pulp and other Dehydrated Fruits

Fruit (g/100g)	Alanine	Arginine	Aspartic Acid	Cystine	Glutamic Acid	Glycine	Histidine	Proline	Serine	Tyrosine
Baobab ^{1,*}	0.163	0.120	0.268	0.073	0.347	0.157	0.067	0.202	0.298	0.088
Apples ^{2,3,4,**}	0.047	0.042	0.230	0.018	0.137	0.052	0.021	0.045	0.054	0.025
Apricots ^{2,3,4,**}	0.241	0.190	1.122	0.016	0.495	0.151	0.081	0.293	0.281	0.114
Bananas ^{2,**}	0.222	0.176	0.503	0.063	0.399	0.190	0.333	0.229	0.226	0.121
Peaches ^{2,3,4,**}	0.292	0.124	0.817	0.040	0.743	0.171	0.091	0.206	0.226	0.128

¹dried pulp, ²dehydrated (low-moisture), ³sulphured, ⁴uncooked * ⁽⁸⁾, ** ⁽¹⁰⁾

In terms of carbohydrates, Baobab dried fruit pulp contains 16.9-25.3g/100g of available carbohydrates which is low compared with other dehydrated fruits, such as apricots, apples and peaches. The Glycaemic Index (GI) of a product is affected to some extent by the level of available carbohydrate in a product. Most fruits, whether raw or dehydrated are low GI (under 55) (Table 5). No data is available on the GI of Baobab or Baobab-containing food products.

Table 5: Available Carbohydrate Content of Baobab Dried Fruit Pulp and other Fruits

Fruit		Available Sugars (g/100g)	GI***
Baobab	Raw	-	-
	Dried*	16.9 – 25.30	-
Apples	Raw**	11.4	32
	Dried	55.4	29
Apricots	Raw**	8.54	34
	Dried**	47.9	31
Peaches	Raw**	8.89	28-57
	Dried	53.2	35

* ⁽⁸⁾, ** ⁽¹¹⁾, *** ⁽¹²⁾

Baobab dried fruit pulp is high in dietary fibre and is much higher than other dehydrated fruits containing 50.57g/100g compared with only 1.88g/100g in dried banana and 3.96g/100g in dried apricots. (Table 2) ^(8; 10). Baobab dried fruit pulp contains a high level of pectin ranging from 23.4 to 30.00 g/100g ⁽⁸⁾. This indigestible soluble fibre is well known in the food industry as a gelling or thickening agent and stabilizer in food. Soluble fibre is also of interest in relation to its' role in reduction of total and LDL cholesterol. Baobab is high in pectin and work suggests that water soluble fibre from pectin can reduce total and LDL cholesterol, with a meta analysis by Brown *et al.* suggesting that each gram of water soluble fibre from pectin decreases total and LDL cholesterol by -0.070 mmol/L and 0.055 mmol/L, respectively ⁽¹³⁾. Additionally, there is growing interest in this polysaccharide in the pharmaceutical industry for its application as a controlled release drug delivery system ⁽¹⁴⁾.

Recently interest has focused on the potential gut health benefits associated with pectin. It has been shown that pectin exhibits bioactive health-promoting properties in the gastrointestinal tract. This polysaccharide has been found to have a potential as a prebiotic, as it enhances the growth of probiotic bacteria in the large intestine ^(15; 16). Research has also shown that pectin prevents pathogenic bacteria from binding to the intestinal wall and that it chelates heavy metals which are then eliminated by urinary excretion ^(15; 16).

Micronutrients

Minerals and Trace Elements

It is rare for calcium to be found in large quantities in fruit and vegetables. Baobab dried fruit pulp contains impressive amounts of this micronutrient ranging from 257 to 370 mg/100g ⁽⁸⁾. This is lower than some other good dietary sources of calcium, for example, dried skimmed milk (960-1890 mg/100g) ⁽¹¹⁾ but is much higher than in other fruit and vegetables ⁽¹⁷⁾. Baobab contains 4 times the amount of calcium found in dehydrated apricots and 13 times that of dehydrated apples (Table 6) ⁽¹⁰⁾.

As shown in Table 6, Baobab dried fruit pulp also has the highest concentration of potassium, magnesium, copper and manganese amongst the selected dehydrated fruits and the second highest concentration of zinc ^(8; 10; 18). Magnesium content of Baobab is similar to that found in dehydrated banana, whereas iron levels are comparable to those found in dehydrated apricots and peaches ^(8; 10).

Based on the European RDA's for calcium, iron and magnesium of 800mg, 14mg and 375mg, respectively per day, Baobab powder in a product could provide to be a useful contributory dietary source of these minerals, provided that sufficient amounts could be added to a product to enable an on pack claim ⁽¹⁹⁾. To be permitted and mentioned on pack the product must contain 15% of the RDA of the vitamin or mineral per 100g or per package in a single serving. See APPENDIX for full list of European vitamin and mineral RDA's (Commission Directive 2008/100/EC).

Table 6: Minerals and Trace Elements in Baobab Dried Fruit Pulp and other Dehydrated Fruits

Fruit (mg/100g)	Na	K	Ca	Mg	P	Fe	Zn	Cu	Mn
Baobab ^{1,*}	13	2188	317	148	63	5.94	0.81	0.661	0.901
Apples ^{2,3,4,**}	124	640	19	22	55	2.00	0.29	0.271	0.128
Apricots ^{2,3,4,**}	13	1850	61	63	157	6.31	1.00	0.576	0.369
Bananas ^{2,**}	3	1491	22	108	74	1.15	0.61	0.391	0.574
Peaches ^{2,3,4,**}	10	1351	38	57	162	5.51	0.78	0.493	0.413

¹dried pulp, ²dehydrated (low-moisture), ³sulphured, ⁴uncooked
* (⁸), ** (¹⁰)

Vitamins

The main vitamins found in Baobab include vitamin C and some of the B vitamins. Since the dried pulp is obtained in a very traditional way, which involves minimal processing, is it very favourable for the preservation of the vitamins, which are sensitive to heat and moisture. Based on data from PhytoTrade Africa, Baobab dried fruit pulp shows significantly higher levels of vitamin C than other commonly consumed dried fruits (Table 7).

On dry basis, ascorbic acid (vitamin C) levels in Baobab dried fruit pulp are ten fold higher than dried peaches and apricot. (⁸; ¹⁰). In addition, this value is twice the amount of ascorbic acid commonly detected in fresh oranges (46mg/100g) or fresh strawberries (61mg/100g) (⁷). Based on the EC RDA for vitamin C of 80mg per day, Baobab powder added to a product could provide a useful source of vitamin C (¹⁹).

Table 7: Vitamins in Baobab Dried Fruit Pulp and other Dehydrated Fruits

Fruit (mg/100g)	Vitamin C	Thiamine (B ₁)	Riboflavin (B ₂)	Niacin (B ₃)
Baobab ^{1,*}	107.8	0.078	0.020	2.160
Apples ^{2,3,4,**}	2.2	0.046	0.130	0.680
Apricots ^{2,3,4,**}	9.5	0.043	0.148	3.580
Bananas ^{2,**}	7.0	0.180	0.240	2.800
Peaches ^{2,3,4,**}	10.6	0.039	0.110	4.825

¹dried pulp, ²dehydrated (low-moisture), ³sulphured, ⁴uncooked
* (⁸), ** (¹⁰)

Baobab pulp contains double the amount of thiamin (vitamin B₁) to that found in dried peaches and about half the amount of that present in dried banana. Very low levels of riboflavin (vitamin B₂) and moderate levels of niacin (vitamin B₃) are found in the Baobab fruit pulp when compared to the other dehydrated fruits.

Baobab versus Superfruits

To date, the term “superfruit” does not have an official definition, but fruits marketed as superfruits are generally high in a variety of nutrients and thus associated with beneficial health effects. Commonly known superfruits include açai berry, blueberry, cranberry, goji berry, mangosteen and pomegranate. It has been suggested that Baobab is a new superfruit. A selection of the micronutrients found in Baobab dried

fruit pulp have been compared with selected superfruits, as shown in Table 8. When comparing the data, it has to be taken into account that the values for Baobab are for the dried fruit pulp, whereas the data for the selected superfruits are for the raw foods. The vitamin C content of Baobab dried fruit pulp is up to five times higher than that of raw blueberries and 15 times higher than in pomegranates. It has much higher levels of niacin, slightly higher thiamin (vitamin B₁) content and the same amount of riboflavin (vitamin B₂) as the selected superfruits (Table 8). Baobab dried fruit pulp has also been found to contain much higher levels of the minerals calcium, magnesium and iron.

Table 8: Vitamins and Minerals in Baobab Dried Fruit Pulp and Selected Raw Superfruits

Fruit (mg/100g)	Vitamin C	Thiamin	Riboflavin	Niacin	Ca	Mg	Fe
Baobab ^{1,*}	107.8	0.078	0.020	2.160	317	148.0	5.94
Blueberry ^{2,**}	22.0	0.020	0.020	0.400	10	2.4	0.74
Cranberry ^{2,***}	13.5	0.030	0.020	0.100	7	5.0	0.20
Pomegranate ^{2,**}	7.0	0.050	0.020	0.300	8	3.0	0.50

¹dried fruit pulp, ²raw
* (⁸), ** (¹¹), *** (¹⁰)

Antioxidant Capacity

Epidemiological evidences links intake of ascorbic acid and other antioxidant micronutrients to health, in virtue of their capability of trapping reactive oxygen species that have been linked with damage to biological systems and therefore degenerative diseases (²⁰). This has led to a consumer interest in supplementing the diet with antioxidants, especially those derived from natural sources. Several studies have been directed toward the evaluation of antioxidant properties of many naturally occurring compounds (²¹).

Baobab fruit pulp can be considered a highly valuable source of ascorbic acid (vitamin C), while the leaves are characterized by the content on provitamin A (²²). The red funicles, present in the fruit have an impressive antioxidant capacity higher than other parts of the Baobab and of many other fruits. However, the specific antioxidant composition has not been identified.

The most widely used methods for measuring antioxidant activity involve the generation of radical species and the presence of antioxidants determining the disappearance of these radicals. The scavenging activity of antioxidants is measured against a reference compound, often Trolox, a water soluble equivalent of vitamin E. Most published antioxidant activity investigations conducted on Baobab have focused on fresh leaves only, not considering any other parts of the plant (²³). Vertuani *et al.* have investigated fresh fruit pulp, fruit shell and dry leaves of Baobab, and compared the antioxidant values to those of others commonly consumed fresh fruits (i.e. orange, kiwi, apple and strawberry) (⁷). In this study, the antioxidant activity was measured with a photochemiluminescence method (PCL) of aqueous/methanol extracts from Baobab products (^{24; 25}). This method allows the measurement of the antioxidant capacity of the water- and lipid-soluble components respectively. In the water soluble fraction, antioxidants such as flavonoids, ascorbic acid are detected, while in the lipid soluble fraction, tocopherols and carotenoids are measured.

Table 9 summarises the water-soluble antioxidant capacity of Baobab versus some other commonly consumed fruits with high vitamin C content. The highest result was observed for Baobab products, in particular for dry leaves and fruit pulp with a antioxidant capacity corresponding to 6-7 mmol/g of Trolox. In comparison to the Baobab fruit pulp: orange, strawberry, apple and kiwi all showed a much a lower antioxidant capacity.

Table 9: Water-Soluble Antioxidant Capacity, Corresponding to the Activity Expressed as mmol Equivalents of Trolox for Gram of Tested Product. The Value is the Mean of 3 Measures \pm SD (⁷)

Products	Trolox s (mmol/g)
Baobab fruit pulp	6,96 \pm 0.057
Baobab dry leaves	6,39 \pm 0,344
Baobab fruit shell, grounded	9,35 \pm 1,100
Kiwi fruit pulp	0,34 \pm 0,007
Orange fresh pulp	0,10 \pm 0,009
Strawberry fresh pulp	0,90 \pm 0,004
Apple fresh pulp	0,16 \pm 0,014

With regard to the lipid-soluble antioxidant component, again Baobab fruit pulp showed the highest antioxidant capacity (4.148 mmol/g) followed by the dry leaves (2.35 mmol/g) (Table 10). The other fruit pulps had very limited capacity; which might be explained on the basis of a low content of lipid-soluble antioxidants.

Table 10 : Lipid Soluble Antioxidant Capacity, Corresponding to the Activity Expressed as mmol Equivalents of Trolox for Gram of Tested Product. The Value is the Mean of 3 Measures \pm SD (⁷)

Products	Trolox s (mmol/g)
Baobab fruit pulp	4,148 \pm 0.706
Baobab dry leaves	2,35 \pm 0,762
Baobab fruit shell, grounded	0,46 \pm 0,066
Kiwi fruit pulp	0,0035 \pm 0,0013
Orange fresh pulp	0,003 \pm 0,0008
Strawberry fresh pulp	0,0062 \pm 0,0002
Apple fresh pulp	0,0015 \pm 0,0002

When comparing water- to lipid-soluble antioxidant capacity of fruit products, it can be observed that the fruit pulp and dry leaves from Baobab showed the highest values in both cases. In all other products, the higher antioxidant capacity was observed in the water soluble component, thus suggesting that the ascorbic acid content is the major contributor to the activity. These antioxidant capacity data are comparable with the ascorbic acid content of the fruit investigated.

A widely used method to assess antioxidant activity is the ORAC assay (Oxygen Radical Absorbance Capacity); this method measures antioxidant inhibition of peroxy radical induced oxidations and thus reflects classical radical chain breaking antioxidant activity by H atom transfer (²⁶).

To account for potential effects of secondary antioxidant products and to avoid underestimation of antioxidant activity, the ORAC assay follows the reaction for extended periods. Values in this method are also reported as Trolox equivalents. Seasonal variation in fruit products, different methods of extraction and treatment of a sample can lead to differences in the outcome value. Absolute ORAC values are more significant when tested in the same condition. Table 11 summarises ORAC values reported from various sources comparing fruits, superfruits and Baobab to give an indication of hierarchy of antioxidant capacity.

**Table 11: Hierarchy of ORAC Values for Different Fruits
Units Expressed in μ mol Trolox Equivalents per Gram of Fruit.**

Fruit Product	ORAC unit (μ mol TE/g)
Açai berry (freeze-dried)**	1614.00
Baobab fruit red funicles ****	750.00
Goji berry***	253.00
Baobab fruit pulp***	200.00
Pomegranate****	105.00
Cranberries*	95.84
Blueberries*	65.52
Blackberries*	53.47
Raspberries*	48.82
Strawberries*	35.77
Gala Apples*	28.28
Oranges*	18.19
Grapes, red*	12.60
Kiwi*	12.10
Grapes, white or green*	11.18

* (27), ** (28), *** (29), **** (30)

The ORAC antioxidant capacity of the Baobab funicle is the highest compared with many other fruits and superfruits, with the exception of the açai berry. The Baobab fruit pulp has an ORAC value twice as high as cranberries and pomegranate. These data suggest an additional potential antioxidant benefit from the consumption of Baobab-containing products.

Conclusions

Baobab is a nutritious fruit that could have considerable application in products positioned on a healthy or functional foods platform. Previous work undertaken at Leatherhead, has shown that the amount of Baobab dried pulp that can be added to foods such as cereal bars and smoothies ranges from 10-20% i.e. 5-10g typically. This must therefore be borne in mind when assessing its' contribution to overall nutritional intakes.

In terms of macronutrients, Baobab dried fruit pulp is low in fat and very high in fibre at around 50g/100g. The pulp has a low sugar content compared with other fruits. It is relatively low in protein but is a source of amino acids. Baobab dried fruit pulp would therefore be ideal as an ingredient for adding fibre to foods, as well as raising the overall nutritional profile. The EC Nutrition and Health Claims Directive (1924/2006) covers nutrition claims including fibre. A claim that a food is a source of fibre may only be made where the product contains at least 3 g of fibre per 100 g or at least 1.5 g of fibre per 100 kcal. A claim that a food is high in fibre may only be made, where the product contains at least 6 g of fibre per 100 g or at least 3 g of fibre per 100 kcal. No specific information is available on the GI or satiating effects of Baobab but its' profile compared to other foods would indicate that it may have real potential to be both low GI and a satiating ingredient due to its low sugar and high soluble fibre content.

Baobab is rich in vitamins and minerals. It contains over 100mg vitamin C per 100g and is much higher in vitamins C than other fruits, including many superfruits. Provided it was added to a product in sufficient quantities, it could therefore provide the vitamin C needed to claim it as a source (12mg or 15% of the RDA). It is a good source of calcium (317g/100g), iron (5.94g/100g) and magnesium (148g/100g) as compared with other fruits on a g/100g basis. Whilst typical Baobab incorporation levels of up to 20% would unlikely be sufficient to be able to claim a source of these minerals, Baobab could contribute to the levels of minerals in a product. In addition, the presence of vitamin C in conjunction with iron could be a very effective combination for optimising iron uptake, as the presence of vitamin C has been associated with improved iron uptake in humans ⁽³¹⁾.

Based on its' ORAC values, the antioxidant capacity of the Baobab fruit pulp is higher than many berries and is twice as high as pomegranate and cranberries. This is an added selling point for Baobab, as consumers are increasingly interested in products high in antioxidants and manufacturers have developed a variety of antioxidant products - from soft drinks based on superfruits such as pomegranate, açai, etc., as well as some of the newer shelf stable applications, for example, antioxidant breakfast cereals.

References

1. Diarra B (2006) Book review, Baobab - *Adansonia digitata*, M. Sidibe', J.T. Williams, International Centre for Underutilized Crops, University of Southampton, Southampton, UK, 2002. *Agricultural Systems* **89**, 478-481.
2. Kerharo J & Adam JG (1974) La pharmacopée sénégalaise traditionnelle. *Plantes Médicales et Toxiques*.
3. Lockett CT, Calvert CC & Grivetti LE (2000) Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Study of rural Fulani, Northeastern Nigeria. *International Journal of Food Sciences and Nutrition* **51**, 195-208.
4. Lunven P & Adrian J (1960) Intérêt alimentaire de la feuille et de la pulpe du fruit de baobab (*Adansonia digitata*). *Ann Nutr* **14**, 263-276.
5. Obizoba IC & Anyika JU (1994) Nutritive value of baobab milk (gubdi) and mixtures of baobab (*Adansonia digitata* L.) and hungry rice, acha (*Digitaria exilis*) flours. *Plants Foods Hum Nutr* **46**, 157-165.
6. Nour AA, Magboul BI & Kheiri NH (1980) Chemical composition of baobab fruit (*Adansonia digitata* L.). *Trop Sci* **22**, 383-388.
7. Vertuani S, Braccioli E, Buzzoni V & Manfredini S (2002) Antioxidant capacity of *Adansonia digitata* fruit pulp and leaves. *ACTA PHYTOTHERAPEUTICA* **V**.
8. (2009) Data provided by PhytoTradeAfrica.
9. Sena LP (1998) Analysis of nutritional components of eight famine foods of the Republic of Niger. *Plant Foods for Human Nutrition* **52**, 17-30.
10. USDA (1982) *Composition of Foods Raw, Processed, Prepared*, Agriculture Handbook No. 8-9 ed. Washington D.C.: U.S. Department of Agriculture.
11. Souci SW, Fachmann W & Kraut H (2000) *Food Composition and Nutrition Tables*, 6th revised and completed ed. Stuttgart: Medpharm Scientific Publishers, CRC Press.
12. The University of Sydney (2009) The Glycemic Index.
13. Brown L, Rosner B, Willett WW & Sacks FM (1999) Cholesterol-lowering effects of dietary fiber: a meta-analysis. *American Journal of Clinical Nutrition* **69**, 30-42.
14. Liu LS, Fishman ML & Hicks KB (2009) Pectin in controlled drug delivery. *Cellulose* **14**, 15-24.
15. Hotchkiss AT, Rastall R, Gibson G, Eliaz I, Liu LS & Fishman ML (2009) New bioactive and biobased product applications of pectin. In *Pectins and Pectinases*, pp. 305-312 [HA Schols, RGF Visser, and AGJ Voragen, editors]. Wageningen: Wageningen Academic Publisher.
16. Rhoads J, Manderson K, Hotchkiss AT, Gibson G, Formentin K, Beer M & Rastall RA (2008) Pectic oligosaccharide mediated inhibition of the adhesion of pathogenic escherichia coli strains to human gut culture cells. *Journal of Food Protection* **71**, 2272-2277.
17. McCance RA (2002) *McCance and Widdowson's the composition of foods*, 6th summary ed. Cambridge: Royal Society of Chemistry.
18. Gebauer J, El-Siddig K & Ebert G (2002) Baobab (*Adansonia digitata*): a Review on a Multipurpose Tree with Promising Future in the Sudan. *Gartenbauwissenschaft* **67**, 155-160.
19. Department of Health (1991) *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*, 41 ed. London: HMSO.
20. Elsayed NM (2001) Antioxidant mobilization in response to oxidative stress: a dynamic environmental-nutritional interaction. *Nutrition* **17**, 828-834.
21. Farrukh A & Mukhtar H (2002) Photochemoprevention by botanical antioxidants. *Skin Pharmacol Appl Skin Physio* **15**, 297-306.
22. Odetokun SM (1996) The nutritive value of Baobab fruit (*Adansonia digitata*). *Riv Ital Sost Grasse* **73**, 371-373.
23. Cook JA, VanderJagt DJ, Dasgupta A, Mounkaila G, Glew RS, Blackwell W & Glew RH (1998) Use of the Trolox assay to estimate the antioxidant content of seventeen edible wild plants of Niger. *Life Sci* **63**, 105-110.
24. Popov I, Lewin G & Baehr R (1987) Photochemiluminescent detection of antiradical activity. I. Assay of superoxide dismutase. *Biomed Biochem Acta* **46**, 775-779.
25. Popov I & Lewin G (1999) Oxidants and Antioxidants Part B – Antioxidative homeostasis: characterization by means of chemiluminescent technique. *Methods in Enzymology* **300**, 437-456.
26. Cao G, Alessio HM & Cutler RG (1993) Oxygen-radical absorbance capacity assay for antioxidants. *Free Radic Biol Med* **14**, 303-311.
27. (2007) *Nutrient Data Laboratory, Agriculture Research Service, US Department of Agriculture, Oxygen radical absorbance capacity (ORAC) of Selected Foods*.
28. Schauss AG, Wu X, Prior RL, Ou B, Huang D, Owens J, Agarwal A, Jensen GS, Hart AN & Shanbrom E (2006) Antioxidant capacity and other bioactivities of the freeze-dried

- amazonian palm berry, Euterpe oleraceae mart. (acai). *J Agric Food Chem* **54**, 8604-8610.
29. (2009) *Brunswick Laboratories, MA.*
 30. (2009) *ORAC values data obtained by AMBROSIALAB Lab Ferrara.*
 31. He WL, Feng Y, Li XL & Yang XE (2008) Comparison of iron uptake from reduced iron powder and FeSO₄ using the Caco-2 cell model: effects of ascorbic acid, phytic acid, and pH. *J Agric Food Chem* **56**, 2637-2642.
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Appendix

**COMMISSION DIRECTIVE 2008/100/EC
of 28 October 2008
amending Council Directive 90/496/EEC on nutrition labelling for foodstuffs as
regards recommended daily allowances, energy conversion factors and
definitions**

**Vitamins and minerals which may be declared and their recommended daily
allowances (RDAs)**

Vitamin A (µg) 800
Vitamin D (µg) 5
Vitamin E (mg) 12
Vitamin K (µg) 75
Vitamin C (mg) 80
Thiamin (mg) 1.1
Riboflavin (mg) 1.4
Niacin (mg) 16
Vitamin B6 (mg) 1.4
Folic acid (µg) 200
Vitamin B12 (µg) 2.5
Biotin (µg) 50
Pantothenic acid (mg) 6
Potassium (mg) 2 000
Chloride (mg) 800
Calcium (mg) 800
Phosphorus (mg) 700
Magnesium (mg) 375
Iron (mg) 14
Zinc (mg) 10
Copper (mg) 1
Manganese (mg) 2
Fluoride (mg) 3.5
Selenium (µg) 55
Chromium (µg) 40
Molybdenum (µg) 50
Iodine (µg) 150

As a rule, 15 % of the recommended allowance specified in this Annex supplied by 100 g or 100 ml or per package if the package contains only a single portion should be taken into consideration in deciding what constitutes a significant amount