An assessment of the composition and nutrient content of an Australian Aboriginal hunter-gatherer diet

Richard M. Smith

Miln Walker and Associates, Belair

Pamela A. Smith

Flinders University, Adelaide

Abstract: *Detailed ethnographic records of hunter-gatherer subsistence diet among the Ngaatjatjarra Aboriginal people made by the ethnoarchaeologist, Richard Gould, in the Western Desert in 1969 have been analysed for nutrient composition using a 1993 table of Indigenous foods. Over a period of five months the dietary staples of meat, fresh and dried fruit and grass seeds provided group members with 10 kilojoules per day of energy, comprising 124 grams of protein, 24.5 grams of fat and 411 grams of carbohydrate, together with adequate levels of those accessory food factors for which compositional data are available. The average diet contained a very low level of total fat (9.2% of energy), a very high level of carbohydrate (69% of energy, of which 40% of energy was present as whole grain) and total protein, including that of meat, to make up 21% of energy. Meat itself, including its fat, made up 9.6% of total energy.*

Comparison of the nutrient content of a hunter-gatherer diet with that of a modern diet designed to avert chronic disease showed some close similarities and indicated the absence of recognised risk factors for the chronic diseases found in the present Aboriginal population of northwestern Australia.

The continuing poor health of Indigenous Australians has been attributed to the adoption of a Western diet and lifestyle following their displacement from their traditional lands and the retrograde transition from their former diet (reviews: Lee 1996; Thomson 1991). The change to a more sedentary lifestyle was greatly delayed in some remote areas of central and northern Western Australia, however, where pockets of hunter-gatherer existence persisted into the 1960s. This permitted some direct records to be made of traditional diets at that time (Cane 1984, 1987; Gould 1980, 1986). Reconstructions of traditional diets have also been made elsewhere in Australia using a variety of methods (Altman 1987; Meehan 1982; O'Connell and Hawkes 1981), and evidence of past diets derived from bone collagen analysis has been advanced by Pate (1998). There have been few opportunities, however, to document the diet of Aboriginal people living a fully traditional lifestyle. Such diets have sometimes been proposed as reference standards for modern human nutrition and as models for defence against certain diseases of affluence (Cordain et al 2000).

Following the publication of the *Tables of Composition of Australian Aboriginal Foods* (Brand Miller et al 1993), it became possible to calculate the nutrient composition of some previously recorded traditional diets and to assess their nutritional adequacy. Our aim here is first to review previously recorded traditional Aboriginal diets and to identify those that represent a traditional diet with little or no supplementation by Western foods. The nutrient composition and energy content of the diets selected are then calculated by evaluating the protein, fat and carbohydrate content of each component. Finally, the diet assessed is compared with a modern recommended diet (Baghurst et al 1992; Willett and Stampfer 2003) and its nutritional adequacy examined.

A scrutiny of existing records identified three studies that we consider represent the diets of Aborigines living close to a traditional hunting and gathering lifestyle, despite their having been recorded in the recent past. These studies are by McArthur

(1960), a nutritionist who worked with several communities in Arnhem Land in 1948, by Gould (1980,1986), an ethnoarchaeologist who worked with the Ngaatjatjarra in the Western Desert during the 1960s, and by Cane (1984), an archaeologist who worked with the Kukatja and Pintupi in the Tanami and Western Deserts in the 1980s. Each study used a methodology sufficiently rigorous to provide an accurate set of dietary data suitable for further analysis and each of the Aboriginal groups had maintained a traditional hunting and gathering lifestyle for some time during each year. Although all are incomplete (below), they represent unique and valuable records of Australian traditional hunter-gatherer diets that are unlikely to be repeated.

Of the three diets, Gould's records were selected for a detailed analysis of its composition and nutrient content. The nutrient compositions of the dietary data of several small groups recorded by McArthur (1960) were not analysed as they had previously been published in the report of the American–Australian Scientific Expedition to Arnhem Land and the diet included non-traditional foods. Those records would, however, benefit from re-analysis using the more recently published food composition tables (Brand Miller et al 1993).

The nutrient content of the dietary data recorded by Cane has also been previously derived and was not recalculated for this reason and because less data were available than in Gould's study. It should be noted that the recency of Cane's study does not detract from its relevance, as the Pintupi and Kukatja had lived fully traditional lifestyles as recently as the 1950–60s and several older people continued to live a traditional lifestyle for some months each year (Cane 1987:391). Gould worked with the Ngaatjatjarra, a dialectal group of the Western Desert cultural bloc (Berndt 1959), located around the Rawlinson Ranges and north of the Warburton Ranges (Figure 1). Gould's data are limited to staple foods, but those dietary records were nevertheless selected for a detailed analysis of composition and nutrient content.

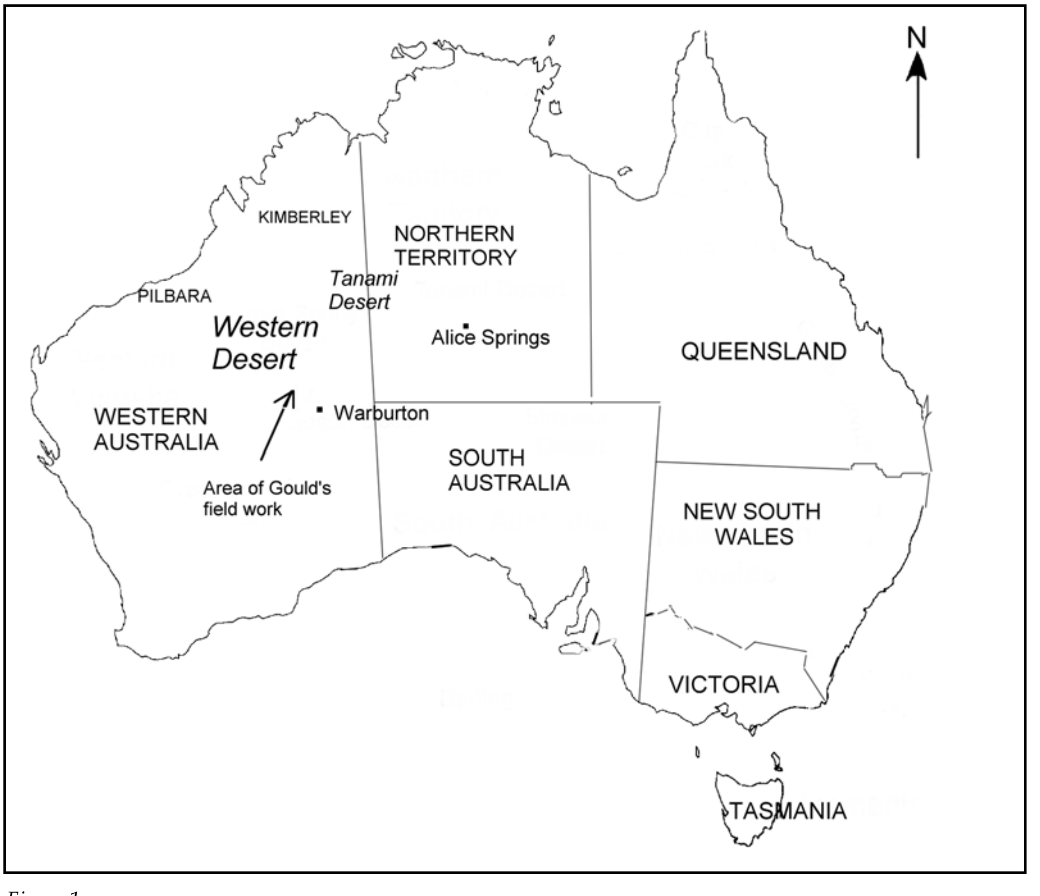


Figure 1
Map showing the location of Gould's fieldwork near Warburton in the Western Desert

Analysis of Gould's dietary data

Richard Gould (1980, 1986) documented the operational aspects of hunting and gathering in the Western Desert, Western Australia, in a very harsh and sparsely resourced region. His studies took place during 1966–67 (a relatively wet period) and again during 1969–70 (regarded as a drought period) and involved extended field operations in company with traditionally oriented hunting and gathering groups that ranged in size from 9 to 107 individuals. Gould described the physical environment there, in terms of water supply and plant and animal resources, as perhaps the most unreliable and impoverished in the world where people live, or have lived, directly off the land. The limiting factor was water, with its close correlate in the meagre variety and amount of edible materials. He observed that the diet of the hunter-gatherer groups was primarily vegetarian and that, for at least 90% of the time, females provided 95% of the food available to the group. This included all of the vegetable material and much of the small game. Although men hunted constantly, this was mostly with poor success and game was plentiful only following good rains.

The dietary information recorded by Gould is sufficient to make a reasonable assessment of that part of the diet that is made up of what he refers to as the dietary staples. A staple is defined by Gould as a dietary component (in the case of plant foods, the fruit or seed of a single species) that makes up at least 30% by weight of the diet at some particular time. He describes seven plant food staples (named species) and an animal food staple, referred to as large game, which may consist of any of several species. Large game was only rarely obtained but a relatively constant supply of small game ensured a small intake of animal food that contributed less than 9% of the diet by weight.

Availability of fruits and grass seeds

Gould (1980:Table 2) shows, in diagrammatic form, the months of the year 1966–67 in which each of the seven plant species was available either as a full staple (i.e. it contributed 30% or more of dietary mass) or as an emerging or disappearing staple. The way in which the latter information is conveyed makes it possible to estimate the actual contribution of that component (as a percentage of the diet) during those months. As many as five part staples and as few as a single staple contributed to the diet in different months. Similar but much less complete information on staples is given for the period 1969–70, but this has not been used in the present reconstruction of the diet.

Maximum yield of fruits

Gould (1980:Table 4) also records his estimates of the average amounts of five of the seven staples collected by gatherers for each member of the party daily on 73 days between July 1966 and April 1967 and on 17 days between April 1969 and July 1970. These values vary between 410 grams per day of sun-dried *Solanum chippendalei* (bush tomato) and 1230 grams (g) per day of sun-dried *Solanum centrale* (bush raisin). The average amounts set upper limits to the daily intakes per person of the particular fruit during the months that it is fully or partly available, as shown in Gould's (1980) Table 2. The two plant species for which yields are not stated are the seeds of the two grasses, *Eragrostis eriopoda* (woollybutt grass) and *Chenopodium rhadinostachyum* (crumble weed). Maximum yields are not given on a monthly basis for any of the large game.

Availability of small amounts of game

Gould (1980:Table 5) lists the total weights of large and small game animals caught on 73 days in 1966–67 and on 17 days in 1970, a period of observations spanning one year. This information has been used by Gould to nominate an average amount of 85 g of meat available to each person each day on a continuing basis throughout the year. Only in December 1966 and in January 1967 did large game reach the status of a part staple (i.e. it provided more than 30% of the weight of food available for a part of each of these months). In correspondence, Gould has pointed out to us that his Tables 5 and 6 both contain a dual error. Thus, all values in the second column in both tables (total weight, kilograms, of animals recorded) should be divided by 10, and all values in the third column (average amounts of meat, grams per person per day) should be multiplied by 10.

Values for nutrient content

Use of the *Tables of Composition* (Brand Miller et al 1993) makes it possible to convert the weights of the various staples derivable from Gould's data into amounts of protein, fat and carbohydrate and to state values for the energy content. All of the plant products and most of the animal products named in Gould's work are listed in those published tables. The values employed are given in Table 1, together with veal substituted to represent feral cat (Paul and Southgate 1979). In addition, Table 1 gives a value for whole quandong which combines the values for fruit and kernel by assuming 70% of the weight to be fruit, 20% kernel and 10% the shell of the kernel (discarded).

Calculation of food consumption

The basic assumption made was that the energy needs of the population being fed, including men, women and children, amounted to a daily average of 2390 kilocalories (10,000 kJ). This was based on an estimate of the daily energy expenditure of male building workers (12.6 mJ), female factory workers (9.7 mJ) and 7-year-old children (7.7 mJ), assuming equal numbers of men, women and children, and was based on Davidson et al (1979:22, 154). The mean of

Table 1: Nutrient composition of some bush foods

		Nutrients (g)/100g of edible portion				
Species	**Common name**	**Energy (kcal)**	**Water**	**Protein**	**Fat**	**Carbo-hydrate**
Solanum centrale (fresh)	Bush raisin	136	61.9	3.8	0.6	30.3
S. centrale (dried)	Bush raisin	281	12.5	8.5	3.8	55.6
S. chippendalei (fruit)	Bush tomato	92	75.1	1.6	0.6	20.6
Canthium latifolium (fruit)	Currant bush	199	41.6	2.8	0.1	48.9
Santalum acuminatum (fruit) 70%	Quandong	80	68.5	2.3	0.2	18.2
S. acuminatum (kernel)	Quandong	698	2.4	16.0	63.1	17.1
Ficus spp.—values are for *F. platypoda* (fruit)	Desert fig	136	66.3	3.0	2.1	31.1
Eragrostis eriopoda (seed)	Woollybutt grass	318	8.5	16.2	1.6	62.0
Chenopodium rhadinostachyum (seed)	Crumble weed	297	est.[10]	20.1	2.9	35.5
Varanus spp. (flesh)	Goanna	196	56.1	30.5	7.2	2.2
Amphibolurus spp. (flesh and skin)	Dragon lizard	188	60.6	30.2	7.2	0.4
Macropus spp. (flesh)	Kangaroo	158	63.8	25.3	3.7	5.9
Ardeotis australis (whole bird)—flesh	Bustard/Bush turkey	182	60.4	29.1	6.6	1.5
Rabbit (European) (flesh), also representing mouse	Rabbit	124	74.6	21.9	4.0	0.0
Veal—representing feral cat (flesh)		110	74.9	21.1	2.7	0.0
Santalum acuminatum — whole fruit and kernel	Quandong: fruit (70%) kernel (20%)	196	48.5	4.8	12.7	16.1

Source: Derived from Brand Miller et al 1993

10,000 kJ (2390 kcal) was taken to have been met if the amounts of the various staples (plus the small amount of continuous meat) available in any particular month permitted this.

The staples involved (both full and part staples) were taken directly from Gould's (1980) Table 2 and assignments of quantities between staples were made in terms of weight of food. If two or three full staples contributed in any one month, assignment was made in proportion to the daily amounts of that staple gathered, as given in Gould's Table 4. In the case of the two grass seeds, no gathering limits are given and it has been assumed that both contributed equally if this was consistent with Gould's Table 2. Because of the energy density of the seeds, the amounts involved were not excessive and are considered to be well within the gathering capacities of Aboriginal women in this region. Cane, working in an adjacent region, observed that 1000 g of seed were easily collected in about half an hour and that claims about the dietary importance of seeds were supported by the high number of grinding stones (1984:69–79).

The daily average take for any full staple given in Gould's Table 4 constituted an upper limit for that species' contribution and, if short, dictated extra assignment of the other staples but again in proportion to their gathered limits and not exceeding those limits. Calculation of such assignments of weight to constitute a given calorie intake is algebraically simple and within the above paradigm yields a unique result. It was carried out for each month (see results in Table A1 in Appendix). In the January–May period, the energy goal of 2390 kcal was readily achieved but for the remaining months of the year it was not, and the weight limits set out in Gould's Table 4 failed to provide enough food. The extent of this deficit can be calculated from the June–November sections of Table A1.

Gould mentions that a total of 38 edible plant species and 47 named varieties of meat were identified in the region at the time. It is quite likely that the energy deficit from the staples alone was made up by adventitious use of some of these, but there is no information in his paper that asserts this or identifies or quantifies other food sources.

Calculation in the above way is not possible for December, where it seems that the two staples listed in Gould's (1980) Table 2 (*Ficus* spp. and large game) can account for a total of only 30% of actual intake over one month.

The nature and nutritional limitations of the traditional diet

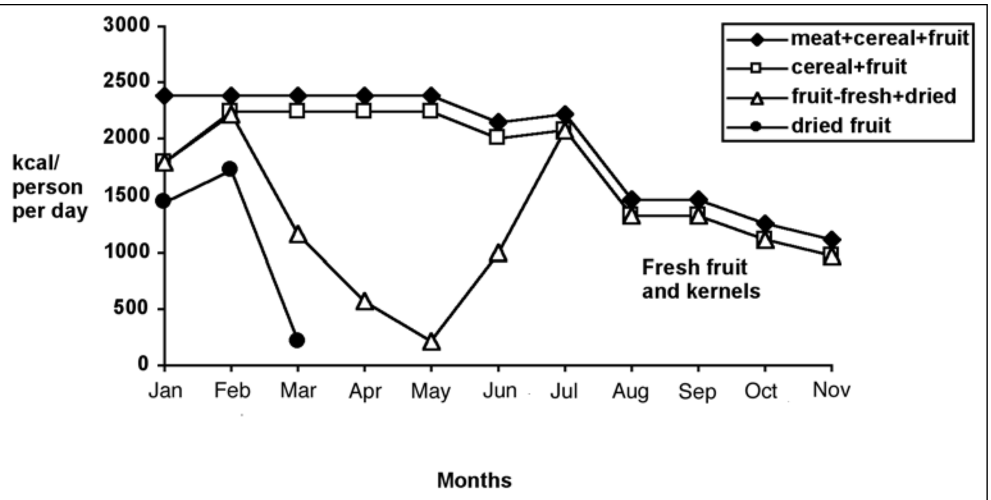
The energy and protein supplied by the staples are shown graphically in Figure 2 and Figure 3, respectively. During January–May, the staple-based diet readily provided for an adequate energy supply and an adequate protein intake. During that time the major source of energy was either sun-dried fruit or grass seeds, and the main contribution of protein came from meat (in January), from sun-dried fruit (in February) or from grain (in the other months).

From June onward, the grain supply rapidly diminished and the major energy source reverted to fresh fruit. Except for quandong kernels, those sources were not sufficiently rich in energy or protein to act as satisfactory sole staples and both energy and protein intakes from them became increasingly inadequate. In the case of protein the situation was particularly serious since the proteins of fruit (and even of seeds) are of poorer quality than is meat protein or the protein from legumes. As revealed by Gould's data, the diet in June and July approached adequacy, but from August to November it was very poor. Other food sources would have become important but Gould does not describe them.

Table 2 Average daily nutrient intakes from a staple-based diet, January–May

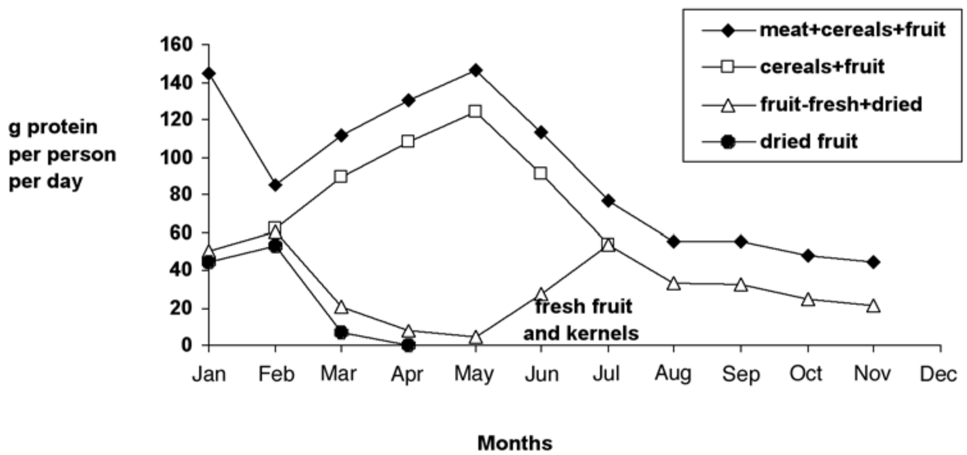
Food type	Energy (kcal/d)	Protein (g/d)	Fat (g/d)	Carbohydrate (g/d)
Meat	229	37.0	6.7	5.0
Fresh fruit	513	7.9	1.2	122.4
Dried fruit	680	20.6	9.2	134.7
Cereal grain	967	58.2	7.4	148.4
Total	**2390**	**123.7**	**24.5**	**410.5**

Note: Assigned total energy of 2390kcal per day



Note: For January–May, an arbitrary energy ceiling of 2390 kcal per person per day was applied. For the remaining months, the amounts are the maxima yielded by the available staples.
Source: Derived from Gould 1980

Figure 2
Progressive total of energy available from staples, January–November 1996



Note: For January–May, an arbitrary energy ceiling of 2390 kcal per person per day was applied.
Source: Derived from Gould 1980

Figure 3
Progressive total of protein available from staples, January–November 1996

We have therefore chosen to represent the results for the January–May months as a more satisfactory rendering of the traditional diet in the region concerned than would have arisen either from an acceptance of lower energy and protein levels for the rest of the year or from arbitrary assumptions about the nature and extent of supplementary food to make up the deficits. A further consideration in excluding the later months is the heavy reliance on *S. acuminatum* (quandong) from July to October. Quandong kernel is rich in both protein and fat but it is not clear that the kernel, although listed as a food by Brand Miller et al (1993), was actually eaten. The average results for the major nutrients are given in Table 2 for January to May.

From the mean daily intakes of the various dietary components over this five-month period it becomes apparent that grain served as the major source of both energy and protein and that sun-dried fruit was also very important in both of these respects. Fresh fruit, although it supplied the bulk of the dietary mass and was undoubtedly a major source of accessory food factors, emerges as only a moderately important source of energy and as a minor contributor to the protein needs. Animal meat would have been indispensable both as a source of accessory food factors (in particular, iron, zinc and vitamin B12) and because it represents the only source of very high quality protein, but it provided only 30% of the total protein and 10% of the total energy of the diet.

Comparison of the traditional diet with a modern recommended diet

Smith and Smith (1999) published a comparison between the nutrient composition of this traditional diet with a station diet, with a diet recommended for Aboriginal people on cattle stations in 1952, with a self-select/store diet recorded in the early 1980s and with a modern recommended diet.

The fruit and vegetable components of a modern recommended diet (Baghurst et al 1992) are combined in Figure 4 to allow a comparison with the traditional diet that has no separate vegetable component. Likewise the meat and fat components are combined in the modern diet as these are not separated in the traditional diet. The hunter-gatherer diet (which assigns an adequate intake of 2390 kcal per person/day) is essentially one of cereal and fresh fruit plus dried fruit (combined together), with a moderate amount of meat. Except for the absence of vegetables

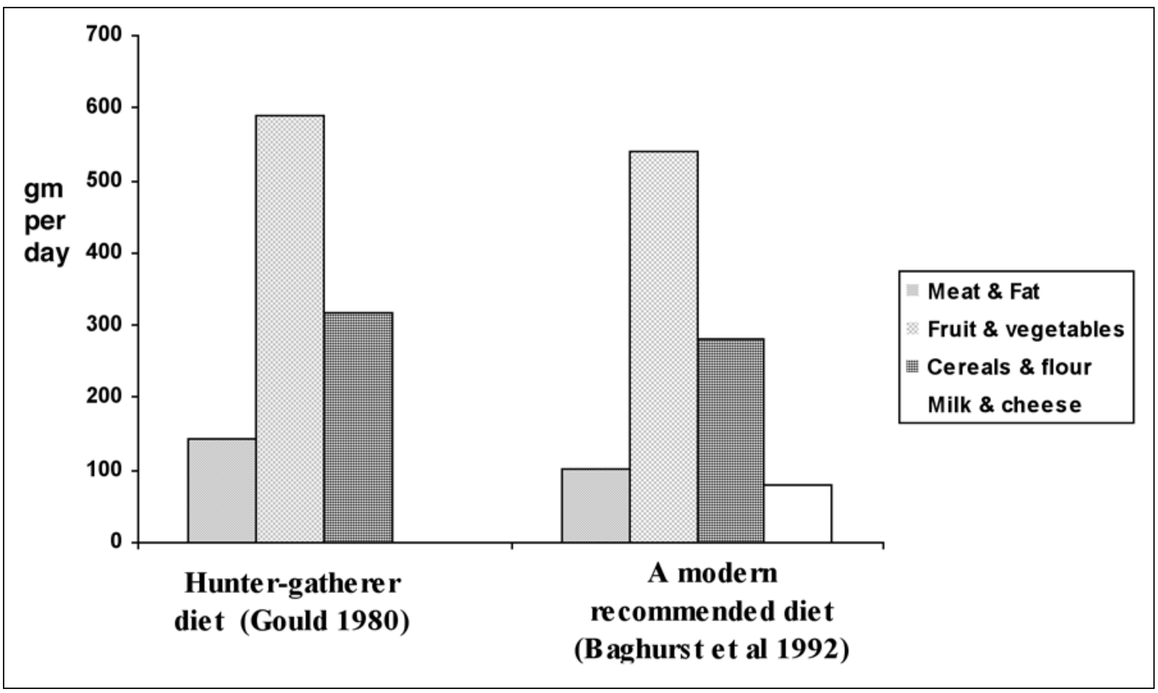


Figure 4
Comparison between the hunter-gatherer diet and a modern recommended diet

and dairy products, it is not dissimilar to a modern diet when the vegetable and fruit components are combined. Noteworthy in both diets is the presence of only small amounts of energy-dense dietary fat and the absence of added sugar, although it is likely that the hunter-gatherer diet contained very substantial amounts of free sugars derived from fruit. The levels of meat in the two diets are also quite similar.

Table 3 shows that the hunter-gatherer diet was high in vitamin C, derived almost entirely from fresh and dried fruits, but did not achieve the high vitamin C content of the modern recommended diet that contained large amounts of fresh fruits and vegetables. The significant contribution of vitamin B1 from bush raisin (*S. centrale*) and bush tomato (*S. chippendalei*) to the traditional diet allows it to exceed that in the modern diet, whereas the high calcium level of the traditional diet almost achieved the calcium levels of the modern diet from fruit and cereals. The iron content of the traditional diet was found to be significantly higher than that of the modern recommended diet and, again, this was accounted for by the high levels found in the staple fruits and in the cereals, *E. eriopoda* (woollybutt seed) in particular.

Discussion

This traditional diet contained relatively small amounts of meat (10% of the energy, 30% of the protein). The diet is very low in fat (9.2% of the energy) and very high in carbohydrate (69% of the energy). Total protein, including that of meat, provides 21–22% of the energy. For the overall period examined, January–May, grass seeds were the major provider of energy (40%) and protein (47%). Meat provided only 27% of the total dietary fat, with fruit and cereal grain making up the rest, but the fatty acid composition of none of the indigenous foods is directly available. Thus, while the total fat levels in the Indigenous diet can be derived from Brand Miller et al's (1993) tables, the distribution into saturated, mono-unsaturated and poly-unsaturated fatty acids (PUFA) can be approached only by the substitution of selected proxies for which such compositions are available (Paul and Southgate 1979).

Table 3: Comparison of nutrient content between the traditional diet and a modern recommended diet

Nutrient supplier per person per day	Traditional Aboriginal diet (Gould 1980)	Modern recommended diet (Baghurst et al 1992)
Energy (kcal)	2390	2150
Protein (g)	124	75
Fat (g)	*24.5 (9%)	***76 (32%)
Total carbohydrates (g) (starch+dextrins)	411 (148)	268 (268)
Calcium (mg)	670	986
Iron (mg)	**101	13
Vitamin A (mg)	–	2163
Vitamin B1 (mg)	**2503	1500
Vitamin C (mg)	**78	143

*Percentage of available energy derived from fat.
**Assay values not reported for all staples so these are minimum values.
***This contains 11g/d of fat added as one of two 'indulgences' by which this particular diet achieves the calorie content specified.
Sources: Summarised from Smith and Smith (1999:Table 4). The values for minor dietary constituents in the hunter-gatherer diet have been derived from Brand Miller et al (1993), together with underlying data for dietary composition from Figure 4.

In this way we applied the average fatty acid proportions for barley, wheat and rye to the known total fat content of the indigenous grass seeds, and the average composition of several European and American game meats to the fat content of the indigenous small and large game and those of non-indigenous fruits to the fat contents of the fruits specified by Gould. This procedure, although it cannot be verified, allows the calculation of plausible values for the fatty acid composition of the average daily fat consumed (as shown in Table 2). On that basis the daily average fat consumption of approximately 24 g would have contained about 8 g of saturated fat, 6 g of mono-unsaturated fat and 10 g of PUFA, including 4.7 g of the dietary essential fatty acid (EFA) linoleic acid (18:2). The latter estimate, if correct, represents 1.8% of the daily caloric intake, compared with the recommended levels of 1–2% (Davidson et al 1979:57). Thus, the diet was very low in both total fat and saturated fat, while the level of PUFA was probably adequate.

In analysing the data from his extended field studies, Gould found that the diet of the group he lived with in the Western Desert was largely vegetarian and that, for most of the year, meat comprised less than 9% by weight of the total diet. The division of labour was generally as follows (Gould 1980:63):

> The diet is primarily vegetarian. Women and girls forage for a total of seven plant species and thus provide the bulk of the diet…at least 90% of the time women provide about 95% of the food available to the group as a whole…Men hunt constantly but generally with poor success. Both they and the women collect small game that provides the only [animal] protein available most of the time...yet from the point of view of time expended, hunting ranks as a major subsistence activity.

Although the predominant role of women as food providers for Indigenous hunter-gatherer groups is well established (Lee 1996), the degree of predominance of vegetable foods, and especially of grain, observed by Gould is uncommon among hunter-gatherer peoples generally. Combined with only 10% of energy contributed by animal sources this situation has been suggested to be restricted to hunter-gatherer peoples living in arid and marginal environments (Cordain et al 2000). The extreme scarcity of game was undoubtedly associated with an acute scarcity of drinking water available to game.

In those months of the year when the staples recorded by Gould were plentiful, the diet was adequate, but only so because of the extremely high content of calcium, iron and other accessory food factors in some of the fruits and cereals. Examples of foods rich in micronutrients are: Ficus spp. (120mg calcium/100g); *E. eriopoda* (111mg calcium/100g; 31mg iron/100g); *S. chippendalei* (86mg calcium/100g); and dried *S. centrale* (0.85mg vitamin B1/100g). This must have been a significant factor in the ability of hunter-gatherer groups to survive in the desert environment. For the remainder of the year the nutritional adequacy of the diet was presumably made good by the other species of plant foods referred to but not listed by Gould, as they were not staple foods.

Despite the frugal and seemingly precarious nature of the recorded diet, its overall adequacy is attested to in three ways. First is the long-term reproductive survival of the Ngaatjatjarra in the Western Desert (Figure 1). Second is Gould's (1977) ethnographic description of the Ngaatjatjarra as adequately nourished and healthy people, an observation that matches the conclusions reached earlier by Elphinstone (1971), a medical officer working in the same region. The third indication of nutritional adequacy relates to the general similarity of the diet with what was accepted in 1992 as an ideal diet to reduce the incidence of chronic disease and expressed then as a diet pyramid and promoted by the US Department of Agriculture (Baghurst et al 1992).

It is pointed out, however, that the 1992 diet pyramid is now regarded as flawed and is due to be extensively revised in 2004. A preview of the new pyramid has been published (Willett and Stampfer 2003). The modifications proposed have arisen in large part from the long-term Nurses Health Study of, inter alia, the incidence of heart disease in over 84,000 American women since 1980 (Stampfer et al 2000). Compliance with all five of certain specified low-risk diet and lifestyle factors over the 14-year period was found to have led to more than an 80% reduction in coronary events. The chief differences to be introduced into the new diet pyramid are: (i) a reduction in the recommended intake of foods containing much refined or essentially pure carbohydrate, but with a substantially increased use of whole-grain foods; (ii) an increased consumption of vegetable oils containing high levels of mono- and/or poly-unsaturated fatty acids, accompanying a greatly reduced intake of saturated fat from animal products; (iii) a reduced intake of red meat, with an increased emphasis on the consumption of fish; (iv) the introduction of daily exercise and weight control, with abstinence from smoking; and (v) a moderate intake of alcohol.

It is worthwhile noting that in a number of ways—low intake of red meat, extensive use of whole-grain food, low intake of saturated fat and, of course, vigorous daily exercise, the absence of obesity and absence of smoking—the Ngaatjatjarra traditional diet is even closer to the proposed new diet pyramid than it was to the old one. Perhaps this is fortuitous but, in a context of long-term survival in a harsh environment, perhaps it was inevitable. We have already mentioned the proposed use of traditional hunter-gatherer diets as models for defence against the diseases of affluence (Cordain et al 2000).

The change in health status of Aboriginal people moving from an active and culturally disciplined life with a healthy diet to a sedentary existence in which diet and lifestyle incorporated most of the risk factors for chronic disease identified above has been profound. In the Kimberley and Pilbara regions, the transition from a desert environment to life on cattle stations and missions introduced Aboriginal people to a diet that was high in red meat containing much saturated fat, high in refined carbohydrate both as starch and as sugar, and very low in fresh fruit and vegetables. The change in diet was acceptable to Aboriginal people, as it seemed to incorporate many of the food preferences already held and when the station and mission eras ceased in the 1970s, the self-selected diet in towns and large communities still reflected the same preferences (Smith and Smith 1999). Over the longer term and when combined with the introduction of smoking and the excessive use of alcohol, the disease patterns now seen, emerged.

The major components of this pattern of chronic disease are cardiovascular disease and non-insulin-dependent diabetes mellitus (NIDDM), both either caused or exacerbated by obesity. In addition the level of nutrition itself in Aboriginal communities is often deficient and this is reflected in the lowered growth rates and high prevalence of infectious disease in infants and children (Gracey 1986). In the Western Desert regions of the southeast Kimberley and eastern Pilbara regions, where people have close relationships with the Ngaatjatjarra, there is clear evidence of these conditions.

A randomised and age- and sex-stratified survey in the late 1980s in the Kimberley region showed a very high prevalence of hypertension in both men and women, for which the main risk factors detected were consumption of alcohol in men and obesity in both men and women (Smith et al 1992a, b). It is likely that a high intake of sodium also contributes to the current high blood pressure but this has not been directly established. It would certainly have been true that the largely vegetarian hunter-gatherer diet was low in sodium. The prevalence of ischaemic heart disease in the Aboriginal population was also two to three times higher than that in non-Aboriginal Australians and the chief risk factor identified for that condition was hypertension. Obesity was also highly prevalent and especially so in women. The prevalence of diabetes (NIDDM) is very high in this region and it too is linked to obesity (Lee 1996). The association between lifestyle and NIDDM was shown in the partial reversal of the condition by a relatively brief return to the hunter-gatherer lifestyle (O'Dea et al 1980). Detection of impaired glucose tolerance in Aboriginal people as young as 12–18 years served to indicate that the propensity to develop NIDDM under the prevailing conditions might be established during childhood (White et al 1990).

Nutritional inadequacies also partly underlie the low rates of growth of infants and children that have been endemic in Aboriginal communities in the Kimberley and Pilbara since the 1970s (Gracey 1986). In the case of infants and children under 3 years of age, normal rates of growth may be fully restored by culturally appropriate nutritional intervention (Smith et al 2000).

The Ngaatjatjarra are one of the few hunter-gatherer groups who have survived into the latter half of the twentieth century sufficiently undisturbed to allow a thorough analysis of their diet. In reviewing such groups, Eaton and Konner (1985) recorded that those living in semi-tropical inland habitats derived 20–50% by weight of their food from animal sources but that they consumed surprisingly small amounts of seeds. The overall diet recorded by Gould is unusual for hunter-gatherers, particularly in the absence of meat, tubers and legumes from among their staple foods and this is presumably attributable to the harsh desert environment (Cordain et al 2000). From Gould's (1980, 1986) accounts, Aboriginal people in the Western Desert constantly maximised their intake of animal foods and cereals but were constrained by the harsh environment to adapt to whatever nutritious material could be recovered.

APPENDIX

Table A1 Daily food consumption per person, January–November

Species name	Common name	Total (g/d%)	Energy (kcal/d)	Protein (g/d)	Fat (g/d)	Carbohydrate (g/d)
JANUARY						
Solanum centrale	Bush raisin (dried)	517 (40.8)	1452	43.9	19.6	287.5
Solanum chippendalei	Bush tomato (fresh)	380 (30)	350	6.1	2.3	78.3
Small game (6 spp.)		85 (6.7)	139	22.6	4.6	1.6
Large game (macropods)		285 (22.5)	450	72.1	10.5	16.8
Totals		**1267**	**2391**	**144.7**	**37.0**	**384.2**
FEBRUARY						
Solanum centrale	Bush raisin (dried)	616 (53.9)	1731	52.4	23.4	342.5
Solanum chippendalei	Bush tomato (fresh)	343 (30.0)	316	5.5	2.1	70.7
Canthium latifolium	Currant bush (fruit)	86 (7.5)	171	2.4	0.1	42.1
Chenopodium rhadinostachyum	Crumble weed (seed)	11 (1)	33	2.2	0.3	3.9
Small game (6 spp.)		85 (7.4)	139	22.6	4.6	1.6
Totals		**1142**	**2390**	**85.1**	**30.5**	**460.8**
MARCH						
Solanum centrale	Bush raisin (dried)	78 (7.5)	219	6.6	3.0	43.4
Solanum chippendalei	Bush tomato (fresh)	78 (7.5)	72	1.2	0.5	16.1
Canthium latifolium	Currant bush (fruit)	440 (42.3)	876	12.3	0.4	215.2
Eragrostis eriopoda	Woollybutt (seed)	78 (7.5)	248	12.6	1.2	48.4
C. rhadinostachyum	Crumble weed (seed)	281 (27.0)	835	56.5	8.1	99.8
Small game (6 spp.)		85 (8.1)	139	22.6	4.6	1.6
Totals		**1039**	**2389**	**111.8**	**17.8**	**424.5**
APRIL						
Canthium latifolium	Currant bush (fruit)	281 (30.7)	559	7.9	0.3	137.4
Eragrostis eriopoda	Woollybutt (seed)	275 (30)	875	44.6	4.4	170.5
C. rhadinostachyum	Crumble weed (seed)	275 (30)	817	55.3	8.0	97.6
Small game (6 spp.)		85 (9.3)	139	22.6	4.6	1.6
Totals		**916**	**2390**	**130.4**	**17.3**	**407.1**
MAY						
Solanum centrale	Bush raisin (fresh)	66 (7.5)	90	2.5	0.4	20.0
Canthium latifolium	Currant bush (fruit)	66 (7.5)	131	1.8	0.1	32.3
Eragrostis eriopoda	Woollybutt (seed)	330 (37.6)	1049	53.5	5.3	204.6
C. rhadinostachyum	Crumble weed (seed)	330 (37.6)	980	66.3	9.6	117.2
Small game (6 spp.)		85g (9.7)	139	22.6	4.6	1.6
Totals		**877**	**2389**	**146.7**	**20.0**	**375.7**

Table A1 cont. on next page.

Table A1 (continued) Daily food consumption per person, January–November

Species name	Common name	Total (g/d%)	Energy (kcal/d)	Protein (g/d)	Fat (g/d)	Carbohydrate (g/d)
JUNE						
Solanum centrale	Bush raisin (fresh)	610	830	23.2	3.7	184.8
Santalum acuminatum	Quandong*	83	163	4.0	10.5	13.4
Eragrostis eriopoda	Woollybutt (seed)	83	264	13.4	1.3	51.5
C. rhadinostachyum	Crumble weed (seed)	250	743	50.3	7.3	88.8
Small game (6 spp.)		85	139	22.6	4.6	1.6
Totals		**1111**	**2139**	**113.5**	**27.4**	**340.1**
JULY						
Solanum centrale	Bush raisin (fresh)	610	830	23.2	3.7	184.8
Santalum acuminatum	Quandong*	640	1254	30.7	81.3	103.0
Small game (6 spp.)		85	139	22.6	4.6	1.6
Totals		**1335**	**2223**	**76.5**	**89.6**	**289.4**
AUGUST						
Solanum centrale	Bush raisin (fresh)	59	80	2.2	0.4	17.9
Santalum acuminatum	Quandong*	640	1254	30.7	81.3	103.0
Small game (6 spp.)		85	139	22.6	4.6	1.6
Totals		**784**	**1473**	**55.5**	**86.3**	**122.5**
SEPTEMBER						
Santalum acuminatum	Quandong*	640	1254	30.7	81.3	103.0
Ficus spp.	Desert fig (fruit)	59	80	1.8	1.2	18.3
Small game (6 spp.)		85	139	22.6	4.6	1.6
Totals		**784**	**1473**	**55.1**	**87.1**	**122.9**
OCTOBER						
Santalum acuminatum	Quandong*	65	127	3.1	8.3	10.5
Ficus spp.	Desert fig (fruit)	720	979	21.6	15.1	223.9
Small game (6 spp.)		85	139	22.6	4.6	1.6
Totals		**870**	**1245**	**47.3**	**28.0**	**236.0**
NOVEMBER						
Ficus spp.	Desert fig (fruit)	720	979	21.6	15.1	223.9
Small game (6 spp.)		85	139	22.6	4.6	1.6
Totals		**805**	**1118**	**44.2**	**19.7**	**225.5**

*Fruit (70%); kernel (20%)
Source: Based on Gould's data (1980)

ACKNOWLEDGMENTS

We thank Professor Richard Gould, Department of Anthropology, Brown University, for his assistance and for clarification of some details about this traditional diet. We also thank Associate Professor Donald Pate, Department of Archaeology, Flinders University; Professor Stewart Truswell, Nutrition Department, Sydney University; and Kim Akerman, formerly with the Museum and Art Gallery of the Northern Territory, for their comments on drafts of this paper.

REFERENCES

Altman, J.1987 *Hunter-Gatherers Today: An Aboriginal economy in north Australia*, Australian Institute of Aboriginal Studies, Canberra.

Baghurst, K.I., A.A. Hertzler, S.J. Record and C. Spurr 1992 The development of a simple dietary assessment and education tool for use by individuals and nutrition educators, *Journal of Nutrition Education* 24:165–74.

Berndt, R.M. 1959 The concept of 'the tribe' in the Western Desert of Australia, *Oceania* 30(2):81–107.

Brand Miller, J., K.W. James and P.M.A. Maggiore 1993 *Tables of Composition of Australian Aboriginal Foods*, Aboriginal Studies Press, Canberra.

Cane, S. 1984 Desert camps: a case study of stone artefacts and Aboriginal behaviour in the Western Desert, doctoral thesis, Australian National University, Canberra.

Cane, S. 1987 Australian Aboriginal subsistence in the Western Desert, *Human Ecology* 15:391–434.

Cordain, L., J. Brand Miller, S.B. Eaton, N. Mann, S.H.A. Holt and J.D. Speth 2000 Plant–animal subsistence ratios and macronutrient energy estimates in worldwide hunter-gatherer diets, *American Journal of Clinical Nutrition* 71:682–92.

Davidson, S., R. Passmore, J.F. Brock and A.S. Truswell 1979 *Human Nutrition and Dietetics*, 7th edn, Churchill Livingstone, Edinburgh.

Eaton, S.B. and M. Konner 1985 Paleolithic nutrition: a consideration of its nature and current implications, *New England Journal of Medicine* 312:283–9.

Elphinstone, J.J. 1971 The health of Australian Aborigines with no previous association with Europeans, *Medical Journal of Australia* 2:293–302.

Gould, R.A. 1977 Puntutjarpa rockshelter and the Australian desert culture, *Anthropological Papers of the American Museum of Natural History* 54(1):168–83.

—— 1980 *Living Archaeology*, Cambridge University Press.

—— 1986 To have and have not: the ecology of sharing among hunter-gatherers. In N.M. Williams and E.S. Hunn (eds), *Resource Managers: North American and Australian hunter-gatherers*, Australian Institute of Aboriginal Studies, Canberra, 69–98.

Gracey, M. 1986 The nutrition of Australian Aborigines. In M.L. Wahlqvist and A.S. Truswell (eds), *Recent Advances in Clinical Nutrition*, Libby, London, 57–68.

Lee, A. 1996 The transition of Australian Aboriginal diet and nutritional health, *World Review of Nutrition and Dietetics* 79:1–52.

McArthur, M. 1960 Food composition and dietary levels of groups of Aborigines living on naturally occurring foods. In C.P. Mountford (ed.), *Records of the American–Australian Scientific Expedition to Arnhem Land*, vol. 2, Melbourne University Press, 90–135.

Meehan, B. 1982 *Shell Bed to Shell Midden*, Australian Institute of Aboriginal Studies, Canberra.

O'Connell, J.F. and K. Hawkes 1981 Alyawarra plant use and optimal foraging theory. In B. Winterholder and E. Smith (eds), *Hunter-Gatherer Foraging Strategies: Ethnographic and archaeological analyses*, University of Chicago Press, 99–125.

O'Dea, K., R.M. Spargo and K. Akerman 1980 The effect of transition from traditional to urban lifestyle on the insulin secretory response in Australian Aborigines, *Diabetes Care* 3:31–7.

Pate, F.D. 1998 Bone collagen stable nitrogen and carbon isotopes as indicators of prehistoric diet and landscape use in the southeastern South Australia, *Australian Archaeology* 46:23–9.

Paul, A.A. and D.A.T. Southgate 1979 *The Composition of Foods* (4th edn with first supplement, 1980), Her Majesty's Stationery Office, London.

Smith, P.A. and R.M. Smith 1999 Diets in transition: hunter-gatherer to station diet and station diet to the self-select store diet, *Human Ecology* 27:117–34.

Smith, R.M., P.A. Smith, M. McKinnon and M. Gracey 2000 Birthweights and growth of infants in five Aboriginal communities, *Australian and New Zealand Journal of Public Health* 24:124–35.

Smith, R.M., R.M. Spargo, E.M. Hunter, R.A. King, R.L. Correll, I.H. Craig and P.J. Nestel 1992a Prevalence of hypertension in Kimberley Aborigines and its relationship to ischaemic heart disease, *Medical Journal of Australia* 156:557–62.

Smith, R.M., R.M. Spargo, R.A. King, E.M. Hunter, R.L. Correll and P.J. Nestel 1992b Risk factors for hypertension in Kimberley Aborigines, *Medical Journal of Australia* 156:562–6.

Stampfer, M.J., F.B. Hu, J.E. Manson, E.B. Rimm and W.C. Willett 2000 Primary prevention of coronary heart disease in women through diet and lifestyle, *New England Journal of Medicine* 343:16–22.

Thomson, N.A. 1991 Review of Aboriginal health status. In J. Reid and P. Trompf (eds), *The Health of Aboriginal Australia*, Harcourt Brace Jovanovich, 37–79.

White, K., M. Gracey, L. Schumacher, R. Spargo and N. Kretchmer 1990 Hyperinsulinaemia and impaired glucose tolerance in young Australian Aborigines, *Lancet* 335:735.

Willett, W.C. and M.J. Stampfer 2003 Rebuilding the food pyramid, *Scientific American* 288:52–9.

Richard Smith, DSc, is a former Chief Research Scientist, CSIRO, Division of Human Nutrition, Adelaide, and specialist in the health outcomes of poor nutrition. He worked for many years with Aboriginal people in the Kimberley and Pilbara regions, Western Australia, and is currently a consultant medical scientist with Miln Walker & Associates Pty Ltd.

Miln Walker and Associates Pty Ltd, PO Box 167, Belair SA 5052
<smithric@tpg.com.au>

Pam Smith, PhD, has qualifications in both archaeology and anthropology and has worked in the Kimberley region, Western Australia, for the past 10 years. She is currently a Postdoctoral Research Fellow with the Department of Archaeology, Flinders University, South Australia.

Department of Archaeology, Flinders University, GPO Box 2100, Adelaide SA 5001
<Pamela.Smith@flinders.edu.au>