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AN INPUT/OUTPUT ENERGY ANALYSIS OF TI GATHERING

Barry Fankhauser
Department of Anthropology
University of Otago
Dunedin

Large Maori earth ovens occur and have been recorded over wide areas of Canterbury, Otago, and Southland. Ethnographic accounts indicate that these ovens were used for cooking cabbage trees (Cordyline australis, ti in Polynesian) and have the name of umu ti (Kauru n.d.; Best 1976; Brunner 1952:125). Hardwicke Knight (1966) and I (Fankhauser 1986) have carried out archaeological investigations on umu ti in Otago and South Canterbury, respectively.

Ti was an important plant prehistorically throughout the Pacific. C. australis is the most widespread of the five species in New Zealand and would have been the main species available in southern New Zealand. I did a nutritional analysis of C. australis and found that it is equal in energy value to other common starchy foods which form the basis of diets throughout the world (Table 1). Its sugar content, mainly fructose, surpasses that of sugarcane and sugar beet in both sweetness and quantity (Fankhauser and Brasch 1985).

In this article, I present a scenario of how ti could have been harvested and cooked in South Canterbury. This scenario is based on my thesis research (Fankhauser 1986). I estimate the energy involved in the process and give an input/output energy analysis to determine if ti gathering was worthwhile. The scenario takes place over four days in early summer about 500 years B.P.

Energy requirements for various activities have been given by Pyke (1970), Clark and Haswell (1970), and Altman and Dittmer (1968). The energy expended in any task is above that of the basal metabolism rate (BMR). In the input/output analysis below, I use mainly the BMR value of 45 kcal/hour (small calorie) given by Pyke (1970), although this value varies depending on the study (cf. Altman and Dittmer 1968:344-345). I use kcal because they are more familiar to most people, but conversion to kilojoules (kJ) can be made by multiplying kcal by 4.19.

Ti gathering in South Canterbury

Preparations for gathering ti were made in advance and thus, when ten men leave at 6 a.m. on day one, they are well

Food	Water	Ash	Fat	Carbo-hydrate	Fibre	Protein	kcal / 100g	kJ / 100g
Potato (<u>Solanum tuberosum</u>)	79.8	0.9	0.1	17.1	0.5	2.1	76	318
Sweet Potato (<u>Ipomoea batatas</u>)	70.6	1.0	0.4	26.3	0.7	1.7	114	477
Taro (<u>Colocasia esculenta</u>)	72.5	1.2	0.2	24.2	0.9	1.9	104	435
Yam (<u>Dioscorea sp.</u>)	73.5	1.0	0.2	23.2	0.9	2.1	101	423
Wheat-cooked (<u>Triticum aestivum</u>)	87.7	0.8	0.3	9.4	0.3	1.8	45	188
<u>Cordyline australis</u>*:								
Root	64.0	0.9	1.4	23.6	10.3	0.4	103	431
Stem	68.3	0.7	1.5	14.9	13.6	0.4	71	297
Top	81.5	1.7	3.2	8.8	4.5	1.4	68	283

* Average of November through February analyses.

TABLE 1. Food composition: nutritive value of edible portion (%).

Input: Activity	No. Men	Hours	Energy Required (kcal/hr)	Total Energy (kcal)
Travel to location (20 km)	10	5	225	11250
Gathering and preparing <u>ti</u>	10	20	320	64000
Collecting stones	5	4	300	6000
Collecting wood	5	2	280	2800
Digging oven	5	5	320	8000
Preparing oven	5	5	280	2800
Uncovering oven	5	1	300	1500
Return to settlement	10	6	385	23100
			Subtotal	119450
Other activities	10	15	130	19500
Sleep	10	27	70	18900
			Total	157850
Output: <u>ti</u>, 325 kg (dry wt.)				811000
Output/input ratio:				5.1

TABLE 2. Energy analysis of <u>ti</u> (<u>C. australis</u>) gathering.

Figure 1. Collecting stones and digging pit for umu ti.

Figure 2. Throwing stones on to burning wood of umu ti.

prepared for the task ahead. They carry adzes, rope, baskets, some food, and matting for covering the ti while it is being cooked. Matting was also made on site. They leave their permanent settlement on the coast and walk 20 km inland to the foothills just above the plain. They walk at an average rate of 4 km per hour which requires an additional 180 kcal per hour above BMR giving 225 kcal/hr per man for a total of 11250 kcal for ten men in the five hour trip (Table 2).

They select a site to dig the oven in a sheltered valley on a stream bank. This area is well known to them because this is their second trip to cook ti this year and they have been returning to this general area for many years. Cooked ti from their first trip is dry and ready to carry back to the settlement. All the materials needed are close at hand. Stones are in the stream. They agree to dig a completely new oven rather than reuse the old one. The new oven will be reused again this summer.

After a brief meal, they start to work. They reuse some digging sticks left from their first trip and made some new ones. They set to work gathering and preparing the ti. This is fairly strenuous work and requires about 320 kcal/hour per man (Table 2). They select young plants with an average usable stem length of 1.5 m and a diameter of 10 cm. The cone shaped roots are, on average, 0.75 m long.

After some plants are dug, two of the men strip the bark and cut them into lengths of from 60-75 cm. The bark comes off easily when the plants are fresh and a single adze blow cuts through the stems. Some tops (undeveloped leaves) are saved for food and the leaves are saved for covering the stones in the oven. The other tops are replanted.

At the end of the first day the ti has been gathered. After some leisurely activities and repairs to adzes and digging sticks, the men sleep for nine hours.

They rise at 6 a.m. on the second day, eat and start work. On this day they complete the preparations for cooking. Four men collect stones from the stream. This activity requires 300 kcal per hour (Table 2). They pile them next to the pit which is being dug (Figure 1). Others are collecting wood. They pick off branches from totara trees which have fallen. These trees were killed in a forest fire which occurred in the past hundred years.

Some men catch eels from the stream. These are cooked along with C. australis tops in a small steam oven located in their camp, a short distance from the oven site.

At the end of the day everything is ready for lighting the oven in the morning. The three metre diameter pit is filled with wood and the ti is bundled. A shallow oven has been dug next to the large oven. A short ceremony is performed by the tohunga where some tops of the ti are cooked in the shallow oven. The men again sleep nine hours.

On the third day, a fire is lighted in the pit. It is a windy day causing the fire to burn intensely. When the wood is alight, the stones are thrown in the pit (Figure 2). After four hours, the fire has burned down and the stones are hot. The stones are shifted about with poles, and then fern and ti leaves are spread over the stones. The bundles of ti are placed in the oven (Figure 3). Water is poured over the bundles which are then covered with matting and soil.

After this is done, there is very little to do for the rest of the day except to bundle the ti from the first cooking and prepare for the return journey. The men have a good sleep.

In the morning, the oven is opened and the ti removed (Figure 4). This operation requires 300 kcal per hour (Table 2). The sweet smell of burning sugar permeates the air. The ti is put on drying racks to dry until they return again to carry this lot back to the settlement.

They return to the settlement carrying dry ti from their first harvest. Now they are carrying a heavy load, they take longer to return (six hours) and expend more energy (385 kcal/hour). Total energy expenditure for the four days is 157850 kcal.

Now I look at the output for this activity. The fresh weight of the 80 ti plants which were cooked totals 1188 kg which includes 1008 kg for the stems and 180 kg for the roots. Note that I have assumed the stems are cylindrical and the roots are conical. The density of fresh ti is greater than that of water: 1.07 g/cm³ for stems and 1.13 g/cm³ for roots. Unless an oven was located near to settlements, it would be a difficult task to carry freshly cooked plants. However, when ti is dry the stems have a density of about 0.26 g/cm³ and the roots are 0.35 g/cm³. The dry weight of the 80 ti plants would be 325 kg and the amount carried would only be limited by the bulk which one could handle.

The energy value from the fresh ti can be determined using my results in Table 1. Note that the energy which could be provided by the tops is not included in this analysis. The stems at 71 kcal/100 g will supply 715680 kcal of food energy. The roots supply 185400 kcal. If a 10% loss of nutrients during cooking is assumed, then the total energy provided

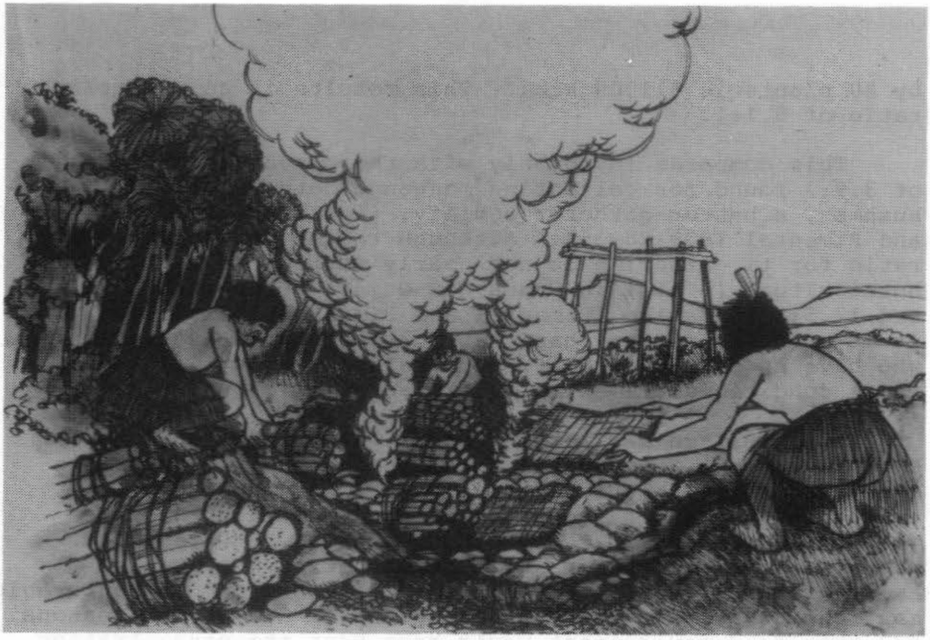

Figure 3. Placing bundles of ti in oven for cooking.

Figure 4. Opening umu ti and removing cooked ti. Drying platform for ti in background.

by 80 plants is 811000 kcal. This results in an output/input ratio of 5.1:1.

This compares favourably with the output/input ratio of 3.9:1 found for collecting mongongo nuts by the !Kung bushmen, a hunter-gatherer society, (Lee 1969; Pimental and Pimental 1979:28-35). Although the output/input energy ratio for ti gathering is not nearly as high as that for horticulture (- 16:1 in Papua New Guinea [Rappaport 1971] and 12.5:1 in Mexico [Pimental and Pimental 1979:39-40], it is probably better than that for most hunter-gatherers who have an average output/input ratio of about 4:1 under ideal conditions (Pimental and Pimental 1979:39).

The southern New Zealand Maori was fortunate to have Cordyline close at hand. A single hectare of C. australis plants of the size which I have described, if spaced an average of 5 m apart, contains about 4.5 million kcal of potential food energy. Each !Kung bushman requires 1040 hectares of habitat from which to gather food (Pimental and Pimental 1979:31). Maori would have had a more favourable environment in which to hunt and gather. One of the reasons for this good environment would have been the concentration of ti in certain areas (cf. Clark and Haswell 1970).

Although it was a strenuous activity, I conclude that the gathering of ti was worthwhile. No doubt this is one of the reasons it was so widely used throughout most of the Pacific and particularly in New Zealand.

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References

Altman, P.L. and D.S. Dittmer 1968 Metabolism. Federation of American Societies for Experimental Biology, Bethseda, Maryland.

Best, E. 1976 Maori Agriculture (second edition). Government Printer, Wellington.

Brunner, T. 1952 The Great Journey. Pegasus Press, Christchurch.

Clark, C.G. and M. Haswell 1970 The Economics of Subsistence Agriculture (4th edition). Macmillan, London.

Fankhauser, B.L. 1986 Archaeometric Studies of Cordyline (ti) Based on Ethnobotanical and Archaeological Research. PhD thesis, Anthropology Department, University of Otago, Dunedin.

Fankhauser, B.L. and D.J. Brasch 1985 Preparation of high-fructose syrup from the New Zealand cabbage tree, Cordyline australis. New Zealand Journal of Technology 1:27-31.

Kauru, n.d. South Island food-gathering methods. M.S. Papers 1187, 208. Polynesian Society Papers. Alexander Turnbull Library, Wellington.

Knight, H. 1966 Umu-ti. Jnl Polyn. Soc., 75:332-347.

Lee, R.B. 1969 !Kung bushman subsistence: an input-output analysis. Pp.47-79 in Vayda, A.P. (ed), Environment and Cultural Behaviour: Ecological Studies in Cultural Anthropology. Natural History Press, Garden City, New York.

Pimental, D. and M. Pimental 1979 Food, Energy and Society. Edward Arnold, London.

Pyke, M. 1970 Man and Food. McGraw Hill, New York.

Rappaport, R.A. 1971 The flow of energy in an agricultural society. Scientific American, 225:116-132.