NUTRITIONAL PROPERTIES OF SOME FRUITS EATEN BY THE POSSUM *TRICHOSURUS VULPECULA* IN A NEW ZEALAND BROADLEAF – PODOCARP FOREST

C. K. WILLIAMS

Division of Wildlife Research. CSIRO, P.O. Box 84, *Lyneham, A.CT. 2602. Australia.*

SUMMARY: Previous studies have shown fruits of native plants to be an important part of the diet of the possum *(Trichosurus vulpecula* Kerr) in the broadleaf-podocarp forest of Orongorongo Valley, New Zealand. Fruits from six species of native plants, abundant in the valley in late summer and autumn, 1979, were analysed physically and chemically and compared with the leaf-only portion of the possum diet. These fruits were generally moist, rich in available carbohydrate and low in fibre and appeared to be a source of readily digestible energy. The fruits and dietary leaves were generally similar in levels of crude protein, lipid and ash, with the exception of pigeonwood fruit which was very high in lipid. Some physical characteristics of some fruits seemed to detract from their value as food for possums. It is hypothesised that inclusion of fruit in the natural diet permits greater rates of intake of digestible nutrients than is possible by consumption of leaves alone.

The high status of hinau *(Elaeocarpus dentatus)* fruit as a source of available energy supports the conclusion of a demographic study (Bell, 1981) that its abundance in autumn enhances the success of winter reproduction of possums in Orongorongo Valley.

INTRODUCTION

The diet of the possum *Trichosurus vulpecula* Kerr in the broadleaf-podocarp forest of Orongorongo Valley near Wellington, New Zealand, has been analysed from stomach contents by Mason (1958). In the same area, Fitzgerald (1976, 1978) quantified the leaf component of the possum diet as relative wet weights of the species consumed, using faecal analyses and correcting for the relative degrees of persistence of leaf cuticle in the possum's alimentary tract. The non-leaf components of the diet, flowers and buds, fruits, bark and fern flesh, were not quantified, although both studies showed that flowers and fruits were important components of the diet. Fruits were consumed mainly in summer and autumn, and flowers and buds were eaten in greater quantities in winter and spring, in accordance with availability (Fitzgerald, 1976).

The present study reports some physical and chemical properties of fruits of some common native species. These are compared with the same properties of the leaf portion of the diet in an attempt to assess their value in the natural diet of possums.

In Orongorongo Valley during late summer and autumn (February - May inclusive) of 1979, ripe fruits were abundant on some common species of tree and liane. The analyses included the following six species chosen mainly on the basis of abundance: karaka *(Corynocarpus laevigatus),* hinau *(Elaeocarpus dentatus),* pigeonwood *(Hedycarya arborea),* kawakawa *(Macropiper excelsum),* kanono *(Coprosma grandifolia),* and the liane, supplejack *(Ripogonum scandens).* In addition, the leaves of mahoe *(Melicytus ramiflorus)* were analysed.

Mason (1958) reported that the skin and flesh (hereinafter called 'flesh'), but usually not the seeds, of hinau and pigeonwood fruits were commonly eaten by possums, and the fruit of kawakawa was also commonly eaten although the seeds were not mentioned. Kawakawa fruit includes many minute seeds which appear in the possum's faeces mainly undigested (P. Cowan, pers. com.). Mason (1958) reported that the flesh of supplejack fruit was eaten, which Fitzgerald (1976) confirmed. Kanono fruit was not often eaten, and seeds of *Coprosma* sp. occurred rarely in the stomach contents (Mason, 1958). Karaka fruit was eaten (Mason, 1958) and present observations indicate that the flesh only is eaten, and only when fully ripe. These observations suggest that flesh but not the seeds of some of these fruits were important in the possum diet, while other abundant fruits were eaten infrequently.

METHODS

Samples of fruit were collected from tree or ground, either by hand or by using a tree pruner on an extendable pole. The fruits and mahoe leaves were plucked from the stems and then sealed in

TABLE 1. *Mean wet and dry weights of ripe fruits and fruit flesh of six native plants* in *Orongorongo Valley*.

Species	n	Wet weight		% dry matter in flesh	Dry Weight Mean Weight flesh per fruit (g)
		Mean weight per fruit (g)	% flesh		
Corynocarpus laevigatus (karaka)	35	4.91	52	13	0.34
Elaeocarpus dentatus (hinau)	35	1.05	56	44	0.26
Macropiper excelsum (kawakawa)	70	2.82	57	14	0.22
Hedycarya arborea (pigeon wood)	69	0.67	42	24	0.07
Ripogonum scandens (supplejack)	88	0.83	51	13	0.06
Coprosma grandifolia (kanono)	150	0.24	74	8	0.01

plastic bags. In the laboratory, a scalpel was used to strip all flesh from the seeds of all species except kawakawa for which the seeds were removed from the flesh with fine forceps. The flesh of kawakawa fruit was oven dried at 60°C and the flesh of the other five fruits and mahoe leaves was vacuum freeze dried. The dried flesh and mahoe leaves (including the midribs which were excluded by Fitzgerald (1976)) were finely ground in a Wiley mill, and analysed by D.S.I.R. Applied Biochemistry Division for total nitrogen (Kjeldahl digestion and autoanalyser, crude protein = N x 6.25), lipid (crude total of chloroform-methanol phase extract), acid detergent fibre (A.D. fibre), ash, energy (bomb calorimetry), water soluble sugars, and methanol-soluble sugars (water-soluble portion of methanol, chloroform, water, 12 : 5 : 3, extraction, anthrone colorimetry with glucose standards). Pentoses, pectins and gums were apparently present in some analyses of sugars so the non-structural carbohydrate fractions are also reported as nitrogen-free extract (N.F.E.), determined by differences from the totals. These are described hereinafter as available carbohydrate, implying that they are mainly digestible to possums, although there may be some included fractions which are not. The chemical analyses were done in duplicate, except for the energies which were estimated in triplicate. and the results of the replicates were averaged.

RESULTS

The mean wet and dry weights of the flesh per fruit are shown in Table 1. Karaka, hinau and kawakawa, in that order, yielded considerably more dry weight of flesh per fruit than the other three species which had low yields. Although kanono fruit contained a high percentage of wet flesh, there was little dry matter in the flesh and for this reason was not analysed chemically.

The chemical analyses of the fruit flesh are shown in Table 2 and compared with species means and dietary means (based on mean percentage occurrence by dry weight) for the leaf-only portion of the possum diet. The leaf data are from Fitzgerald (1976, 1978 and unpubl. data) and some data on moisture content of the leaves are from Froude (1979). The 12 most abundant leaf species (by wet weight) included in this comparison constituted 99.6 % of the leaf-only portion of the average annual possum diet in Orongorongo Valley for 1969-73 (Fitzgerald, 1976). (For leaves of tawa, *Beilschmedia tawa,* data were available only for moisture, lipid and energy contents. This could have little effect on the mean values because leaves of this species constituted only l.l ± 1.9% of the annual average leaf diet (Fitzgerald, 1978)).

Compared with the other fruits, hinau fruit was low in moisture, crude protein, lipid and ash, and high in available carbohydrate (N.F.E.). The available carbohydrate of hinau had only a small component of sugars (12.9%), both water-soluble and alcohol-soluble especially. In the sugar analyses the hin1,iu samples were difficult to filter. This raises the possibility that the samples contained non-structural carbohydrates of large molecular size, such as pectins, and therefore the analysed hinau fruits may have been unripe. Karaka fruit had moderately low levels of A.D. fibre and high levels of available

TABLE 2. *Comparisons of mean water contents and compositions (dry weight basis) of fruit flesh of five common species and leaves of the 12 principal species of the average annual leaf diet of the possum in Orongorongo Valley (Fitzgerald, 1978). Sources (1) this study; (2) Fitzgerald (1976, 1978 and unpubl. data), and Froude (1979) for water data on some species.*

	Water %	Crude protein %	Lipid %	Ash %	A.D. Fibre % or *Crude Fibre %	N.F.E. %	Water-soluble sugars %	Methanol-soluble sugars %	gross energy KJ/g
Fruit Species(1)									
Corynocarpus laevigatus (karaka)	87	8.1	4.0	8.9	14.3	64.7	5.7	50.1	16.5
Elaeocarpus dentatus (hinau)	56	3.4	1.7	3.2	21.8	69.9	10.0	2.9	18.0
Macropiper excelsum (kawakawa)	85	10.3	9.2	12.5	7.7	60 3	9.0	61.5	18.4
Hedycarya arborea (pigeonwood)	76	9.9	21.4	8.2	23.7	36.7	3.9	3.2	23.8
Ripogonum scandens (supplejack)	87	6.8	5.7	9.1	29.4	49.0	3.3	33.5	17.5
12 Principal dietary leaf species(2)									
Mean ± S.D. (%)	63 ± 9	9.0 ± 3.8	5.0 ± 2.8	6.9 ± 2.3	*43.5 ± 10.3	35.9 ± 11.3	—	—	19.6± 1.3
Mean for average leaf diet (%)	62	7.0	4.9	5.2	*41.3	40.9	—	—	20.1
Melicytus ramiflorus (mahoe) (leaves)									
with midribs(1)	72	13.6	11.0	10.7	35.8	28.9	2.1	11.9	18.0
without midribs(2)	67	14.5	2.4	9 7	*50.6	22.8	—	—	18.2

carbohydrate, particularly alcohol-soluble sugars. Kawakawa fruit is notable for the low level of contained A.D. fibre and, like karaka, had high levels of N.F.E. and alcohol-soluble sugars. Pigeonwood fruit was low in available carbohydrate and total soluble sugars (7.1%), and very high in lipids which were more than double those of the other analysed fruits. This probably accounts for the very high gross energy of pigeonwood fruit. Supplejack fruits were relatively high in A.D. fibre, but also contained moderate amounts of available carbohydrate and alcohol-soluble sugars.

Compared with the leaf portion of the average annual possum diet (Fitzgerald, 1976, 1978), these fruits were relatively moist (except hinau fruit), but similar in the levels of protein, lipid and energy (except pigeonwood fruit), and ash. The analyses of crude fibre in leaves and A.D. fire in fruits may have measured slightly different carbohydrate fractions, and this also influences the comparison of N.F.E. levels. Nevertheless the crude fibre levels in the leaves were considerably higher than the A.D. fibre levels in the fruits, suggesting that the carbohydrate in the fruits was more available than that in the leaves. The levels of A.D. fibre and N.F.E. in mahoe leaves compared with that in fruits indicate lower levels of fibre and more available carbohydrate in all the fruits analysed. There are no data on the relative availabilities of the gross energy contained in the leaves and fruit flesh.

Hinau fruit had lower levels of protein, lipid and ash than the values obtained for hinau leaves by Fitzgerald (1976 and pers. comm.). This indicates a greater proportion of total carbohydrate in the fruit (91.7%) than the leaves (85.9%), and the different fibre analyses indicate more fibre in the leaves (54% crude fibre in leaves and 22% A.D. fibre in the fruit) and more N.F.E. in the fruit (70%) than the leaves (32%). Supplejack fruit had higher levels of moisture, lipid and ash, and lower levels of protein than the levels obtained for supplejack leaves (Fitzgerald 1976 and pers. comm.), indicating similar levels of total carbohydrate in the fruit (78.4%) and leaves (77.4%). The crude fibre levels of supplejack leaves (64%) greatly exceeded the A.D. fibre level in supplejack fruit (29%), and the estimate of N.F.E. in the fruit (49%) was much greater than that in leaves (13%).

DISCUSSION

The analyses of the six fruits showed that they were rich in moisture and available carbohydrate. Comparisons of the fruits with the main dietary leaves showed that the levels of protein, lipids (except

for pigeonwood fruit) and ash were generally similar. Fibre and N.F.E. comparisons between fruits and leaves were confounded by different analytical techniques, but are suggestive of greater availability of carbohydrate in the fruits. Comparisons between the fruits and mahoe leaves analysed by the same techniques indicated lower fibre levels and more available carbohydrate in the fruits. This suggests that if fruits in the diet replace mahoe leaves, there would be increased dietary availability of moisture and digestible carbohydrate, a source of available energy, This dietary change occurred in years of low rainfall, particularly in autumn-winter (Fitzgerald and Ward, unpubl. data). In Orongorongo Valley, free water is abundant throughout most of the year, and probably always available to possums. This suggests that fruits in the broadleaf forests are probably more important to possums as a source of readily available energy than as a source of water.

The amounts of flesh dry matter per fruit and the levels of available carbohydrate were particularly high in fruit of hinau, karaka and kawakawa (Table 2), and, although low in available carbohydrate and dry matter per fruit, pigeon wood fruit was very high in lipids. Therefore, if the lipid in pigeonwood fruit is in an available form, all these fruits may be very important energetically to possums.

Many factors impinge on a fruit's value as food for possums, e.g. (a) the abundance of the species in the forest, (b) the density of the fruit crop on the tree, (c) the duration of the fruit in edible form, (d) the accessibility of the fruit and the yield of dry matter per collecting effort, (e) the gross nutritional value of the flesh or whether it contains any scarce nutritional elements physiologically required, and (f) whether the fruit contains any toxic secondary compounds in unripe or ripe forms. Karaka is limited in distribution to near the coast and has toxic compounds in the unripe and ripe states (Connor, 1977), and possums eat it only when ripe. Hinau is widely distributed and abundant in the broad leaf forest of Orongorongo Valley. It often produces heavy fruit crops which persist for a long time (Fitzgerald, 1976), and possums eat the unripe and ripe fruit mainly in autumn and winter (Ward, 1978). Hinau fruit, therefore, seems to be nutritionally important to possums in the broadleaf forests.

These interpretations of the relative compositions of fruits and leaves, and the value of fruit to possums in Orongorongo Valley, are consistent with two other aspects of possum ecology. Bell (1981) showed that reproductive success in Orongorongo Valley was correlated with body weights of females in autumn and winter months. High success followed warm dry summers and heavy fruitfall of hinau (Bell, 1981). Low success was associated with low body weights, high adult mortality and light fruitfall in the previous autumn. Years of higher recruitment were associated with fewer rain-nights and greater availability and consumption of fruit (Fitzgerald and Ward, unpubl. data).

A contributory cause for these correlations is provided by the qualities of hinau fruit and its consumption by possums during autumn and winter. The abundance of ripe hinau fruit in those seasons emphasises the importance to possums of storing energy as body fat, which, by implication from observed weight variations appeared to enhance reproductive success in winter and early spring when energy demands on females were increased by lactation. Additional energy supplies may also be required to detoxify increased amounts of leaf secondary compounds (Rinks and Bolliger, 1957; Freeland and Winter, 1971) caused by a change of diet during the more severe winters and when less fruit is consumed (Fitzgerald and Ward, unpubl. data). These aspects of possum ecology indicate the special importance of dietary energy to the possum in the broadleaf-podocarp forests of Orongorongo Valley, and that reproductive success may be related to its variable availability and abundance.

ACKNOWLEDGEMENTS

I thank Dr John Gibb, then Director, and staff of Ecology Division, D.S.I.R. for hospitality during my exchange visit to New Zealand. The chemical analyses were performed by Mrs Catherine Gurney, Mrs Anna Ngan and Dr Brian Tapper of Applied Biochemistry Division, D.S.I.R., Palmerston North. I am grateful to Mrs Alice Fitzgerald and Mr Dave Ward for permission to refer to their unpublished data in manuscript. The manuscript was typed by Mrs Janice Rudd, and critical comments were kindly given by Drs Hugh Tyndale-Biscoe, Steven Cork and Graeme Caughley of Division of Wildlife Research, C.S.I.R.O., and Mrs Alice Fitzgerald and Drs Bob Brockie and Phil Cowan of Ecology Division, D.S.I.R.

REFERENCES

BELL, B. D. 1981. Breeding and condition of possums *Trichosurus vulpecula* in the Orongorongo Valley, near Wellington, New Zealand, 1966-1975. *In:* Bell, B. D. (Editor). *Proceedings of the First Symposium on Marsupials in New Zealand*. pp. 87-139. Zoology Publication No. 74. Victoria University of Wellington.

CONNOR, H. E. 1977. *The poisonous plants in New Zealand*. 2nd rev. ed., D.S.I.R. Bulletin 99. Govt. Printer, Wellington.

FITZGERALD, A. E. 1976. Diet of the opossum *Trichosurus vulpecula* (Kerr) in the Orongorongo Valley, Welling-

ton, New Zealand, in relation to food-plant availability. *New Zealand Journal of Zoology* 3: 399-419.

FITZGERALD, A. E. 1978. Aspects of the food and nutrition of the brush-tailed opossum, *Trichosurus vulpecula* (Kerr, 1972), Marsupialia: Phalangeridae, in New Zealand *In:* Montgomery, G. G. (Editor) *The Ecology of Arboreal Folivores*. pp. 289-303. *Symposia of the National Zoological Park*. Smithsonian Institution, Washington, D.C.

FREELAND, W. J.; J. W. WINTER 1975. Evolutionary consequences of eating: *Trichosurus vulpecula* (Marsupialia) and the Genus *Eucalyptus*. *Journal of Chemical Ecology*.1: 439-55.

FROUDE, V. A. 1979. The allelopathic potential of some abundant New Zealand forest and scrub plants. Unpublished report. D.S.I.R. Ecology Division, Wellington. 18 pp.

HINKS, N. T.; A. BOLLIGER 1957. Glucuronuria in a herbivorous marsupial *Trichosurus vulpecula*. *Australian Journal of Experimental Biology*. 35: 37-44.

MASON, R. 1958. Foods of the Australian opossum *(Trichosurus vulpecula*. Kerr) in New Zealand indigenous forest in the Orongorongo Valley, Wellington. *New Zealand Journal of Science*. I: 590-613.

WARD, G. D. 1978. Habitat use and home range of radiotagged opossums *Trichosurus vulpecula* (Kerr) in New Zealand lowland forest. *In:* Montgomery, G. G. (Editor) *The Ecology of Arboreal Folivores*. pp. 267-287. *Symposia of the National Zoological Park*. Smithsonian Institution, Washington, D.C.