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Metabolizable energy of wild duck foods

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Abstract

Metabolizable energy (ME) was measured in 18 plant and 3 invertebrate foods fed to captive Blue-winged Teal (*Anas discors*). ME was determined with a reference diet and a chromic oxide digestion indicator. Although the birds adapted well to the experimental diets, the natural foods had consistently low ME values considering their chemical composition. Three foods showed negative values. ME values measured with captive birds probably do not reflect the energy derived from the same foods eaten in the wild.

Résumé

On a mesuré l'énergie métabolisable (EM) de 18 plantes et de 3 invertébrés donnés en nourriture à une Sarcelle à ailes bleues (*Anas discors*) en captivité. On a déterminé l'EM à l'aide d'un régime de référence et d'un indicateur de digestion à base d'oxyde chromique. Bien que les oiseaux se soient bien adaptés aux régimes expérimentaux, les aliments naturels ont constamment donné des valeurs d'EM faibles, compte tenu de leur composition chimique. Trois aliments ont donné des valeurs nulles. Les valeurs d'EM mesurées à l'aide d'oiseaux captifs n'indiquent probablement pas la quantité d'énergie que produiraient les mêmes aliments mangés par des oiseaux en liberté.

Introduction

The relative values of foods eaten by waterfowl are commonly expressed as percentages of volume, weight or frequency of occurrence. Because these do not show the energy contributed by each food item, Sugden (1971) suggested that units of metabolizable energy (ME) would be superior. It was recommended that formulas for predicting ME of a food from its chemical composition be investigated. Use of formulas would eliminate the need for biological assay.

The present paper describes attempts to measure ME of duck foods using Blue-winged Teal (*Anas discors*). Objectives were to measure ME in a representative series of natural duck foods and determine if published formulas for poultry are applicable to duck foods for predicting ME from chemical data.

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Materials and methods

Foods for assay were collected in a fresh state and, except for seeds, kept frozen until preparation. Included were 3 invertebrates and 18 plants. On the basis of other studies, some foods were regularly eaten by ducks while others were seldom taken even in minor amounts. Unfortunately, because of their relative scarcity, it was not practical to collect sufficient quantities of insects that have been found important in duck diets. Before preparation (Table 1), aquatic plants were thoroughly rinsed in fresh water. Larger plants were rinsed in a washing machine. The Feed Testing Laboratory, University of Saskatchewan, made proximate analyses following AOAC methods (Horwitz, 1965). For assay, a test food was mixed with a reference or basal diet (Sibbald and Slinger, 1962) at levels ranging from 30.3 to 51.7 per cent (Table 1). The basal diet was composed primarily of ground wheat (57.2 per cent), soya bean meal (19.8 per cent), ground oats (10.0 per cent) and ground barley (5.7 per cent). Chromic oxide was mixed into the experimental diet (test food plus basal) at a level of 0.3 per cent to measure metabolizability (Dansky and Hill, 1952). The mixture was moistened with water and passed through a 5/16-inch die in a power meat grinder. The resulting strings were broken into pellets before feeding.

The diet was usually fed 96 hours before metabolite collection began and never less than 72 hours. Samples of diet taken during the collection period were ground and analysed for moisture by drying at 65°C for 48 hours, for gross energy (GE) by oxygen bomb calorimeter and for chromic oxide by Brisson's (1956) method. Photometric determination of chromic oxide was made with a Bausch & Lomb "Spectronic 20" with absorbancy read at 400 mμ.

Excreta were collected for 2 to 6 days, usually 4. Duration was influenced by the amount of test food available as well as the production of excreta. Daily collections from each duck were pooled and frozen, and later dried at 65°C in a vacuum oven, ground and analysed for moisture, gross energy and chromic oxide.

Laboratory conditions and metabolism pens have been described (Sugden, 1971). All tests were made with full-grown Blue-winged Teal that had been reared in captivity. A few tests included two full-grown Canvasbacks (*Aythya valisineria*). ME values determined with the Canvasbacks consistently fell within the ranges determined with the Teal so are pooled in the results. Ducks were weighed 1 day before collection and again at the end of the test. Between tests (about 6 days) they were fed the pelleted basal diet. The number of ducks (replicates) used varied with tests (Table 1) and was governed by the amount of test food available.

ME of the basal and experimental diets was calculated from the following formula (Sibbald *et al.*, 1960):

$$\text{ME/g feed} = \text{GE/g feed} - \left[\frac{Cr_2O_3\text{/g feed}}{Cr_2O_3\text{/g excreta}} \times \text{GE/g excreta}\right]$$

ME of test foods was calculated from the formula:

$$\text{ME/g test food} = \frac{\text{ME/g exptl diet} - (\text{ME/g basal} \times \%\ \text{basal in exptl diet})}{\%\ \text{test food in exptl diet}}$$

Table 1
Treatment of test foods, proportion of basal in experimental diets, and metabolizability (M) and metabolizable energy (ME) of experimental diets

Food	No. ducks	% Basal	Experimental diet* M (%)	Experimental diet* ME (kcal./g)
Basal†	23	100.0	62.9±0.4	3.09±0.01
Wheat, hard‡	11	50.8	67.4±1.0	3.08±0.04
Shrimp (*Gammarus* sp.)§	13	48.3	50.0±0.5	2.69±0.05
Alkali grass seeds (*Puccinellia Nuttalliana*)†	11	51.5	53.0±0.6	2.53±0.03
Waterlily seeds (*Nuphar variegatum*)‡	11	49.8	52.7±1.7	2.31±0.08
Slough grass seeds (*Beckmannia syzigachne*)†	10	60.5	47.5±0.5	2.34±0.02
Slough grass seeds with grit†	8	60.2		2.54±0.04
Duck weed (*Lemna minor*)§	12	54.0	40.3±0.7	2.17−0.03
Bulrush nutlets (*Scirpus paludosus*)†	12	66.2	48.6±1.5	2.35±0.08
Bulrush nutlets with grit (*S. paludosus*)†	12	66.5		2.62±0.05
Bulrush nutlets soaked (*S. paludosus*)#	12	66.5	54.7±0.9	2.59±0.04
Widgeon grass foliage (*Ruppia maritima*)°	10	59.9	46.3±0.7	2.19−0.02
Micro-crustaceans (Cladocera)§	12	48.4	34.1±0.6	1.92±0.02
Snails (Lymnaeidae)§	12	68.6	44.4±0.6	2.31±0.02
Duck weed (*Lemna trisulca*)°	12	49.6	37.2±0.8	1.83±0.02
Bulrush nutlets (*Scirpus validus*)†	8	54.3	40.5±1.3	1.92±0.06
Aquatic moss (Musci)°	11	59.7	43.0±0.7	2.04±0.03
Burrweed nutlets (*Sparganium eurycarpum*)†	5	64.7	43.9±1.7	2.16±0.08
Green alga (*Cladophora* sp.)°	10	64.1	43.4±0.5	2.13±0.03
Green alga (*Enteromorpha* sp.)°	9	69.7	48.5±1.4	2.26±0.07
Pondweed foliage (*Potamogeton pusillus*)°	9	48.9	32.1±1.3	1.66±0.06
Pondweed foliage (*P. pectinatus*)°	12	64.4	41.2±0.3	2.03±0.01
Milfoil foliage (*Myriophyllum exalbescens*)°	12	64.5	40.6±0.7	2.02±0.03
Aquatic liverwort (*Ricciocarpus natans*)§	5	69.3	43.5±0.9	2.13±0.03
Dock fruits (*Rumex maritimus*)†	12	60.2	35.9±0.9	1.71±0.05
Pondweed foliage (*Potamogeton Richardsonii*)°	12	59.8	31.2±0.9	1.67±0.03

*Test food plus basal.
†Air-dried.
‡Air-dried, crushed.
§Oven-dried at 65°C, ground.
#Soaked for 3 months.
°Air-dried and ground.

The percentage (M) of experimental diet that was metabolized was calculated from the formula:

$$\%\,M = 1 - \left[\frac{Cr_2O_3/g\ feed}{Cr_2O_3/g\ excreta}\right] \times 100$$

An estimate of variance for ME of test foods was calculated from the formula:

$$V_t = \frac{V_e + (V_b)p^2}{q^2}$$

where V_t = variance for test food
V_e = variance for experimental diet
V_b = variance for basal diet
p = percentage of basal in experimental diet
q = percentage of test food in experimental diet.

Results and discussion

The ducks adapted well to the different diets and weight changes were small. In most tests, a few had small gains while others had small losses. Mean daily weight change ranged from −0.5 to 2.4 per cent of starting weight. Average of all was 0.5 per cent.

Percentage of diet metabolized (Table 1) could not be calculated for two tests that included granite grit because intake of grit was unknown. The degree of variability in these measurements is considered acceptable for this type of assay.

Proximate composition values (Table 2) are from material "as fed" and, except for seeds and nutlets, cannot be considered free of contamination. Despite several rinsings, it was impractical to remove all foreign material, particularly from foods such as duck weeds, algae, moss and liverwort.

Metabolizable energy values (Table 2) are consistently low, considering the proximate composition of the foods. The fact that three foods showed negative values indicates that some factor(s) prevented the ducks from utilizing all the available energy not only in the test food but in the basal portion as well. Potter *et al.* (1960) obtained small negative values for non-nutritive alpha cellulose fed in combination with a basal diet to chicks and suggested that some nutrients from the basal portion may have been absorbed into the cellulose and excreted. In contrast, Sibbald *et al.* (1960) obtained small positive values for cellulose and believed

Table 2
Proximate analysis and energy values of test foods on a dry matter basis

Food	Protein %	Fat %	Fibre %	NFE* %	Ash %	GE kcal./g	ME kcal./g
Basal	23.4	3.8	5.3	61.5	6.0	4.39	3.09±0.01
Wheat, hard	18.5	1.9	4.1	73.7	1.8	4.42	3.07±0.05
Gammarus sp.	47.8	7.7	9.6	12.1	22.8	3.78	2.32±0.05
Puccinellia Nuttalliana seeds	12.8	0.7	27.3	55.1	4.1	4.52	1.92±0.04
Nuphar variegatum seeds	9.0	0.4	13.1	76.4	1.1	4.33	1.53±0.09
Beckmannia syzigachne seeds	8.8	4.3	31.2	45.4	10.3	4.37	1.19±0.03
B. syzigachne seeds with grit							1.70±0.06
Lemna minor	32.4	3.3	13.9	40.7	9.7	4.56	1.07±0.04
Scirpus paludosus nutlets	6.3	2.9	27.7	60.3	2.8	4.58	0.89±0.14
S. paludosus nutlets with grit							1.69±0.06
S. paludosus nutlets soaked							1.58±0.07
Ruppia maritima foliage	16.6	2.5	15.0	41.8	24.1	3.41	0.85±0.03
Cladocera	31.7	2.1	13.8	1.7	50.7	2.63	0.82±0.03
Lymnaeidae	16.1	1.3	0.9	5.7	76.0	1.25	0.59±0.04
Lemna trisulca	12.2	2.0	13.4	52.8	19.6	3.39	0.59±0.02
Scirpus validus nutlets	6.7	3.5	39.7	47.0	3.1	4.87	0.53±0.07
Musci	12.1	1.7	31.0	46.2	9.0	4.03	0.48±0.05
Sparganium eurycarpum nutlets	16.1	0.8	32.7	46.3	4.1	4.51	0.46±0.09
Cladophora sp.	8.8	0.5	22.3	40.3	28.1	2.83	0.41±0.05
Enteromorpha sp.	15.1	1.0	7.3	54.9	21.7	3.23	0.35±0.13
Potamogeton pusillus foliage	17.9	1.3	29.8	42.9	8.1	4.28	0.29±0.06
P. pectinatus foliage	14.5	2.6	22.1	44.5	16.3	3.60	0.11±0.03
Myriophyllum exalbescens foliage	10.4	1.3	15.9	50.4	22.0	3.15	0.07±0.05
Ricciocarpus natans	12.3	0.5	15.7	37.6	33.9	2.81	−0.06±0.05
Rumex maritimus fruits	9.3	2.4	27.3	54.1	6.9	4.50	−0.37±0.07
Potamogeton Richardsonii foliage	15.7	2.1	18.6	47.6	16.0	3.70	−0.45±0.05

*Nitrogen-free extract.

that it diluted and slowed the passage of the basal material, thereby increasing utilization of the latter. This resulted in a calculated positive value for cellulose.

Metabolizable energy values for two foods in this study are lower than values measured previously. The same wheat fed to Mallards (*Anas platyrhynchos*) and measured by total collection had an ME value of 3.52 kcal./g (Sugden, 1971) compared with 3.07 kcal./g in this study. *Gammarus* fed fresh to two Lesser Scaup (*Aythya affinis*) and measured by total collection had values of 2.97 and 3.14 (avg., 3.05 kcal./g) (Sugden, unpubl.), compared with 2.32 kcal./g in this study.

Reasons for the poor utilization of test foods are largely unknown. To determine if the acclimatization period was adequate, percentage metabolized during the 5th and 6th days was compared with that for the 9th and 10th days in tests with Cladocera and *Potamogeton Richardsonii*. Percentages did not differ significantly ($P > 0.05$) between the two periods in either test, and the acclimatization period is considered sufficient. Sibbald and Slinger (1963) showed that 2-week-old chicks acclimatized to most diets within 1 day of first being fed. They recommended a 3–4-day acclimatization period when diets were high in fibre.

Many nutlets of *Scirpus* passed through the ducks intact, as found in other studies (Swanson and Bartonek, 1970). The addition of granite grit to diets containing *S. paludosus* nutlets and *Beckmannia* seeds increased the available energy in both cases, but many whole nutlets of *S. paludosus* still passed through the ducks. Soaking them in water for 3 months also improved their metabolizability (Table 2). Grinding or crushing the other foods would tend to compensate for lack of grit in the experimental diets. Finally, it is possible that captive birds do not possess adequate intestinal microflora (Hill *et al.*, 1968) nor gut adaptations (Moss, 1972) necessary for wild birds to assimilate energy from natural foods, particularly those high in fibre.

In view of the low ME values derived by bio-assay, there was no point in attempting to correlate them with values calculated by formula from chemical data. Even without the necessary data on starch and sugar content, an inspection of the chemical and energy data in Table 2 indicated an absence of correlation. Moreover, published formulas are not reliable for poorly digested foods such as those high in fibre (Vohra, 1966).

Although the ME values measured with captive ducks may not reflect values for the same foods eaten in the wild, they should indicate the relative value of the different items. Foods in Table 2 with over 0.5 kcal. ME/g have been reported as important in duck diets while, with two exceptions, those under that value have been unimportant. *Potamogeton pusillus* foliage and Cladophora were important in the diets of young Gadwalls (*Anas strepera*) and Widgeon (*Mareca americana*) (Sugden, 1973).

Results of 10 test foods indicate that Canvasbacks do not differ from Teal in their ability to metabolize food energy. This supports the conclusions of Scott and Holm (1964)

who found that Redheads (*Aythya americana*) had the same protein requirements as Mallards and Pintails (*Anas acuta*).

Conclusions

The derived ME values for duck foods are apparently low and probably do not reflect the energy available in the same foods eaten in the wild. The technique, developed primarily for chickens, may not be applicable to ducks at least under the given conditions. These results support Watson (1973) who stated that laboratory results of nutrition research are often misleading when extrapolated to wild conditions.

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