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Indirect Estimation of the Digestible Energy in the Diets of Swine by Post-Mortem Analyses of Digesta

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In order to develop a method to estimate dietary quality in free-ranging wild and feral swine, a digestibility trial was conducted with domestic pigs fed at two energy levels to determine whether caloric and elemental analyses of digesta could be used to predict digestible energy. Digesta from the stomachs and rectums of freshly slaughtered pigs were analyzed for gross energy, ash, and 13 elements. Digestible energy was estimated by three methods: (1) in the live animal trial, using the chromic oxide indicator technique (DE); (2) post-mortem, using gross energy in stomach contents and the 13 elements as indicators (DE'); and (3) using elemental ratios in stomach contents and feces as independent variables in regression equations. DE' estimates using P, Mg, Mn, Zn, Sr and Ba as indicators were positively correlated ($p<0.05$) with DE across diets at both energy levels. Of the elemental ratios, Sr alone explained 82% of the variation in DE across both diets. Stepwise regression analyses indicated that the ratios of Sr, Mg and ash in stomach contents and feces accounted for 97.2% of the variation of DE. Percent total lipids in femur marrow correlated with DE' and with elemental ratios, suggesting that this index may be used in conjunction with post-mortem estimates of DE to study the nutritional status of free-ranging swine.

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1. INTRODUCTION

Free-ranging wild and feral swine (*Sus scrofa* Linnaeus, 1758) are important components of many of the world's ecosystems into which they have either been released (feral swine) or in which they naturally occur (wild boar) (Tisdell, 1982; Mayer, 1983). Where they occur, such animals have often become significant agents of habitat destruction, although they are often valued as game animals. In either case, wise management programs are important for such populations and of particular importance in this regard is the ability to assess the dietary energy available to these free-ranging animals in the various habitats which they occupy. Relatively few techniques have been developed to study energy availability in the diets of free-ranging monogastric animals.

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Evaluations of wild species' diets should be restricted to post-mortem sampling if results are to reflect normal food selection (Bruggemann *et al.*, 1968). The latter author also suggested that analyses of digesta sampled from different parts of the digestive tract could be used to study diet assimilation if a suitable reference substance is chosen. Kaufman *et al.* (1976) determined digestible organic matter in the diets of cotton rats (*Sigmodon hispidus* Say *et* Ord, 1825), through a captive feeding trial and then compared results obtained post-mortem, using ash and various elements in stomach contents and feces as indicators. Although certain elements were assimilated by the rats, they suggested that elements excreted primarily through the feces (*e.g.* Ba, Zn, Mn and Sr) could serve as internal indicators in digestion studies in free-ranging populations.

The following assumptions must be made when using a digestible indicator in digesta sampling techniques: (1) the animal must be in balance with the chosen indicator, (2) the animal must excrete the indicator in the same proportion in feces in the wild as it does in the laboratory, and (3) feces sampled from the rectum must represent the undigested portions of the same kinds of foods found simultaneously in the stomach contents (Johnson & Groepper, 1970). Composition of stomach content samples must also accurately reflect overall dietary composition.

The relationship between long-term differences in energy intake and carcass fat of domestic swine is well documented. However, the relationship between dietary energy and indices of body fat in free-ranging populations has not yet been investigated.

The objectives of this study were: (1) to determine whether gross energy, ash and elemental composition of stomach contents were reflective of dietary composition for swine, (2) to determine whether digestible energy of swine diets could be predicted from analyses of stomach contents and feces, and (3) to examine the relationship between indices of carcass fat and digestible energy estimated from analyses of digesta

2. MATERIAL AND METHODS

Twenty domestic, crossbred (Yorkshire × Hampshire) swine averaging 55 kg live weight and 118 days of age were divided into two groups (five males, five females per group), and were randomly assigned to one of two dietary energy levels. Experimental diets (Table 1) were the same as those used in a previous study (Coffey, 1978) which compared carcass traits of swine fed different levels of fat and fiber. The low energy (LE) diet was formulated to provide 13.7 MJ digestible energy per kg diet and contained 10% dehydrated bermudagrass and no animal fat. The high energy (HE) diet contained no bermudagrass and 5% animal fat to raise calculated digestible energy to 15.4 MJ/kg. Pigs were housed in individual pens with aluminum-slatted floors. Feed and water were provided *ad libitum*.

When the majority of the animals on test reached a live weight of 80 kg, chromic oxide was added to each diet at a rate of 5 mg g and mixed thoroughly.

Table 1

Composition of two experimental swine diets.

Ingredient	Energy Level Low (%)	High (%)
Ground yellow corn	74.84	78.37
Soybean meal	12.98	14.45
Dehydrated grass	10.00	0
Animal fat	0	5.00
Mineral premix [1]	2.00	2.00
Vitamin premix [2]	0.125	0.125
Antibiotic [3]	0.01	0.01
Selenium premix [4]	0.05	0.05
Calculated analysis:		
Digestible energy, MJ/kg	13.7	15.4
Crude protein, %	14.00	14.00

[1] Provided (ppm): Zn, 105; Fe, 200; Mn, 40; Cu, 20; Co, 2; I, 2. Salt, Ca and P provided at 0.5, 0.6 and 0.5% of the diet, respectively.
[2] Provided per kg diet: Vit. A, 2475 IU; Vit. D, 440 IU; Vit. E, 11.0 IU; riboflavin, 2.20 mg; pantothenic acid, 8.80 mg; niacin, 13.2 mg; choline chloride, 27.5 mg; Vit. B_{12}, 11.0 μg; biotin, 2.75 μg.
[3] Provided 16 mg chlortetracycline per kg diet.
[4] Provided 0.1 ppm Se.

After an adjustment period of seven days, grab samples of feces (about 500 g) were taken daily for five days. Daily fecal samples from each pig were oven-dried at 80° for 16 hours, pulverized, and composited prior to chemical analyses.

Pigs were killed in a commercial slaughterhouse when they reached a live weight≥90 kg (approximately 50 days on test). Digesta from the stomach (approximately 1 kg) and rectum (about 300 g) were sampled upon evisceration, sealed in air-tight plastic bags, and frozen. These samples were later freeze-dried and then ground to pass through a 20-mesh screen prior to chemical and elemental analyses. Feed samples were also ground prior to analysis.

2.1. Caloric and Elemental Analyses of Feeds and Digesta

Feed samples and stomach contents were analyzed for gross energy (Parr Instrument Company, 1948), chromic oxide (Brisson, 1956) and ash (AOAC, 1975). Fecal material obtained during the live trial was analyzed for gross energy and chromic oxide. Feces collected from the rectums of slaughtered pigs were analyzed for gross energy and ash. Values for chromic oxide and ash were reported on a dry matter (DM) basis. Gross energy values were corrected for ash content and expressed on an organic matter (OM) basis.

Subsets of five pigs per treatment were randomly selected for elemental analyses. Feed samples, stomach contents, and post-mortem fecal samples from these individuals were analyzed for 13 elements (Al, B, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, P, Sr and Zn) by direct-reading emission spectroscopy (Jones & Issac, 1969). Elemental concentrations were expressed on a DM basis.

2.2. Determination of Digestible Energy

The ratio of chromic oxide and gross energy in the feed and feces was used in the following equation (adapted from Kane *et al.*, 1950) to calculate digestible energy (DE) of the diets:

$$DE = GE_d - (GE_f \times Cr_d/Cr_f) \quad (1)$$

Where: GE_d and GE_f represent the gross energy (MJ/kg OM) in the diets and feces, respectively, and Cr_d and Cr_f are the concentrations of chromic oxide (mg/g) in the diet and feces, respectively.

Post-mortem estimates of digestible energy (DE') were determined by substituting gross energy of stomach contents for gross energy in feeds and using each of the 13 elements in stomach contents and feces as indicators in the following equation:

$$DE' = GE_s - (GE_f \times I_s/I_f) \quad (2)$$

Where: GE_s and GE_f represent the gross energy of stomach contents and feces, respectively, and I_s and I_f represent the concentration of the element (μg/g DM) in the stomach contents and feces, respectively. Repeated calculations of equation 2 yielded 13 separate values (one for each element) for DE' for each of the two dietary energy levels.

Digestible energy was also estimated post-mortem, using 13 elemental ratios and the ratio of ash in stomach contents and feces as independent variables in stepwise regression analyses (SAS Institute, 1979). These predictor variables were calculated by simply dividing the concentration of ash (% DM) or of a particular element (μg/g) in stomach contents, by the corresponding concentration of ash or that same element in the feces.

2.3. Carcass Fat Indices

Measurements of total weight, backfat depth, and depth of brisket fat were taken from the chilled carcasses of the slaughtered pigs. Carcass weights were expressed as a fraction of carcass length to correct for differences in body size (Brisbin *et al.*, 1977). Backfat depth was measured at the dorsal midline over the last lumbar vertebra. Brisket fat was determined at the sternum, at the level of the forelegs. One untrimmed ham and one loin section were also obtained from each carcass. Specific gravities of hams and loin sections were determined by dividing the weight of the section in air by the difference between its weight in air and water (Brown *et al.*, 1951). All the marrow contained within a 5-cm section from the center of the femur was then removed from each ham and assayed for total lipids (Folch *et al.*, 1957). Total lipids were reported as a percent (fresh-weight basis) of marrow weight.

2.4. Statistical Analyses

Two-way univariate analyses of variance (Steel & Torrie, 1960) were used to determine the effects of diet, sex, and the interaction of diet and sex, on DE, gross energy and ash in feeds, stomach contents, and feces, and on carcass fat measurements. Data from two pigs were not included in the two-way analyses because of insufficient quantities of stomach or rectal contents. One-way analyses of variance were used on the subset data to identify dietary differences in the concentrations of each of the 13 elements in feeds and digesta, and in DE values.

A stepwise regression technique, designed to maximize the coefficient of determination (r^2), was used to generate a regression model to predict DE from elemental ratios in digesta. With this technique, any variable entered into the regression model may later be replaced by another variable, if that replacement produces a significant improvement in r^2 (SAS Institute, 1979).

Correlation analyses were used to determine whether elemental concentrations in stomach contents were reflective of dietary concentrations, and whether gross energy in either stomach contents or feces was related to DE. Correlation analyses were also used to examine the relationship between body fat measurements and DE intake as determined by live trial, and between body fat measurements and long-term differences in available energy intake as estimated post-mortem.

3. RESULTS AND DISCUSSION

3.1. Gross Energy, Ash, and Elemental Composition of Feeds and Digesta

In order to evaluate a post-mortem technique to predict DE, it was necessary to first determine whether the composition of stomach contents truly reflected dietary composition. Results of gross energy, ash and elemental analyses of feeds, stomach contents, and feces are summarized in Table 2. Stomach contents of pigs fed the HE diet had significantly more gross energy than did those of pigs fed the LE diet. The gross energy of the diets and stomach contents did not differ significantly, suggesting that gross energy of stomach contents reflected dietary energy, and were unaffected by the animals' salivary or peptic secretions. Fecal material taken from the rectums of pigs fed the HE diet also contained significantly more gross energy than the feces of pigs fed the LE diet.

The concentration of ash in feeds and in stomach contents did not differ between dietary treatments. However, pigs fed the HE diet had a significantly greater proportion of ash in feces than did those fed the LE diet. The percentage of ash tended to increase in both the stomach and feces, indicating the progressive digestion of organic matter. In a previous study, using re-entrant cannuals, Low *et al.* (1978) found more ash in the duodenums of pigs than in their feed.

The concentrations of Ba, K, Mg, Mn and Zn in feed samples differed between dietary treatments. The higher amounts of K and Mg found in the LE diet may have been due to the inclusion of bermudagrass in that diet. Bermudagrass was substituted largely to replace corn in the LE diet, and dehydrated bermudagrass contains about 1700 ppm Mg and 1.57% K, whereas corn contains only 1100 ppm Mg and 0.32% K (Committee on Animal Nutrition, 1964). Dietary differences in these elements were reflected by elemental analyses of stomach contents, as both Mg and K were more concentrated in the stomach contents of pigs

Table 2

Gross energy, ash and elemental content of feeds, stomach contents and feces of crossbred swine fed high energy (HE) and low energy (LE) diets.

Item	Feeds		Stomach contents		Feces	
	HE	LE	HE	LE	HE	LE
Gross	20.5 ***	19.6	20.5 ***	19.4	22.6 ***	21.2
energy [1]	(0.013) [3]	(0.073)	(0.205)	(0.135)	(0.268)	(0.162)
(MJ/kg OM)						
Ash	5.23	5.38	8.48	7.46	17.9 ***	13.7
(% DM) [1]	(0.21)	(0.26)	(1.21)	(0.80)	(0.20)	(0.21)
Elements						
(ppm) [2]	3746	4365	3662	4077	31008 ***	15164
P	(224)	(297)	(204)	(206)	(2408)	(1316)
K	5677 *	6863	2669 *	4480	10640 **	7493
	(231)	(317)	(179)	(649)	(670)	(531)
Ca	6545	6817	5703	6545	17220	15074
	(291)	(855)	(225)	(312)	(4543)	(846)
Mg	1578 *	1746	772 *	1211	5953 ***	4480
	(40.9)	(36.3)	(82.2)	(152)	(229)	(60.3)
Na	2035	2165	2854	2352	3156	2659
	(230)	(313)	(216)	(170)	(353)	(164)
Mn	113 **	81.4	85.5	116	562 ***	370
	(2.34)	(6.54)	(10.1)	(9.62)	(33.0)	(15.0)
Fe	133	134	448	571	683 *	508
	(7.15)	(11.6)	(150)	(80.0)	(55.3)	(28.0)
Al	31.3	51.3	1238	929	311 *	255
	(7.28)	(11.0)	(639)	(416)	(21.0)	(28.2)
B	8.04	8.66	2.62	4.36	8.21	8.72
	(0.49)	(0.58)	(0.45)	(0.66)	(1.30)	(0.51)
Cu	14.6	10.3	13.5	13.5	60.2 ***	31.0
	(5.30)	(2.04)	(1.95)	(1.69)	(2.87)	(1.47)
Zn	98.0 *	88.2	117	126	1306 *	714
	(2.06)	(3.50)	(11.4)	(8.31)	(135)	(131)
Sr	6.06	8.07	10.7	9.95	52.4 ***	31.2
	(0.33)	(1.48)	(1.37)	(1.01)	(1.96)	(1.40)
Ba	3.95 **	5.52	7.92	9.96	23.9 **	18.0
	(0.20)	(0.34)	(1.93)	(0.98)	(1.30)	(0.53)

[1] Values represent means of nine observations for HE and nine observations for LE.
[2] Elemental results based on five observations per energy level.
[3] Values in parentheses are SEM.
* Differences between energy levels within main effects significant at $p<0.05$; ** $p<0.01$; *** $p<0.001$.

fed the LE diet than in those of pigs fed the HE diet. Across both diets, correlations between concentrations of these elements in feeds and stomach contents were 0.94 and 0.89 for Mg and K, respectively.

While the concentrations of only two (K and Mg) of the 13 elements in stomach contents differed between diets, ten elements (P, K, Mg, Mn, Fe, Al, Cu, Zn, Sr and Ba) were all significantly more concentrated in the feces of pigs fed the HE diet than in the feces of those fed the LE diet. It was necessary to express results for Ca, Mg, Cu and Ba in feces as natural logarithms to achieve homogeneity of variance between dietary treatments.

Most of the 13 elements tended to be more concentrated in feces than in stomach contents within both diets (Table 2). The same trend was noted by Kaufman *et al.* (1976) for ash, P, Ca, Mg, Mn, Fe, Cu, Zn, Sr and Ba in digesta sampled from cotton rats.

Table 3

Linear correlation coefficients (r) between elemental concentrations in feeds and stomach contents of five swine fed high energy (HE) and five fed low energy (LE) diets.

Element	LE diet (N=5)	HE diet (N=5)	Both diets (N=10)
P	0.80	0.77	0.82 ***
K	0.83	0.87	0.89 ***
Ca	0.96 *	0.98 **	0.81 **
Mg	0.98 *	0.90 *	0.94 ***
Mn	0.97 **	0.73	−0.18
Fe	0.94	0.82	0.78 *
Al	−0.82	−0.45	−0.57
B	0.66	0.86	0.75 *
Cu	0.86	0.65	0.64 *
Zn	0.90 *	0.88 *	0.47
Sr	0.84	0.99 **	0.52
Ba	0.93 *	0.82	0.66 *
Na	0.62	0.86	0.22

* Correlation coefficient (r) significant at $p \leqslant 0.05$ level, ** $p \leqslant 0.01$, *** $p \leqslant 0.001$.

Results of correlation analyses (Table 3) suggested that the elemental composition of stomach contents was related to dietary elemental composition. Significant positive correlations were found between the concentrations of P, K, Ca, Mg, Fe, B, Cu and Ba in feeds and stomach contents across both diets.

3.2. Post-Mortem Prediction of DE Through Caloric and Elemental Analyses of Digesta

As expected, digestible energy determined by the chromic oxide method (DE) differed significantly between dietary treatments (Table 4).

DE values were 14.1 ± 0.243 and 15.6 ± 0.188 MJ/kg OM for the LE and HE diets, respectively. The effect of diet on DE did not vary significantly between the sexes. DE' values for both diets, calculated with equation (2), using gross energy and ash or elements in digesta as indicators, are also presented in Table 4. No simple transformation provided homo-

Table 4

Post-mortem estimates of digestible energy (DE') for high energy (HE) and low energy (LE) swine diets, calculated using gross energy of stomach contents and ash or elements in stomach contents and feces as indicators [1].

Element used as indicator	MJ/kg organic matter Diet: (HE)	(LE)
Live trial method [2]	15.6±0.188 ***	14.1±0.243
Ash	9.64±1.65	7.81±1.19
P	18.1±0.465 ***	13.6±0.632
Ca	14.2±0.841 **	10.3±0.373
Mg	17.9±0.402 ***	13.3±0.548
Mn	17.3±0.557 ***	12.8±0.368
B	13.5±1.02 *	8.92±1.30
Cu	15.7±0.904 *	10.1±1.34
Zn	18.7±0.406 *	16.2±0.402
Sr	16.1±0.820 *	12.5±0.779
Ba	13.3±1.96 *	7.62±1.12
Na	2.89±1.20	2.05±1.05

[1] Each value represent the mean ±SEM for five observations per diet

[2] Digestible energy determined using chromic oxide indicator in live feeding trials.

* Difference between diets significant at $p \leq 0.05$ level, ** $p \leq 0.005$, *** $p \leq 0.001$.

geneity of variances between dietary treatments when K was used as the indicator in DE', and this calculation was therefore deleted from further statistical analyses. Results using Al and Fe were also omitted because these elements yielded negative DE' values. Negative DE' values calculated with Al were due mainly to the disproportionately high concentration of Al in stomach contents relative to feces (1084 vs. 268 ppm Al, respectively). This may have been the result of pigs licking the aluminum-slatted floors of their pens. Aluminum is poorly absorbed and is excreted primarily through the feces (Underwood, 1971). The data in Table 2 suggest that large amounts of Al were retained in the stomach. Concentration of Al in the stomach contents of free-ranging swine could result from soil ingested during rooting, thus decreasing the usefulness of Al as an indicator for DE' for the diets of feral pigs, and therefore it was dropped from further consideration.

DE' values calculated with ash considerably underestimated DE of both diets (Table 4). Kaufman *et al.* (1976) found that digestible organic matter in cotton rats' diets was likewise underestimated when ash in stomach contents and feces was used as the indicator. This may be due to absorption of minerals with subsequent excretion in the urine, thereby resulting in an imbalance between mineral ingestion and excretion in the feces. Low estimates of DE' using Na were probably due to salivary contributions to stomach contents.

DE' values calculated from P, Ca, Mg, Mn, B, Cu, Zn, Sr and Ba each differed significantly between diets. Each of these indicators yielded higher DE' values for the HE diet. Although all of the DE' estimates differed from respective DE values obtained by the chromic oxide method (Table 4), correlations between DE and DE' values calculated with P, Mg, Mn, Zn, Sr and Ba were positive across both diets (Table 5). DE' calculated with Sr was closely correlated with DE ($r=0.90$; $p=0.001$).

Table 5

Linear correlations between post-mortem estimates of digestible energy (DE') across two dietary energy levels. DE' was calculated by using gross energy of stomach contents and feces and elemental concentrations in stomach contents and feces as indicators, and digestible energy (DE) determined with chromic oxide [1].

	DE	DE'^{2}_{P}	DE'_{Mg}	DE'_{Mn}	DE'_{Zn}	DE'_{Sr}	DE'_{Ba}
DE		0.77	0.85	0.92	0.74	0.90	0.89
DE'_{P}	0.015		0.92	0.92	0.91	0.85	0.76
DE'_{Mg}	0.004	0.0002		0.92	0.76	0.78	0.77
DE'_{Mn}	0.019	0.0002	0.0002		0.86	0.84	0.72
DE'_{Zn}	0.035	0.008	0.017	0.003		0.84	0.74
DE'_{Sr}	0.001	0.002	0.008	0.002	0.005		0.77
DE'_{Ba}	0.001	0.011	0.009	0.018	0.022	0.009	

[1] Numbers above the diagonal represent coefficients of correlation, (r); numbers below the diagonal are probability levels (p).
[2] Subscripts are elements used as the indicator in DE'.

These data suggest that P, Mg, Mn, Zn, Sr and Ba could be useful post-mortem indicators to compare available energy in the diets of free-ranging swine, over a wide range of dietary energy levels. However, the technique does not appear to be useful within narrow energy ranges, since none of the DE' values correlated significantly with DE within dietary treatments.

Results of stepwise regression analyses, using elemental ratios in post-mortem digesta as independent variables to predict DE, are summarized in Table 6. A total of 97.2% of the variation in DE of both diets was explained by the equation:

$$Y=16.8-3.09x_1-4.49x_2-0.784x_3; \quad (SEM=0.891\ MJ/kg) \qquad (3)$$

where: $Y=DE$ and x_1, x_2 and x_3 are the ratios, in stomach contents and feces, of Sr, Mg and ash, respectively. The ratio of Sr alone, accounted for 82% of the variation in DE in this study, as illustrated in Fig. 1. Successive additions of other ratios, beyond the three variable model, did not improve r^2 significantly.

These results suggest that DE in swine diets can be predicted postmortem by analyses of stomach contents and feces (DE'). If only one element can be used to predict DE, Sr appears to be the one of choice.

Table 6

Percentage of the variation in digestible energy of pooled high energy and low energy swine diets explained by elemental ratios in stomach contents and feces. [1]

No. of ratios in linear model	Elemental ratio added to model	% Variation explained	Significance level (p) of r^2
1	Sr	81.8	0.001
2	Mg	92.3	0.028
3	Ash	97.2	0.031
4	Ca	97.9	0.073

[1] Percent explained variation was calculated by multiplying the coefficient of determination (r^2) by 100. Elemental ratios were calculated by dividing the concentration of an element in stomach contents by its concentration in feces.

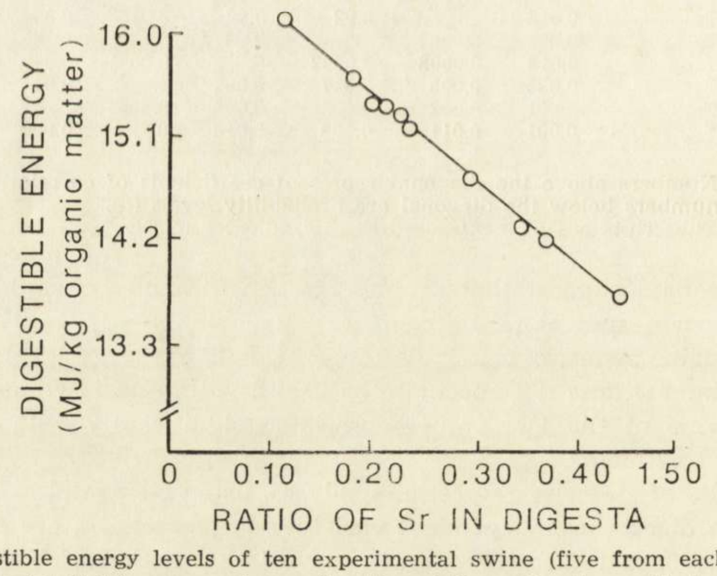

Fig. 1. Digestible energy levels of ten experimental swine (five from each of the two experimental diets), expressed as a function of the ratio of ppm Sr in stomach contents to ppm Sr in feces. Sr concentrations are expressed on a dry matter basis, and digestible energy was determined by chromic oxide feeding trials. Linear regression calculated for ten observations was $Y=16.8-6.95x$ ($r^2=0.82$). Standard error of the estimate=1.24 MJ/kg.

3.3. Relationship Between Carcass Fat and Long-Term Differences in Energy Intake

Pigs fed the HE diet tended to have more backfat, brisket fat, femur marrow fat, and lower specific gravities of loin sections and hams than pigs fed the LE diet (Table 7); however differences in these measurements were not significant. No significant correlations were found between any

Table 7

Carcass characteristics of 18 domestic pigs fed at two energy levels.

Characteristic	Energy Level	
	Low	High
Backfat (cm)	2.32 ±0.17 [1]	2.74 ±0.25
Brisket fat (cm)	1.35 ±0.11	1.52 ±0.18
Femur marrow lipids (%)	58.66 ±2.09	65.01 ±2.38
Specific gravity of ham	1.060±0.002	1.056±0.001
Specific gravity of loin section	1.073±0.002	1.068±0.003
Carcass weight (kg)	61.42 ±1.75	63.70 ±1.36

[1] Values represent means±SEM for nine pigs from each energy level. No differences were statistically significant ($p>0.05$).

carcass fat measurements and DE determined by the feeding trial, nor between fat measurements and gross energy in stomach contents. However percent femur marrow lipids was positively correlated with DE' values calculated wih P, K, Mg, Mn and Sr as indicators (Table 8).

Table 8

Linear correlation coefficients (r), between carcass fat measurements and post-mortem estimates of digestible energy (DE) for pooled dietary energy levels [1].

Indicator of (DE)	N	Back fat	Brisket fat	Femur lipids marrow	Carcass weight/ carcass length	Spec. Grav. loin	Spec. Grav. ham
Cr	17	0.43	0.29	0.44	0.11	−0.47	−0.58 *
P	10	0.14	0.07	0.65 *	−0.10	−0.33	−0.34
K	10	0.14	0.00	0.69 *	−0.08	−0.38	−0.57
Mg	10	0.22	0.10	0.73 *	−0.22	−0.36	−0.47
Mn	10	0.12	0.07	0.85 **	−0.22	−0.50	−0.27
Zn	9	0.12	0.19	0.60	−0.15	−0.28	−0.07
Sr	10	0.22	0.28	0.79 **	0.08	−0.39	−0.37
Ba	10	0.11	0.21	0.53	−0.44	−0.23	−0.05

[1] Digestible energy determined by live-animal trial, using Cr_2O_3 indicator method
* Correlation coefficient, r, significant at $p \leqslant 0.05$ level, ** $p \leqslant .01$.

A significant negative correlation ($r = -0.73$) was found between the ratio of Sr in digesta and percent femur marrow lipids. Since elemental ratios were inversely related to DE (Fig. 1), a negative correlation between elemental ratios and any body fat index suggests a positive relationship between body fat and post-mortem predictors of DE. Negative correlations were also found between the ratios of Ca, Mg, Mn and K in digesta and femur marrow lipids ($p<0.05$; $r=-0.79$, -0.69, -0.88 and -0.65, respectively). Thus, while percent femur marrow lipids was not statistically related to DE, it was indirectly related to DE because femur marrow fat was correlated with DE' values and with elemental ratios, which in turn, were correlated with DE. Of the carcass measurements studied, percent femur marrow lipids was apparently the most sensitive to changes in energy level of the diet.

The results of this study suggest that post-mortem estimation of digestible energy can be coupled with body fat measurements to study available energy in the diet and its effect on the body condition of free-ranging swine. Statistical comparisons of such estimates would be conservative with respect to identifying differences in DE between treatment groups. While smaller differences may go undetected, the demonstration of significant differences in DE' would strongly suggest the existence of real differences in diet quality. These techniques would be of most value in situations where diets are known to consist primarily of a few food staples that are consumed over an extended period of time. Such a situation commonly occurs when wild or feral swine forage on acorns or other mast in the fall. The technique may be useful in comparing annual or locational differences in diet quality for such populations.

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POŚREDNIA OCENA ENERGII STRAWNEJ W DIETACH ŚWIŃ Z POMOCĄ POUBOJOWEJ ANALIZY ŻYWIENIOWEJ

Streszczenie

Podjęto próbę opracowania metody oceny jakości diety dzików i świń domowych. Eksperymenty pokarmowe przeprowadzono na świniach trzymanych na dwu dietach (Tabela 1). Po uboju analizowano zawartość żołądków i kału pod kątem zawartości energii ogólnej, popiołu i 13 pierwiastków. Energię strawną oceniano trzema metodami: (1) przyżyciową — z zastosowaniem Cr_2O_3 jako indykatora (DE); (2) poubojowo, oznaczając energię ogólną w treści żołądka i przyjmując zawartości 13 pierwiastków jako wskaźniki (DE'); oraz (3) przyjmując zawartości wskaźniko-

wych pierwiastków w treści żołądkowej i w kale jako zmienne niezależne równań regresji (Tabele 2—5).

Wyniki metody DE' z użyciem P, Mg, Mn, Zn, Sr i Ba jako wskaźników były wysoko skorelowane z danymi uzyskanymi metodą DE. Najlepszym pierwiastkiem wskaźnikowym okazał się Sr (Ryc. 1). Udział Sr, a także Mg i popiołu w treści żołądka wyjaśniał 97,2% zmienności poziomu energii strawnej w diecie (Tabela 6).

Zawartość tłuszczu w szpiku kości udowej korelowała z DE' i zawartością pierwiastków wskaźnikowych (Tabele 7 i 8). Korelacja ta wraz z oznaczeniami DE mogą być użyte do oceny sytuacji żywieniowej wolnożyjących świń i dzików.