Evaluating Nutrient Composition of Diets and Management Foods

Debra McDonald

Proximates

1. Dry matter (100°C)
2. Lipid content (extract with ether)
3. Crude Fibre (insoluble organic residues): reflux with sulphuric acid, boil with sodium hydroxide (least digestible fibrous matter)
4. Nitrogen: Kjeldahl method
5. Protein: multiply nitrogen by 6.25
6. Ash (500°C)
7. Subtract % ether extract, crude fibre, crude protein, and ash from 100 to estimate nitrogen-free extract (NFE) (highly digestible carbohydrates).

Guaranteed Analysis

Not required to analyse every batch of food

Required to guarantee minimal levels:

- crude protein, fat and fiber
- some companies will also include information about mineral levels such as calcium and phosphorus as well as vitamins levels.
- Often values listed are from calculated values

Ingredients List

Listed in order of quantity, not alphabetically

Plant protein products: soybean meal, cottonseed meal

Processed grain by-products: brewer's yeast, wheat bran, corn gluten feed

Protein

Crude Protein: not all protein will be digested

- calculated from nitrogen content of feed (N x 6.25)
- some nitrogen not proteinaceous
- some nitrogen bound to other chemicals and unavailable (chitin)

Complete Protein:

- plant-based proteins do not contain full complement of essential amino acids

Fat

Crude fat: total amount of fats and oils in the product.

- doesn't clarify degree of unsaturation or whether essential fatty acid
- birds have a dietary requirement for the essential fatty acid α-linolenic acid
- recent studies suggest that birds also have requirements for other essential dietary fatty acids.

Energy Calculations

Calculated using Atwater factors

Fat 37 kJ/g
Protein 17 kJ/g
Carbohydrate 16 kJ/g

Calories
Metabolic Energy value of a food calculated from measurements on cats and dogs. Assume average apparent digestibility of 80% for protein, 90% for crude fat and 84% for carbohydrate. The digestion coefficients are then multiplied by energy values of 4.4, 9.4 and 4.15 kcal/g resulting in values of 3.5, 8.5 and 3.5 kcal/g for typical commercial pet foods.

Method overestimates ME content of foods high in fibre or ash or foods with very low protein, fat and carbohydrate digestibility. Also underestimates ME content of highly digestible and low-fibre foods.

Conversion of kJ to kcal multiplication factor of 0.239
Conversion of kcal to kJ multiplication factor of 4.184

Joule: expresses daily energy requirement by its power needs or watts. One watt equals one joule per second

Calorie: expresses energy in terms of heat. One calorie is the amount of heat required to raise the temperature of 1 g water from 14.5ºC to 15.5ºC.

Energetics

Passerine BMR

$kcal\ day^{-1} = 114.8 \times kg^{0.726}$
$kJ\ day^{-1} = 480 \times kg^{0.73}$

Nonpasserine BMR

$kcal\ day^{-1} = 73.5 \times kg^{0.734}$
$kJ\ day^{-1} = 308 \times kg^{0.73}$

Fibre

Crude Fibre:

- doesn't distinguish between digestible and indigestible components
- doesn't distinguish lignin component

- indicative of fibre that is slowly fermentable
- doesn't include gums and pectins

Total dietary fiber:

- lipids are extracted with ethanol and the sample is digested with α-amylases to convert readily digestible starches to soluble sugars.
- water-soluble components such as the sugars, degraded starch, pectins, gums and most of the hemicellulose are separated from the water-soluble components (insoluble fibers) such as cellulose, lignin and a small fraction of hemicelluloses.
- water-soluble components are further extracted with ethanol to remove the sugars and degraded starch with the remaining *soluble fiber* residue containing pectins and gums.

Nitrogen-free Extract (NFE):

- carbohydrate fraction of a proximate analysis
- addition of percent values of water, crude protein, crude fat, ash and crude fiber are subtracted from 100% to provide a value for readily digestible carbohydrates such as sugars and starches.

Neutral Detergent Fiber (NDF):

this is the residue remaining after boiling with a solution containing neutral pH detergent and EDTA

residue that remains is mostly plant cell walls including hemicellulose, cellulose and lignin, with the loss of pectins.

Acid Detergent Fiber (ADF):

- determined by boiling the analytical sample in an acidic detergent solution
- fraction remaining contains cellulose and lignin
- NDF and ADF assays do not measure the more soluble fiber fractions such as pectins and gums

Vitamins

Vitamin A:

- deposited in liver and fatty tissue
- assessment from blood chemistry is inadequate
- low blood level indicates a deficiency
- vitamin A status cannot be evaluated from blood
- vitamin A content of liver of newly hatched chick is good measure of vitamin A nutrition of breeding hen
- vitamin A deficiency will not occur in chickens with storage levels > 2-5 IU vitamin A per gram of liver.

Presumed upper safe levels:

- 4-10 times nutritional requirements
- upper safe level for growing chicken is 15,000 IU/kg

Vitamin A activity is expressed in International Units (IU):

One IU = biological activity of 0.300 μg of vitamin A alcohol (retinol)
or
0.550 μg of vitamin A palmitate

One IU of provitamin A activity = in activity to 0.6 μg of β-carotene

Retinol Equivalents

Provitamin A expressed as retinol equivalents (RE) instead of IU

1 retinol equivalent is equal to:

- 1 μg of retinol
- 6 μg of β-carotene
- 12 μg of other provitamin A carotenoids

1 RE = 3.33 IU of retinol or 10 IU of β-carotene.
6 beta – carotenes > 1 retinol

Liver normally contains about 90% of total-body vitamin A.
Low correlation between blood and liver retinol.

Carotenenoids

Not all carotenoids are converted to vitamin A

- of > 500 identified, only 50-60 have vitamin A activity
- lycopene has no vitamin A activity

Conversion ability may be species specific

Carotenoid	Biopotency
α-carotene	25
β-carotene	100
γ-carotene	14
Cryptoxanthine (main carotenoid of corn)	29

Theoretically, 1 mol of β-carotene can yield 2 mol of retinal. But tests show that pure vitamin A has twice the potency of β-carotene on a wt-to-wt basis.

Efficiency of conversion of vitamin A from β-carotene decreases with higher levels of intake AS β-carotene level is increased, conversion efficiency drops from a ratio of 2:1 to 5:1 for the chicken.

Cooking transforms all-*trans* forms to *cis* forms.

Vitamin D

1 IU vitamin D activity = activity of 0.025 μg vitamin D3 contained in the vitamin D reference standard

For poultry, international chick unit (ICU) is used with reference to D_3 versus D_2 as D_2 had 1/10 activity of D_3 in chicks.

Dietary Requirement for chicken 200 IU/kg

Safe upper limit less than 60 days is 40,000 IU/kg and > 60 days, 2,800 IU/kg

Vitamin E

Vitamin E status can be assessed from circulating blood levels.

Exists as tocopherols (α, β, γ and δ) and tocotrienols (α, β, γ and δ).

Synthetic vitamin E has 8 isomers all of varying vitamin E activity

Management Food Allowances for Passerines

Animal Weight (kg)	BMR Caloric Requirement (kcal/day)	Maintenance Caloric Requirement (kcal/day)	Management Foods (kcal/day)
0.005	2	4	0.6
0.01	4	6	0.9
0.02	7	10	1.5
0.03	9	14	2
0.04	11	17	2.5
0.05	13	20	2.9
0.06	15	22	3.4
0.07	17	25	3.7
0.08	18	28	4.1
0.09	20	30	4.5
0.1	22	32	4.9
0.2	36	54	8
0.3	48	72	10.8
0.4	59	89	13.3
0.5	69	104	15.6

Management Food Allowances for Birds

Passerines Active

Weight (g)	BMR (kcal/day)	Maintenance (kcal/day)	Management Food Allowance (kcal/day)
10	6	8	1.2
20	9	13	2.0
30	12	18	2.7
40	15	22	3.3
50	17	26	3.8
60	19	29	4.4
70	22	33	4.9
80	24	36	5.4
90	26	39	5.8
100	28	42	6.3

Passerines Nonactive

Weight (g)	BMR (kcal/day)	Maintenance (kcal/day)	Management Food Allowance (kcal/day)
10	4	6	0.9
20	7	10	1.5
30	9	14	2.0
40	11	17	2.5
50	13	20	2.9
60	15	22	3.4
70	17	25	3.7
80	18	28	4.1
90	20	30	4.5
100	22	32	4.9

Management Food Allowances for Birds

Nonpasserines Active

Weight (g)	BMR (kcal/day)	Maintenance (kcal/day)	Management Food Allowance (kcal/day)
10	3	5	0.7
20	5	8	1.2
30	7	11	1.6
40	9	13	2.0
50	10	15	2.3
60	12	18	2.6
70	13	20	2.9
80	14	22	3.2
90	16	24	3.5
100	17	25	3.8

Nonpasserines Nonactive

Weight (g)	BMR (kcal/day)	Maintenance (kcal/day)	Management Food Allowance (kcal/day)
10	3	4	0.6
20	4	6	0.9
30	6	8	1.3
40	7	10	1.6
50	8	12	1.8
60	9	14	2.1
70	10	16	2.3
80	12	17	2.6
90	13	19	2.8
100	14	20	3.1

Management Foods for Birds
Whole Prey

Prey Item	Serving Size	Serving Wt (g)	kcal/g	kcal/serving
Mealworm (Tenebrio molitor)	10	1	2	2
Mighty Mealys (Tenebrio molitor)	5	2	3	6
Super Mealworm (Zophobas morio)	5	3.75	3	11
Cricket (Achaeta domesticus)	10	2	2	4
Waxworm (Galleria mellonella)	10	3	3	9
Earthworm (Lumbricus terrestris)				
wildcaught	10	11	1	9
commercial	5	14.5	1	15
Mix: mealworm/crickets	5:5	1.5	2	4
Mix: super mealworms/crickets/waxworms	5:5:5	6.25	3	17
Mouse (Mus domesticus) pinkie	1	1.7	1	2

Management Foods for Birds

Fruits

Management Food Item	Serving Size	Serving Wt (g)	kcal/g	kcal/serving
Apple	1/4 medium	35	0.59	21
Banana	1/8 medium	23	0.92	21
Blackberries	1/4 cup	35	0.52	18
Blueberries	1/4 cup	30	0.57	17
Boysenberries	1/8 cup	30	0.88	26
Cantaloupe	1/8 medium	100	0.36	36
Cranberries	1/4 cup	10	2.10	21
Crushed Pineapple	1/4 cup	65	0.59	38
Grapefruit	1/4 medium	100	0.30	30
Grapes	1/4 cup	20	0.63	13
Guava	1/4 medium	20	0.50	10
Honeydew Melon	1/8 medium	289	0.33	95
Kiwi	1/8 medium	10	0.61	6
Lime	1 medium	67	0.30	20
Orange	1/4 medium	50	0.46	23
Pear	1/4 medium	50	0.59	30
Plum	1 medium	33	0.55	18
Raisins	1 Tbls	10	3.00	30
Raspberries	1/4 cup	30	0.50	15
Strawberries	1/4 cup	40	0.30	12
Watermelon	1/4 cup	40	0.31	12

Management Foods for Primates

Grains, Nuts and Cereals

Management Food Item	Serving Size	Serving Wt (g)	kcal/g	kcal/serving
All-bran (Kelloggs)	1/8 cup	10	5	50
Bran Flakes	1/4 cup	10	3.00	30
Cheerios	1/4 cup	6	4.00	24
Cracklin Bran	1/3 cup	28	3.90	109
Crisped Rice	1/4 cup	7	4.10	29
Finch Seeds	1 Tbls	8	3.50	29
Peanut Butter	1 Tbls	16	5.90	94
Peanuts no shells	1/8 cup (18 nuts)	20	5.00	100
Peanuts in shell	1/4 cup	15	3.60	54
Puffed Rice	1/4 cup	4	3.90	14
Shredded What	1 oz	28	3.60	101
Sunflower Seeds	1 Tbls	5	5.80	29
Wheat Chex	1/4 cup	11	3.60	38