

The Potential to Increase Neutral Detergent Fiber Levels in Ape Diets Using Readily Available Produce

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Abstract

Many studies report what wild orangutans (*Pongo pygmaeus*) select for food. Hamilton and Galdikas (1994) determined wild diets contained dietary neutral detergent fiber (NDF) levels of 75%. NDF represents structural polysaccharides (cellulose and hemicellulose (HMC)) potentially digested by microbial fermentation in the lower gut. Fiber presence in the gut and fermentation end-product production have been shown to prevent obesity and diabetes (Anderson et al., 1987) and maintain gut health (Kerley and Sunvold, 1996). Based upon their intestinal anatomy and diet selection in the wild, we were interested to learn the potential to increase NDF levels in diets for captive orangutans using available produce and manufactured primate biscuits. We questioned whether or not feeding more produce in lieu of manufactured feed would result in higher levels of dietary NDF. A variety of readily obtainable, whole produce items were analyzed for dry matter, crude protein, NDF, acid detergent fiber and ash. Published values for many items omit the plant/fruit portion not consumed by humans, yet these portions are consumed by animals and should be included in the nutrient analyses. NDF levels ranged from 3.1% to 26.8% for fruit, 13.3% to 27.7% for greens and 7.5% to 30.9% for vegetables. Sugarcane and a banana flower, examples of browses, had NDF levels of 32.6% and 41.2%, respectively. Other browse items were not readily available and therefore not analyzed. Commercially available, high-fiber biscuits had NDF levels of 27.9%, 28.6% and 29.6%. Dietary NDF levels, similar to those consumed by wild orangutans, could not be met with produce alone. Based on these data, increasing dietary NDF will require browse incorporation into the captive orangutan diet or higher NDF in manufactured diets.

Introduction

Much of the field research on free-ranging orangutans documents what they eat and how much time they spend eating (MacKinnon, 1974; Rodman, 1977; Galdikas, 1978), however, only Hamilton and Galdikas (1994) have made an attempt to quantify the nutrient composition of diets consumed by wild orangutans. Neutral detergent fiber (NDF) levels ranged between 20 - 85 % and average crude protein (CP) levels were approximately 8 - 15%. Captive orangutans are generally fed diets that consist of nutritionally complete, commercially manufactured primate biscuits along with readily available fresh produce including fruits, vegetables and leafy-green vegetables. The manufactured biscuits, which may constitute as much as two-thirds of the daily diet (by weight on a dry matter basis), contain low levels of insoluble fiber (28 - 30%) and high

levels of protein (21 - 27%) when compared to items consumed by free-ranging orangutans. Edwards (1995) conducted a study using higher fiber biscuits in diets for captive folivores in which soybean hulls were used as an ingredient to increase ADF levels to 15% or 30%. Edwards studied digestibility differences among species and concluded that appropriate fiber types and levels, similar to those in free-ranging primate diets, need to be incorporated into manufactured biscuits fed to captive animals.

Materials & Methods

Subsamples of produce used to feed apes at the St. Louis Zoological Park were cut into small pieces, weighed, freeze-dried and reweighed. Dried samples were ground in a Wiley Mill through a 2mm screen. Subsamples were weighed, placed in a 105°C oven for 24 hours to determine dry matter (DM) and then moved to a 550°C muffle furnace for complete combustion and organic matter (OM)/ash determination. Other subsamples were analyzed for NDF and ADF levels according to Van Soest et al. (1991). Nitrogen was measured by thermal conductivity (LECO Corp., St. Joseph, MI, 1994) and then multiplied by 6.25 for CP determination.

Results & Discussion

Animals generally consume more plant parts than humans, therefore it is essential to analyze whole produce items including cores, peels, and sometimes seeds. NDF was the measurement of greatest interest because it is the insoluble portion of dietary fiber and could be compared with data from Hamilton and Galdikas (1994). Other variables measured included dry matter (DM), crude protein (CP), acid detergent fiber (ADF) and ash. Values were also included for hemicellulose (HMC), calculated by subtracting ADF from NDF, and organic matter (OM), determined by subtracting the ash value from 100.

The produce, divided into fruits, greens and vegetables, offered a wide range of measured variables. NDF levels ranged from 3.1% to 26.8% for fruit, 13.3% to 27.7% for greens and 7.5% to 30.9% for vegetables. Produce high in NDF included blackberries, raspberries, chickpeas, whole ear corn, spaghetti squash and alfalfa sprouts (which are also exceptionally high in protein).

Meeting the NDF levels consumed by wild orangutans would not be possible with produce alone based on these results. Matching NDF levels to those consumed by wild orangutans will require higher NDF levels in manufactured biscuits, a point made by Edwards (1995) with folivorous primates. Digestibility research with captive orangutans is the next step to determine the effect of feeding higher NDF diets on nutrient use and animal health.

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Composition of Readily Available Fruits

Item	% DM	% HMC	% NDF	% ADF	% ASH	% OM	% CP
apple (golden delicious)	14.39	4.22	9.75	5.54	2.06	97.94	2.51
apple (red delicious)	12.85	4.19	10.16	5.97	1.64	98.36	2.99
apricots	12.02	2.60	7.30	4.70	3.87	96.13	7.33
banana (green)*	18.60	7.86	12.36	4.51	4.66	95.34	5.41
banana (ripe)*	19.87	9.50	12.26	2.76	3.64	96.36	5.69
banana (baby)*	26.22	11.02	16.14	5.12	4.25	95.75	5.52
banana (burro)*	25.46	10.66	15.23	4.57	3.47	96.53	4.41
blackberries	14.06	7.45	25.42	17.96	2.89	97.11	9.77
blueberries	12.80	6.15	13.22	7.07	0.99	99.01	3.65
cantaloupe	7.89	1.33	15.85	14.52	6.75	93.25	12.34
cantaloupe w/rind	7.46	1.67	22.04	20.37	8.12	91.88	13.09
figs	64.86	2.02	9.99	7.97	2.59	97.41	4.18
grapes (black)	16.13	1.10	7.16	6.06	3.04	96.96	4.42
grapes (green)	16.32	0.83	3.27	2.45	2.22	97.78	3.57
grapes (red)	14.34	1.35	3.13	1.77	2.39	97.61	2.71
grapefruit	14.64	4.15	12.68	8.53	2.63	97.37	4.83
grapefruit peel	29.12	1.42	17.15	15.73	4.37	95.63	5.02
honeydew	9.83	3.35	17.42	14.07	5.33	94.67	9.62
honeydew w/rind	8.12	2.50	15.04	12.54	6.53	93.47	8.92
kiwi	12.97	3.52	16.15	12.64	5.18	94.82	8.32
mamey sapote	31.53	14.03	20.38	6.35	1.72	98.28	2.88
mango	19.33	5.25	11.51	6.26	1.31	98.69	3.08
nectarine	12.89	4.12	7.29	3.17	3.74	96.26	4.64
orange	16.19	3.89	11.00	7.10	2.68	97.32	5.98
orange peel	25.71	2.73	15.99	13.26	2.77	97.23	6.80
papaya (giant)	7.83	1.57	13.73	12.16	8.78	91.22	13.57
pear (anjou)	14.37	6.82	16.36	9.53	1.74	98.26	2.97
pear (bartlett)	13.13	4.56	12.71	8.14	1.95	98.05	3.66
pear (bosc)	12.10	5.14	15.64	10.50	2.02	97.98	1.80
pineapple	10.38	9.56	15.33	5.77	3.25	96.75	3.26
pineapple peel	17.73	34.58	56.40	21.82	4.56	95.44	4.58
plantain	29.98	6.35	8.62	2.27	2.49	97.51	3.11
plum (red)	10.07	2.53	6.13	3.60	2.64	97.36	6.07
pumpkin melon	20.02	14.31	22.02	7.71	4.56	95.44	7.30
raspberries	13.53	4.83	26.83	22.01	3.12	96.88	9.41
strawberries	8.66	3.93	11.41	7.48	5.39	94.61	8.98
watermelon	6.81	0.99	6.10	5.11	3.86	96.14	7.53
watermelon w/rind	6.72	1.78	11.65	9.86	4.79	95.21	7.78

* bananas analyzed with peel.

DM - Dry Matter, HMC - Hemicellulose, NDF - Neutral Detergent Fiber, ADF - Acid Detergent Fiber,

Ash - Minerals, OM - Organic Matter, CP - Crude Protein

Composition of Readily Available Vegetables

Item	% DM	% HMC	% NDF	% ADF	% ASH	% OM	% CP
artichoke	13.39	8.66	29.37	20.71	7.44	92.56	17.29
asparagus	6.77	5.51	17.87	12.36	5.84	94.16	19.91
bean sprouts	6.06	4.95	18.02	13.07	5.57	94.43	39.65
broccoli	9.66	1.95	16.60	14.65	8.38	91.62	31.18
cassaba root	37.45	7.62	11.88	4.26	2.03	97.97	2.31
carrot	11.83	0.79	9.72	8.94	6.14	93.86	5.95
cauliflower	6.37	1.93	19.11	17.18	11.76	88.24	26.46
celery	4.77	3.10	15.73	12.63	11.95	88.05	17.22
chickpeas	30.23	21.04	30.59	9.56	1.76	98.24	20.25
corn (cob)	31.74	37.84	77.46	39.63	1.34	98.66	4.45
corn (husk)	26.06	34.09	63.68	29.59	3.52	96.48	11.07
corn (whole ear)	20.80	25.18	44.22	19.03	3.04	96.96	10.85
cucumber	3.97	3.16	18.61	15.46	11.21	88.79	16.78
eggplant	8.16	11.04	22.03	10.99	6.76	93.24	15.52
green beans	6.48	3.59	21.85	18.26	8.13	91.87	26.33
green pepper	5.25	2.61	19.65	17.04	7.51	92.49	17.66
mushrooms	6.72	15.21	25.79	10.58	9.31	90.69	31.01
okra	12.56	4.42	14.16	9.75	7.62	92.38	17.37
onion (green)	9.14	6.79	13.77	6.98	8.74	91.26	20.72
onion (red)	9.08	2.05	9.47	7.42	5.14	94.86	15.49
onion (yellow)	10.28	2.83	10.25	7.41	4.32	95.68	9.05
pea pods	9.22	5.41	16.29	10.89	4.44	95.56	31.39
potato	27.99	5.00	7.54	2.54	4.04	95.96	9.65
radishes	5.73	1.41	15.47	14.06	6.41	93.59	15.71
rutabaga	11.16	3.52	14.54	11.02	4.84	95.16	16.04
squash (acorn)	11.57	3.07	19.66	16.59	5.21	94.79	11.21
squash (butternut)	7.72	2.76	17.49	14.73	8.42	91.58	26.04
squash (chayote)	6.05	4.52	16.58	12.06	5.92	94.08	15.83
squash (spaghetti)	10.50	6.77	30.94	24.17	8.08	91.92	17.16
squash (yellow)	6.11	6.43	13.75	7.32	6.89	93.11	14.55
sweet potato	23.75	15.18	20.04	4.86	2.82	97.18	4.21
sweet potato (cooked)	23.04	7.36	10.97	3.61	3.26	96.74	4.94
tomatillos	7.95	8.39	26.16	17.77	5.82	94.18	14.33
tomato	4.73	2.39	16.63	14.24	10.45	89.55	25.94
turnip	6.98	5.06	19.66	14.60	10.47	89.53	20.84
zucchini	4.35	4.92	15.13	10.20	13.38	86.62	24.86

DM - Dry Matter, HMC - Hemicellulose, NDF - Neutral Detergent Fiber, ADF - Acid Detergent Fiber, Ash - Minerals, OM - Organic Matter, CP - Crude Protein

Composition of Readily Available Greens

Item	% DM	% HMC	% NDF	% ADF	% ASH	% OM	% CP
alfalfa sprouts	4.59	6.94	27.74	20.80	5.09	94.91	58.44
bok choy	4.78	2.96	13.27	10.31	10.51	89.49	23.72
brussel sprouts	16.53	7.54	18.09	10.55	6.43	93.57	27.17
cabbage	4.52	6.84	17.22	10.38	7.46	92.54	22.63
collards	9.34	6.35	18.96	12.62	11.02	88.98	23.08
kale	13.67	5.07	18.20	13.13	8.42	91.58	27.21
lettuce (iceberg)	4.00	3.85	16.93	13.08	6.78	93.22	21.87
lettuce (romaine)	6.95	2.23	16.32	14.09	9.00	91.00	17.46
mustard greens	9.03	2.91	19.71	16.80	12.95	87.05	36.70
napa	3.49	3.09	17.14	14.04	10.22	89.78	27.58
parsely	12.03	3.25	21.06	17.81	12.23	87.77	24.05
spinach	8.91	8.37	20.08	11.70	19.97	80.03	38.74
turnip greens	8.86	2.60	20.10	17.50	14.42	85.58	34.15

DM - Dry Matter, HMC - Hemicellulose, NDF - Neutral Detergent Fiber, ADF - Acid Detergent Fiber, Ash - Minerals, OM - Organic Matter, CP - Crude Protein.

Composition of Readily Available Enrichment Items & Biscuits

Item	% DM	% HMC	% NDF	% ADF	% ASH	% OM	% CP
banana flower	8.70	18.64	41.19	22.55	11.12	88.88	15.79
popcorn	93.88	22.84	29.68	6.84	1.18	98.82	13.88
sugarcane	20.08	11.36	32.60	21.24	1.12	98.88	1.33
sugarcane w/o casing	20.33	11.54	26.18	14.64	1.75	98.25	1.59
Biscuit A	93.14	14.97	28.65	13.68	6.10	93.90	27.41
Biscuit B	91.96	10.42	29.60	19.18	7.04	92.96	26.81
Biscuit C	91.09	8.19	27.85	19.65	6.90	93.10	21.06

DM - Dry Matter, HMC - Hemicellulose, NDF - Neutral Detergent Fiber, ADF - Acid Detergent Fiber, Ash - Minerals, OM - Organic Matter, CP - Crude Protein