NUTRITIONAL ANALYSIS OF MIXED PRODUCE FOR EXOTIC SPECIES USING NEAR INFRARED REFLECTANCE SPECTROSCOPY (NIRS)

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Abstract
Near Infrared Reflectance Spectroscopy (NIRS) has long been established as a fast, easy, and cost effective technology for measuring basic organic components utilized in diet formulations. In zoological facilities, accurate timely quality control of diet ingredients, including highly variable items and those with a short shelf life, such as produce, can be difficult. We utilized traditional wet chemistry data from produce items (n = 85) to create novel calibrations using NIRS to measure protein, fat, and carbohydrate composition. This calibration was cross validated and demonstrated strong predictive power for fibers, sugars, protein and dry matter. Further samples across time and season will strengthen this calibration, improving efficacy of frequent quality control.

Introduction
Nutritional profiles of produce vary due to both pre- and post-harvest factors, including cultivar, seasonality, maturity, handling, and storage (Kader, 2001). Capturing this variability in nutrient content for diet evaluation is often challenging in terms of practical costs for frequent wet chemistry analysis and lack of predictability across time and season. The USDA database nutrient information for produce items are average values that may not represent the quality of specific items received at every facility. Ongoing quality control is an important aspect of any animal nutrition program. The ability to utilize Near Infrared Reflectance Spectroscopy (NIRS) to monitor these fluctuations and provide more immediate, cost effective feedback and would allow for better understanding of changing nutritional factors presented to our animals.

Materials and Methods
Our laboratory has sampled produce items (n = 85) as part of an ongoing quality control and analysis program at Disney's Animal Kingdom. Produce items used in animal diets include greens, fruits, vegetables, nuts, and seeds (Table 1). Samples were analyzed at Dairy One Forage Laboratory (Ithaca, NY) for dry matter (DM), crude protein (CP), crude fat, neutral detergent fiber (NDF), acid detergent fiber (ADF), starch, and ethanol soluble carbohydrates (sugar). These wet chemistry data were utilized as reference values for subsequent NIRS calibration development and cross validation (Table 2). The dried and ground samples were returned from Dairy One and then scanned using NIRS (SpectraStar 2500X- RTW System with InfoStar Software v. 3.11.1, Unity Scientific, Brookfield, CT) with reflectance spectra collected over a range of 680-2500nm with 1nm wavelength increments. Calibration development was achieved by treating the full spectra with partial least squares and cross validation of the prediction

equation was achieved by dividing the calibration set into groups and predicting nutrient values of every sample in the calibration set.

After initial prediction calibration was performed our results indicated that seed and nut type samples represented a unique subset of samples that would benefit from independent calibration development. For the remainder of the abstract "full set" (n = 69) refers to all samples once these items were removed from the population.

Results and Discussion

The prediction calibration utilizing the full set of samples produced strong R^2 values (0.74 to 0.96). For all constituents tested, R^2 for the cross validation test (R^2CV) was also considered strong (R^2CV= 0.72 to 0.87), except for fat (R^2CV=0.50). For the full set of samples, the calibration standard error (SEC) ranged from 6.9 for sugar to 0.98 for fat. Most of this variability can be attributed to the range in standard deviation (SD) of the wet laboratory value for each constituent. Likewise, SE of cross validation (SECV) showed similar fluctuation from 8.95 for sugar to 1.3 for fat. This is not surprising, considering the range of produce included (dark leafy greens, fruits, and vegetables) with similarly low fat content with highly variable sugars. For the purposes of this calibration, both the SEC and SECV are very acceptable and indicate a calibration with good predictive power. While we continue to collect and add samples across time and season, the calibration predictions can be further improved as unique spectra are identified. The goal is with time to develop specific calibrations to more accurately predict specific items or categories (e.g. leafy greens, high sugar fruits, high fiber vegetables, or apples, sweet potatoes etc.). By consistently scanning and predicting new samples, we can identify those samples which present unique spectra. Incorporating this diversity with wet chemistry data would increase our calibrations predictive robustness; with our aim toward minimize future wet chemistry needs and maximizing the sustained utilization of NIRS technology.

Literature Cited

Kader, A.A (2001) Quality parameters of fresh-cut fruit and vegetable products. In: O. Lamikanra edited Fresh-cut fruits and vegetables: science, technology, and market. CRC Press, Boca Raton, FL. Pp. 11-20.

Table 1. Produce Analyzed for Nutritional Content

Almond	Green Leaf Lettuce	Pineapple
Apple	Green Pepper	Plantain
Banana	Honeydew	Prune
Beet	Kale	Radish
Brazil Nut	Kiwi	Red Kidney Beans
Cantaloupe	Macadamia Nut	Romaine Lettuce
Carrot	Mango	Safflower seed
Coconut	Millet	Strawberry
Corn on the Cob	Napa Cabbage	Sweet potato
Endive	Onion	Tomato
Fig	Orange	Turnip
Frozen Corn	Papaya	Walnut
Garlic	Peanut	White Potato
Grapefruit	Pear	Yellow Squash
Green bean	Pea	Zucchini

Table 2. Laboratory Values for Dried Mixed Produce Samples

Produce, Dry	**NDF**	**ADF**	**Sugar**	**CP**	**Fat**
N	69	69	69	69	69
Min	3.30	1.10	1.50	2.30	0.20
Max	54.70	37.60	80.70	29.00	8.90
Mean	17.87	13.22	33.60	10.98	2.58
SD	12.25	8.05	20.42	7.33	1.93

Table 3. Calibration Statistics for Prediction of Dried Mixed Produce

Produce, Dry	**NDF**	**ADF**	**Sugar**	**CP**	**Fat**
SEC	4.19	2.99	6.90	1.49	0.98
R^2	0.88	0.86	0.89	0.96	0.74
SECV	5.90	4.00	8.95	2.38	1.30
R^2CV	0.73	0.72	0.77	0.87	0.50