National Animal Nutrition Program: Development of online feed composition tables

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Introduction

Feed composition tables produced as part of reports coordinated by the National Academy of Sciences, Engineering, and Mathematics (NASEM; formerly the National Research Council, NRC) are commonly used for diet formulation purposes around the globe, allowing optimization of feeding resources, decreasing production costs, and maximizing productive potential of animals. Although nutritionists routinely submit samples to commercial feed testing laboratories and report nutrient composition data, they typically rely on feed composition tables to provide estimates of nutrient composition of feeds not commonly analyzed (Tedeschi et al. (1)). For example, due to the low variation in nutrient composition among batches, nutritionists routinely use tabular nutrient composition values for ingredients such as corn, soybeans, and wheat (St-Pierre and Weiss (2)). Nutritionists also rely on feed composition tables to estimate concentration of nutrients which are expensive to analyze such as amino acids, minerals, and fatty acids. Finally, feed composition tables can be a source of estimates for true variability in nutrient composition defined as the nutrient variation intrinsic to a feedstuff (i.e., plant genetics, growing conditions, locations, agronomic practices, feed processing, etc.); without variability associated to analytical protocols (i.e., sampling, chemical analytes, laboratory). Knowing accurate estimates of nutrient true variability allows nutritionist to adjust safety factors (defined as offering excess of nutrient to minimize risk of deficiency associated to nutrient variability) to a minimum, thereby allowing more efficient diet formulation (St-Pierre and Weiss (2)).

Although traditional feed composition tables (i.e., 'book values') have been useful tools during the last 70 years, these traditional tables are not in agreement with current requirements of a dynamic industry and scientific community. Traditional feed composition tables are presented as printed books and require experts to gather and review feed composition information as well as decide which feeds and nutrients should be documented. These characteristics make traditional feed composition tables difficult to update (e.g., NASEM/NRC animal nutrition reports are updated on average every 10 to 20 years) to new trends in production practices, genetic improvements, nutrient determination, and inclusion of new feeds. Currently, the National Animal Nutrition Project (NANP) aims to create feed composition tables based on large datasets and generate database-driven website to display nutrient composition of different feeds commonly used in poultry and other livestock species. Initially, NANP consolidated existing databases containing nutritional information of feed composition tables from existing NASEM/NRC animal nutrition reports. However, NANP is currently developing a dynamic database that relies on large datasets with data provided by commercial labs. Database-driven webpages allow a user to display and filter feed composition tables using a flexible platform and at the same time, store and display large amounts of information on feed composition collected from different sources. However, developing such on-line tools has technical challenges associated with development of computer codes to manage and evaluate large datasets in an automated or supervised manner.

Considering the relevance of feed composition tables and the increasing interest of the animal science community in data science, the goal of this paper is to describe consolidated feed composition database and tables developed by the NANP.

Data sources, literature vs commercial laboratories

The first step to create feed composition tables is to construct a database containing nutritional information from a wide variety of ingredients. Currently, the NANP feed composition database contains nutritional information provided by different NASEM/NRC committees collected either by literature reviews or from commercial laboratories. The literature-derived dataset contained in NANP database was created by consolidating two datasets provided by the Swine (2012 (3)) and Poultry (forthcoming) NASEM/NRC committees. The segment of literature reviewed for Swine (2012) NASEM/NRC dataset included articles published between 1998 and 2011 and contained 2,277 feed samples divided into 147 unique ingredients and values for 67 nutrients. Similarly, the Poultry NASEM/NRC dataset was created with a systematic literature review collecting feed composition data reported in >30,000 articles published between 2011 and 2018 in 20 of the most influential peer-reviewed journals in poultry nutrition. The Poultry NASEM/NRC dataset included nutritional information for 2,130 feed samples, 131 different ingredients, and 91 unique nutrients. An advantage of literature-based feed composition datasets is that they rely on relatively small datasets with simple data management process. Collecting data from literature, however is a time-consuming process, requiring review and extraction of data from large numbers of publications. Furthermore, literature-based feed composition tables rely on small datasets and may result in some imprecision in population parameters of feed composition values.

Feed composition tables based on datasets provided by commercial laboratories are constructed using large datasets containing thousands or even millions of data-points for every ingredient and nutrient. Use of large datasets improves statistical parameters and ensures they are more representative of the nutrient composition of feedstuffs being evaluated. On the other hand,

it is difficult to process and manage large datasets, so computer-assisted cleaning and management of the data are required. Additionally, file formats, data structure, and feed classifications differ among the feed testing laboratories, adding further complication to true identity of analyzed ingredient data. Furthermore, managing such large databases requires computers with high processing power and software capable of running automated procedures to consolidate files, generate output to identify outlying observations, and detect misclassified feeds. For instance, a commercial lab dataset provided by the Dairy NASEM/NRC (forthcoming) committee initially contained 2.76 million data-points received from 4 commercial feed testing laboratories. The data management process began by standardizing feed names and nutrient analytes across laboratories, then erroneous data and duplicate samples were removed. Histogram, univariate, and principal component analyses were performed to identify and remove outliers having nutrients outside of the mean ± 3.5 standard deviations. Later a hierarchical clustering procedure was used to identify subgroups of feeds within a feedstuff (Yoder et al (4)). The described procedure was useful for eliminating outlier data points and allowed identification of feeds within large dataset, both important actions aimed at increasing the accuracy of true variability of nutrient composition. The procedure was helpful to classify oilseeds and oilseed meals according to crude fat values (i.e., whole seed ~20% crude fat, expeller meal ~6% crude fat, and extracted meal ~2% crude fat), byproducts as dry or wet according dry matter (DM) content (i.e., dry ~80% DM, wet ~30% DM), and identify misclassified samples in feed samples with similar names (i.e., corn gluten feed and corn gluten meal, soybean meal expellers and soybean meal extruded). In addition, the procedure was useful for classifying forages according to storage method (i.e., fresh ~15% DM, silage ~35% DM, and hay ~80% DM), maturity stage (i.e., immature, mid-mature, and mature based on NDF, ADF and lignin contents), and for grass-

legume mixtures, the procedure classified samples as predominantly-grass or predominantly-legume according hemicellulose content. After the screening procedure, the final commercial lab dataset included 174 feedstuffs with 1.48 million feed samples represented in the database.

Database and on-line feed composition tables

Currently the NANP database contain nutritional information of 4,807 samples of 99 different ingredients and 67 nutrients obtained only by literature reviews (i.e., consolidated swine and poultry NASEM/NRC datasets). However, it is expected that in the near future the NANP database will contain nutritional information of >400 feedstuffs and 137 nutrients derived from more than 2 million analyzed feed samples.

The information contained in the database is summarized and displayed in feed composition tables available in the NANP webpage (https://animalnutrition.org). In order to facilitate a user to find information, the feedstuffs are divided into categories: 'animal proteins', 'by-products and others', 'forages, grain crops', 'forages, legumes and grasses', 'grain products', 'oilseeds and plant proteins', 'minerals', and 'fats and oils'. When selected, information of a feed is displayed in an on-line feed composition table split in two parts, with the upper section, showing descriptive information of a feed as well as several filters, and the lower section showing nutritional information of the selected feedstuff without or with applied filters. A picture of a NANP feed composition table for 'corn grain, dry' is shown in Figure 1. For each feedstuff, displayed in the upper part of the table is the feed definitions, scientific name, common feed name(s), and available identification numbers according to the Association of American Feed Control Officials (AAFCO (5)), International Feed Nomenclature (IFN, Harris et al (6)) and the European Union (7). Currently, NANP on-line feed composition tables include 3 filters to: 1) transform nutritional information from a 'dry matter' basis (default) into an 'as fed' basis

according a custom dry matter value, 2) select nutrient composition from feedstuffs that were analyzed in a specified range of years, and 3) select nutrient composition according different types of data sources [peer-reviewed (data obtained from scientific journals), commercial (data obtained from commercial laboratories), and academic (data obtained from academic laboratories that has not been published)].

In order to facilitate the review of information by users, nutrients were separated by categories such as main constituents (including dry matter, crude protein, crude fiber, (acid) ether extract, ash, and gross energy), carbohydrates (estimated with detergent methods (Van Soest, (8)), enzymatic-gravimetric methods (Prosky et al. (9)), enzymatic-chemical methods (Bach Knudsen (10) and several monosaccharides and oligosaccharides relevant in animal nutrition), proteins (including amino acids and neutral/acid insoluble crude protein), lipids (values for 23 different fatty acids as well as total saturated, poly-unsaturated, and mono-unsaturated fatty acids), minerals (including 8 macro and 12 micro minerals), and vitamins (including water soluble, fat soluble, and pseudo-vitamins). Information displayed for each nutrient include: number of samples (n), mean, standard deviation (SD), coefficient of variation (CV), and 10% and 90% percentiles.

Summary

The National Animal Nutrition Project (NANP) has created feed composition tables based on large datasets and has implemented a database-driven website to display nutrient composition of different feeds commonly used in poultry and other livestock species. Database-driven webpages allows the development and to display feed composition tables in a flexible platform helping to meet requirements of the industry and scientific community, and at the same time, store and display large amounts of information on feed composition collected from

different sources. Initially, NANP is consolidating databases based on nutritional information from existing NASEM/NRC animal nutrition reports, but the committee is simultaneously developing a dynamic database that relies on large datasets with values provided by commercial analytical laboratories. The NANP feed composition database currently contains nutritional information from 4,807 samples in 99 different ingredient categories and 67 nutrients obtained only by literature reviews (i.e., consolidated swine and poultry NASEM/NRC datasets). However, it is expected that in the near future the NANP database will expand nutritional information to more than 400 feedstuffs and 137 nutrients based on more than 2 million feed samples. The information contained in the database is summarized and displayed in feed composition tables that are accessible through the NANP website (https://animalnutrition.org). NANP is open to receive new analytical data from any source to produce a reference feed composition database and tables.

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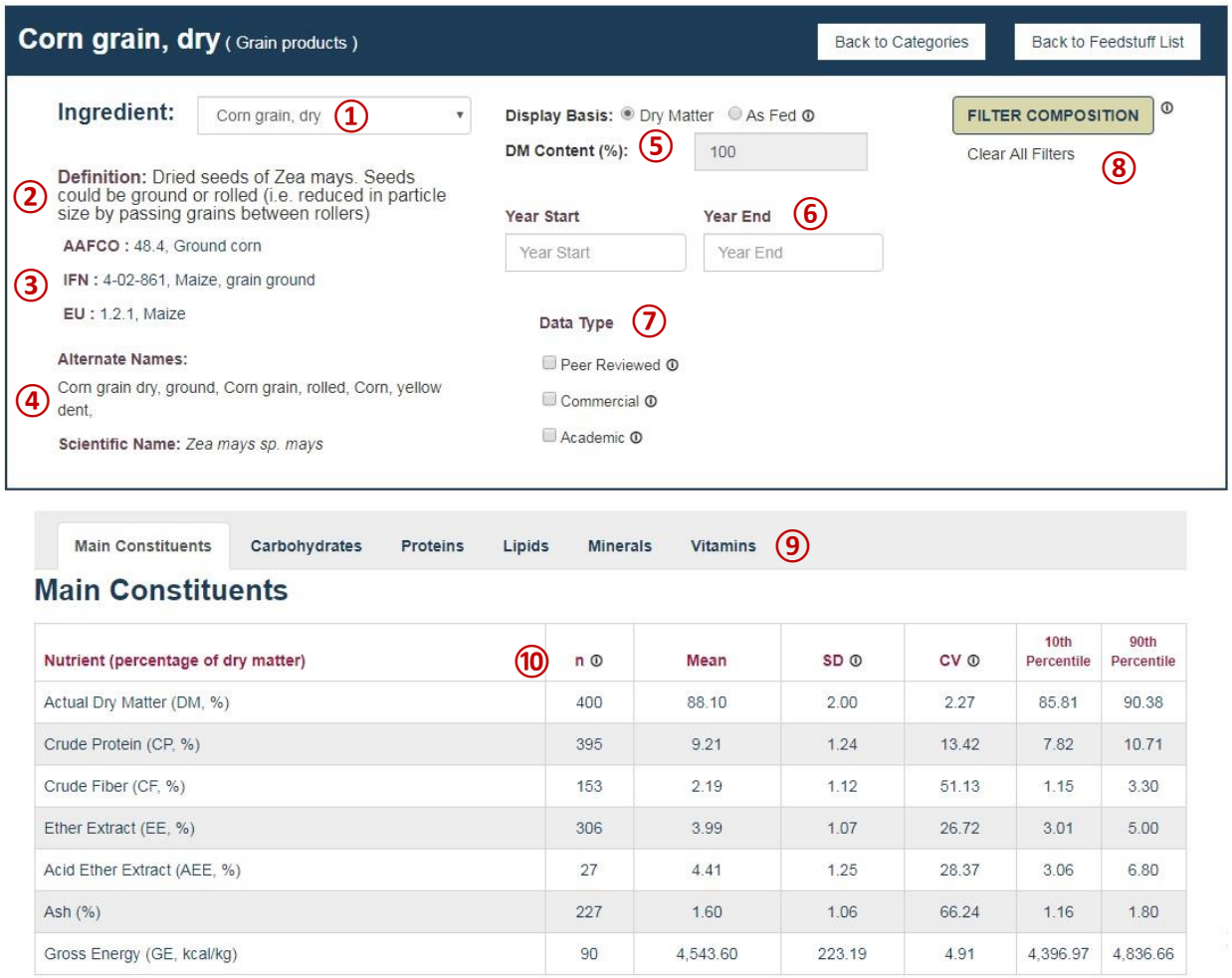

Figure 1. Functionality of on-line feed composition tables developed by NANP. ① Feed selection, ② Feed definition, ③ Feed name and number according: Association of American Feed Control Officials (AAFCO), International Feed Nomenclature (IFN) and European Union (EU), ④ Alternate and scientific names for the selected feed, ⑤ Show nutrient composition as "dry matter basis" (default) or "as fed basis". If "as fed" is selected it is possible to introduce a desired dry matter value to transform nutrient composition from default dry matter into as fed basis, ⑥ Filter by Year, ⑦ Filter by data type, ⑧ Press "Filter Composition" button to apply selected filters, ⑨ Select different types of nutrients, ⑩ Descriptive statistics for nutrients: number of samples (n), mean, standard deviation (SD), coefficient of variation (CV), 10% and 90% percentiles.