Standardization of Analytical Methodology for Feeds

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Relationship to INFIC: Feed Data Documentation and Standardized Methods

H. Haendler

The worldwide need for feed data has led to the development of centres for feed data documentation and to international cooperation within INFIC. The principles of feed data documentation include generalization of statements that are collected in the form of data. Generalization requires identification of all constituents of the statements.

For the identification of the “object” of the statement, i.e. the feed, a system for conceptual analysis and description has been developed. A multilingual feed vocabulary, consisting of six facets with descriptors for denoting the different types of characteristics, allows the systematic analysis and description of a feed. Within the recording and coding system codes are provided for an additional (“individual”) description of the feed samples.

For generalizing the second constituent of the statements, i.e. the property of the feed as found by chemical analyses, standardized analytical methods and standardized designations for the results are demanded. Special attention should be given to an international standardization of the systems for energetic evaluation of the feed value. Efforts to adopt accurate and simple methods — at least for estimating digestibility in vitro — should be endorsed.

Within agriculture there exists a special need for information dealing with results of feed analyses. The units of information are called informemes, and can be regarded as statements that inform users. Informemes are represented by data. Data on feed composition are a necessary ingredient for all decisions concerning the feeding and nutrition of farm animals, the preparation of diets, the manufacture of mixed feeds, and the planning of forage production.

In an exceptional case it may be possible to “produce” such information on feeds by carrying out experiments with animals and chemical analyses in a laboratory. This requires time and money, mostly much more than available, and the more complete and exact the knowledge that is demanded, the more time and money that are required. The costs for the production of such information increase considerably from one level of analyses to the next: the lowest in cost are simple analyses of nutrients; the next, detailed analyses (minerals, amino acids, vitamins etc.); considerably increased are the costs for trials with animals for determining digestibility; and finally, obtaining energy values with respiratory equipment is extremely expensive.

This way of “self-producing information” therefore is not practicable for answering regular demands of information. But, the results of different experiments and analyses, being the single pieces of knowledge, can be used again and again for the information requirements of many users. Information — contrary to other commodities — has the advantage of not becoming exhausted by being used; it can be stored for unlimited periods and can be used wherever and whenever it is demanded.

For more than 100 years, feeds have been analyzed in laboratories all over the world. Experiments have been carried out with animals to determine nutritive value, digestibility, or particular effects of feeds in diets. This work was done initially to answer a particular question, and the results of this experimental and analytical work were used for actual research on, or control of, a special feed and were not stored for general information and retrospective retrieval. Later it was recognized that these data, scattered in many institutions around the world, constituted an enormous source of information. But, to make use of this information it must be collected systematically and processed using specific

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methods. This kind of work comprises feed data documentation.

There is no question that efficient work in data documentation, especially the utilization of data sources distributed worldwide, demands international cooperation. This was started after valuable preliminary efforts made by FAO, with the foundation of the International Network of Feed Information Centers (INFIC) in 1971 (INFIC 1979). The preliminary work has been carried out to develop a new international system and to prepare methods for worldwide data exchange and for data distribution in different languages. This coordination required hard work to overcome the incompatibility of single systems and to prepare new documentation tools and methods acceptable to and usable by all INFIC members.

The Principles of Feed Data Documentation

Analytical work in laboratories and feed data documentation have the common goal of providing information on the composition and/or nutritive value of feeds. The difference is that analytical work in the laboratories leads to a specific statement about a special sample of a feed concerning a specific property or value; whereas, feed data documentation communicates general information to different types of users. Hence, the documentalist must generalize the results of laboratory work: i.e. the special statement (given as the result of a single observation) must be modified to a general statement (useful beyond the special situation). To do this work of induction (in the philosophical meaning of the term) without affecting the reliability of the information, some presuppositions must be made.

The first problem is statistical and well known: How many single observations are necessary to allow an inductive conclusion? This problem is very closely combined with the question: How representative are the single observations? To give an example, one does not need many observations to come to statements like “swans are white” or “ravens are black” because black swans and white ravens are very rare birds. Thus, relatively small populations of swans and ravens are representative enough to permit the conclusion that these birds are white and black, respectively. But, to make a real statement like that given in the example, one must be able to distinguish between swans and ravens. This is not as simple as it looks at a first glance, and stresses a very important point concerning the relationship between laboratory and documentary work. To keep the example: If one “analyst” reports an observation on a white bird and another observation on a black bird — and both may be exactly right — the “documentalist” cannot conclude “birds are gray.”

Returning to feeds, let us assume that an analyst has received a sample of an unknown feedstuff, analyzed it, and told the customer its protein content and that he did not find toxic substances in it. This may be good and valuable information for the customer (he may have 100 tonnes of this material and want to feed it to his pigs), but it is not the information required by the user of the feed information centre. Therefore, the centre will not record and process such data.

The analyst may use the best and most reliable method to determine a component or the nutritive value of a feedstuff, and his work may be very successful for his customer, but to make further use of the results via data documentation a very clear and exact identification of the “object of observation,” i.e. the analyzed feed, must be given. Generalizing specific statements is feasible only if the object of the single case is well identified. Identification here is meant in its strictest meaning: Is one object identical or equal to the object one wants information about? Someone who wants information about ravens cannot use any information about swans; he can only use information on the identical bird!

However, identification in the case of feeds is much more difficult than in the case of swans and ravens or of any other birds or animals or things. This is because swans, ravens, and things like these are objects in the narrower sense of the word, objects having a form, a body with a shape. On the contrary, feeds are amorphous substances. One cannot really distinguish between single individuals, and therefore one cannot really group individuals into classes. Nevertheless, if we want to process data from different observations, made at different places of the world, we have to decide exactly which data can be brought together for generalizing statements and for calculating averages and which data have to be handled separately.

An observation on a feed is the result of the chemical analysis on a specific sample. There is no other choice but to regard such a sample as a quasi-individual even if it is not an object in the strong sense of the word.

If we want to identify or classify something, we have to look for its characteristics. The sum of its essential characteristics determines the concept of the “thing,” its relationship to other concepts, and, therefore, its place in a conceptual system (classification system). The determination of the characteristics of a feed may be regarded as
its conceptual analysis. The history of philosophy shows that this type of analysis is much older than chemical analysis — say 2000 years. Aristotle, the father of logic, introduced the term “analytics” for what was later called “formal logic.”

Although chemical analysis of a feed sample leads to results like protein content, fibre content, etc. and definitely to its nutritive value, conceptual analysis leads to characteristics (conceputal factors) and definitely to the concept. Just as the result of a chemical analysis can be made into a statement, so can the result of a conceptual analysis. The generalization of statements needs standardization. This is true for statements on both chemical composition and conceptual composition. In both cases standardization concerns the methods of the analysis as well as the description of the results. Only materials designated in the same manner can be compared or summarized.

The first step toward generalizing statements must be the standardization of the constituents of these statements. These are, as has been shown, the results of the conceptual analysis (including their description) on the one hand and the results of the chemical analysis (including their designation) on the other. Both sides are equally important for feed data documentation and information.

**Systematic Feed Description**

The methods and tools for conceptual feed analysis and the description of its results have been developed for practical purposes by INFIC (INFIC 1979). Although this work has been carried out by members of the INFIC group, using the experiences of Hohenheim University in Stuttgart and Utah State University, the principles of the methodology date back to Aristotle’s theory of categories. These principles have led to the elaboration of faceted indexing languages and classification systems. All these systems not only assign the concepts (represented by its denominations or terms) to different categories or facets but also distinguish sharply between the “basic category” of substance (according to Aristotle; named entities, objects, concretes, etc. by others) on the one hand and attributes, properties, processes, etc. on the other.

The necessity to differentiate in faceted indexing languages between “concretes” and “processes” was pointed out by Kaiser (1911), and has been recently discussed by Svenonius (1978). It should also be remembered that the addition of concepts (like properties, processes) as new characteristics to “concretes” means specification. Both these principles are included in the faceted system for systematically describing feeds. This is the “International Feed Vocabulary,” which has been extended for practical use to the “INFIC Feed Thesaurus.”

For the special purposes of feed description, the facets had to be adapted to those types of characteristics essential for determining a specific feed. The “concretes” in our case could be well described by determining the raw or original material of the feed (plants, animals, or other). In most cases not the whole plant or animal is prepared as feed. Thus, for feed description the category “concretes” must be divided into two facets, one for the “original material” and another for determining the part used as feed. This second facet consists of the terms that are necessary for the more specific characterization of the first facet. The next constituent for analyzing and describing the characteristics of a feed is, according to Kaiser, the process the “concrete” has undergone. Thus, the processes or treatments must be considered as a third facet.

Although the essential characteristics of a feed are covered by these three facets, it has been found that in some cases additional characteristics must be analyzed to describe the feed completely. This is especially true in the case of plants, and under certain circumstances in the case of animals too. For an exact characterization of a feed, therefore, the stage of maturity, the time of cutting or the crop, and eventually the degree of quality, if not already characterized by the preceding description, must be considered.

The system for analyzing (conceptually) and describing feeds therefore consists of six facets: (1) original material (plant, animal, or other basic material); (2) parts of this material used as feed; (3) processes or treatments the material has been subjected to; (4) stage of maturity in which plants or animals are used; (5) the cutting or crop (for plants only); and (6) grade (quality). Each of these facets is a list of controlled and fixed terms called “descriptors,” which represent a characteristic (as a concept element) for analyzing (conceptually) and describing a special feed. Thus, the feed description is the synthesis of the adequate descriptors taken from the facets, at least of facets one, two, and three. Faceted indexing systems are therefore regarded as analytical-synthetic systems.

For the correct use of a vocabulary, grammar is necessary, and it is this that makes the vocabulary into a language, in our case a documentary language. Grammar consists of syntactical rules (syntax) for combining the terms/descriptors and
making combinations (syntagmas) understandable. The syntax of the feed description systems lies in the facet structure, which gives each type of characteristic the right place in the syntagma and fixes its syntagmatic relationship to the other constituents. Therefore, a faceted description system ensures proper concept analysis and description as well as high retrieval performance (recall and precision). To exclude polysemy of terms the thesaurus allows the proper use of descriptors by offering scope notes and concept relationships.

Because the system for feed description was to be used for the purposes of an international network, it was necessary to use a multilingual thesaurus. Therefore the vocabulary, i.e. the totality of descriptors, was established in three versions: English, German, and French (a Spanish version is in preparation). This means that each descriptor has three different lingual equivalences, all of which represent exactly the same concept. Great care was taken to obtain this semantic equivalence even in cases where homonymy or polysemy existed in a term in one of the languages. The whole vocabulary provides multilingual descriptors for about 5700 concepts.

Besides the vocabulary, the thesaurus contains other terms (nondescriptors) from which reference is made to the adequate descriptor. In this part are included — beside synonyms within the "system languages" — referring terms from other languages, especially those from tropical and subtropical countries, that concern plants used as feeds in those regions. A provisional version of the "INFIC Feed Thesaurus" includes about 25,000 entries. By using the methods and tools that have been developed for identifying feeds one can produce systematic concept analyses using unambiguous descriptions that are independent of national languages and local idioms.

Another point should be kept in mind. This method of describing feeds systematically makes it possible to distinguish (artificially) between "classes" or "species" and "individuals." The facets of the vocabulary provide descriptors that represent essential characteristics of a feed. An individual may have individual characteristics beside the essential characteristics that are typical for the species. If a swan has a broken wing, then this is an individual characteristic restricted to this particular bird, and it cannot be considered as typical for the species.

Beside the essential characteristics of feeds, there may also be "individual" characteristics of different samples. These may be influenced by environmental conditions. To consider these individual characteristics a very sophisticated system for sample description has been developed. Thus, where necessary, individual characteristics of a single feed sample can be used as selection factors for data selection.

**Standardization of Analytical Techniques**

Having treated the first constituent of a statement, we must now turn to the other constituent, the property of the "object" determined by chemical analysis or by trials with animals. What has been said before about generalization of statements is also appropriate here. Only the same type of properties can be compared or can be used for generalizing, for calculating averages, or for deducing values. The problem of standardizing analytical methods has been discussed in previous papers; therefore, this section will be restricted to the information aspects of this standardization.

Feed data documentation in Germany started 30 years ago with the recording of results from the "classical" analyses according to the "Weende" method. Soon the spectrum of data that had to be recorded began to increase constantly. In addition to information on the 470 substances that occur in the feeds, other factors like digestibility by different animals, availability, and biological value had to be considered. In all there are about 800 items. With this increase in volume, more and more problems were encountered. The first of these involved general problems of recording and coding the different kinds of values. Thus, a new system for data recording within INFIC was developed. A second problem soon developed — the consideration of nutrients or values for which different analytical methods were used. The more different two methods are in their results, the less comparable are their results.

This fact made it necessary to include in the recording and coding system separate codes for different analytical methods, which had to be added to the codes for the nutrient and its content figures. These codes can be used to separate data originating from different analytical methods. If for instance an unsatisfactory method has been replaced by a new and better one, the data derived from the ancient method can be excluded for cases of information output, provided enough single results based on the new method are available.

There is no question that the use of different methods for analyzing the same nutrient of a feed makes the recording and coding system complicated. However, the user would be confused if he were provided with different figures for
the same property, and if the information centre
mixed data resulting from different methods the
information would be unreliable. Therefore,
from the point of view of the information system
and its users it can be concluded that analysts
should standardize the methods for feed analyses
on a worldwide basis. The most exact methods
should be used, but of course the possibility of
applying these methods in all laboratories of all
countries, including developing countries, should
be considered as well.

When enough data from these standardized
methods are stored in the data bank, former data
 gained from unreliable methods can be neglected.
But, until that time, data documentation must use
exact coding of different methods and take this
into consideration for all information purposes.

If the efforts of the analysts to promote and
standardize the methodology of analytical tech-
niques lead to new and better methods, it is no
problem to denote the results of these new
methods with new codes; thus, they can be cor-
correctly processed. In this case, it is desirable that
enough data from the more exact method be col-
clected and stored as soon as possible, so as to have
a broad basis for reliable averages and for
generalizing statements.

Not only does the analysis have to be stan-
dardized, but the way of designating the result has
to be standardized because many different
methods are practiced. The INFIC system for
data recording, therefore, provides codes for the
different bases on which data are recorded, for
example, dry matter basis, “as fed” basis, or, for
amino acids, a 100-g protein basis. These codes
are used to standardize recorded information a
posteriori by computer. Nevertheless, a priori
standardization of the designation of analysis
results in the laboratories could reduce the work
in the information centres and probably reduce
mistakes.

Standardization of Energy Value
Determination

The heterogeneity of methods for the
determination and designation of energy values is
extremely high. The first level of this hetero-
genesis exists in the different kinds of energy that
are calculated: gross energy, digestible energy,
metabolizable energy, and net energy. Another
level of differentiation is caused by the method
for determining or calculating the energy content
of a feed. A distinction must be made between
direct trials with animals in respiratory equip-
ment or similar methods, and different methods
for calculating energy content by using regression
equations on the basis of raw nutrients or of
digestible nutrients. A third level of differentia-
tion concerns the designation of energy values.
The first measurements of energy value were
compared with a standard feed (hay value, barley
unit, oat unit, nordisk feed unit etc.) or with a
standard nutrient (Kellner's starch equivalents),
but later, caloric values were used, and more
recently the Joule has been introduced.
The preferred method differs from country to
country because the systems developed in a
region are most used and well-known there. The
degree of confusion concerning energetic feed
evaluation is reflected in the literature on this
special subject. In a retrospective search of the
literature in the Hohenheim Documentation
Center, which covers only the last 20 years, about
500 documents dealing with energy evaluation of
feeds were retrieved.

What was said regarding the different methods
of analytical techniques is much more pertinent
with regard to the determination of energy. In
data documentation different formulae and
different computer programs can be used to
calculate different types of energy. Indeed we did
so, and by using different calculation methods in
different tables and for special purposes we
produced tables in which different energy values
could be compared.

Although this makes the system complicated,
this is not the most important problem. The user
can be confused by so many figures on the energy
value of a feed; therefore, worldwide standardiza-
tion of the systems for energetic feed evaluation
would be very desirable. We are observing with
great interest the efforts of competent organiza-
tions in this field like the EAAP working group
"Feed Evaluation for Practical Application." Based
on the report by van Es (1976) about the
activities of this group one cannot be optimistic
regarding the possibility of finding a satisfactory
solution in the near future. It is hoped that inter-
national cooperation on a large scale — as
promoted by this workshop — will soon lead to
more success.

From the point of view of feed data
documentation some points should be
remembered. First, the kind of energy must be the
same. It should not be forgotten that for a general
statement concerning energetic value, different
kinds of production can hardly be considered. A
measure must be used that can designate a general
nutritive value. For practical purposes, the
requirement of energy for different kinds of
production must be designated in an adequate
way.

Second, results of direct determinations of
energy content — using animals in respiratory
equipment — are restricted to the special feed sample used in the trial. These results can be used only for exactly the same feed (not only as described according to the conceptual analysis but also found to have exactly the same content of nutrients). Because this cannot be realized, the average energy value of a feed must be calculated on the basis of the average content of nutrients of that feed. This is the reason the Hohenheim Documentation Center did not record single directly determined energy values, but rather calculated values in each case by using the average values of digestible nutrients. However, we have recently started to record directly determined values so as to complete our data bank and to have data for comparison.

This does not mean that direct trials for the determination of energy values are not necessary. On the contrary, they should be applied to provide better knowledge about the energy values of different kinds of feeds with the view toward correlating the content of digestible nutrients with the energy value.

This leads to the question of the determination of the digestibility of different nutrients. From the beginning of our feed documentation work in Germany we were very keen to collect and record all existing data about the digestibility of the nutrients of different feeds by different animals. Such data are very valuable and become a broad basis for averages. We preferred to have such data from animal trials. Recently, however, only a few institutions are carrying out such expensive and complicated trials. Instead, in vitro methods for determining the digestibility of the nutrients are being increasingly used. For a long time we hesitated to record them, being afraid of unreliable data.

We think that the new methods promise to be reliable. Besides accuracy, the simplicity of a method must be considered if it is to be used in the various countries of the world. We are hopeful that scientists will agree to use the method developed by Menke et al. (1979), which uses gas production in vitro with rumen liquor for determining digestibility, and allows the calculation of the metabolizable energy of a feed.

It would be a great benefit to feed data documentation and information, if the standardization of such methods and their worldwide use produced new data that would broaden the data base and allow more generalized statements concerning the feeding value of all feeds. This would be valuable to INFIC in its task of supplying information to users in all parts of the world. But such standardization would also help the different feed information centres within INFIC to work closely together, to exchange data, to develop these to reliable information by using adequate processing methods, and to make them available to users in all countries for promoting animal production, agriculture, and the welfare of man.