

TECHNICAL BULLETIN



MITA (P) NO. 070/10/2001

FT52-2001

NEAR INFRARED SPECTROSCOPY: PRESENT AND FUTURE APPLICATIONS

by

Nelson Ruiz, Ph.D.
ContiGroup Companies, Inc
U.S.A.

This material is allowed to be duplicated, as long as credits are given to the author and ASA.
FO1GX19400-092001-0800

美国大豆协会

AMERICAN SOYBEAN ASSOCIATION

541 ORCHARD ROAD #11-03 LIAT TOWERS, SINGAPORE 238881. TEL: (065) 6737 6233 FAX: (065) 6737 5849

E-mail: asaspore@pacific.net.sg

<http://www.asasea.com>

NEAR INFRARED SPECTROSCOPY: PRESENT AND FUTURE APPLICATIONS

Nelson Ruiz, Ph.D.
ContiGroup Companies, Inc
U.S.A.

INTRODUCTION

The application of Near Infrared Reflectance Spectroscopy to feeds is not a new concept. The pioneer work by Hymowitz *et al.* (1974), Rinne *et al.* (1975), Williams (1975), and Norris *et al.* (1976) is already 25 years-old. What is new is the tremendous progress in computer technology and its commercial accessibility so that the creativity of statisticians, mathematicians and chemists for the treatment of large amounts of data is now compiled in the form of programs, or software and therefore, you do not have to be a NIRS statistician to develop acceptable and sound applications. However, you need to have a clear understanding of what you are attempting to analyze when you use NIRS as the analytical tool as well as of the reference or primary method. NIR is a secondary method. By no means it is implied that NIRS can analyze every possible analyte in a biological product. It is intended for the major constituent in biological products and minor associated organic and inorganic analytes.

The major advantages of NIRS is that it is a non-destructive analytical method, therefore requires no chemical reagents, and once calibrations are in place, it takes just minutes to have the result of one or more constituents which by conventional chemistry, may take hours or days.

It is the objective of this presentation to review the usage of NIRS as an analytical tool in the manufacture of animal feeds.

NIRS IN BRIEF

Infrared is the region of the electromagnetic spectrum located after the visible region in the direction of longer wavelengths. Near infrared owns its name for being the "near" section of the infrared region to the visible region (Fig. 1). Spectroscopy specialists divide the infrared region into near, middle, and far infrared. For practical purposes, near infrared comprises wavelengths between 800 and 2500 nanometers (nm). There are several very good, simple, and descriptive explanations of what is exactly we measure with near infrared technology when applied to pure chemicals or complex matrices such as feed ingredients, premixes, and mixed feeds (Dyer and Feng, 1997; McGinnis, 1998; Anonymous, undated).

It is important to understand that there are at the present time two technological ways to use near infrared technology: Near Infrared Reflectance (NIR) and Near Infrared Transmittance (NIT). The former is based on reflecting the near infrared radiation from the surface of the sample to the detector. The latter is based on the near infrared radiation that passes through the sample. While NIR normally requires sample grinding to obtain a uniform surface for measurement of reflectance, NIT requires very little or no sample preparation. Consequently, NIT is quicker and more reproducible than NIR, but NIT is less sensitive than NIR. Dyer and Feng (1997) summarized in their paper an excellent discussion on the advantages and disadvantages of these two technologies. For the remaining of this paper, all reference to near infrared applications is for NIR.

Basically, NIR is applied to organic compounds rich in O-H bonds (such as moisture, carbohydrates, fat), C-H bonds (such as organic compounds, petroleum derivatives), and N-H bonds (such as proteins, amino acids). The way NIR instruments operate is by statistically correlating NIR signals at several wavelengths with the characteristic or property intended to be measured (Jordon, 1996a). In other words, the near infrared spectra are treated mathematically to “extract” so to speak, the information from the sample. All biological substances contain thousands of CH, OH, and NH molecular bonds. Therefore, the exposure to near infrared radiation of a biological sample such as a feed ingredient results in a complex spectrum which contains qualitative and quantitative information about the physical and chemical composition of that sample.

Every biological substance has a unique NIR spectrum. If two biological samples have the exact same spectrum, it can be assumed that they have the exact physical and chemical composition. If spectra are different, then the samples are different either physically or chemically or both.

The actual numerical value of a specific analyte in the sample such as protein or lysine is mediated by a calibration approach known as “CHEMOMETRICS”. As simply expressed by Jordon (1996b): it is “a discipline with one foot in chemistry and one in mathematics.” Chemometrics applies statistical methods such as multiple linear regression (MLR), partial least squares (PLS), and principle component analysis (PCA) to the spectral data and correlates them with a physical property or other factor, that property or factor is directly determined rather than the analyte concentration itself. Of course, the primary method provides the “wet chemistry” data of the samples required to develop the calibration, but the actual

measurement when a sample not used in the calibration set is scanned in the NIR instrument is a “prediction” based on the statistics of the data, not on the direct quantification of the analyte.

From the practical standpoint, there are two chemometrics concepts that need to be understood: The GLOBAL H and the NEIGHBORHOOD H. Chemometrics involves the transformation of the two dimension spectral data to multidimensional space by one of a number of loading-score mathematics. The loadings represent the independent patterns in the set of data and the scores represent the proportion of each pattern in the spectrum of each sample (Anonymous, undated). This means basically that the spectrum of each sample is given a mathematical description and can be seen graphically in a three-dimensional cube. Each pattern can be described by the distances from the center of the spectra in multiple dimension space to the “periphery” of the cluster of spectra (Global H), and the distance each spectrum is from every other spectra can also be quantified (Neighborhood H), see Fig. 2.

The practical significance of the Global H (GH) is that the software tells you when a predicted value for a given sample is out of the population of samples that make the calibration. A GH less than 3.0 means that the spectrum for that sample is similar to samples already in the population. A GH larger than 3.0 means that the spectrum of the unknown sample is different than the population used in the calibration and is considered an outlier. It is important to determine that it is a true outlier since sample contamination (for instance, at the lab mill level) may create artificial outliers. The outlier sample should be sent to wet chemistry so that its lab values become part of a future expansion of the existing calibration.

A Neighborhood H (NH) of less than 0.6 means that the spectrum of the unknown sample has very close “neighbors” in the spectral population, and therefore it is indicating that the prediction is very robust. NH values around 1.0 suggest that even if GH is lower than 3.0 the prediction is not that reliable, and samples should be sent to wet chemistry. In simple terms, GH and NH values is a way for the software to tell you “yes, I have seen samples like this before, here is my prediction, believe me”, or “no, I am sorry, I have not seen something like that before, better check with your wet chemistry lab”.

NIRS REQUIREMENTS

The use of NIR for analytical purposes requires the following:

1- A NIR SPECTROMETER. There are different models and several trademarks in the market for different needs. Suggested criteria to decide which to choose should include the range of intended applications and the SOFTWARE available for those applications. For poultry and animal feeds in general, we are dealing with a relatively large number of ingredients and given the diversity of applications, a good number of analytes. Therefore, hardware and software should be carefully selected. The range of wavelengths frequently used in agricultural applications is 1100-2500 nm. However, there may be opportunities to use a wider wavelength range which may include the visible region. Instruments with a scanning range 400-2500 nm are available in the market.

2- A COMPUTER. Several current NIR instruments are physically independent from the calibration and operating software. Recommendations on the appropriate computer specifications should be requested from the NIR instrument manufacturer.

3- A laboratory MILL. It is possible to develop calibrations with unground samples such as whole grains. However, for products that are heterogeneous in particle size such as silages and forages, or for applications such as total and digestible amino acids, grinding of the sample is still needed. PARTICLE SIZE is a very critical and important variable in conducting reproducible and reliable NIR analysis. Grinding to particle sizes smaller than 1000 microns may result in significant moisture loss. There are several alternatives to deal with the moisture determination so that all of the results issued by NIR analysis are expressed at a standardized dry matter content or “as received”.

4- A WET CHEMISTRY LAB/REFERENCE LAB. Using a NIR instrument for your routine analytical needs will result in a substantial decrease in wet chemistry activity in your lab if you have one, or in your commercial reference lab. Companies with several manufacturing plants may decide to NETWORK their NIR instruments having their “master” NIR instrument at their central laboratory where wet chemistry is run, and calibrations are developed. The NIR instruments in the “satellite” locations are standardized to the master one. If your company works with a commercial lab then that laboratory will become your REFERENCE LAB for NIRS. You need to monitor your reference lab because wet chemistry is the primary method, and all your NIR calibrations are dependent on the accuracy and precision of the wet chemistry lab.

5- A competent MANAGER of the NIR analysis program. The quality assurance manager should be responsible for the NIR program. However, it is recommended that the manager for the NIR program itself be a chemist. This person is not only in charge of the instrument and its software, he or she is also in charge of developing the correct

calibrations and maintaining them. The person has to monitor the reference lab, and understand the wet chemistry involved.

ADVANTAGES, DISADVANTAGES AND CALIBRATIONS IN NIRS

The major advantages of using NIR are:

- It is quick, it does not use chemical reagents, it is safe.
- For routine proximate analysis, the cost by NIR was calculated at about one-third of the cost by wet chemistry.
- Sample preparation is simpler.
- Several more analysis per day.
- If your company has several plants and doing networking of NIR, only one lab (or reference lab) is needed for routine proximate analysis and its calibration development.
- NIRS is more precise than wet chemistry.

Some disadvantages:

- Initial investment is high.
- Calibration development is time consuming.

In reference to CALIBRATION development, it should be emphasized that the most critical issue is not the mathematical/statistical model to use, but DEVELOPING THE DATABASE for the product (that is, ingredient, feed, excreta, meat, etc.). The database or library of spectra needs to cover a wide range of variability for the analyte. You do not need to analyze every single sample you get in order to develop a calibration. What you need is to scan as many samples as reasonable, and then use the software to select which samples need to be analyzed by the wet chemistry lab.

The wet chemistry lab is critical for calibration development. Your laboratory or your reference lab should be in a sample checking program (such as AAFCO) for the analytes you are working. Of course, there are no sample checking programs for every

application. Therefore, you should find ways to evaluate your reference method and lab to check ACCURACY and PRECISION. For instance, you may want to run "blind duplicates" as part of your QA program. As already indicated, NIR is the secondary method and is not going to be more accurate than your primary method. In fact, the NIR results "inherit" the error associated with the primary method. NIR is however, more precise, that is, more reproducible than the primary method. For all these reasons, you need to have a good understanding of the primary method because if for some reason you happen to distrust a set of NIR results you can always re-check the tested samples against wet chemistry.

FEED APPLICATIONS

A classical NIR application to an ingredient is presented in Fig. 3 (for the prediction of the oil content in yellow corn and high oil corn). Calibrations for individual proximate analysis of ingredients including ash content have been widely used by the feed industry during the last 15 to 20 years. The statistics for this calibration and those presented in subsequent figures are shown in Table 1.

At the Poultry Science Informal Nutrition Symposium in 1997 on Precision Nutrition for Poultry (Sifri, 1997), two papers referred specifically to near infrared technology as a tool to improve precision and speed in quality control (Leeson, 1997) as well as in formulation (Kempen *et al.* 1997). Kempen *et al.* (1997) discussed the VARIABILITY associated with the content of digestible amino acids in commercial feedstuffs used in poultry feeds and their qualitative and quantitative implications in animal and economical performances. These authors illustrated the inability of the protein (Nx6.25) analysis to predict amino acid digestibility for certain ingredients such as corn, while for other ingredients like poultry by-product

meal or soybean meal the correlations were mediocre.

Kempen *et al.* (1997) and Kempen and Bodin (1998) described some of the typical predictions of error and r-square values that can be expected when NIRS is used to predict true ileal amino acid digestibility in feed ingredients. A calibration for NIR versus digestible lysine in soybean meal (Parada and Ruiz, 2000) determined with the precision-fed cecectomized rooster assay (Anderson-Hafermann *et al.* 1992) is presented in Fig. 4 which is an example of the tremendous potential of NIR technology for the development of *in vitro/in vivo* correlations for routine quality assurance and formulation (Ruiz, 1997). NIR is today very likely the quickest *in vitro* technology available. If such a technology can be correlated at an acceptable level of accuracy with complex, expensive and cumbersome *in vivo* methodologies, wouldn't you give it a try?

Another example for the applicability of NIR for *in vitro/in vivo* correlations in poultry nutrition is the work by Valdes and Leeson (1992a, 1992b). These authors successfully demonstrated the potential for NIR to predict apparent metabolizable energy (AMEn) of both, ingredients and poultry feeds.

Finally, Fig. 5 and 6 illustrate the application of NIR for the quality control of complete poultry feeds indicating that you can test quickly and less-expensively for the composition of complete feeds before leaving the mill. In the past, it was thought that the application of NIR to complete feeds was restricted to feeds manufactured from very similar or "fixed" formulas. With today's technology, such a restriction does not exist.

NON-FEED POULTRY APPLICATIONS

NIRS analysis is an indirect methodology that correlates spectral data with characteristics or properties in biological products that are

not defined (or at least known) in chemical terms. This makes the technique potentially useful for unique applications. For instance, one USDA research laboratory has worked on the classification of raisins which are normally classified by trained inspectors who look at the shape and size of wrinkles (Jordon, 1996a). Research seems to support the concept that the size and shape of wrinkles depend on the amount of sugars, moisture, and acidity, which are in turn determined by compounds that produce spectra in the near infrared region (Jordon, 1996a.). Similarly, the application of NIR technology beyond strictly nutritional applications is already in the imagination of several poultry scientists and technicians.

The application of visible/NIR spectroscopy has been reported for the prediction of cooking loss and yield force in cooked chicken patties (Chen and Marks, 1998) as well as for the separation of unwholesome and normal poultry carcasses (Park *et al.*, 1996).

Smith *et al.* (1999) have developed NIR calibrations to predict phytate phosphorus in broiler excreta. This is a very promising application in areas with intensified manure management guidelines because it will provide a quick and reliable method to assist companies abiding by the regulations, and the agencies enforcing them. In fact, Smith *et al.* (1999) concluded that NIR could also be used to predict moisture, nitrogen, calcium, total phosphorus, and gross energy in broiler excreta.

It is not the objective to thoroughly review the subject here, but to suggest that several previously unthought opportunities may be there. Once an NIR instrument has been purchased and the most urgent applications are in place, new creative applications can be developed. The possibility of routine NIR scanning of excreta to investigate field problems related to malabsorption and undigested feed may prove useful.

Electromagnetic Spectrum

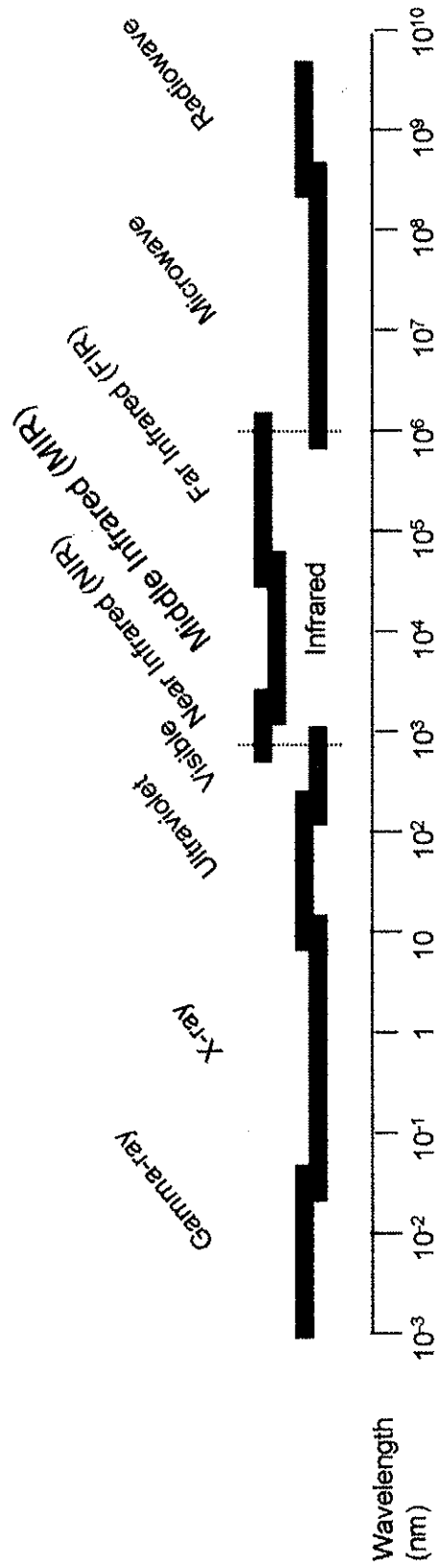


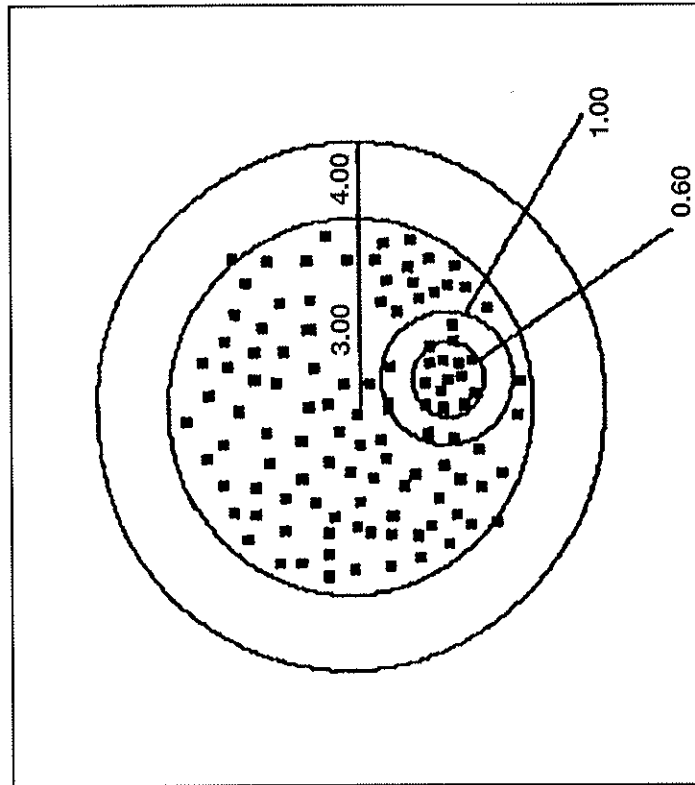
Fig. 1

Cortesia de Foss NIRSystems

FOSS TECATOR

Fig 2: GLOBAL H & NELGHBORHOOD H

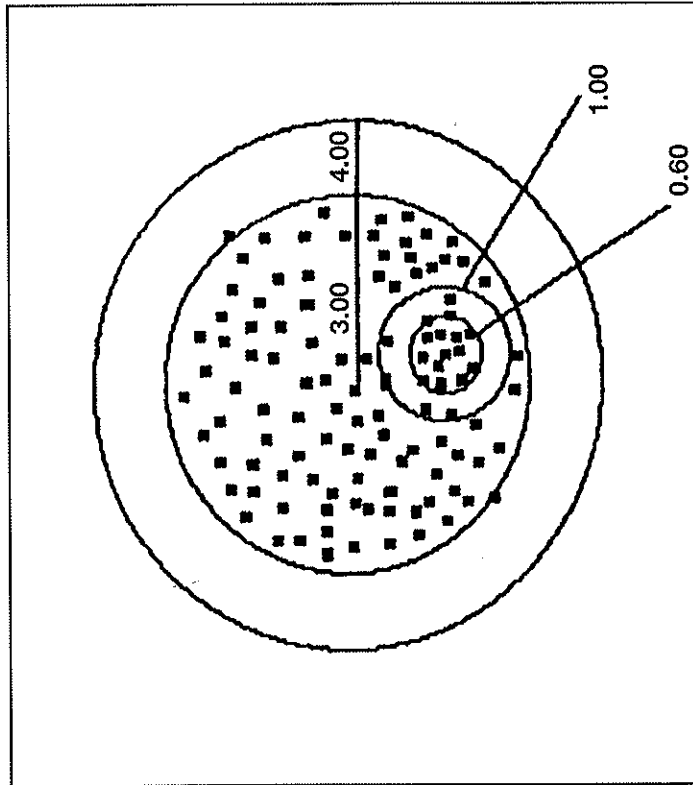
MIXED FEEDS



Global H = G 'H'

- 0.00 - 2.99 = No Stars
- 3.00 - 3.99 = One Star * High G 'H'
- 4.00 - >4.00 = Two Stars ** High G 'H'

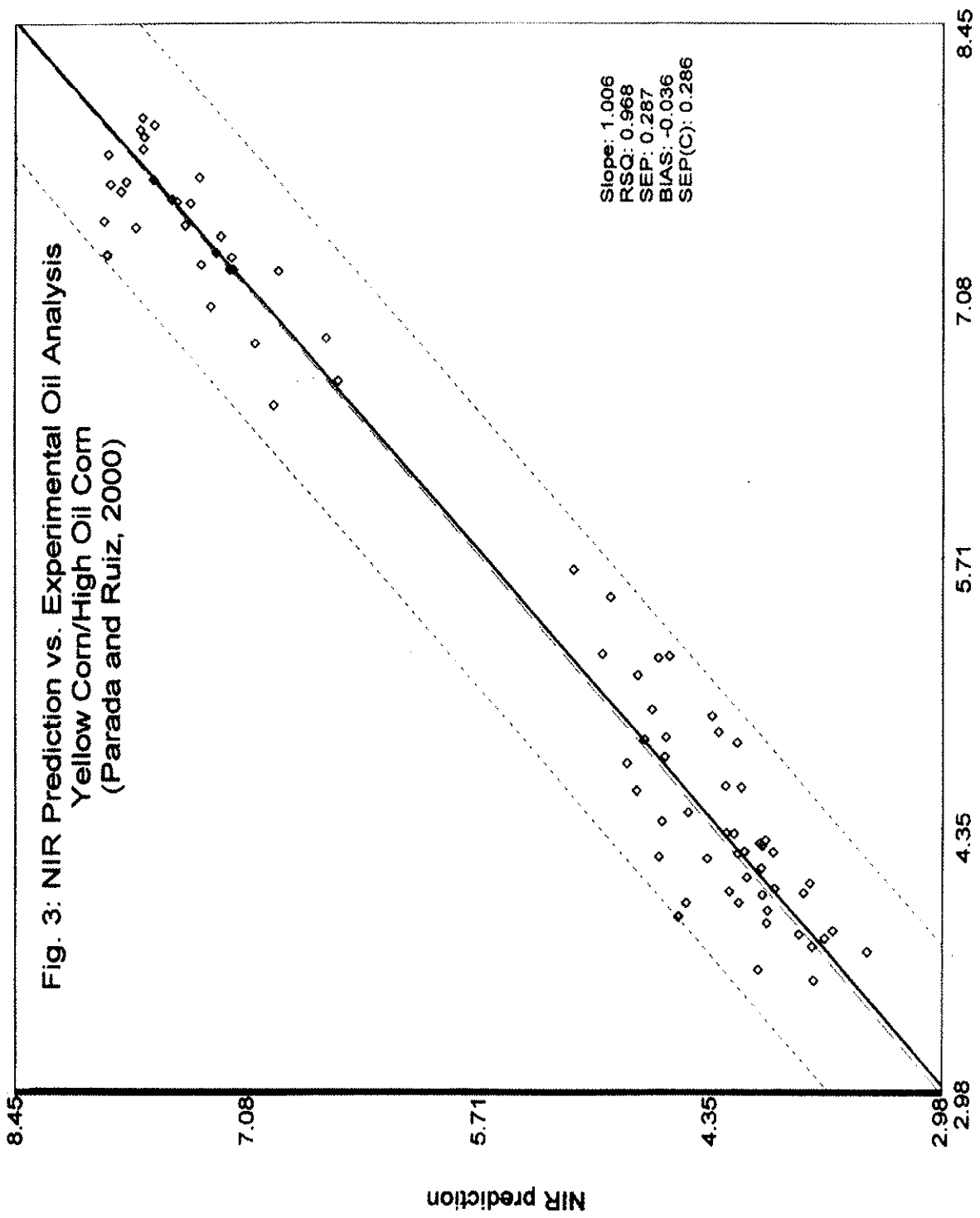
MEAT AND BONE MEAL



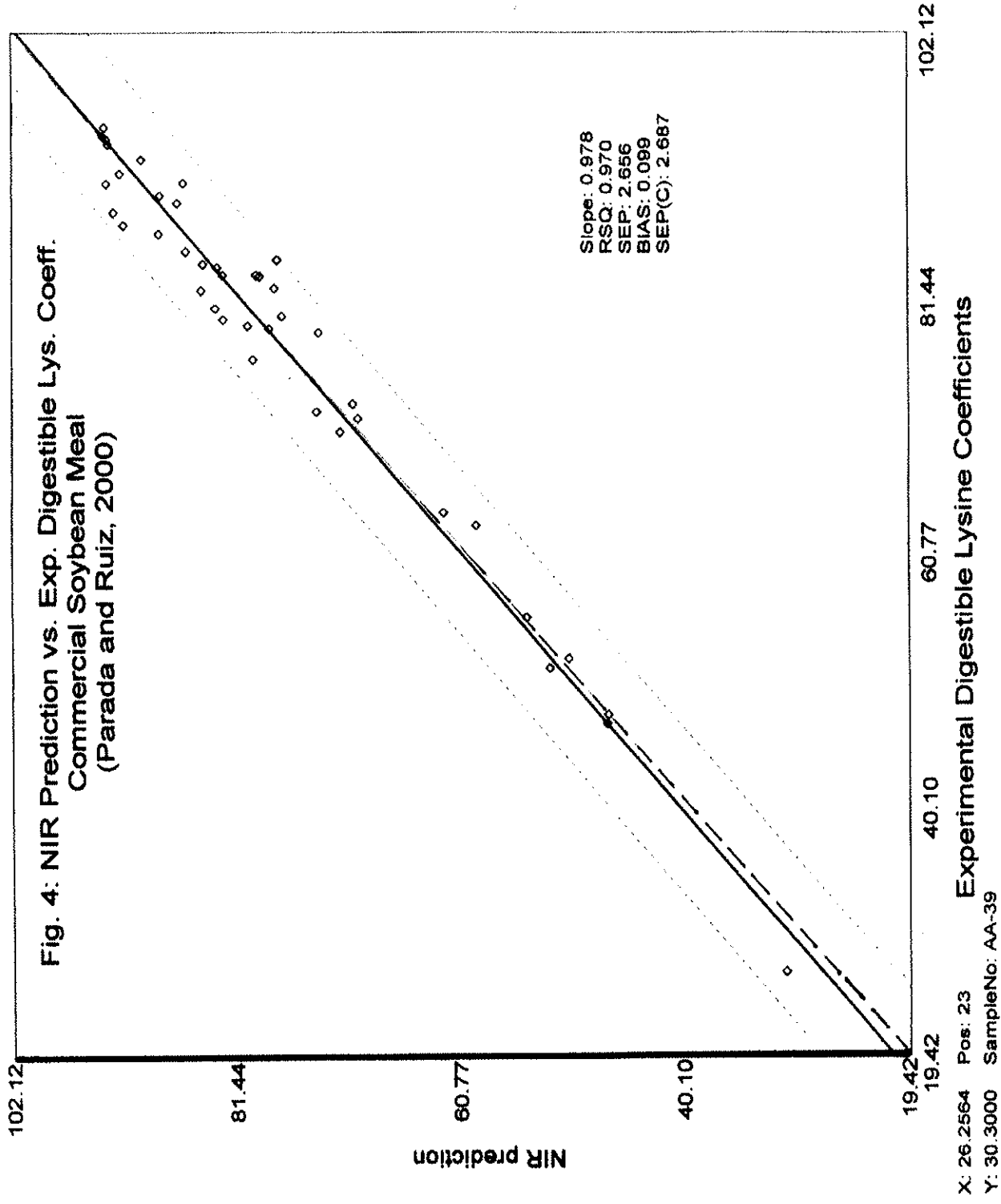
Neighborhood H = N 'H'

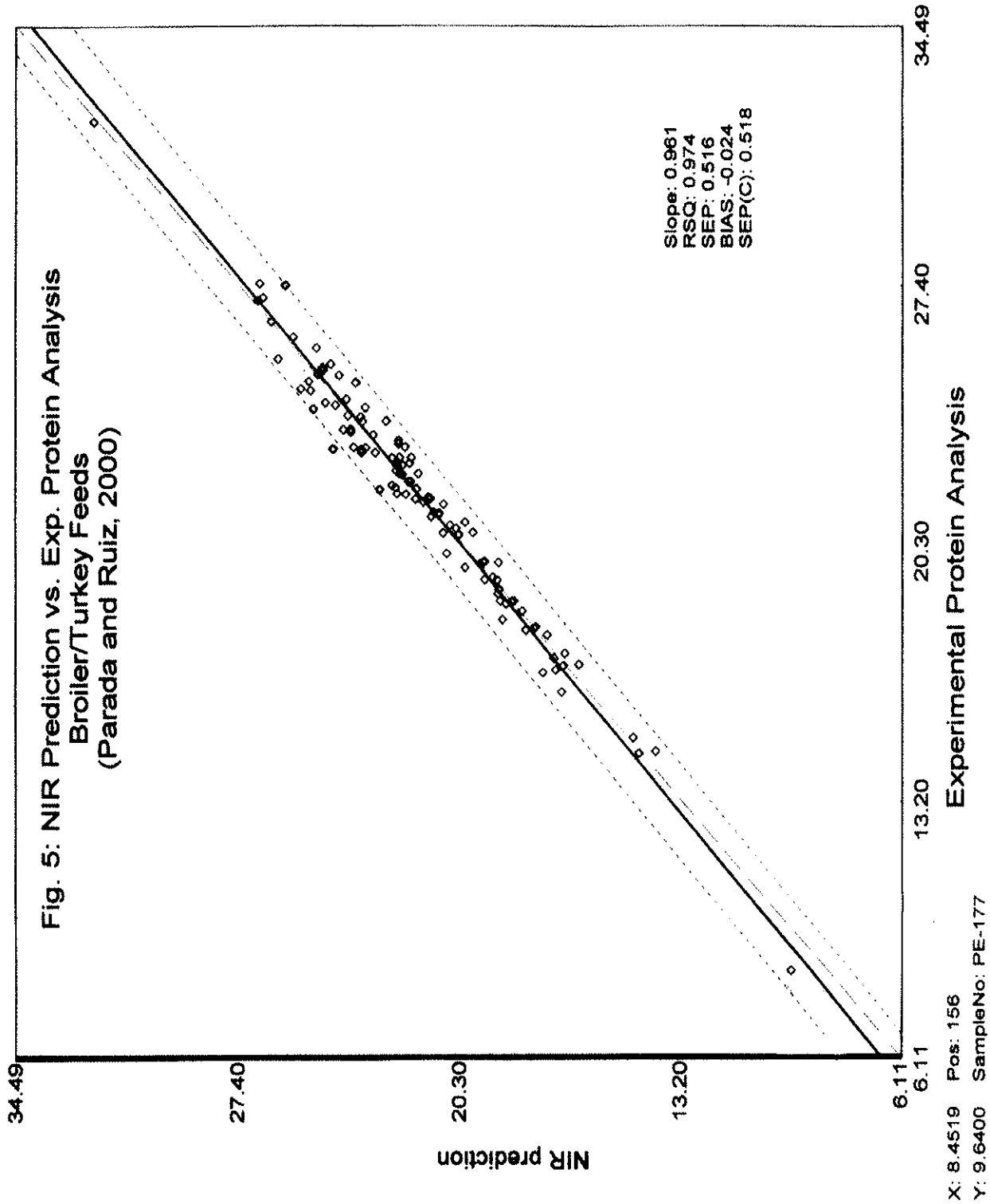
- 0.00 - 0.59 = No Stars
- 0.60 - 0.99 = One Star * High G 'H'
- 1.00 - >1.00 = Two Stars ** High G 'H'

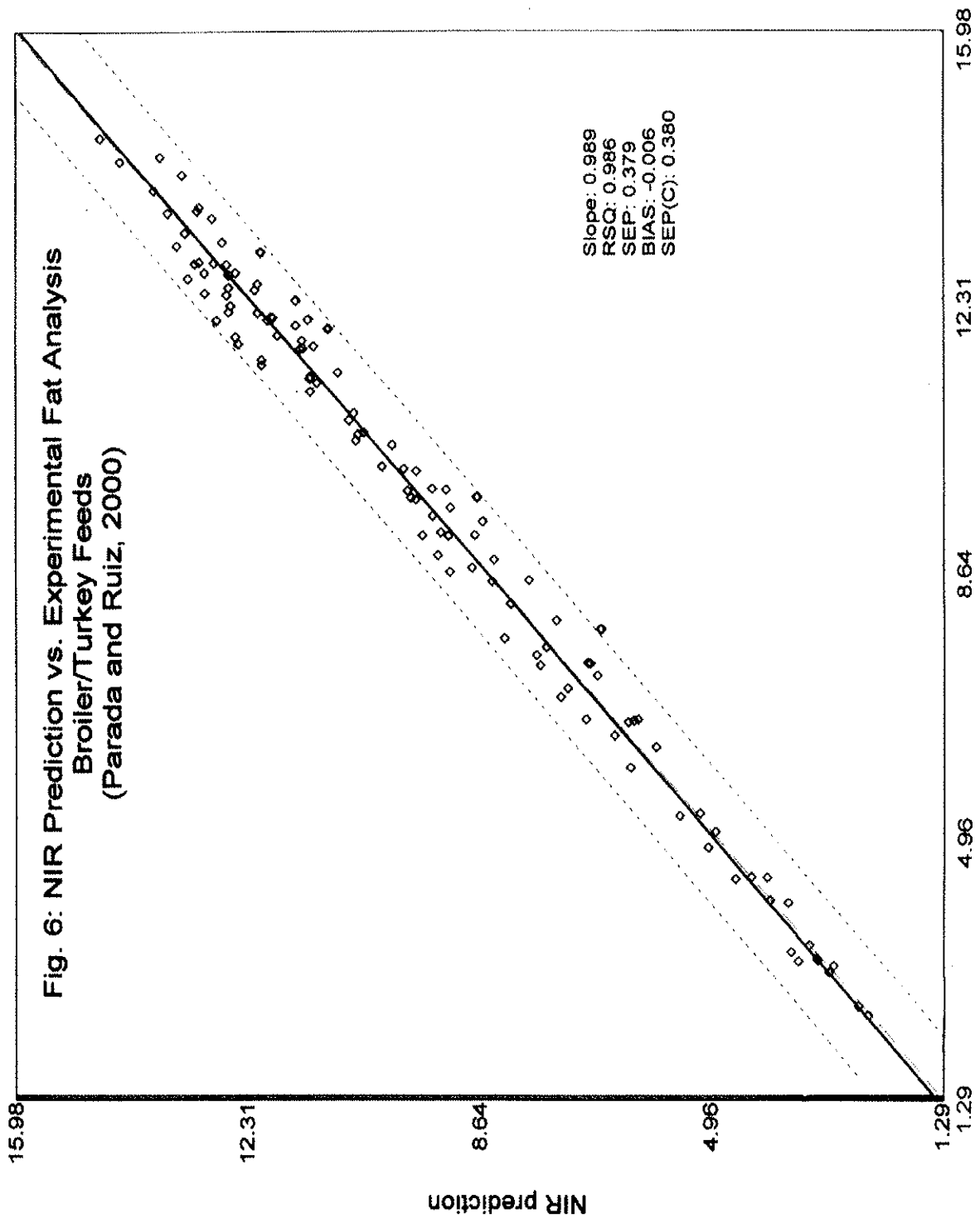
(Courtesy of Foss NIRSystem)



X: 6.5200 Pos: 28
 Y: 6.9600 SampleNo: MA-150







X: 2.4918 Pos: 137
Y: 2.5300 SampleNo: PE-160

Table 1. Statistics for calibrations presented in figures 3-6

Calibration	SEP	RSQ	N	Range, %	Slope
Fig. 3. Oil content in yellow corn/high oil corn	0.287	0.968	78	3.43-7.91	1.006
Fig. 4. Digestible Lysine coefficients in SBM	2.656	0.970	41	30.3-93.8	0.978
Fig. 5. Protein in complete poultry feeds	0.516	0.976	130	9.6-32.0	0.968
Fig. 6. Fat in complete poultry feeds	0.546	0.972	134	2.53-14.34	0.985

SEP: Standard Error of Prediction Range: minimum-maximum lab values

RSQ: r-square or coefficient of determination Slope: slope of experimental vs. NIR

N: Number of samples used in the calibration SBM: soybean meal

REFERENCES

- Anonymous, undated. ISI Windows Near Infrared Software. A Collection of New NIRS Topics. Foss NIRSystems, Inc., Silver Spring, MD, USA.
- Anderson-Hafermann, Y. Zhang, and C.M. Parsons, 1992. Effect of heating on nutritional quality of conventional and Kunitz trypsin inhibitor-free soybeans, Poultry Sci. 71: 1700-1709.
- Chen, H., and B.P. Marks, 1998. Visible/near-infrared spectroscopy for physical characteristics of cooked chicken patties. J. Food Sci. 63:279-282.
- Dyer, D.J., and P. Feng, 1997. NIR destined to be major analytical influence. Feedstuffs 69 (20).
- Hymowitz, T., J.W. Dudley, F.I. Collins, and C.M. Brown, 1974. Estimation of protein and oil concentration in corn, soybean, and oat seed by near-infrared light reflectance. Crop Sci. 14:713-715.
- Jordon, J. R., 1996a. Near infrared: breaking analytical traditions. The Referee. AOAC International, February.
- Jordon, J.R., 1996b. Chemometrics: calibration for the 90s. The Referee. AOAC International, February.
- Kempen, T. van, and P.H. Simmins, 1997. Near-infrared reflectance spectroscopy in precision feed formulation. J. Appl. Poultry Res. 6:471-477.
- Kempen, T. van, and J.C. Bodin, 1998. Near infrared reflectance spectroscopy (NIRS) appears to be superior to nitrogen-based regression as a rapid tool in predicting the poultry digestible amino acid content of commonly used feedstuffs. Anim. Feed Sci. Technol. 76:139-147.
- Leeson, S., 1997. Potential for real-time ingredient quality control procedures. J. Appl. Poultry Res. 6:501-506.

- McGinnis, C.H., 1998. Near infrared reflectance spectroscopy: a tool for quality feed production. Multi-State Poultry Feeding and Nutrition Conference, Indianapolis, IN, USA
- Norris, K.H., R.F. Barnes, J.E. Moore, and J.S. Shenk, 1976. Predicting forage quality by infrared reflectance spectroscopy. *J. Anim. Sci.* 43:889-897.
- Parada, H.J., and N. Ruiz, 2000. Work with NIRS at the Central Laboratory, ContiLatin Division, ContiGroup Companies, Inc. Unpublished data.
- Park, B., Y.R. Chen, and R.W. Huffman, 1996. Integration of visible/NIR spectroscopy and multispectral imaging for poultry carcass inspection. *J. Food Eng.* 30:197-207.
- Rinne, R.W., S. Gibbons, J. Bradley, R. Sief, and C.A. Brim, 1975. Soybean protein and oil percentages determined by infrared analysis. U.S.D.A. Agric. Res. Publ. ARC-NC-26.
- Ruiz, N., 1997. [Quality control of animal feeds: a discussion on the in vitro/in vivo relationship.], American Soybean Association Seminar in Santafe de Bogota, Colombia. Original in Spanish.
- Sifri, M., 1997. Precision nutrition for poultry. *J. Appl. Poultry Res.* 6:461.
- Smith, T.N., G.M. Pesti, R.I. Bakalli, J. Kilburn, and H.M. Edwards, Jr., 1999. Use of NIRS to predict the moisture, nitrogen, calcium, phosphorus, gross energy, and phytate phosphorus content in broiler excreta. *Poultry Sci.* 78 (Suppl. 1):54 (Abstract).
- Valdes, E.V., and S. Leeson, 1992a. Near infrared reflectance analysis as a method to measure metabolizable energy in complete poultry feeds. *Poultry Sci.* 71:1179-1187.
- Valdes, E.V., and S. Leeson, 1992b. The use of near infrared reflectance spectroscopy to measure metabolizable energy in poultry feed ingredients. *Poultry Sci.* 71:1559-1563
- Williams, P.C., 1975. Application of near infrared reflectance spectroscopy to analysis of cereal grains and oilseeds. *Cereal Chem.* 52:561-576.
- 9th ASA Regional Feed Technology and Nutrition Workshop (c) 27-30 May, 2001 (c) Kuching, Sarawak

ASA WORLD HEADQUARTERS

American Soybean Association
12125 Woodcrest Executive Drive
Suite 100 St. Louis
MO 63141-5829, U.S.A.
Tel: (1314) 576-1770
Fax: (1314) 576-2786
Email: im.office@soya.sprint.com



ASA INTERNATIONAL OFFICES

SOUTHEAST ASIA

Mr. John A Lindblom, Regional Director
American Soybean Association
541 Orchard Road
#11-03 Liat Towers
REPUBLIC OF SINGAPORE
238881
Tel: (65) 6737-6233
Fax: (65) 6737-5849
Email: asaspore@pacific.net.sg
Website: www.asasea.com

INDONESIA

Mr. Ali Basry, Consultant
American Soybean Association
Wisma Mitra Sunter, #402
Bluk C-2 Boulevard Mitra Sunter
Jl Yos Sudarso Kav. 89, Jakarta
14350
INDONESIA
Tel: (6221) 651 4752
Fax: (6221) 651 4753
Email: asagrains@indosat.net.id

PHILIPPINES

Mr. Teodoro M Cortes, Consultant
American Soybean Association
1408-B, Robinsons - Equitable
Tower
#4 ADB Avenue cor. Poveda,
Ortigas Ctr. 1605 Pasig City, MM
PHILIPPINES
Tel: (632) 637 5384
Fax: (632) 637 5388
Email: asatcj@pacific.net.ph

THAILAND

Mr. Opas Supamornpun,
Consultant
American Soybean Association
59/43 Baan Klang Muang
Ladprao 71 Road
Ladprao, Bangkok 10230
THAILAND
Tel: (662) 5395373, 5395332
Fax: (662) 539 5256
Email: asathai@loxinfo.co.th

VIETNAM

Mr. Tran Trong Chien, Consultant
American Soybean Association
13/F Hanoi Towers
49 Hai Ba Trung Street
Hanoi, Vietnam
Tel: (844) 934 3979
Fax: (844) 934 3966
Email: asa-usgc@hn.vnn.vn

PEOPLE'S REPUBLIC OF CHINA

Mr. Phillip Laney, Country Director
American Soybean Association
Suite 902 China World Tower 2
No. 1 Jianguomenwai Avenue
BEIJING 100004, PRC
Tel: (8610) 6505-1830
Fax: (8610) 6505-2201
Email: beisoya@asachina.org

American Soybean Association
Rm. 1802, SITC
No. 2200 Yanan Xi Lu
SHANGHAI, 200336, PRC
Tel: (8621) 6219-1661
Fax: (8621) 6219-5590
Email: shasoya@asachina.org

ASIA SUBCONTINENT

Mr. Virgil Miedema, Director
American Soybean Association
168 Jor Bagh
New Delhi - 110 003
INDIA
Tel: (91 11) 465-1659
Fax: (91 11) 465-1526
Email: asaasc@ndc.vsnl.net.in
Website: www.asaasc.com

JAPAN

Mr. Kei-ichi Ohara, Country Director
American Soybean Association
7th Fl., Toshin Tameike Building
1-1-14 Akasaka
Minato-ku, Tokyo 107-0052
JAPAN
Tel: (81 3) 5563-1414
Fax: (81 3) 5563-1415
Email: asatokyo@gof.com
Website: www.asa.japan.co.jp

KOREA

Mr. Say Young Jo, Country Director
American Soybean Association
3rd Floor, Leema Building
146-1 Susong-dong, Chongro-ku
Seoul 110-755
KOREA
Tel: (822) 738-7056
Fax: (822) 736-5501
Email: soyakor@kornet.net
Website: www.asa.or.kr

TAIWAN

Mr. Anthony Thang, Country Director
American Soybean Association
6 Fl., No. 27, Chang An East
Road
Section 1, Taipei 104,
TAIWAN, REPUBLIC OF CHINA
Tel: (8862) 2560-2927
Fax: (8862) 2568-3869
Email: thang@gcn.net.tw
Website: www.soybean.org.tw

NORTH EUROPE

Mr. Dieter Kundrun, Director
American Soybean Association
c/o US Ag Trade Office
US Consulate General
Alsterufer 27/28,
D-20354 Hamburg
FED. REP. OF GERMANY
Tel: (49 40) 41 34 55 01
Fax: (49 40) 41 34 55 08
Email: hamsoya@aol.com
Website: www.asa-hamburg.de

WEST EUROPE & OTHER AFRICAN COUNTRIES

Dr. Hans Hoyer, Regional Director
American Soybean Association
Rue du Luxembourg, 16b,
1000 Brussels, BELGIUM
Tel: (322) 548 9385
Fax: (322) 502-6866
Email: soyabru@attglobal.net
Website: www.asa-europe.org

CARIBBEAN

Mr. Kent Nelson, Director
American Soybean Association
11555 Heron Bay Boulevard,
Suite 303 Coral Springs, FL 33076
U.S.A.
Tel: (954) 757 8887
Fax: (954) 757 2533
Email: asamiami@sprynet.com
Website: www.soyasa.com

MEXICO

Mr. Mark Andersen, Regional Director
Asociacion Americana de Soya
U.S. Agriculture Trade Office
Jaime Balmes #8, 2do. Piso
Col. Los Morales Polanco
Mexico, D.F. C.P. 11510
Tel: (52 55) 5281-0120 ext. 230
Fax: (52 55) 5281-6154 & 281-0147
Email: asamex@soyamex.com.mx
Website: www.soyasa.com

COMMONWEALTH OF INDEPENDENT STATES

Mr. Michael Moditch, Director
American Soybean Association
6, 1st Kolobovskiy per.
Building 3
Moscow 103051
RUSSIA
Tel: (7 095) 795-0664
Fax: (7 095) 795-0665
Email: asa.moscow@co.ru

TURKEY & MIDDLE EAST

Mr. Christopher Andrew, Regional Director
American Soybean Association
BJK Plaza, Spor Caddesi 92
A Blok, Kat: 8 85/86
80680 Besiktas, Istanbul, TURKEY
Tel: (90 212) 258 2800
Fax: (90 212) 236 2620
Email: asatr@superonline.com