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The Role of the American Oil Chemists' Society in World Trade ——Quality Assurance Testing, Certified Reference Materials, and International Liaison Activities (英文原文)

Scott BLOOMER

(The American Oil Chemists' Society (AOCS), Illinois, 61802, USA)

Abstract: The American Oil Chemists' Society (AOCS) is a volunteer-led association. AOCS develops and publishes methods of analysis for fats, oils, proteins, surfactants, and related materials according to accepted international standards to ensure equitable trade practices on a global scale. AOCS Official Method development has been going on for over a hundred years. The founding vision of AOCS in 1909 was "an organization designed for the development and advancement of analytical methods for cottonseed products." AOCS Official Methods are essential to world trade and are used to confirm the value of billions of pounds of oilseed-based commodities and finished products each year. In addition, AOCS conducts proficiency testing, provides certified reference materials, and collaborates with other standards developers including the International Organization for Standardization (ISO) and the Codex Alimentarius Commission. AOCS serves as a professional scientific membership organization providing current and emerging information as well as disseminating research results in oils, fats, lipids, proteins, surfactants, and related materials. Several avenues are used, especially meetings, publications, interest groups, networking opportunities, and web presence. Many scientists, experts, and others engaged in working in these fields find their professional "home" in AOCS. The AOCS Technical Leadership Committee comprises some of the most experienced AOCS members and scientists. The AOCS Technical Services department staff relies on this committee for guidance on scientific matters and for advice in prioritizing the opportunities facing AOCS.

Key words: analytical methods; proficiency testing; genetic modification; reference materials; oilseed meal; cereals and pulses; fats and oils; codex alimentarius

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Author: Scott BLOOMER, male, Born in 1954, Doctor, Director of Technical Services, Research field: Nonaqueous Enzymology. E-mail: scott.bloomer@aocs.org. See more details in PC16.

1. ANALYTICAL METHODS

Throughout its history, AOCS has been regarded as the definitive source for analytical methods that the oilseed industry depends upon and turns to on a daily basis[1]. Today, the *Official Methods and Recommended Practices of the AOCS* lists more than 400 analytical methods that form a vital foundation for the multibillion-dollar oilseed industry. A key aspect of the effect of their utilization around the world is assurance that AOCS Methods used in the marketplace are reliable and meet acceptable performance levels. To help ensure that the harmonization of methods facilitates trade on a global basis, AOCS maintains active roles in the International Organization of Standardization (ISO) and the Codex Alimentarius Commission.

AOCS Analytical methods are made available through publication of a printed book, and for download of individual methods or the complete set. In addition, electronic site licenses of the entire electronic methods book are available for laboratories that need such access.

1.1 Method development process

1.1.1 The principle and requirements for the establishment of standards

Development and establishment of analytical methods and the standards that depend from them relies on two essential factors: 1) a method under development must be reviewed and critiqued by experienced high-level analytical scientists, and 2) one or more rigorously designed and conducted collaborative trials.

1.1.2 Step-by-step process

The AOCS method development process is similar to the processes used worldwide for all manner of official method development (Figure 1). In response to an industry need, a method proposer contacts AOCS. AOCS staff members work with the proposer to align the method draft to AOCS norms, and the draft is sent to the experts of one of the Uniform Methods Committee (UMC) Subcommittees described below. These experts scrutinize the draft to determine whether it is complete and unambiguous; any lack of clarity is corrected by correspondence with the method proposer. After the UMC Subcommittee is convinced that the method is clear and complete, a Study Director is selected. This is customarily the method proposer. A collaborative study design is drafted. The design is evaluated by the Chair of the Uniform Methods Committee. After the chair approves the design, the collaborative study

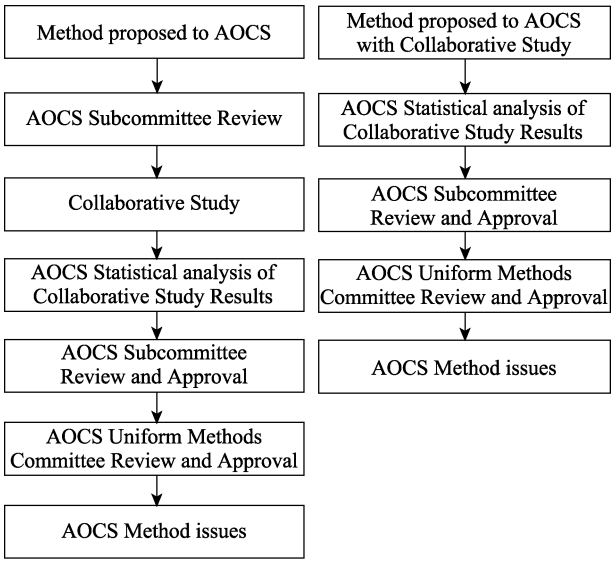

Fig.1 Two primary review paths for AOCS Official Methods
In the most common path at left, a scientist brings their method to AOCS. Dedicated AOCS Subcommittees review the draft and suggest revisions until they approve it as clear and complete enough for a collaborative study. After the Chair of the AOCS Uniform Methods Committee (UMC) approves the study design, AOCS and the method proposer work together to run a collaborative study. AOCS carries out the statistical analysis of the results and the Subcommittee reviews the results. After their approval, the UMC reviews the entire package and approves the method. Occasionally (right path below) a collaborative study has been carried out before the method is brought to AOCS

is carried out by laboratories recruited by AOCS. The resulting study data is analyzed by an AOCS statistician, and the entire package containing the method, collaborative study results, and statistical analysis is returned to the Subcommittee for review and a vote on acceptance. After a positive outcome, yet another review is carried out by members of the AOCS Uniform Methods Committee. After their approval, the method can issue as an Official AOCS Method. In some cases, a method is brought to AOCS after a collaborative study has been carried out. If the conditions of the collaborative study meet the requirements of an AOCS-led collaborative study, the first steps of the evaluation can be skipped. In addition, a finished AOCS method can be adopted by the International Organization for Standardization (ISO).

1.2 Uniform Methods Committee and Subcommittees

Uniform Methods Committee and Subcommittees are the groups of AOCS experts that review and suggest revisions and improvements to new methods, and vote on the final approval of new AOCS methods. Their guiding objective is “To identify developing areas of interest and to establish official methods and recommend practices for the analysis of oilseeds, fats, oils, and their derivatives to meet the needs of

industry and AOCS members." The Uniform Methods Committee is the oldest part of AOCS, as it was formed in 1909.

1.2.1 The UMC has many responsibilities in AOCS, including

1) Assessing industry needs for standard methods of analysis.

2) Searching for existing methods of analysis which meet AOCS standards to satisfy industry needs.

3) Directing the efforts of the UMC Subcommittees in the development, testing, and validation of new methods.

4) Reviewing and voting for adoption of methods that have been validated and recommended for adoption by the technical expert of the AOCS Subcommittees.

5) Reviewing current AOCS methods for technical and editorial accuracy and recommending revision or execution of a new collaborative study of expanded scope or using more modern equipment.

1.2.2 List of AOCS Uniform Methods Subcommittees and their areas of focus

Chromatography: Promotes the development, evaluation, and standardization of chromatographic procedures for the analysis of oilseeds, fats, oils, and their derivatives which will meet AOCS standards and satisfy industry needs

Rapid and Nondestructive Technologies: Proposes, evaluates, and formalizes methods for measuring the thermal, spectral, structural, rheological, and textural properties of fats, oils, and fat-based products

Seed and Meal Analysis: Promotes the development and standardization of test methods and sampling procedures for oilseeds, oilseed meals, and flours

Flavor, Quality and Stability: Promotes the formulation, adoption, and use within the Society of uniform specifications and nomenclature in methods, publications, and related activities; to institute a statistical technique which will ensure the validity of data which results in AOCS Official Methods; to encourage the collection and dissemination of physical and chemical characteristics of fats and oils; and to standardize the nomenclature of flavors Plant Proteins: Supports the establishment of methods for determining the proximate composition, nutritional profile (including antinutritional factors), sensory attributes, protein quality, allergenicity, and functional properties of developing protein products as commodities and in finished foods.

1.3 AOCS Expert Panels

1.3.1 AOCS Olive Oil Expert Panel

The rapidly developing US olive oil industry prompted AOCS to convene an Olive Oil Expert Panel. At that time the USDA was in the final stage of the approval of the United States Standards for Grades of Olive Oil and Olive Pomace Oil. AOCS brought together US and international experts to discuss approaches to solving the problems of authenticity and quality that are central to the trade and consumption of this highly valued vegetable oil. Attendees included representatives of the California Olive Oil Council (COOC), North American Olive Oil Association (NAOOA), USDA, FOSFA International, ISO/TC 34/SC 11, Australian Olive Association, University of California Davis, and AOCS. Discussions revolved around sample collection from both US grown and imported sources, the use of methods of analysis to detect fraud, and the development and maintenance of critical expertise in the USA.

1.3.2 AOCS Process Contaminants Expert Panel

In 2008 AOCS was made aware of the possible existence of 3-MCPD esters in refined vegetable oil products. There were some suggestions that this family of contaminants could give rise to free 3-MCPD, which had recently been recognized as a carcinogen.

True levels of 3-MCPD esters, their molecular species and toxicity are not precisely known since there are many problems inherent in the indirect methods of analysis used for their measurement. Nonetheless, several groups of researchers have made assertions on the levels of these compounds in oils and foods. In the last few months another related process contaminant, glycidyl (glycidol) esters, has been reported. At first it was thought this compound could be a precursor of 3-MCPD monoesters, however this is unlikely from our understanding of the relevant chemistry. Glycidyl esters have been found in some oils causing the temporary suspension of supply of these products to the marketplace.

1.3.3 AOCS focused on two issues

1. The accurate measurement of 3-MCPD- and glycidyl- esters

2. The collection and dissemination of articles, news releases and commentary on these process contaminants.

As a result, AOCS led the development of several vital analytical methods for these process contaminants. They can be found in the *Official Methods and Recommended Practices of the AOCS*.

1.3.4 Avocado Oil Expert Panel

The expansion of consumer interest in avocado oil prompted AOCS to convene an Avocado Oil Expert Panel in 2020. The committee serves as a central point for networking of stakeholders. The

Expert Panel discusses the requirements for the inclusion of avocado oil in the Codex Alimentarius Committee on Fats and Oils “Standard for Named Vegetable Oils (CXS 210—1999)”. Other questions discussed by the Expert Panel include regulatory issues, sensory panel evaluation, crude avocado oil compared to refined avocado oil, authenticity, the need for proven analytical methods, and oxidative stability of the oil.

2. AOCS LABORATORY PROFICIENCY PROGRAM

2.1 Laboratory Proficiency Program (LPP)

The AOCS Laboratory Proficiency Program (LPP) dates to May 1909, the earliest days of AOCS. Dr. Frank Smalley, chief chemist of the Southern Cotton Oil Company, routinely sent samples of cottonseed meal to the district laboratories of the company, requiring them to determine the oil content and nitrogen content (for protein determination, as ammonia). Sometime between 1912 and 1915, other members of the newly formed AOCS asked to participate in the evaluations, and about 1915 the LPP was formed. This program was known as the Smalley Check Sample Program for many years. Several of the labs that participated in the earliest days are still dedicated Society members and provide an important service in the industry.

The international AOCS LPP relies heavily on AOCS Official Methods and provides a valuable tool for quality control in labs using the methods. It provides an objective measure of the correctness of the results a lab achieves, and good performance can be the basis of recognition for the analyst achieving good results. Thus, the AOCS LPP is a valuable measure for both scientists and equipment. Despite routine calibration of analytical instruments, the results obtained in the LPP have been vital in identifying laboratory problems and providing an opportunity for correction.

Computerization of the LPP results was started in 1968 with a Honeywell Series 200 Computer. AOCS members wrote the programs needed to compile the results and carry out the needed statistical evaluations. Currently, the LPP uses state-of-the-art software that allows data entry online and provides very through reports to each LPP participant in a timely manner.

The AOCS LPP serves about 500 labs and analytical chemists around the world each year through the materials listed in Table 1.

Table 1 AOCS LPP series

Series number and name	Series number and name	Series number and name
02 Edible Fat	18 Marine Oil Fatty Acid Profile	34 Aflatoxin in Peanut Paste Test Kit
03 Tallow and Grease	19 Soybean Oil	35 Aflatoxin in Corn Meal Test Kit
04 Oilseed Meal	20 Cottonseed Oil	37 Phosphorus in Oil
05 Unground Soybean Meal	21 Olive Oil Chemistry	38 Nutritional Labeling
08 Peanut	22 Palm Oil	39 Feed Microscopy
10 Soybean	23 Vegetable Oil for Color Only	40 Aflatoxin - Pistachio and Almond
12 Cholesterol	24 NIOP Fats and Oils	41 Fumonisin
13 Gas Chromatography	25 Specialty Oils	43 Olive Oil Sensory Panel
14 GOED Nutraceutical Oils	27 *trans* Fatty Acid Content	47 Moisture in Almonds
15 Trace Metals in Oil	28 Solid Fat by NMR	49 DDGS from Corn Meal
16 Fish Meal	30 Aflatoxin - Peanut Paste	57 Plant Protein Meals
17 Marine Oil	31 Aflatoxin - Cottonseed Meal	58 MCT Oil
	32 Aflatoxin - Corn Meal	59 Trypsin Inhibitor Activity in Soybeans and Pulses

When the year-end results are compiled, those labs that have obtained results closest to the mean (or consensus value on the summary of z scores) are regarded as the best performers of the series.

After the conclusion of an LPP testing year, remaining samples in storage at AOCS are made available to interested labs as reference materials. These “Quality Reference Materials” are accompanied by a blinded report of all of the test results obtained in the previous year. They are useful for confirming the accuracy of instrumentation as well as for training new analysts.

2.2 Approved Chemists

AOCS grants “Approved Chemist” status each year to analytical chemists in the fields of oilseeds, oils, fats, waxes, proteins, surfactants and other related materials. Most of the methods used are from the *Official Methods and Recommended Practices of the American Oil Chemists’ Society*. The Approved Chemist

Program honors the most accomplished participants in the Laboratory Proficiency Program (LPP). Approval is earned by superior performance during the previous LPP year. This year-long status is granted analysts that are members of AOCS, have successfully completed four quarters of LPP samples in the previous year's cycle without missing a sample, work in an independent, government or industrial laboratory, and achieve a combined score of less than 1.4 in the AOCS LPP.

2.3 AOCS Certified Laboratory

AOCS Certified Laboratories are those laboratories recognized to be proficient in the use of AOCS methodologies for the analysis of soybean meal, as determined by criteria established by the AOCS Examination Board. Certification entitles a laboratory to recognition as a National Oilseed Processors Association (NOPA) referee lab for soybean meal analyses. Both independent and industrial laboratories may apply for certification. There must be no conflict of interest when analyses are performed at industrial laboratories.

AOCS Certified Laboratories are called upon to settle any disputes about the composition of soybean meal. This dedicated AOCS program certifies laboratories for the referee analysis of soybean meal according to NOPA trading rules. The National Oilseed Processors Association (NOPA) advocates for an efficient global supply chain system, by providing leadership through education, information and market-based solutions to policymakers, trade negotiators and others. AOCS is part of that effort by ensuring the certified labs show competency and skill. Requirements of NOPA/AOCS Certified Laboratories include:

The laboratory must have an AOCS Approved Chemist on staff for the analysis of Oilseed Meal;

The laboratory must have demonstrated successful participation in the Oilseed Meal series of the Laboratory Proficiency Program for one year prior to application;

The laboratory must allow members of the AOCS Examination Board to inspect the laboratory facilities;

The laboratory must complete all other Certified Laboratory Criteria specified by NOPA and AOCS.

3. AOCS CERTIFIED REFERENCE MATERIALS

Genetically modified crops have been commercially available since the mid-1990s. Laws governing importation of these crops vary from nation to nation. The European Commission (EC) mandated that a validated published method for detecting a new genetically modified event and a Certified Reference Material (CRM) must be available before the EC will authorize planting of a new crop containing GM traits. In addition, several nations outside of Europe require grain and ingredients to be labeled as genetically modified when the GM trait levels exceed mandated thresholds.

AOCS CRMs are used by labs that perform those analyses. AOCS provides CRMS for Soybean, Maize, Canola, Cotton, Rice, Potato, and Sugar beet, and is one of only two sources of Certified Reference Materials worldwide. AOCS currently makes more than 70 such materials available or purchase. They comprise ground seeds or frozen leaf DNA. The CRMS are rigorously tested each year by CRM to ensure they meet several essential standards. These CRMs are intended for use as quality control materials or calibrants in methods for the detection, identification and/or quantification of genetically modified events. The AOCS CRM program is A2LA accredited to ISO 17034:2016 and corresponding certificates are provided with each CRM.

4. THE INTERNATIONAL ACTIVITIES OF AOCS

4.1 AOCS and ISO

AOCS is involved in the International Organization for Standardization (ISO), a global network of the world's leading standards experts dedicated to the development of standards and analysis methods. ISO standards are used in all areas of food and agriculture, allowing for the use of globally harmonized standards methods for quality assurance. ISO standards allow for agreed-upon testing, equipping suppliers and customers with a transparent set of testing methods for establishing the value of ingredients and manufacturers world. These standards also equip trade organizations and courts with tools to make decisions regarding trade and allow governmental regulatory agencies to understand the impact of their decisions on the value of their country’s products in international commerce.

Standards and conformity assessment activities are the focus of ISO and are inextricably linked to all facets of business. Within ISO, AOCS works with industry leaders domestically and internationally to find creative solutions to emerging issues and obstacles and prevent the adoption of unworkable standards that would impact the freedom to operate of AOCS stakeholders. These stakeholders include government, private companies, educational institutions, non-profit organizations and ultimately, consumers.

The platforms for the work of ISO are both national and international. Each nation that participates in ISO can form a "Technical Advisory Group", or TAG. The Technical Advisory Groups are made up of experts from within that nation, or that have a verifiable link to the interests of the topic in that nation. AOCS serves US Technical Advisory groups in these topics: Oleaginous seeds and fruits and oilseed meals (TC34/SC2); Cereals and pulses (TC34/SC4); Animal and vegetable fats and oils (TC34/SC11); and Horizontal methods for molecular biomarker analysis (TC34/SC16). AOCS organizes regular meetings with the members of the US TAG to discuss the standards and actionable items that have been generated within ISO.

In addition, ISO provides international platforms for the work of ISO. These include Expert Panels, Working Groups, and Plenary Meetings. Unlike the TAGs, participation on Expert Panels is not tied to a nation. Individuals with expertise and interest volunteer as individuals to provide expertise and input on topics they find important. For example, AOCS has recently identified experts in Grain/Oilseed Sampling and the Randall Method for measuring fat in a large variety of matrices; AOCS then connected the experts directly to ISO for the work of the Expert Panel. In addition, ISO Working Groups are formed to focus on development of analytical methods (which are called "Standards" in the ISO context). AOCS is currently leading a Working Group comprising members of ISO/TC34/SC11 and ISO/TC34/SC5 (Milk and milk products) for the implementation of a method for the analysis of "Fatty acids at the *sn*-2 position of triacylglycerol molecules- Enzymatic transesterification method." This method was developed by the Japan Oil Chemists' Society and later adopted by AOCS. The Working Group is expanding the scope of the Standard to include matrices like infant formula, where the identity of the fatty acid occupying the *sn*-2 position of the fats can have a large impact on the digestion processes of the infant.

Worldwide ISO Plenary meetings are held periodically. Voting members of ISO include the national bodies described above, and non-voting advisory bodies such as AOCS. AOCS coordinates with the ISO committee of the USA and serves in an advisory capacity and is frequently called upon to provide expert advice to the voting members in the Plenary meetings. In addition, AOCS is able to address the matters on the Plenary meeting agendas from a worldwide perspective due to our broad membership base.

4.3 AOCS and Codex Alimentarius

The Codex Alimentarius Commission was formed to implement the Joint FAO/WHO Food Standards Program. Codex Alimentarius seeks to protect the health of consumers and promote fair trade by establishing science-based guidelines for food, including commodities and finished foods. Codex seeks consensus on international food standards and codes of practice to meet these ends. Codex seeks to provide a global reference point for growers, commodity suppliers, food companies, consumers, and national food control/regulatory agencies, providing internationally agreed-upon definitions and testing methods. In many cases, Codex standards serve as a basis for national legislation; this is especially valuable in developing nations.

Codex Alimentarius relies heavily on the analytical methods established by test-developing agencies like AOCS, AOAC, Cereals and Grains, and ISO. AOCS holds Observer status in Codex Alimentarius and is active in the Codex Committee on Fats and Oils, the Codex Committee on Methods of Analysis and Sampling, Codex Committee on Nutrition and Foods for Special Dietary Uses, and Codex Committee on Contaminants in Foods. Just as in ISO, AOCS attends the worldwide meetings of these Committees to provide scientific expertise and advice on matters within our scope of knowledge.

One of the strongest contributions AOCS makes to Codex Alimentarius is found in the central place of AOCS analytical methods on the Codex Alimentarius STAN 234—1999 list.[2] This list, curated by the Codex Committee on Methods of Analysis and Sampling, is intended to serve as a repository of analysis methods that have been agreed on by world experts, at times after vigorous discussion, to be the best methods for defining and confirming the composition of food commodities and finished foods. Many of the analysis methods chosen by worldwide experts for this list are AOCS methods.

REFERENCES

See in its Chinese version P72.