IAG proficiency test feed composition 2019

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- Food and Consumer Product Safety Authority (NVWA; K. Zwaagstra, M. van Brakel, S. Danneel)

Contents

Summary

A proficiency test was organized for the microscopic determination and semi-quantification of botanic ingredients in the formulation of an animal feed, in the framework of the annual proficiency tests of the IAG - International Association for Feeding stuff Analysis, Section Feeding stuff Microscopy. The organizer of the proficiency test was Wageningen Food Safety Research, The Netherlands. The aim of the proficiency study was to provide the participants information on the performance of the local implementation of the method for composition analysis of feed.

The current proficiency test was focusing on the control of the label declaration of the botanic composition of a ruminant feed. Participants received a sample of the ruminant feed and were asked to check the correctness of the label information. Therefore, the label declaration was provided together with the sample. The formulation as declared by the label showed the correct composition. Results should show the share of the different ingredients in percentages. Indicated shares were considered under- or overestimations when exceeding the limits of the IAG uncertainty interval model.

A total of 22 sets of results was returned.

Six of the nine ingredients had shares with intervals of which the lower limits were still higher than zero percent in the IAG estimation model. Correct estimation of these shares needs more precision than in a situation where only an upper limit applies. The reported shares of these six ingredients were within the limits of the uncertainty model in 87.9% of the total number of estimations. The correct estimations of all reports of the shares of nine ingredients is 80.3%. Six out of 22 participants delivered an errorless composition, which is 27%. Besides this, six participants made one error, three made two errors and two participants made three errors. There is no clear correlation with the method applied. Only three participants reported an indication of the correctness of the label. The current information on the capability of botanic composition analysis reveals that this technique is valuable as part of the enforcement of feed and food safety.

The current lack of a complementary system for the analysis of chemical composition (ash, proteins, fat, dietary carbohydrates, fibres, etc.), which would provide parameters for the control of an established botanic composition, could be a drawback for the overall performance of the technique for botanic composition analysis. Besides a proper method description and up-to-date descriptions of ingredients, well developed skills of technicians are vital for a good performance. The use of an expert system as tool for maintenance and dissemination of expertise might improve future performance.

The analysis of composition in terms of ingredients is important for detecting economic fraud and for monitoring feed safety. Botanic composition analysis and label control of feed is regulated in Regulation (EC) 767/2009. This technique can support traceability (Regulation (EC) 178/2002), for detection of fraud (Regulation (EU) 2017/625) and for categorization (Regulation (EU) 1308/2013; Regulation (EU) 2016/1821). In a broader view, composition analysis in the entire food chain can improve the effect of monitoring actions. The legislation on food labelling (Regulation (EC) 1169/2011) obliges to provide more detailed information to customers on composition and related topics.

1 Introduction

In the framework of transparency and the demand for traceability of the source of feed ingredients, it is necessary to establish the formulation of a feed. The legal basis for this examination is the obligatory label declaration of feeds, regulated for years by EU legislation and currently part of Regulation (EC) 767/2009. The main objectives are the prevention of economic fraud and a sufficient monitoring of feed safety.

The analysis of composition of feeds by means of microscopic methods has a long history. It has been a major activity of the IAG section Microscopy from its existence in 1959 (www.iag-micro.org). In 1998 a protocol on the microscopic identification of ingredients in feed was established in German, and translations to English and French were decided to be prepared (http://www.iag-micro.org/files/39_wien98.pdf?10,12).

The method IAG-A2 is based on a procedure of sieving the sample and applying several embedding and staining methods. The different sieve fractions consist of a fine, mediate and coarse material. The presence of specific ingredients (e.g. starch, fibres seed hulls) deviates largely among the sieve fractions. Examinations are to be carried out with both a binocular microscope (up to 70 x magnification) and a compound microscope (100 – 400 x magnification; IAG, s.n.). At the final stages the share of the different ingredients are summed up over the different sieve fractions. The methods relies on identification of the ingredients supported by handbooks or reference material (IAG, s.n.). The identification of legal ingredients (Feed catalogue: Regulation (EC) 68/2013) is a complicated procedure.

Besides the availability of a protocol, the current practices are heavily based on the existing skills of the technicians. In the view of a process of improvement of monitoring programs, which was established for food in Regulation (EC) 1169/2011, the maintenance and dissemination of these skills needs attention.

In this report the proficiency test for composition 2019 is presented, which was organised by RIKILT (which is part of Wageningen Food Safety Research as of June 1, 1999) in March 2019 on behalf of the IAG Section Feeding Stuff Microscopy.

2 Methods

2.1 Materials and procedure

The IAG proficiency test for botanic composition 2019 was chosen to be based on an average ruminant feed, containing corn gluten feed (22%), palm kernel meal (16%), beet pulp (13%), citrus pulp (10%), molasse (10%), coconut meal (9%), rapeseed meal (8%), wheat (8%), corn (2%), soybean meal (1.2%), magnesiumoxyde (0.4%), vegetable fat (0.2%), vitamin/mineral mix (0.2%). The material was produced in a dedicated pilot plant in the framework of the EU funded project STRATFEED. The test was intended for label control.

The IAG proficiency test for botanic composition 2019 was combined with the IAG proficiency test for animal proteins. Sample 2019-B was intended for composition analysis. The composition as originally declared is presented in Table 1. This formulation was checked by the WFSR microscopy team and a few deviations were found. The presumed formulation as adjusted by the WFSR team was used as basis for the label information, which is also presented in Table 1.

Table 1 *Intended composition and label declaration of sample 2019-B. The min-max range is calculated according to the IAG model for uncertainty limits; see paragraph 2.3.*

	original formulation	Range	(MIN MAX):	label
cornglutenfeed	22.0%	12.0%	32.0%	24.0%
palmkernelfeed	16.0%	8.0%	24.0%	16.0%
beetpulp	13.0%	6.5%	19.5%	13.0%
citruspulp	10.0%	5.0%	15.0%	10.0%
coconutmeal	9.0%	4.0%	14.0%	1.0%
rapeseedmeal	8.0%	3.0%	13.0%	8.0%
wheat	8.0%	3.0%	13.0%	15.0%
corn	2.0%			
soybean meal	1.2%	0.0%	2.4%	1.2%
minerals	0.6%	0.0%	2.0%	<1%
grass and lucerne meal		0.0%	2.0%	1.0%
molasse	10.0%	5.0%	15.0%	10.0%
vegetable fat	0.2%			

The microscopists of WFSR did not participate in the proficiency test.

2.2 Organization of the proficiency trial

All IAG members, all NRLs, participants of former proficiency tests and a series of possibly interested laboratories were informed about the proficiency test for 2019. In all cases an invitation letter included in the IAG Newsletter 2018 and a participation form were distributed. Until the beginning of March 2019 a total of 25 participants for the microscopic composition analysis were listed. The samples with an accompanying letter were sent to all participants on Tuesday 12th of March 2019. On Wednesday March 13th an E-mail message was sent to all participants, together with a file containing a sheet with instructions and the electronic report forms, and the request to confirm the receipt of the package. The information sheet of the report form is shown in Annex 1, the form for the procedural survey is reproduced in Annex 2, the report forms for the results of both the composition analysis and the label control are presented in Annex 3, and the letter sent with the samples is reproduced in Annex 4.

The closing date for reporting results was fixed at Monday April 18th. Several requests were received to extent the period for analysis. Results received after the date at which the evaluation of the results was started were ignored. The analysis of the results was carried out between 24th and 28th May.

The samples were intended to be analysed according to IAG method 2: "Method for the Identification and Estimation of Constituents in Animal Feedingstuff" (IAG, s.n.). Further instructions to the participants were enclosed in the box with samples, which are reproduced in Annex 4. Label control is primarily based on the analysis of the presence of ingredients, as is the situation for composition analysis. The availability of a label declaration can be either supportive or confusing. Therefore, to be able to reconstruct the basic data upon which the final conclusion was based, the assumed composition was requested in the report form.

The draft report was finalised at June 4th.

2.3 Analysis of results

The results are analysed according to the IAG scheme of uncertainty limits as approved during the 2006 meeting in Rostock and include in IAG method A2. These limits are presented in Table 2. The model is graphically presented in Figure 1. Shares of ingredients in the feed formulation outside the limits of the model were indicated as "wrong".

Table 2 *IAG model for uncertainty analysis of the composition of a compound feed.*

Actual amount in %	Accepted uncertainty limits
< 2%	"traces "
2.0 – 5.0%	+/- 100% relative
5.01 – 10.0%	+/- 5% absolute
10.01 – 20.0%	+/- 50% relative
– 50.0%	+/- 10% absolute
> 50%	+/- 20% relative

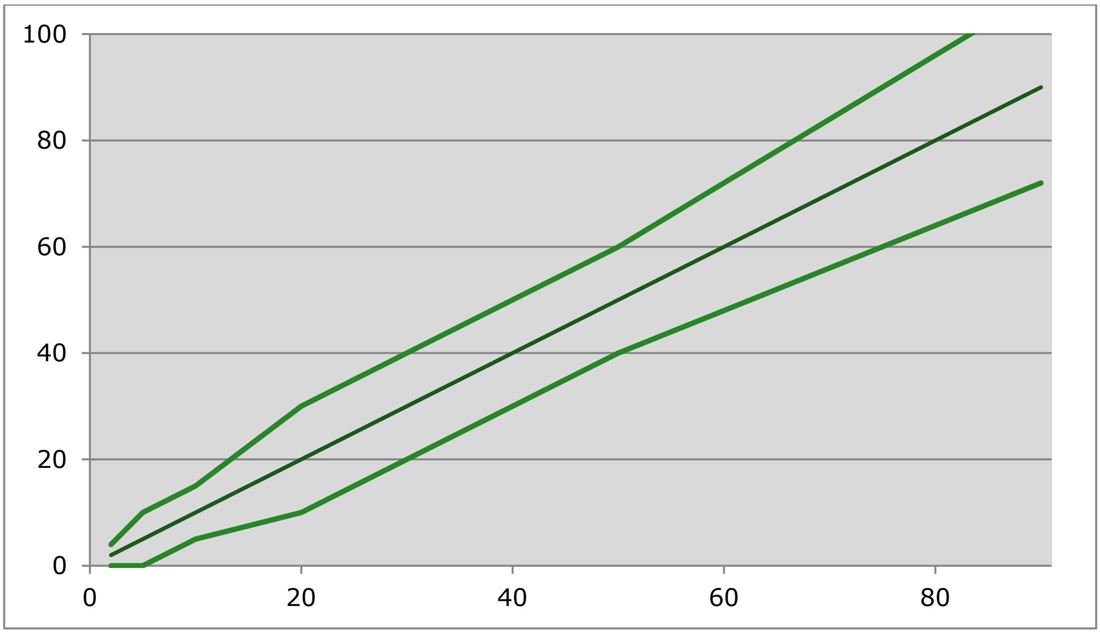

Figure 1 *IAG model for estimating uncertainty. X-axis: correct portion of ingredient in %, Y-axis: estimated portion of ingredient in %. Inner line: correct estimation, outer lines: limits for uncertainty interval at a given percentage.*

3 Results

Twenty-five samples were sent to all participants and results for composition analysis were returned in by 22 participants. In all those cases that a participant submitted several versions of the report sheet the most recent version was used. All reports were included.

The 22 participants, which successfully submitted their results, originated from 11 countries: 9 member states of the European Union, and two other countries. The list of participants is presented in Annex 5. Almost half of the participants originated from Germany (10).

The procedure for the analysis of the composition is described in IAG method A2 (IAG, s.n.). This method, familiar to most participants as members of IAG section Microscopy, was applied by 16 participants. Other applied methods include the AFNOR V18A method, an AOCS method, and internal laboratory procedures.

3.1 Composition

The results of the 22 participants are fully presented in Annex 6 and summarised in Table 3. The evaluations will be based on the pooled results per participants for the wheat products and for the corn products, since some participants did not discriminate between the specific types.

Table 3 *Overview of the main ingredients of the analysed sample, the correct composition, the a-priori calculated uncertainty range, and the statistics of the results in terms of median and numbers of participants that under- or overestimated the share of the ingredients. N = 22.*

Ingredient	Label	Range:	Median	# (%) under est.	# (%) over est.
Corn total	24.0%	14.0-34.0%	22.0%	5 (23%)	0 (0%)
Palmkernel meal	16.0%	8.0-24.0%	18.3%	2 (9%)	2 (9%)
Wheat total	15.0%	7.5-22.5%	10.0%	3 (14%)	0 (0%)
Beet pulp	13.0%	6.5-19.5%	13.0%	0 (0%)	1 (5%)
Citrus pulp	10.0%	5.0-15.0%	12.0%	2 (9%)	3 (14%)
Rapeseedmeal	8.0%	3.0-13.0%	8.0%	1 (5%)	0 (0%)
Soybeanmeal	1.2%	0.0- 2.4%	2.0%		8 (36%)
Coconutmeal	1.0%	0.0- 2.0%	2.0%		4 (18%)
Grass and lucerne meal	1.0%	0.0- 2.0%	2.0%		7 (32%)

There were major differences between the declared amount of coconut meal and of grass and lucerne meal with the actual amounts for these two ingredients. The label was modified for these two ingredients as based on the estimations made by the organiser prior to the study. The results were therefore evaluated along the label information as correct composition. The reported shares of the ingredients with a lower limit in the IAG estimations model higher than zero (first six ingredients in Table 3) were within the limits of the uncertainty model in 87.9% of the total number of estimations. The correct estimations of all reports of the shares of nine ingredients is 80.3%. Some participants made their estimations ignoring the molasse. This ingredient is not evaluated. Six out of 22 participants delivered an errorless composition, which is 27%. Besides this, six participants made one error, three made two errors and two participants made three errors. There is no clear correlation with the method applied. There is a relative overestimation of the ingredients with a low share and underestimation of some ingredients with a higher share in the composition (Figure 2). Coconut meal was not reported by six participants. This "share" falls in the limits of the uncertainty model (0.0%-2.0%), and is therefore not evaluated as a wrong report.

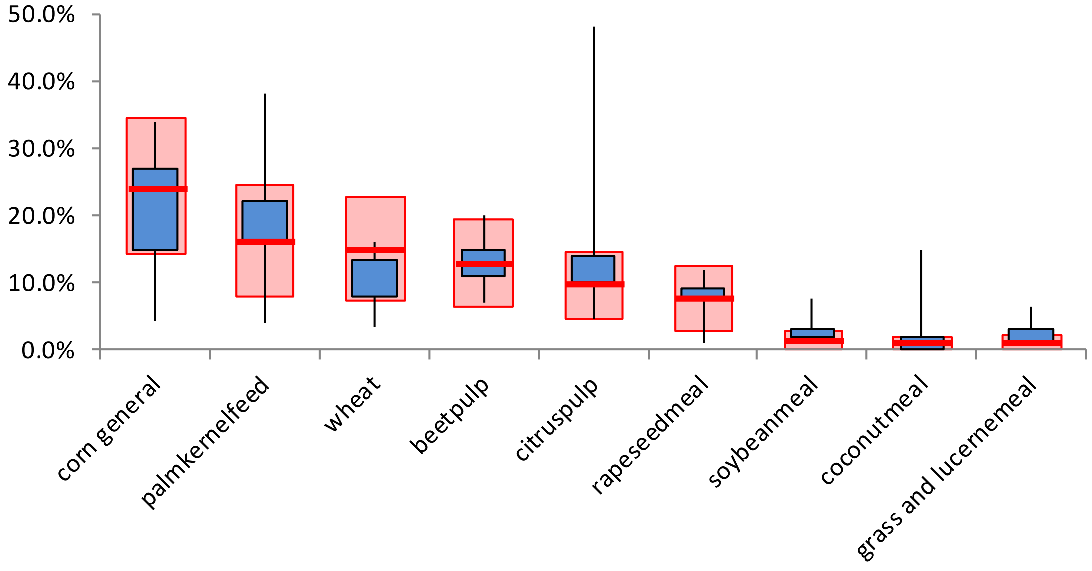

Figure 2 *The results of the IAG proficiency test composition 2019. Y-axis: share of ingredient. Blue bars: P_{25} – P_{75} percentile interval, vertical line: minimum – maximum range. Red background: upper and lower limit interval of the IAG uncertainty model, horizontal red line: share of the ingredient. N=22.*

The indications of the target animal for this type of feed included cattle (8), ruminant (5), calf (1), pig (1) and other (1). Six participants did not provide an indication. Considering the choice to mimic a formulation of a ruminant feed, this result is near to optimal. All participants were asked to judge the label indication. Only three participants indicated that the content was correctly expressed.

4 Discussion

4.1 Justification for the establishment of composition

European legislation requires that feeds and feed materials are labelled according to a range of requirements, including composition. It has been stated that labelling serves enforcement, traceability and control purposes (Regulation (EC) 767/2009, pre-ambule 17).

There are several aspects in the monitoring of feed safety and security where the analysis of botanic composition or identity is a major tool for enforcement:

- Label control (Regulation (EC) 767/2009).
- Traceability (Regulation (EC) 178/2002).
- Detection of fraud (Regulation (EU) 2017/625 repealing Regulation (EC) 882/2004).
- Organisation of markets for agricultural products demanding tools to identify materials for proper categorization (Regulation (EU) 1308/2013; Regulation (EU) 2016/1821).

In a declaration of composition feed materials should be mentioned in order of decreasing share, and additional information on composition should be available on request with uncertainty limits of +/- 15% (Regulation (EC) 767/2009, Article 17). It is not stated if this is a relative or absolute range. Annex IV of Regulation (EC) 767/2009 presents requirements for the labelling of basic parameters such as crude proteins, crude fibres, sugars, starch, oils and fats, minerals, moisture, crude ash and related parameters with a mix of absolute and relative ranges.

A most important aspect is the possibility to redirect the presence of a prohibited substance to one of the ingredients or fractions. Knowledge of the ingredients in a compound feed eases the traceability of prohibited substances. The fractionation of a sample in a sediment and a flotate can help to pinpoint the presence of contaminants and might improve their traceability. A multidisciplinary approach for evaluating incidences in the area of feed and food safety is a major achievement.

Economic fraud can be based on the replacement of an expensive ingredient by a cheaper one. Another aspect is the possibility that ingredients not fit for animal consumption, i.e. due to mould infestation, can be mixed in compound feeds.

In a broader view, composition analysis in the entire feed chain can improve the effect of monitoring actions. Likewise, legislation on food labelling (Regulation (EC) 1169/2011) obliges to provide more detailed information to customers on composition and related topics.

Strict quality assurance measures for monitoring feed and food products are demanded upon getting into force of Regulation (EU) 2017/625. Proficiency tests, as the current one on botanic composition, will gain in importance in the framework of the extended requirements.

4.2 Label control

In general, ingredients with a high share in the composition are commonly underestimated, and ingredients with a low share are usually overestimated. This applies to blind establishment of botanic composition of compound feed as well as for label control (van Raamsdonk et al., 2014; 2017). An exception was found in the results of the 2015 test. Total wheat (51.7%) was still slightly overestimated in the presence of 7.5% bakery by-product, which was generally overlooked (van Raamsdonk et al., 2015). Notwithstanding this, a wrong and a correct label declaration for two identical samples provided for control of composition in the proficiency test of 2107 revealed that the labels were in majority correctly judged, either correct or wrong (van Raamsdonk et al., 2017:

Table 4). In the several IAG tests of the last five years several ingredients were included which appeared to be difficult for identification: bakery-by-products (2015, 2018), citrus vs. beet pulp (2016, 2017), oat husks (2017) and tapioca (2018).

4.3 Composition analysis

There are two aspects influencing the quality of the results of an analysis of botanic composition. The first one is the lack of supporting evidence for compensating possible under- and over-estimation. The sole visual analysis of the composition of a compound feed without complementary information lacks the possibility of confirmation and of adjustment, which might influence the precision of the final result. In the past assessment of the biological composition of a feed was confirmed and, if necessary, adjusted by proximate analysis, of which Weende analysis is the classical approach (German: Weender Analyse; https://de.wikipedia.org/wiki/Futtermittelanalytik). Weende analysis, originally developed in the 19th century (Henneberg and Stohmann, 1859) provides information on basic chemical parameters: moisture, contents of ash, fat, protein and crude fibres. Since extensive information is available on the parameters of individual ingredients, the initial visually estimated shares of the several biological ingredients can be confirmed or optimized using this detail data. Currently several approaches exist for proximate analysis, such as Cornell Net Carbohydrate and Protein System (CNCPS), Van Soest and Near-Infrared Reflectance Spectroscopy, although these systems do not aim at the same set of parameters (Bovera et al., 2003; Godoy et al., 2016).

The second aspect is the level of expertise of the technician. In specific situations a particular ingredient might be overlooked. Because of this situation, a knowledge system for identification of ingredients of compound feeds could assist in composition analysis. Such a system should be able to document individual identifications as well in order to store choices made in the process of identification.

A good process description consisting of necessary steps, sieve fractions, the necessary parameters to be established in every step and for every fraction, and the procedure for combining all data in a final conclusion, together with documentation on identifying feed ingredients could help to improve the method.

5 General conclusions and recommendations

5.1 Conclusions

Two factors seem to influence the result of a composition analysis. Ingredients are generally overestimated at lower shares and underestimated at higher shares in the formulation. Secondly, some specific ingredients are not recognised at every level. Furthermore specific formulations can influence the precision of the estimation of the composition of the feed. The current results show that a label declaration can be confirmed in a qualitative sense. In most cases a correct or at least useful indication of the quantities can be reached. This information is sufficient for monitoring purposes.

The current information on the capability of botanic composition analysis reveals that this technique is valuable as part of the enforcement of feed and food safety. Besides proper label control (Regulation (EC) 767/2009), composition analysis can support traceability (Regulation (EC) 178/2002), for detection of fraud (Regulation (EU) 2017/625) and for categorization (Regulation (EU) 1308/2013; Regulation (EU) 2016/1821).

The current lack of a complementary system for the analysis of chemical composition (ash, proteins, fat, dietary carbohydrates, fibres, etc.) could be a drawback for the overall approach of botanic composition analysis. Besides a proper method description and up-to-date descriptions of ingredients, well developed skills of technicians are vital for a good performance. An identification support system for the major feed ingredients would provide the necessary support for identification.

5.2 Recommendations

- A more detailed process description could help to optimise the method for establishing the composition of a compound feed.
- In the view of the need for proper means for identification, an expert system as tool for maintenance and dissemination of expertise may help to improve future performance.

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Annex 1 Basic instructions for the test procedure

IAG proficiency test 2019 composition

Instructions for the IAG proficiency test

1 You have received a box with an introduction letter and either three or four vials containing 50 grams of possibly contaminated animal feed. Please report the receipt of your package as soon as possible by E-mail to the address mentioned below. If subscribed, all four samples are meant for the analysis of animal proteins. Besides the one sample meant for composition analysis, two other samples are additionally meant for label control. The possibility to control the label information is included on request of IAG members. The numbers of these three samples are mentioned on the letter enclosed in the box. There are two separate report forms for composition analysis and for label control.

2 Analysis for composition is preferably carried out using method A2 of the IAG section Microscopy. Other methods, however, are allowed. Take care to homogenise the content of each vial before taking the amount for analysis.

Link to IAG method A2

3 The results need to be reported as percentual estimations on the tab "Results". The organiser will apply the uncertainty intervals to your estimations as part of the evaluation. Reporting consists of the following steps:

3a Please fill in the questionnaire on the page "Procedure".
Most of the cells contain a drop-down list. These lists can be used to select an answer as follows. When clicking on a cell, the cursor changes into a hand. A second click will open the drop-down list.
Your unique lab number is mentioned in the introduction letter.
All the fields with a drop-down list have to be completed.

3b Please enter your results in the fields at page "Results". Your unique lab number automatically shows up after your have entered it at the page Procedure. Enter yourself the unique label of the vial.

4 After completing the two forms "Procedure" and "Results", they have to be sent to the organisers in two ways:

4a Save the Excel file by using "Save as …", add your unique lab code to the end of name (**replace the ## signs with your lab number**). The forms have to be sent by E-mail as Excel file and as a scan (*.PDF) to leo.vanraamsdonk@wur.nl and to corina.smits@wur.nl.

4b Results will be included in the final evaluation and report only if both forms are sent in by electronic mail, and after the proper receipt of the requested fee.

5 Direct any questions to leo.vanraamsdonk@wur.nl

6 Closing date is April 18th, 2019.

RIKILT Wageningen UR, the Netherlands

Annex 2 Report form for procedure details

Please complete at least all the pink cells with a drop down list that apply to your procedure	select your choice from a drop down list	type in your answer if necessary
IAG proficiency test 2019 composition		
Please select your unique lab number	**-- select --**	
Have you read the proficiency test instructions?	-- select --	
Which detection method do you use?	-- select --	

Annex 3 Report forms results

Please complete the necessary pink cells for showing your composition of the ingredients; add your sample number, the sediment amount and the final conclusion on feed type.

IAG ring test 2019 composition

lab number	
sample number	
	estimated %
Total:	0.0
Final conclusion on feed type:	-- select --
Comment if necessary	

Signature:

Date: 6-5-2019

Annex 4 Additional instructions

Test 2017-B: botanic composition of sample: [ ]

The sample with the number indicated here ↑ is meant for the analysis of the botanic composition. Take care to homogenise the content of the vial before taking the amount for analysis. This sample will be used for two purposes: detection of animal proteins if you have subscribed to this proficiency test, and analysis of botanic composition.

The report form contains a series of empty rows where the ingredients can be entered in order of their share (highest share on top), together with your estimation of the share in percent in the second column. Finally you are requested to indicate the assumed target of the feed (e.g. broiler feed, calve feed).

All results can be entered in the report form with “composition” in the name.

Annex 5 List of participants

Austrian Agency for Health and Food Safety-AGES	Austria
FLVVT	Belgium
Danish Veterinary and Food Administration	Denmark
Inovalys-Nantes	France
Laboratoire Départemental d'Analyse & de Recherche	France
LUFA-Speyer	Germany
LUFA Nord-West	Germany
CVUA-RRW	Germany
SGS Germany GmbH	Germany
BWZ der BFV	Germany
Landeslabor Berlin-Brandenburg	Germany
LTZ Augustenberg	Germany
Futtermittelinstitut Stade (LAVES)	Germany
Staatliche Betriebsgesellschaft für Umwelt und Landwirtschaft, GB6-Labore Landwirtschaft / LUFA, FB62	Germany
Bayerisches Landesamt fur Gesundheit und Lebensmittelsicherheit	Germany
LLFG Landesanstalt für Landwirtschaft	Germany
Landesbetrieb Hessisches Landeslabor, Landwirtschaft und Umwelt	Germany
Department of Agriculture, Fisheries and Food, Backweston Agri Laboratories	Ireland
Ministero delle politiche agricole alimentari e forestali, Laboratorio di Modena	Italy
Nutreco Nederland BV - Masterlab	Netherlands
ForFarmers	Netherlands
Cargill Poland	Poland
Dirección General de Produccion Agropecuaria, Laboratorio Agrario Regional	Spain
Agroscope (ALP), Swiss Research Station	Switzerland
CPF (Thailand) Public Company Limited	Thailand

Annex 6 Results composition analysis

	correct	range:		label	lab:	1	2	3	8	9	11	14	15	19	20	23
					sample:	172	431	578	200	466	361	382	130	228	123	319
corn general	24.0%	14.0%	34.0%	24.0%		19.0%	22.0%	24.0%	33.8%	22.0%	22.0%	26.0%	28.3%	5.0%	20.0%	34.0%
palmkernelfeed	16.0%	8.0%	24.0%	16.0%		22.0%	22.0%	18.0%	18.8%	20.0%	18.0%	18.0%	16.8%	4.0%	15.0%	19.0%
wheat	15.0%	7.5%	22.5%	15.0%		10.0%	8.0%	13.0%	3.5%	15.0%	5.0%	10.0%	15.1%	11.0%	10.0%	4.0%
beetpulp	13.0%	6.5%	19.5%	13.0%		13.0%	15.0%	13.0%	12.3%	15.0%	10.0%	15.0%	11.2%	8.0%	20.0%	14.0%
citruspulp	10.0%	5.0%	15.0%	10.0%		19.0%	10.0%	13.0%	14.8%	12.0%	5.0%	7.0%	13.2%	48.0%	11.0%	10.0%
rapeseedmeal	8.0%	3.0%	13.0%	8.0%		8.0%	7.0%	8.0%	7.6%	8.0%	10.0%	8.0%	9.2%	1.0%	8.0%	9.0%
soybeanmeal	1.2%	0.0%	2.4%	1.2%		4.0%	2.0%	1.0%	2.2%	2.0%	4.0%	2.0%	2.8%	1.0%	1.0%	3.0%
coconutmeal	1.0%	0.0%	2.0%	1.0%		1.0%	5.0%	1.0%	4.0%	2.0%	15.0%	2.0%	1.2%		2.0%	3.0%
grass and lucernemeal	1.0%	0.0%	2.0%	1.0%		3.0%	1.0%	1.0%	2.0%	2.0%	2.0%	1.0%	1.4%	5.0%	2.0%	3.0%
minerals	0.6%	0.0%	1.2%	<1%		1.0%	0.8%	1.0%	1.0%	2.0%	1.0%	1.0%	0.8%	1.0%	1.0%	1.0%
molasse	10.0%	5.0%	15.0%	10.0%		na	7.2%			na	8.0%	10.0%	na		10.0%	0.0%
vegetable fat	0.2%	0.0%	0.4%													
sunflower								1.0%								
peanut expeller														16.0%		
DDGS																
bakery-byproducts									trace							
microplastic									trace							
other																
	100.0%					100%	100%	94%	100%	100%	100%	100%	100%	100%	100%	100%
Final conclusion on feed type						cattle	cattle	rum	rum	rum	cattle	correct	cattle	other	cattle	cattle

	correct	range:		label											
lab:					26	29	30	33	34	35	38	40	42	45	46
sample:					389	207	158	340	592	284	396	487	193	550	410
corn general	24.0%	14.0%	34.0%	24.0%	25.0%	15.0%	27.0%	29.0%	28.0%	4.4%	21.0%	12.0%	24.0%	13.6%	13.0%
palmkernelfeed	16.0%	8.0%	24.0%	16.0%	17.0%	38.0%	16.0%	16.0%	19.0%	7.9%	18.5%	22.0%	16.0%	25.6%	22.0%
wheat	15.0%	7.5%	22.5%	15.0%	16.0%	7.5%	15.0%	10.0%	8.0%	10.4%	13.0%	10.0%	14.0%	13.4%	10.0%
beetpulp	13.0%	6.5%	19.5%	13.0%	9.0%	11.0%	14.0%	7.0%	12.0%	15.9%	14.0%	16.0%	11.0%	13.3%	12.0%
citruspulp	10.0%	5.0%	15.0%	10.0%	12.0%	4.5%	13.0%	18.0%	10.0%		11.0%	14.0%	10.0%	7.1%	15.0%
rapeseedmeal	8.0%	3.0%	13.0%	8.0%	6.0%	8.0%	8.0%	4.0%	10.0%	9.9%	8.0%	9.0%	9.0%	6.7%	12.0%
soybeanmeal	1.2%	0.0%	2.4%	1.2%	2.0%	3.5%	2.0%	2.0%	2.0%	7.5%	1.5%	4.0%	2.0%	2.9%	1.0%
coconutmeal	1.0%	0.0%	2.0%	1.0%	1.0%		2.0%				1.0%		1.0%	0.1%	2.0%
grass and lucernemeal	1.0%	0.0%	2.0%	1.0%	1.0%	2.5%	2.0%	3.0%	5.0%		1.0%	2.0%	2.0%	6.3%	2.0%
minerals	0.6%	0.0%	1.2%	<1%	1.0%	1.0%	1.0%	1.0%	1.0%	0.2%	1.0%	1.0%	1.0%	0.5%	1.0%
molasse	10.0%	5.0%	15.0%	10.0%	10.0%	9.0%		10.0%	5.0%		10.0%	10.0%		9.6%	10.0%
vegetable fat	0.2%	0.0%	0.4%												
sunflower															
peanut expeller															
DDGS										14.0%					
bakery-byproducts										29.8%					
microplastic															
other															
	100.0%				100%	100%	100%	100%	100%	100%	100%	100%	90%	99%	100%
Final conclusion on feed type					rum	cattle	no dev.	----	rum	cattle	pig	-----	correct	calf	-----

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WFSR report 2019.014

The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 12,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.

To explore the potential of nature to improve the quality of life

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