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(Acts adopted under the EC Treaty/Euratom Treaty whose publication is obligatory)

REGULATIONS

COMMISSION REGULATION (EC) No 152/2009

of 27 January 2009

laying down the methods of sampling and analysis for the official control of feed

(Text with EEA relevance)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community,

Having regard to Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules ⁽¹⁾, and in particular Article 11(4)(a), (b) and (c) thereof,

Whereas:

(1) The following acts were adopted for the implementation of Directive 70/373/EEC and remain in force in accordance with Article 61(2) of Regulation (EC) No 882/2004:

- Fourth Commission Directive 73/46/EEC of 5 December 1972 establishing Community methods of analysis for the official control of feedingstuffs ⁽²⁾,
- First Commission Directive 76/371/EEC of 1 March 1976 establishing Community methods of sampling for the official control of feedingstuffs ⁽⁶⁾,
- Seventh Commission Directive 76/372/EEC of 1 March 1976 establishing Community methods of analysis for the official control of feedingstuffs ⁽⁷⁾,
- Eight Commission Directive 78/633/EEC of 15 June 1978 establishing Community methods of analysis for the official control of feedingstuffs ⁽⁸⁾,
- Ninth Commission Directive 81/715/EEC of 31 July 1981 establishing Community methods of analysis for the official control of feedingstuffs ⁽⁹⁾,
- Tenth Commission Directive 84/425/EEC of 25 July 1984 establishing Community methods of analysis for the official control of feedingstuffs ⁽¹⁰⁾,
- Commission Directive 86/174/EEC of 9 April 1986 fixing the method of calculation for the energy value of compound poultry-feed ⁽¹¹⁾,
- First Commission Directive 71/250/EEC of 15 June 1971 establishing Community methods of analysis for the official control of feedingstuffs ⁽²⁾,
- Second Commission Directive 71/393/EEC of 18 November 1971 establishing Community methods of analysis for the official control of feedingstuffs ⁽³⁾,
- Third Commission Directive 72/199/EEC of 27 April 1972 establishing Community methods of analysis for the official control of feedingstuffs ⁽⁴⁾,

⁽¹⁾ OJ L 165, 30.4.2004, p. 1, corrected by OJ L 191, 28.5.2004, p. 1.

⁽²⁾ OJ L 155, 12.7.1971, p. 13.

⁽³⁾ OJ L 279, 20.12.1971, p. 7.

⁽⁴⁾ OJ L 123, 29.5.1972, p. 6.

⁽⁵⁾ OJ L 83, 30.3.1973, p. 21.

⁽⁶⁾ OJ L 102, 15.4.1976, p. 1.

⁽⁷⁾ OJ L 102, 15.4.1976, p. 8.

⁽⁸⁾ OJ L 206, 29.7.1978, p. 43.

⁽⁹⁾ OJ L 257, 10.9.1981, p. 38.

⁽¹⁰⁾ OJ L 238, 6.9.1984, p. 34.

⁽¹¹⁾ OJ L 130, 16.5.1986, p. 53.

- Eleventh Commission Directive 93/70/EEC of 28 July 1993 establishing Community methods of analysis for official control of feedingstuffs ⁽¹⁾,
- Twelfth Commission Directive 93/117/EC of 17 December 1993 establishing Community methods of analysis for official control of feedingstuffs ⁽²⁾,
- Commission Directive 98/64/EC of 3 September 1998 establishing Community methods of analysis for the determination of amino-acids, crude oils and fats, and olaquindox in feedingstuffs and amending Directive 71/393/EEC ⁽³⁾,
- Commission Directive 1999/27/EC of 20 April 1999 establishing Community methods of analysis for the determination of amprolium, diclazuril and carbadox in feedingstuffs and amending Directives 71/250/EEC, 73/46/EEC and repealing Directive 74/203/EEC ⁽⁴⁾,
- Commission Directive 1999/76/EC of 23 July 1999 establishing a Community method of analysis for the determination of lasalocid sodium in feedingstuffs ⁽⁵⁾,
- Commission Directive 2000/45/EC of 6 July 2000 establishing Community methods of analysis for the determination of vitamin A, vitamin E and tryptophan in feedingstuffs ⁽⁶⁾,
- Commission Directive 2002/70/EC of 26 July 2002 establishing requirements for the determination of levels of dioxins and dioxin-like PCBs in feedingstuffs ⁽⁷⁾,
- Commission Directive 2003/126/EC of 23 December 2003 on the analytical method for the determination of constituents of animal origin for the official control of feedingstuffs ⁽⁸⁾.

EC, 1999/27/EC, 1999/76/EC, 2000/45/EC, 2002/70/EC and 2003/126/EC should therefore be repealed.

- (4) The measures provided for in this Regulation are in accordance with the opinion of the Standing Committee on the Food Chain and Animal Health,

HAS ADOPTED THIS REGULATION:

Article 1

Sampling for the official control of feed, as regards the determination of constituents, additives and undesirable substances, with the exception of residues of pesticides and micro-organisms, shall be carried out in accordance with the methods set out in Annex I.

Article 2

Preparation of samples for analysis and expression of results shall be carried out in accordance with the methods set out in Annex II.

Article 3

Analysis for the official control of feed shall be carried out using the methods set out in Annex III (Methods of analysis to control the composition of feed materials and compound feed, Annex IV (Methods of analysis to control the level of authorised additives in feed), Annex V (Methods of analysis to control undesirable substances in feed) and Annex VI (Methods of analysis for the determination of constituents of animal origin for the official control of feed).

Article 4

The energy value of compound poultry feed shall be calculated in accordance with Annex VII.

Article 5

The methods of analysis to control illegal presence of no longer authorised additives in feed set out in Annex VIII shall be used for confirmatory purposes.

Article 6

Directives 71/250/EEC, 71/393/EEC, 72/199/EEC, 73/46/EEC, 76/371/EEC, 76/372/EEC, 78/633/EEC, 81/715/EEC, 84/425/EEC, 86/174/EEC, 93/70/EEC, 93/117/EC, 98/64/EC, 1999/27/EC, 1999/76/EC, 2000/45/EC, 2002/70/EC and 2003/126/EC are repealed.

References to the repealed Directives shall be construed as references to this Regulation and shall be read in accordance with the correlation tables in Annex IX.

- (2) Since Directive 70/373/EEC was replaced by Regulation (EC) No 882/2004 it is appropriate to replace the implementing acts to that Directive by a single Regulation. At the same time the methods should be adapted in the light of developments in scientific and technological knowledge. Methods which are no longer valid for their intended purpose should be deleted. It is foreseen to update the sampling provisions in due time to take into account the recent developments in the way feed are produced, stored, transported and marketed, nevertheless it is appropriate to maintain for the time being the existing provisions on sampling.

- (3) Directives 71/250/EEC, 71/393/EEC, 72/199/EEC, 73/46/EEC, 76/371/EEC, 76/372/EEC, 78/633/EEC, 81/715/EEC, 84/425/EEC, 86/174/EEC, 93/70/EEC, 93/117/EC, 98/64/

⁽¹⁾ OJ L 234, 17.9.1993, p. 17.

⁽²⁾ OJ L 329, 30.12.1993, p. 54.

⁽³⁾ OJ L 257, 19.9.1998, p. 14.

⁽⁴⁾ OJ L 118, 6.5.1999, p. 36.

⁽⁵⁾ OJ L 207, 6.8.1999, p. 13.

⁽⁶⁾ OJ L 174, 13.7.2000, p. 32.

⁽⁷⁾ OJ L 209, 6.8.2002, p. 15.

⁽⁸⁾ OJ L 339, 24.12.2003, p. 78.

Article 7

This Regulation shall enter into force on the twentieth day following that of 20th day following its publication in the *Official Journal of the European Union*.

It shall apply from 26 August 2009.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 27 January 2009.

For the Commission

Androulla VASSILIOU

Member of the Commission

ANNEX I

METHODS OF SAMPLING

1. PURPOSE AND SCOPE

Samples intended for the official control of feed shall be taken according to the methods described below. Samples thus obtained shall be considered as representative of the sampled portions.

2. SAMPLING PERSONNEL

The samples shall be taken by persons authorised for that purpose by the Member States.

3. DEFINITIONS

Sampled portion: A quantity of product constituting a unit, and having characteristics presumed to be uniform.

Incremental sample: A quantity taken from one point in the sampled portion.

Aggregate sample: An aggregate of incremental samples taken from the same sampled portion.

Reduced sample: A representative part of the aggregate sample, obtained from the latter by a process of reduction.

Final sample: A part of the reduced sample or of the homogenised aggregate sample.

4. APPARATUS

4.1. The sampling apparatus must be made of materials which cannot contaminate the products to be sampled. Such apparatus may be officially approved by the Member States.

4.2. **Apparatus recommended for the sampling of solid feed.**4.2.1. *Manual sampling*

4.2.1.1. Flat-bottomed shovel with vertical sides.

4.2.1.2. Sampling spear with a long split or compartments. The dimensions of the sampling spear must be appropriate to the characteristics of the sampled portion (depth of container, dimensions of sack, etc.) and to the particle size of the feed.

4.2.2. *Mechanical sampling*

Approved mechanical apparatus may be used for the sampling of moving feed.

4.2.3. *Divider*

Apparatus designed to divide the sample into approximately equal parts may be used for taking incremental samples and for the preparation of reduced and final samples.

5. QUANTITATIVE REQUIREMENTS

5.A.	In relation to the control of substances or products uniformly distributed throughout the feed
5.A.1.	Sampled portion The size of the sampled portion must be such that each of its constituent parts can be sampled

5.A.2.	Incremental samples	
5.A.2.1.	Loose feed:	Minimum number of incremental samples:
5.A.2.1.1.	sampled portions not exceeding 2,5 metric tons	seven
5.A.2.1.2.	sampled portions exceeding 2,5 metric tons	$\sqrt{}$ 20 times the number of metric tons making up the sampled portion (*), up to a maximum of 40 incremental samples
5.A.2.2.	Packaged feed:	Minimum number of packages to be sampled (**):
5.A.2.2.1.	Packages of more than 1 kg:	
5.A.2.2.1.1.	sampled portions of one to four packages	all packages
5.A.2.2.1.2.	sampled portions of 5 to 16 packages	four
5.A.2.2.1.3.	sampled portions of more than 16 packages	$\sqrt{}$ number of packages making up the sampled portion (*), up to maximum of 20 packages
5.A.2.2.2.	Packages not exceeding 1 kg	four
5.A.2.3.	Liquid or semi-liquid feed:	Minimum number of containers to be sampled (**):
5.A.2.3.1.	Containers of more than one litre:	
5.A.2.3.1.1.	sampled portions of one to four containers	all containers
5.A.2.3.1.2.	sampled portions of 5 to 16 containers	four
5.A.2.3.1.3.	sampled portions of more than 16 containers	$\sqrt{}$ number of containers making up the sampled portion (*), up to a maximum of 20 containers
5.A.2.3.2.	Containers not exceeding one litre	four
5.A.2.4.	Feed blocks and mineral licks	Minimum number of blocks or licks to be sampled (**): one block or lick per sampled portion of 25 units, up to a maximum of four blocks or licks
5.A.3.	Aggregate sample A single aggregate sample per sampled portion is required. The total amount in the incremental samples making up the aggregate sample shall be not less than the following:	
5.A.3.1.	Loose feed	4 kg
5.A.3.2.	Packaged feed:	
5.A.3.2.1.	packages of more than 1 kg	4 kg
5.A.3.2.2.	packages not exceeding 1 kg	weight of the contents of four original packages
5.A.3.3.	Liquid or semi-liquid feed:	
5.A.3.3.1.	containers of more than one litre	four litres
5.A.3.3.2.	containers not exceeding one litre	volume of the contents of four original containers
5.A.3.4.	Feed blocks or mineral licks:	
5.A.3.4.1.	each weighing more than 1 kg	4 kg
5.A.3.4.2.	each weighing not more than 1 kg	weight of four original blocks or licks

5.A.4.	Final samples The aggregate sample gives the final samples on reduction when necessary. Analysis of at least one final sample is required. The amount in the final sample for analysis shall be not less than the following:	
	Solid feed	500 g
	Liquid or semi-liquid feed	500 ml
5.B.	In relation to the control of undesirable substances or products likely to be distributed non-uniformly throughout the feed, such as aflatoxins, rye ergot, castor-oil plant and crotalaria in feed materials (***)	
5.B.1.	Sampled portion: see 5.A.1.	
5.B.2.	Incremental samples	
5.B.2.1.	Loose feed: see 5.A.2.1.	
5.B.2.2.	Packaged feed:	Minimum number of packages to be sampled:
5.B.2.2.1.	sampled portions consisting of one to four packages	all packages
5.B.2.2.2.	sampled portions consisting of 5 to 16 packages	four
5.B.2.2.3.	sampled portions consisting of more than 16 packages	$\sqrt{}$ number of packages making up the sampled portion (*), up to a maximum of 40 packages
5.B.3.	Aggregate samples The number of aggregate samples will vary with the size of the sampled portion. The minimum number of aggregate samples per sampled portion is given below. The total weight of the incremental samples making up each aggregate sample shall be not less than 4 kg	
5.B.3.1.	Loose feed	
	Weight of the sampled portion in metric tons:	Minimum number of aggregate samples per sampled portion:
	up to 1	1
	more than 1 and up to 10	2
	more than 10 and up to 40	3
	more than 40	4
5.B.3.2.	Packaged feed	
	Size of the sampled portion in number of packages:	Minimum number of aggregate samples per sampled portion:
	1 to 16	1
	17 to 200	2
	201 to 800	3
	more than 800	4
5.B.4.	Final samples Each aggregate sample gives the final samples on reduction. Analysis of at least one final sample <i>per aggregate sample</i> is required. The weight of the final sample for analysis may not be less than 500 g	

(*) Where the number obtained is a fraction, it shall be rounded up to the next whole number.

(**) For packages or containers whose contents do not exceed 1 kg or one litre and for blocks or licks weighing not more than 1 kg each, an incremental sample shall be the contents of one original package or container, one block or one lick.

(***) The methods provided for in 5.A are for use in the control of aflatoxins, rye ergot, castor-oil plant and crotalaria in complete and complementary feed.

6. INSTRUCTIONS FOR TAKING, PREPARING AND PACKAGING THE SAMPLES

6.1. **General**

The samples must be taken and prepared as quickly as possible bearing in mind the precautions necessary to ensure that the product is neither changed nor contaminated. Instruments and also surfaces and containers intended to receive samples must be clean and dry.

6.2. **Incremental samples**

6.2.A. *In relation to the control of substances or products uniformly distributed throughout the feed*

Incremental samples must be taken at random throughout the whole sampled portion and they must be of approximately equal sizes.

6.2.A.1. Loose feed

An imaginary division shall be made of the sampled portion into a number of approximately equal parts. A number of parts corresponding to the number of incremental samples required in accordance with 5.A.2 shall be selected at random and at least one sample taken from each of these parts.

Where appropriate, sampling may be carried out when the sampled portion is being moved (loading or unloading).

6.2.A.2. Packaged feed

Having selected the required number of packages for sampling as indicated in 5.A.2, part of the contents of each package shall be removed using a spear or shovel. Where necessary, the samples shall be taken after emptying the packages separately. Any lumps shall be broken up, if necessary, by separating them out and returning into the sample, in each aggregate sample separately.

6.2.A.3. Homogeneous or homogenisable liquid or semi-liquid feed

Having selected the required number of containers for sampling as indicated in 5.A.2, the contents shall be homogenised if necessary and an amount taken from each container.

The incremental samples may be taken when the contents are being discharged.

6.2.A.4. Non-homogenisable, liquid or semi-liquid feed

Having selected the required number of containers for sampling as indicated in 5.A.2, samples shall be taken from different levels.

Samples may also be taken when the contents are being discharged but the first fractions shall be discarded.

In either case the total volume taken must not be less than 10 litres.

6.2.A.5. Feed blocks and mineral licks

Having selected the required number of blocks or licks for sampling as indicated in 5.A.2, a part of each block or lick shall be taken.

6.2.B. *In relation to the control of undesirable substances or products likely to be distributed non-uniformly throughout the feed, such as aflatoxins, rye ergot, castor-oil plant and crotalaria in feed materials*

An imaginary division shall be made of the sampled portion into a number of approximately equal parts, corresponding to the number of aggregate samples provided for in 5.B.3. If this number is greater than one, the total number of incremental samples provided for in 5.B.2 shall be distributed approximately equally over the different parts. Then take samples of approximately equal sizes⁽¹⁾ and such that the total amount in the samples from each part is not less than the minimum 4 kg quantity required for each aggregate sample. Incremental samples taken from different parts shall not be aggregated.

⁽¹⁾ For packaged feed, a part of the contents of the packages to be sampled shall be removed, using a spear or shovel, after having, if necessary, emptied the packages separately.

6.3. **Preparation of aggregate samples**

6.3.A. *In relation to the control of substances or products distributed uniformly throughout the feed*

The incremental samples shall be mixed to form a single aggregate sample.

6.3.B. *In relation to the control of undesirable substances or products likely to be distributed non-uniformly throughout the feed, such as aflatoxins, rye ergot, castor-oil plant and crotalaria in feed materials*

The incremental samples from each part of the sampled portion shall be mixed and the number of aggregate samples provided for in 5.B.3, made up taking care to note the origin of each aggregate sample.

6.4. **Preparation of final samples**

The material in each aggregate sample shall be carefully mixed to obtain an homogenised sample ⁽¹⁾. If necessary the aggregate sample shall first be reduced to at least 2 kg or two litres (reduced sample) either by using a mechanical or automatic divider or by the quartering method.

At least three final samples shall then be prepared, of approximately the same amount and conforming to the quantitative requirements of 5.A.4 or 5.B.4. Each sample shall be put into an appropriate container. All necessary precautions shall be taken to avoid any change of composition of the sample, contamination or adulteration which might arise during transportation or storage.

6.5. **Packaging of final samples**

The containers or packages shall be sealed and labelled (the total label must be incorporated in the seal) in such a manner that they cannot be opened without damaging the seal.

7. SAMPLING RECORD

A record must be kept of each sampling, permitting each sampled portion to be identified unambiguously.

8. DESTINATION OF SAMPLES

For each aggregate sample, at least one final sample shall be sent as quickly as possible to the authorised analytical laboratory, together with the information necessary for the analyst.

⁽¹⁾ Any lumps shall be broken up (if necessary by separating them out and returning them to the sample) in each aggregate sample separately.

ANNEX II

GENERAL PROVISIONS ON METHODS OF ANALYSIS FOR FEED

A. PREPARATION OF SAMPLES FOR ANALYSIS

1. **Purpose**

The procedures described below concern the preparation for analysis of final samples, sent to the control laboratories after sampling in accordance with the provisions laid down in Annex I.

These samples must be prepared in such a way that the amounts weighed out, as provided for in the methods of analysis, are homogeneous and representative of the final samples.

2. **Precautions to be taken**

The sample preparation procedure to be followed is dependent on the methods of analysis used. It is therefore of major importance that it is ensured that the followed sample preparation procedure is appropriate for the used method of analysis.

All the necessary operations must be performed in such a way as to avoid as far as possible contamination of the sample and changes of its composition.

Grinding, mixing and sieving shall be carried out as quickly as possible with minimal exposure of the sample to the air and light. Mills and grinders likely to appreciably heat the sample shall not be used.

Manual grinding is recommended for feed which are particularly sensitive to heat. Care shall also be taken to ensure that the apparatus itself is not a source of contamination of trace elements.

If the preparation cannot be carried out without significant changes in the moisture content of the sample, determine the moisture content before and after preparation according to the method laid down in Part A of Annex III.

3. **Procedure**

Divide the sample into adequate subsamples for analysis and for reference by using adequate splitting techniques like alternate shovelling, stationary or rotary riffing. Coning and quartering is not recommended because this might provide subsamples with high splitting error. Keep the sample for reference in a suitable clean, dry container, fitted with an air-tight stopper, and prepare the subsamples for analysis of at least 100 g as indicated below.

3.1. *Feed which can be ground as such*

Unless otherwise specified in the methods of analysis, sieve the whole sample through a sieve with a square mesh of 1 mm side (in accordance with recommendation ISO R565) after grinding, if necessary. Avoid any over grinding.

Mix the sieved sample and collect it in a suitable clean, dry container fitted with an air-tight stopper. Mix again, immediately before weighing out the amount for analysis.

3.2. *Feed which can be ground after drying*

Unless otherwise specified in the methods of analysis, dry the sample to bring its moisture content down to a level of 8 % to 12 %, according to the preliminary drying procedure described under point 4.3 of the method of determination of moisture mentioned in Part A of Annex III. Then proceed as indicated in section 3.1.

3.3. *Liquid or semi-liquid feed*

Collect the sample in a suitable clean, dry container, fitted with an air-tight stopper. Mix thoroughly immediately before weighing out the amount for analysis.

3.4. *Other feed*

Samples which cannot be prepared according to one of the above procedures shall be treated by any other procedure which ensures that the amounts weighed out for the analysis are homogeneous and representative of the final samples.

4. **Storage of samples**

Samples must be stored at a temperature that will not alter their composition. Samples intended for the analysis of vitamins or substances which are particularly sensitive to light shall be stored in brown glass containers.

B. PROVISIONS RELATING TO REAGENTS AND APPARATUS USED IN METHODS OF ANALYSIS

1. Unless otherwise specified in the methods of analysis, all analytical reagents must be analytically pure (a.p.). When trace analysis is carried out, the purity of the reagents must be checked by a blank test. Depending upon the results obtained, further purification of the reagents may be required.
2. Any operation involving preparation of solutions, dilution, rinsing or washing, mentioned in the methods of analysis without indication as to the nature of the solvent or diluent employed, implies that water must be used. As a general rule, water shall be demineralised or distilled. In particular cases, which are indicated in the methods of analysis, it must be submitted to special procedures of purification.
3. In view of the equipment normally found in control laboratories, only those instruments and apparatus which are special or require specific usage are referred to in the methods of analysis. They must be clean, especially when very small amounts of substances have to be determined.

C. APPLICATION OF METHODS OF ANALYSIS AND EXPRESSION OF THE RESULTS

1. **Extraction procedure**

Several methods determine a specific extraction procedure. As a general rule, other extraction procedures than the procedure referred to in the method can be applied on the condition that the used extraction procedure has been proven to have the equivalent extraction efficiency for the matrix analysed as the procedure mentioned in the method.

2. **Clean-up procedure**

Several methods determine a specific clean-up procedure. As a general rule, other clean-up procedures than the procedure referred to in the method can be applied on the condition that the used clean-up procedure has been proven to result in equivalent analytical results for the matrix analysed as the procedure mentioned in the method.

3. **Reporting of the method of analysis used**

In general a single method of analysis is established for the determination of each substance in feed. Where several methods are given, the particular method used by the control laboratory must be indicated on the analysis report.

4. **Number of determinations**

The result given in the analysis report shall be the average value obtained from at least two determinations, carried out on separate portions of the sample, and of satisfactory repeatability.

However, in case of the analysis of undesirable substances, if the result of the first determination is significantly (> 50 %) lower than the specification to be controlled, no additional determinations are necessary, on the condition that the appropriate quality procedures are applied.

In case of the control of the declared content of a substance or ingredient, if the result of the first determination confirms the declared content, i.e. the analytical result falls within the acceptable range of variation of the declared content, no additional determinations are necessary, on the condition that the appropriate quality procedures are applied.

In some cases this acceptable range of variation is defined in legislation such as in Council Directive 79/373/EEC ⁽¹⁾.

5. **Reporting of the analytical result**

The analytical result shall be expressed in the manner laid down in the method of analysis to an appropriate number of significant figures and shall be corrected, if necessary, to the moisture content of the final sample prior to preparation.

⁽¹⁾ OJ L 86, 6.4.1979, p. 30.

6. Measurement uncertainty and recovery rate in case of analysis of undesirable substances

As regards undesirable substances within the meaning of Directive 2002/32/EC, including dioxins and dioxin-like PCBs, a product intended for animal feed shall be considered as non-compliant with the established maximum content, if the analytical result is deemed to exceed the maximum content taking into account expanded measurement uncertainty and correction for recovery. In order to assess compliance, the analysed concentration is used after being corrected for recovery and after deduction of the expanded measurement uncertainty. This procedure is only applicable in cases where the method of analysis enables the estimation of measurement uncertainty and correction for recovery (e.g. not possible in case of microscopic analysis).

The analytical result shall be reported as follows (in so far the used method of analysis enables to estimate the measurement uncertainty and recovery rate):

- (a) corrected for recovery, the level of recovery being indicated. The correction for recovery is not necessary in case the recovery rate is between 90 % and 110 %;
- (b) as 'x +/- U', whereby x is the analytical result and U is the expanded measurement uncertainty, using a coverage factor of 2 which gives a level of confidence of approximately 95 %.

However, if the result of the analysis is significantly (> 50 %) lower than the specification to be controlled, and on the condition that the appropriate quality procedures are applied and the analysis serves only the purpose of checking compliance with legal provisions, the analytical result might be reported without correction for recovery and the reporting of the recovery rate and measurement uncertainty might be omitted in these cases.

ANNEX III

METHODS OF ANALYSIS TO CONTROL THE COMPOSITION OF FEED MATERIALS AND COMPOUND FEED

A. DETERMINATION OF MOISTURE

1. **Purpose and Scope**

This method makes it possible to determine the moisture content of feed. In case of feed containing volatile substances, such as organic acids, it is to be observed that also significant amount of volatile substances are determined together with the moisture content.

It does not cover the analysis of milk products as feed materials, the analysis of mineral substances and mixtures composed predominantly of mineral substances, the analysis of animal and vegetable fats and oils or the analysis of the oil seeds and oleaginous fruit.

2. **Principle**

The sample is desiccated under specified conditions which vary according to the nature of the feed. The loss in weight is determined by weighing. It is necessary to carry out preliminary drying when dealing with solid feed which has high moisture content.

3. **Apparatus**

- 3.1. Crusher of non-moisture-absorbing material which is easy to clean, allows rapid, even crushing without producing any appreciable heating, prevents contact with the outside air as far as possible and meets the requirements laid down in 4.1.1 and 4.1.2 (e.g. hammer or water cooled micro-crushers, collapsible cone mills, slow motion or cog wheeled crushers).
- 3.2. Analytical balance, accurate to 1 mg.
- 3.3. Dry containers of non-corrodible metal or of glass with lids ensuring airtight closure; working surface allowing the test sample to be spread at about 0,3 g/cm².
- 3.4. Electrically heated isothermal oven (± 2 °C) properly ventilated and ensuring rapid temperature regulation ⁽¹⁾.
- 3.5. Adjustable electrically heated vacuum oven fitted with an oil pump and either a mechanism for introducing hot dried air or a drying agent (e.g. calcium oxide).
- 3.6. Desiccator with a thick perforated metal or porcelain plate, containing an efficient drying agent.

4. **Procedure**

N.B. The operations described in this section must be carried out immediately after opening the packages of samples. Analysis must be carried out at least in duplicate.

4.1. *Preparation*

4.1.1. Feed other than those coming under 4.1.2 and 4.1.3

Take at least 50 g of the sample. If necessary, crush or divide in such a way as to avoid any variation in moisture content (see 6).

4.1.2. Cereals and groats

Take at least 50 g of the sample. Grind into particles of which at least 50 % will pass through a 0,5 mm mesh sieve and will leave no more than 10 % reject on a 1 mm round-meshed sieve.

⁽¹⁾ For the drying of cereals, flour, groats and meal, the oven must have a thermal capacity such that, when pre-set at 131 °C, it will return to that temperature in less than 45 minutes after the maximum number of test samples have been placed inside to dry simultaneously. Ventilation must be such that, when as many samples of common wheat as it can contain are dried for two hours, the results differ from those obtained after four hours of drying by less than 0,15 %.

4.1.3. Feed in liquid or paste form, feed predominantly composed of oils and fats

Take about 25 g of the sample, weigh to the nearest 10 mg, add an appropriate quantity of anhydrous sand weighed to the nearest 10 mg and mix until a homogeneous product is obtained.

4.2. *Drying*

4.2.1. Feed other than those coming under 4.2.2 and 4.2.3

Weigh a container (3.3) with its lid to the nearest 1 mg. Weigh into the weighed container, to the nearest 1 mg, about 5 g of the sample and spread evenly. Place the container, without its lid, in the oven preheated to 103 °C. To prevent the oven temperature from falling unduly, introduce the container as rapidly as possible. Leave to dry for four hours reckoned from the time when the oven temperature returns to 103 °C. Replace the lid on the container, remove the latter from the oven, leave to cool for 30 to 45 minutes in the desiccator (3.6) and weigh to the nearest 1 mg.

For feed composed predominantly of oils and fats, dry in the oven for an additional 30 minutes at 130 °C. The difference between the two weighings must not exceed 0,1 % of moisture.

4.2.2. Cereals, flour, groats and meal

Weigh a container (3.3) with its lid to the nearest 0,5 mg. Weigh into the weighed container, to the nearest 1 mg, about 5 g of the crushed sample and spread evenly. Place the container, without its lid, in the oven preheated to 130 °C. To prevent the oven temperature from falling unduly, introduce the container as rapidly as possible. Leave to dry for two hours reckoned from the time when the oven temperature returns to 130 °C. Replace the lid on the container, remove the latter from the oven, leave to cool for 30 to 45 minutes in the desiccator (3.6) and weigh to the nearest 1 mg.

4.2.3. Compound feed containing more than 4 % of sucrose or lactose: feed materials such as locust beans, hydrolysed cereal products, malt seeds, dried beet chips, fish and sugar solubles; compound feed containing more than 25 % of mineral salts including water of crystallisation.

Weigh a container (3.3) with its lid to the nearest 0,5 mg. Weigh into the weighed container, to the nearest 1 mg, about 5 g of the sample and spread evenly. Place the container, without its lid, in the vacuum oven (3.5) preheated to between 80 °C and 85 °C. To prevent the oven temperature from falling unduly, introduce the container as rapidly as possible.

Bring the pressure up to 100 Torr and leave to dry for four hours at this pressure, either in a current of hot, dry air or using a drying agent (about 300 g for 20 samples). In the latter instance, disconnect the vacuum pump when the prescribed pressure has been reached. Reckon drying time from the moment when the oven temperature returns to 80 °C to 85 °C. Carefully bring the oven back to atmospheric pressure. Open the oven, place the lid on the container immediately, remove the container from the oven, leave to cool for 30 to 45 minutes in the desiccator (3.6) and weigh to the nearest 1 mg. Dry for an additional 30 minutes in the vacuum oven at 80 °C to 85 °C and reweigh. The difference between the two weighings must not exceed 0,1 % of moisture.

4.3. *Preliminary drying*

4.3.1. Feed other than those coming under 4.3.2

Solid feed with a high moisture content which makes crushing difficult must be subjected to preliminary drying as follows:

Weigh 50 g of *uncrushed* sample to the nearest 10 mg (compressed or agglomerated feed may be roughly divided if necessary) in a suitable container (e.g. a 20 × 12 cm aluminium plate with a 0,5 cm rim). Leave to dry in an oven from 60 °C to 70 °C until the moisture content has been reduced to between 8 % and 12 %. Remove from the oven, leave to cool uncovered in the laboratory for one hour and weigh to the nearest 10 mg. Crush immediately as indicated in 4.1.1 and dry as indicated in 4.2.1 or 4.2.3 according to the nature of the feed.

4.3.2. Cereals

Grain with a moisture content of over 17 % must be subjected to preliminary drying as follows:

Weigh 50 g of unground grain to the nearest 10 mg in a suitable container (e.g. a 20 × 12 cm aluminium plate with a 0,5 cm rim). Leave to dry for 5 to 7 minutes in an oven at 130 °C. Remove from the oven, leave to cool uncovered in the laboratory for two hours and weigh to the nearest 10 mg. Grind immediately as indicated in 4.1.2 and dry as indicated in 4.2.2.

5. Calculation of results

The moisture content (X), as a percentage of the sample, is calculated by using the following formulae:

5.1. Drying without preliminary drying

$$X = \frac{(m - m_0)}{m} \times 100$$

where:

m = initial weight, in grammes, of the test sample,

m₀ = weight, in grammes, of the dry test sample.

5.2. Drying with preliminary drying

$$X_p = \left[\frac{(m_2 - m_0) \times m_1}{m_2} + m - m_1 \right] \times \frac{100}{m} = 100 \times \left(1 - \frac{m_1 \times m_0}{m \times m_2} \right)$$

where:

m = initial weight, in grammes, of the test sample,

m₁ = weight, in grammes, of the test sample after preliminary drying,

m₂ = weight, in grammes, of the test sample after crushing or grinding,

m₀ = weight, in grammes, of the dry test sample.

5.3. Repeatability

The difference between the results of two parallel determinations carried out on the same sample shall not exceed 0,2 % of the absolute value of moisture.

6. Observation

If crushing proves necessary and if this is seen to alter the moisture content of the product, the results of the analysis of the components of the feed must be corrected on the basis of the moisture content of the sample in its initial state.

B. DETERMINATION OF MOISTURE IN ANIMAL AND VEGETABLE FATS AND OILS

1. Purpose and scope

This method makes it possible to determine the water and volatile substances content of animal and vegetable fats and oils.

2. Principle

The sample is dried to constant weight (loss in weight between two successive weighings must be less than or equal to 1 mg) at 103 °C. The loss in weight is determined by weighing.

3. Apparatus

3.1. Flat-bottomed dish, of a corrosion-resistant material, 8 to 9 cm in diameter and approximately 3 cm high.

3.2. Thermometer with a strengthened bulb and expansion tube at the top end, graduated from approximately 80 °C to at least 110 °C, and approximately 10 cm in length.

3.3. Sand bath or electric hot-plate.

- 3.4. Desiccator, containing an efficient drying agent.
- 3.5. Analytical balance.

4. Procedure

Weigh out to the nearest mg approximately 20 g of the homogenised sample into the dry, weighed dish (3.1) containing the thermometer (3.2). Heat on the sand bath or hot-plate (3.3), stirring continuously with the thermometer, so that the temperature reaches 90 °C in about 7 minutes.

Reduce the heat, watching the frequency with which bubbles rise from the bottom of the dish. The temperature must not exceed 105 °C. Continue to stir, scraping the bottom of the dish, until bubbles stop forming.

In order to ensure complete elimination of moisture, reheat several times to 103 °C ± 2 °C, cooling to 93 °C between successive heatings. Then leave to cool to room temperature in the desiccator (3.4) and weigh. Repeat this operation until the loss in weight between two successive weighings no longer exceeds 2 mg.

N.B: An increase in the weight of the sample after repeated heating indicates an oxidation of the fat, in which case calculate the result from the weighing carried out immediately before the weight began to increase.

5. Calculation of results

The moisture content (X), as a percentage of the sample, is given by the following formula:

$$X = (m_1 - m_2) \times \frac{100}{m}$$

where:

- m = weight, in grammes, of the test sample,
- m_1 = weight, in grammes, of the dish with its contents before heating,
- m_2 = weight, in grammes, of the dish with its contents after heating.

Results lower than 0,05 % must be recorded as 'lower than 0,05 %'.

Repeatability

The difference in moisture between the results of two parallel determinations carried out on the same sample must not exceed 0,05 %, in absolute value.

C. DETERMINATION OF THE CONTENT OF CRUDE PROTEIN

1. Purpose and scope

This method makes it possible to determine the crude protein content of feed on the basis of the nitrogen content, determined according to the Kjeldahl method.

2. Principle

The sample is digested by sulphuric acid in the presence of a catalyst. The acid solution is made alkaline with sodium hydroxide solution. The ammonia is distilled and collected in a measured quantity of sulphuric acid, the excess of which is titrated with a standard solution of sodium hydroxide.

Alternatively, the liberated ammonia is distilled into an excess of boric acid solution, followed by titration with hydrochloric acid or sulphuric acid solution.

3. Reagents

- 3.1. Potassium sulphate.

- 3.2. Catalyst: copper (II) oxide CuO or copper (II) sulphate pentahydrate, CuSO₄ 5H₂O.
- 3.3. Granulated zinc.
- 3.4. Sulphuric acid, $\rho_{20} = 1,84$ g/ml.
- 3.5. Sulphuric acid, standard volumetric solution, $c(\text{H}_2\text{SO}_4) = 0,25$ mol/l.
- 3.6. Sulphuric acid, standard volumetric solution, $c(\text{H}_2\text{SO}_4) = 0,10$ mol/l.
- 3.7. Sulphuric acid, standard volumetric solution, $c(\text{H}_2\text{SO}_4) = 0,05$ mol/l.
- 3.8. Methyl red indicator; dissolve 300 mg of methyl red in 100 ml of ethanol, $\sigma = 95\% - 96\%$ (v/v).
- 3.9. Sodium hydroxide solution (Technical grade may be used) $\beta = 40$ g/100 ml (m/v: 40 %).
- 3.10. Sodium hydroxide, standard volumetric solution $c(\text{NaOH}) = 0,25$ mol/l.
- 3.11. Sodium hydroxide, standard volumetric solution $c(\text{NaOH}) = 0,10$ mol/l.
- 3.12. Granulated pumice stone, washed in hydrochloric acid and ignited.
- 3.13. Acetanilide (m.p. = 114 °C, N-content = 10,36 %).
- 3.14. Sucrose (nitrogen free).
- 3.15. Boric acid (H₃BO₃).
- 3.16. Methyl red indicator solution: dissolve 100 mg methyl red in 100 ml ethanol or methanol.
- 3.17. Bromocresol green solution: dissolve 100 mg bromocresol green in 100 ml ethanol or methanol.
- 3.18. Boric acid solution (10 g/l to 40 g/l depending on the apparatus used).

When colorimetric end-point detection is applied, methyl red and bromocresol indicators must be added to the boric acid solutions. If 1 litre of the boric acid solution is prepared, before adjusting to volume, 7 ml methyl red indicator solution (3.16) and 10 ml bromocresol green solution (3.17) shall be added.

Dependent on the water used, the pH of the boric acid solution might differ from batch to batch. Often an adjustment with a small volume of alkali is necessary to obtain a positive blank.

Note: The addition of about 3 ml to 4 ml of NaOH (3.11) into 1 litre of 10 g/l boric acid usually gives good adjustments. Store the solution at room temperature and protect the solution from light and sources of ammonia fumes during storage.

- 3.19. Hydrochloric acid standard volumetric solution $c(\text{HCl}) = 0,10$ mol/l.

Note: Other concentrations of volumetric solutions (3.5, 3.6, 3.7, 3.10, 3.11, and 3.19) can be used, if this is corrected for in the calculations. The concentrations shall always be expressed to four decimal places.

4. **Apparatus**

Apparatus suitable for performing digestion, distillation and titration according to the Kjeldahl procedure.

5. **Procedure**

5.1. *Digestion*

Weigh 1 g of the sample to the nearest 0,001 g and transfer the sample to the flask of the digestion apparatus. Add 15 g of potassium sulphate (3.1), an appropriate quantity of catalyst (3.2) (0,3 to 0,4 g of copper (II) oxide or 0,9 to 1,2 g of copper (II) sulphate pentahydrate), 25 ml of sulphuric acid (3.4) and if required, a few granules of pumice stone (3.12) and mix.

Heat the flask moderately at first, swirling from time to time if necessary until the mass has carbonised and the foam has disappeared; then heat more intensively until the liquid is boiling steadily. Heating is adequate if the boiling acid condenses on the wall of the flask. Prevent the sides from becoming overheated and organic particles from sticking to them.

When the solution becomes clear and light green continue to boil for another two hours, then leave to cool.

5.2. *Distillation*

Add carefully enough water to ensure complete dissolution of the sulphates. Allow to cool and then add a few granules of zinc (3.3), if required. Proceed according to 5.2.1 or 5.2.2.

5.2.1. *Distillation into sulphuric acid*

Place in the collecting flask of the distillation apparatus an exactly measured quantity of 25 ml of sulphuric acid (3.5) or (3.7) depending on the presumed nitrogen content. Add a few drops of methyl red indicator (3.8).

Connect the digestion flask to the condenser of the distillation apparatus and immerse the end of the condenser in the liquid contained in the collecting flask to a depth of at least 1 cm (see observation 8.3). Slowly pour 100 ml of sodium hydroxide solution (3.9) into the digestion flask without loss of ammonia (see observation 8.1). Heat the flask until the ammonia has distilled over.

5.2.2. *Distillation into boric acid*

Where titration of the ammonia content of the distillate is performed manually, the procedure mentioned below applies. Where the distillation unit is fully automated to include titration of the ammonia content of the distillate, follow the manufacturer's instructions for operation of the distillation unit.

Place a collecting flask containing 25 ml to 30 ml of the boric acid solution (3.18) under the outlet of the condenser in such a way that the delivery tube is below the surface of the excess boric acid solution. Adjust the distillation unit to dispense 50 ml of sodium hydroxide solution (3.9). Operate the distillation unit in accordance with the manufacturer's instructions and distil off the ammonia liberated by the addition of the sodium hydroxide solution. Collect distillate in the boric acid receiving solution. The amount of distillate (time of steam distillation) depends on the amount of nitrogen in the sample. Follow the instructions of the manufacturer.

Note: In a semi-automatic distillation unit, the addition of excess sodium hydroxide and the steam distillation are performed automatically.

5.3. *Titration*

Proceed according to 5.3.1 or 5.3.2.

5.3.1. *Sulphuric acid*

Titrate the excess sulphuric acid in the collecting flask with sodium hydroxide solution (3.10 or 3.11) depending on the concentration of the sulphuric acid used, until the end-point is reached.

5.3.2. *Boric acid*

Titrate the contents of the collecting flask with the hydrochloric acid standard volumetric solution (3.19) or with the sulphuric acid standard volumetric solution (3.6) using a burette and read the amount of titrant used.

When colorimetric end-point detection is applied, the end-point is reached at the first trace of pink colour in the contents. Estimate the burette reading to the nearest 0,05 ml. An illuminated magnetic stirrer plate or a photometric detector may aid visualisation of the end-point.

This can be done automatically using a steam distiller with automatic titration.

Follow the manufacturers' instructions for operation of the specific distiller or distiller/titrator.

Note: When an automatic titration system is used, titration begins immediately after distillation starts and the 1 % boric acid solution (3.18) is used.

Where a fully automatic distillation unit is employed, the automatic titration of the ammonia can also be carried out with end-point detection using a potentiometric pH system.

In this case an automatic titrator, with a pH-meter is used. The pH-meter shall be calibrated properly in the range of pH 4 to pH 7 following normal laboratory pH-calibration procedures.

The pH end-point of the titration is reached at pH 4,6, being the steepest point in the titration curve (inflection point).

5.4. *Blank test*

To confirm that the reagents are free from nitrogen, carry out a blank test (digestion, distillation and titration) using 1 g of sucrose (3.14) in place of the sample.

6. **Calculation of results**

Calculations are performed according to 6.1 or 6.2.

6.1. *Calculation for titration according to 5.3.1*

The content of crude protein, expressed as a percentage by weight, is calculated according to the following formula:

$$\frac{(V_0 - V_1) \times c \times 0,014 \times 100 \times 6,25}{m}$$

where:

V_0 = is the volume (ml) of NaOH (3.10 or 3.11) used in the blank test,

V_1 = is the volume (ml) of NaOH (3.10 or 3.11) used in the sample titration,

c = is the concentration (mol/l) of sodium hydroxide (3.10 or 3.11),

m = is the weight (g) of sample.

6.2. *Calculation for titration according to 5.3.2*

6.2.1. *Titration with hydrochloric acid*

The content of crude protein, expressed as a percentage by weight, is calculated according to the following formula:

$$\frac{(V_1 - V_0) \times c \times 1,4 \times 6,25}{m}$$

where:

m = is the weight (g) of the test portion,

c = is the concentration (mol/l) of the standard volumetric solution of the hydrochloric acid (3.19),

V_0 = is the volume (in ml) of hydrochloric acid used for the blank test,

V_1 = is the volume (in ml) of hydrochloric acid used for the test portion.

6.2.2. *Titration with sulphuric acid*

The content of crude protein, expressed as a percentage by weight, is calculated according to the following formula:

$$\frac{(V_1 - V_0) \times c \times 2,8 \times 6,25}{m}$$

where:

m = is the weight (g) of the test portion,

c = is the concentration (mol/l) of the standard volumetric solution of sulphuric acid (3.6),

V_0 = is the volume (in ml) of sulphuric acid (3.6) used for the blank test,

V_1 = is the volume (in ml) of sulphuric acid (3.6) used for test portion.

7. Verification of the method

7.1. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed:

- 0,2 % in absolute value, for crude protein contents of less than 20 %,
- 1,0 % relative to the higher value, for crude protein contents from 20 % to 40 %,
- 0,4 % in absolute value, for crude protein contents of more than 40 %.

7.2. Accuracy

Carry out the analysis (digestion, distillation and titration) on 1,5 to 2,0 g of acetanilide (3.13) in the presence of 1 g of sucrose (3.14); 1 g acetanilide consumes 14,80 ml of sulphuric acid (3.5). Recovery must be at least 99 %.

8. Observations

- 8.1. Apparatus may be of the manual, semi-automatic or automatic type. If the apparatus requires transference between the digestion and distillation steps, this transfer must be carried out without loss. If the flask of the distillation apparatus is not fitted with a dropping funnel, add the sodium hydroxide immediately before connecting the flask to the condenser, pouring the liquid slowly down the side.
- 8.2. If the digest solidifies, recommence the determination using a larger amount of sulphuric acid (3.4) than that specified above.
- 8.3. For products with a low nitrogen content, the volume of sulphuric acid (3.7) to be placed in the collecting flask may be reduced, if necessary, to 10 or 15 ml and made up to 25 ml with water.
- 8.4. For routine analysis, alternative methods of analysis can be applied for the determination of crude protein but the Kjeldahl method described in this Part C is the reference method. The equivalence of the results obtained with the alternative method (e.g. DUMAS) compared to the reference method must be demonstrated for each matrix individually. As the results obtained with an alternative method, even after having verified the equivalency, might deviate slightly from the results obtained with the reference method, it is necessary to mention in the analytical report the method of analysis used for the determination of crude protein.

D. DETERMINATION OF UREA

1. Purpose and scope

This method makes it possible to determine the level of urea in feed.

2. Principle

The sample is suspended in water with a clarifying agent. The suspension is filtered. The urea content of the filtrate is determined after the addition of 4-dimethylaminobenzaldehyde (4-DMAB) by measuring the optical density at a wavelength of 420 nm.

3. Reagents

- 3.1. Solution of 4-dimethylaminobenzaldehyde: dissolve 1,6 g of 4-DMAB in 100 ml of 96 % ethanol and add 10 ml of hydrochloric acid (ρ_{20} 1,19 g/ml). This reagent keeps for a maximum period of two weeks.
- 3.2. Carrez solution I: dissolve in water 21,9 g of zinc acetate, $\text{Zn}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$ and 3 g of glacial acetic acid. Make up to 100 ml with water.
- 3.3. Carrez solution II: dissolve in water 10,6 g of potassium ferrocyanide, $\text{K}_4 \text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$. Make up to 100 ml with water.
- 3.4. Active carbon which does not absorb urea (to be checked).

- 3.5. Urea, 0,1 % solution (w/v).

4. **Apparatus**

- 4.1. Mixer (tumbler): approximately 35 to 40 r.p.m.
4.2. Test tubes: 160 × 16 mm with ground-glass stoppers.
4.3. Spectrophotometer.

5. **Procedure**

5.1. *Analysis of sample*

Weigh out 2 g of the sample to the nearest mg and place with 1 g of active carbon (3.4) in a 500 ml volumetric flask. Add 400 ml of water and 5 ml of Carrez solution I (3.2), mix for approximately 30 seconds and add 5 ml of Carrez solution II (3.3). Mix for 30 minutes in the tumbler. Make up to volume with water, shake and filter.

Remove 5 ml of the transparent colourless filtrates, place in test tubes with ground-glass stoppers, add 5 ml of 4-DMAB solution (3.1) and mix. Place the tubes in a water bath at 20 °C (+/- 4 °C). After 15 minutes measure the optical density of the sample solution with the spectrophotometer at 420 nm. Compare with the blank test solution of the reagents.

5.2. *Calibration curve*

Remove volumes of 1, 2, 4, 5 and 10 ml of the urea solution (3.5), place in 100 ml volumetric flasks and make up the volume with water. Remove 5 ml from each solution, add 5 ml of 4-DMAB solution (3.1) to each of them, homogenise and measure the optical density as shown above in comparison with a control solution containing 5 ml of 4-DMAB and 5 ml of water free from urea. Plot the calibration curve.

6. **Calculation of results**

Determine the amount of urea in the sample using the calibration curve.

Express the result as a percentage of the sample.

7. **Observations**

- 7.1. In the case of contents of urea exceeding 3 %, reduce the sample to 1 g or dilute the original solution so that there are not more than 50 mg of urea in 500 ml.
7.2. In the case of low contents of urea, increase the sample as long as the filtrate remains transparent and colourless.
7.3. If the sample contains simple nitrogenous compounds such as amino acids, the optical density shall be measured at 435 nm.

E. DETERMINATION OF VOLATILE NITROGENOUS BASES

I. **BY MICRODIFFUSION**

1. **Purpose and scope**

This method makes it possible to determine the content of volatile nitrogenous bases, expressed as ammonia, in feed.

2. **Principle**

The sample is extracted with water and the solution clarified and filtered. The volatile nitrogenous bases are displaced by microdiffusion using a solution of potassium carbonate, collected in a solution of boric acid and titrated with sulphuric acid.

3. Reagents

- 3.1. Trichloroacetic acid, solution 20 % (w/v).
- 3.2. Indicator: dissolve 33 mg of bromocresol green and 65 mg of methyl red in 100 ml of 95 %-96 % (v/v) of ethanol.
- 3.3. Boric acid solution: in a 1 litre graduated flask dissolve 10 g of boric acid in 200 ml of 95 %-96 % (v/v) ethanol and 700 ml of water. Add 10 ml of indicator (3.2). Mix and, if necessary, adjust the colour of the solution to light red by adding a solution of sodium hydroxide. 1 ml of this solution will fix a maximum of 300 µg of NH₃.
- 3.4. Saturated potassium carbonate solution: dissolve 100 g of potassium carbonate in 100 ml of boiling water. Leave to cool, filter.
- 3.5. Sulphuric acid 0,01 mol/litre.

4. Apparatus

- 4.1. Mixer (tumbler): approximately 35 to 40 r.p.m.
- 4.2. Glass or plastic Conway cells (see diagram).
- 4.3. Microburettes graduated in 1/100 ml.

5. Procedure

Weigh 10 g of sample to the nearest 1 mg and place with 100 ml of water in a 200 ml graduated flask. Mix or stir in the tumbler for 30 minutes. Add 50 ml of trichloroacetic acid solution (3.1), make up to volume with water, shake vigorously and filter through a pleated filter.

Using a pipette, introduce 1 ml of boric acid solution (3.3) into the central part of the Conway cell and 1 ml of the sample filtrate into the crown of the cell. Cover partially with the greased lid. Drop 1 ml of saturated potassium carbonate solution (3.4) quickly into the crown and close the lid so that the cell is airtight. Turn the cell carefully rotating it in a horizontal plane so that the two reagents are mixed. Leave to incubate either for at least four hours at room temperature or for one hour at 40 °C.

Using a microburette (4.3), titrate the volatile bases in the boric acid solution with sulphuric acid (3.5).

Carry out a blank test using the same procedure but without a sample to be analysed.

6. Calculation of results

1 ml of H₂SO₄ 0,01 mol/litre corresponds to 0,34 mg of ammonia.

Express the result as a percentage of the sample.

Repeatability

The difference between the results of two parallel determinations carried out on the same sample shall not exceed:

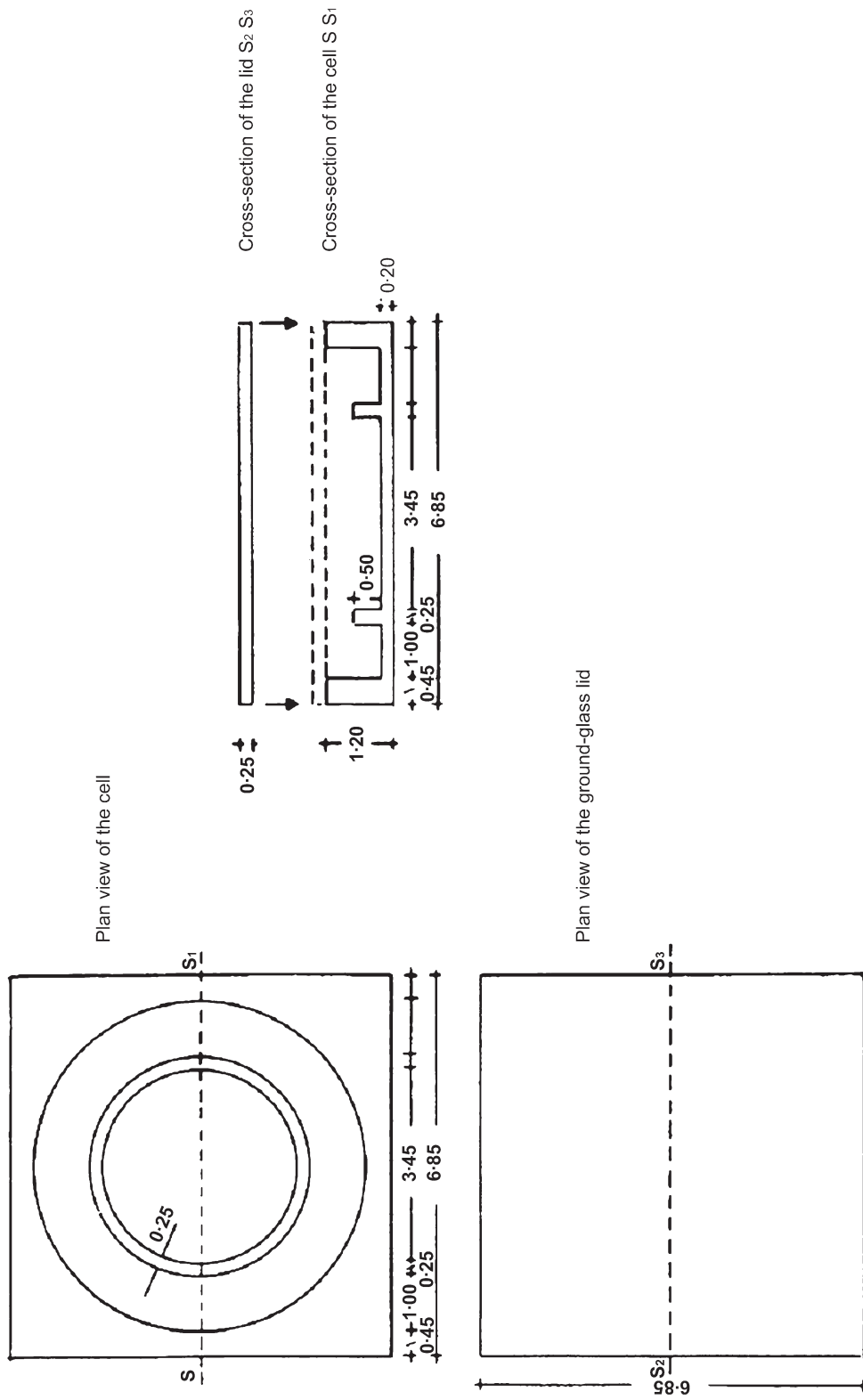
- 10 %, in relative value, for ammonia contents of less than 1,0 %,
- 0,1 %, in absolute value, for ammonia contents of 1,0 % or more.

7. Observation

If the ammonia content of the sample exceeds 0,6 %, dilute the initial filtrate.

CONWAY CELL

Scale 1/1



II. BY DISTILLATION

1. **Purpose and Scope**

This method makes it possible to determine the content of volatile nitrogenous bases, expressed as ammonia, in fish-meal containing practically no urea. It is applicable only to ammonia contents of less than 0,25 %.

2. **Principle**

The sample is extracted with water and the solution clarified and filtered. The volatile nitrogenous bases are displaced at boiling point by adding magnesium oxide and collected in a specific quantity of sulphuric acid, the excess of which is back-titrated with a solution of sodium hydroxide.

3. **Reagents**

- 3.1. Trichloroacetic acid, solution 20 % (w/v).
- 3.2. Magnesium oxide.
- 3.3. Anti-foaming emulsion (e.g. silicone).
- 3.4. Sulphuric acid 0,05 mol/litre.
- 3.5. Sodium hydroxide solution 0,1 mol/litre.
- 3.6. Methyl red solution 0,3 % in 95 %-96 % (v/v) ethanol.

4. **Apparatus**

- 4.1. Mixer (tumbler): approximately 35 to 40 r.p.m.
- 4.2. Distilling apparatus of the Kjeldahl type.

5. **Procedure**

Weigh 10 g of the sample to the nearest 1 mg and place with 100 ml of water in a 200 ml graduated flask. Mix or stir in the tumbler for 30 minutes. Add 50 ml of trichloroacetic acid solution (3.1), make up to volume with water, shake vigorously and filter through a pleated filter.

Take a quantity of clear filtrate appropriate for the presumed content of volatile nitrogenous bases (100 ml is usually suitable). Dilute to 200 ml and add 2 g of magnesium oxide (3.2) and a few drops of anti-foaming emulsion (3.3). The solution must be alkaline to litmus paper; otherwise add some magnesium oxide (3.2). Proceed according to 5.2 and 5.3 of the method of analysis for the determination of the crude protein content (Part C of this Annex).

Carry out a *blank test* using the same procedure but without a sample to be analysed.

6. **Calculation of results**

1 ml of H₂SO₄ 0,05 mol/litre corresponds to 1,7 mg of ammonia.

Express the result as a percentage of the sample.

Repeatability

The difference between the results of two parallel determinations carried out on the same sample shall not exceed, in relative value, 10 % of ammonia.

F. DETERMINATION OF AMINO ACIDS (EXCEPT TRYPTOPHANE)

1. **Purpose and scope**

This method makes the determination possible of free (synthetic and natural) and total (peptide bound and free) amino acids in feed, using an amino acid analyser. It is applicable to the following amino acids: cyst(e)ine,

methionine, lysine, threonine, alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, isoleucine, leucine, phenylalanine, proline, serine, tyrosine and valine.

The method does not distinguish between the salts of amino acids and it cannot differentiate between D and L forms of amino acids. It is not valid for the determination of tryptophan or hydroxy analogues of amino acids.

2. Principle

2.1. Free amino acids

The free amino acids are extracted with diluted hydrochloric acid. Co-extracted nitrogenous macromolecules are precipitated with sulfosalicylic acid and removed by filtration. The filtered solution is adjusted to pH 2,20. The amino acids are separated by ion exchange chromatography and determined by reaction with ninhydrin with photometric detection at 570 nm.

2.2. Total amino acids

The procedure chosen depends on the amino acids under investigation. Cyst(e)ine and methionine must be oxidised to cysteic acid and methionine sulphone respectively prior to hydrolysis. Tyrosine must be determined in hydrolysates of unoxidised samples. All the other amino acids listed in paragraph 1 can be determined in either the oxidised or unoxidised sample.

Oxidation is performed at 0 °C with a performic acid/phenol mixture. Excess oxidation reagent is decomposed with sodium disulphite. The oxidised or unoxidised sample is hydrolysed with hydrochloric acid (3.20) for 23 hours. The hydrolysate is adjusted to pH 2,20. The amino acids are separated by ion exchange chromatography and determined by reaction with ninhydrin using photometric detection at 570 nm (440 nm for proline).

3. Reagents

Double distilled water or water of equivalent quality must be used (conductivity < 10 µS).

3.1. Hydrogen peroxide, w (w/w) = 30 %.

3.2. Formic acid, w (w/w) = 98 %-100 %.

3.3. Phenol.

3.4. Sodium disulphite.

3.5. Sodium hydroxide.

3.6. 5-Sulfosalicylic acid dihydrate.

3.7. Hydrochloric acid, density approximately 1,18 g/ml.

3.8. tri-Sodium citrate dihydrate.

3.9. 2,2'-Thiodiethanol (thiodiglycol).

3.10. Sodium chloride.

3.11. Ninhydrin.

3.12. Light petroleum, boiling range 40-60 °C.

3.13. Norleucine, or other compound suitable for use as internal standard.

3.14. Nitrogen gas (< 10 ppm oxygen).

3.15. 1-Octanol.

- 3.16. Amino acids.
- 3.16.1. Standard substances listed under paragraph 1. Pure compounds containing no water of crystallisation. Dry under vacuum over P_2O_5 or H_2SO_4 for 1 week prior to use.
- 3.16.2. Cysteic acid.
- 3.16.3. Methionine sulphone.
- 3.17. Sodium hydroxide solution, $c = 7,5 \text{ mol/l}$:
Dissolve 300 g NaOH (3.5) in water and make up to 1 litre.
- 3.18. Sodium hydroxide solution, $c = 1 \text{ mol/l}$:
Dissolve 40 g NaOH (3.5) in water and make up to 1 litre.
- 3.19. Formic acid — phenol solution:
Mix 889 g formic acid (3.2) with 111 g water and add 4,73 g phenol (3.3).
- 3.20. Hydrolysis mixture, $c = 6 \text{ mol HCl/l}$ containing 1 g phenol/l:
Add 1 g phenol (3.3) to 492 ml HCl (3.7) and make up to 1 litre with water.
- 3.21. Extraction mixture, $c = 0,1 \text{ mol HCl/l}$ containing 2 % thiodiglycol: Take 8,2 ml HCl (3.7), dilute with approximately 900 ml water, add 20 ml thiodiglycol (3.9) and make up to 1 litre with water, (do not mix 3.7 and 3.9 directly).
- 3.22. 5-Sulfosalicylic acid, $\beta = 6 \%$:
Dissolve 60 g 5-sulfosalicylic acid (3.6) in water and make up to 1 l with water.
- 3.23. Oxidation mixture (Performic acid — phenol):
Mix 0,5 ml hydrogen peroxide (3.1) with 4,5 ml formic acid-phenol solution (3.19) in a small beaker. Incubate at 20-30 °C for 1 hour in order to form performic acid, then cool on an ice-water bath (15 min.) before adding to the sample.
Caution: Avoid contact with skin and wear protective clothing.
- 3.24. Citrate buffer, $c = 0,2 \text{ mol Na}^+/\text{l}$, pH 2,20:
Dissolve 19,61 g sodium citrate (3.8), 5 ml thiodiglycol (3.9), 1 g phenol (3.3) and 16,50 ml HCl (3.7) in approximately 800 ml water. Adjust pH to 2,20. Make up to 1 litre with water.
- 3.25. Elution buffers, prepared according to conditions for the analyser used (4.9).
- 3.26. Ninhydrin reagent, prepared according to conditions for the analyser used (4.9).
- 3.27. Standard solutions of amino acids. These solutions shall be stored below 5 °C.
- 3.27.1. Stock standard solution of amino acids (3.16.1).
 $c = 2,5 \text{ } \mu\text{mol/ml}$ of each in hydrochloric acid.
May be obtained commercially.
- 3.27.2. Stock standard solution of cysteic acid and methionine sulphone, $c = 1,25 \text{ } \mu\text{mol/ml}$.
Dissolve 0,2115 g cysteic acid (3.16.2) and 0,2265 g methionine sulphone (3.16.3) in citrate buffer (3.24) in a 1 litre graduated flask and make up to mark with citrate buffer. Store below 5 °C for not more than 12 months. This solution is not used if the stock standard solution (3.27.1) contains cysteic acid and methionine sulphone.

- 3.27.3. Stock standard solution of the internal standard e.g. norleucine, $c = 20 \mu\text{mol/ml}$.

Dissolve 0,6560 g norleucine (3.13) in citrate buffer (3.24) in a graduated flask and make up to 250 ml with citrate buffer. Store below 5 °C for no more than 6 months.

- 3.27.4. Calibration solution of standard amino acids for use with hydrolysates, $c = 5 \text{ nmol}/50 \mu\text{l}$ of cysteic acid and methionine sulphone and $c = 10 \text{ nmol}/50 \mu\text{l}$ of the other amino acids. Dissolve 2,2 g sodium chloride (3.10) in 100 ml beaker with 30 ml citrate buffer (3.24). Add 4,00 ml stock standard solution of amino acids (3.27.1), 4,00 ml stock standard solution of cysteic acid and methionine sulphone (3.27.2) and 0,50 ml stock standard solution of internal standard (3.27.3) if used. Adjust pH to 2,20 with sodium hydroxide (3.18).

Transfer quantitatively to a 50 ml graduated flask and make up to the mark with citrate buffer (3.24) and mix.

Store below 5 °C for not more than 3 months.

See also observation 9.1.

- 3.27.5. Calibration solution of standard amino acids for use with hydrolysates prepared according to paragraph 5.3.3.1 and for use with extracts (5.2). The calibration solution is prepared according to 3.27.4 but omitting sodium chloride.

Store below 5 °C for not more than 3 months.

4. **Apparatus**

- 4.1. 100 or 250 ml round bottomed flask fitted with a reflux condenser.
- 4.2. 100 ml borosilicate glass bottle with screw cap with rubber/teflon liner (e.g. Duran, Schott) for use in the oven.
- 4.3. Oven with forced ventilation and a temperature regulator with an accuracy better than $\pm 2 \text{ }^\circ\text{C}$.
- 4.4. pH-meter (three decimal places).
- 4.5. Membrane filter (0,22 μm).
- 4.6. Centrifuge.
- 4.7. Rotary vacuum evaporator.
- 4.8. Mechanical shaker or magnetic stirrer.
- 4.9. Amino acid analyser or HPLC equipment with ion exchange column, device for ninhydrin, post column derivatisation and photometric detector.

The column is filled with sulfonated polystyrene resins capable of separating the amino acids from each other and from other ninhydrin-positive materials. The flow in the buffer and ninhydrin lines is provided by pumps having a flow stability of $\pm 0,5 \%$ in the period covering both the standard calibration run and the analysis of the sample.

With some amino acid analysers hydrolysis procedures can be used in which the hydrolysate has a sodium concentration of $c = 0,8 \text{ mol/l}$ and contains all the residual formic acid from the oxidation step. Others do not give a satisfactory separation of certain amino acids if the hydrolysate contains excess formic acid and/or high sodium ion concentrations. In this case the volume of acid is reduced by evaporation to approx. 5 ml after the hydrolysis and prior to pH adjustment. The evaporation shall be performed under vacuum at 40 °C maximum.

5. **Procedure**

- 5.1. *Preparation of the sample*

The sample is ground to pass through a 0,5 mm sieve. Samples high in moisture must be either air-dried at a temperature not exceeding 50 °C or freeze dried prior to grinding. Samples with a high fat content shall be extracted with light petroleum (3.12) prior to grinding.

5.2. *Determination of free amino acids in feed and premixtures*

Weigh to the nearest 0,2 mg an appropriate amount (1-5 g) of the prepared sample (5.1), into a conical flask and add 100,0 ml of extraction mixture (3.21). Shake the mixture for 60 min. using a mechanical shaker or a magnetic stirrer (4.8). Allow the sediment to settle and pipette 10,0 ml of the supernatant solution into a 100 ml beaker.

Add 5,0 ml of sulfosalicylic acid solution (3.22), with stirring and continue to stir with the aid of magnetic stirrer for 5 min. Filter or centrifuge the supernatant in order to remove any precipitate. Place 10,0 ml of the resulting solution into a 100 ml beaker and adjust the pH to 2,20 using sodium hydroxide solution (3.18), transfer to a volumetric flask of appropriate volume using citrate buffer (3.24), and make up to the mark with the buffer solution (3.24).

If an internal standard is being used add 1,00 ml of internal standard (3.27.3) for each 100 ml final solution and make up to the mark with the buffer solution (3.24).

Proceed to the chromatography step according to paragraph 5.4.

If the extracts are not being examined the same day, they must be stored below 5 °C.

5.3. *Determination of total amino acids*

5.3.1. Oxidation

Weigh to the nearest 0,2 mg from 0,1 to 1 g of the prepared sample (5.1) into:

- a 100 ml round-bottomed flask (4.1) for open hydrolysis (5.3.2.3) or,
- a 250 ml round-bottomed flask (4.1) if a low sodium concentration is required (5.3.3.1) or,
- a 100 ml bottle fitted with a screw cap (4.2), for closed hydrolysis (5.3.2.4).

The weighed sample portion must have a nitrogen content of about 10 mg and a moisture content not exceeding 100 mg.

Place the flask/bottle in an ice-water bath and cool to 0 °C, add 5 ml of oxidation mixture (3.23) and mix using a glass spatula with a bent tip. Seal the flask/bottle containing the spatula with an air-tight film, place the ice-water bath containing the sealed container in a refrigerator at 0 °C and leave for 16 hours. After 16 hours remove from the refrigerator and decompose the excess oxidation reagent by the addition of 0,84 g of sodium disulphite (3.4).

Proceed to 5.3.2.1.

5.3.2. Hydrolysis

5.3.2.1. *Hydrolysis of oxidised samples*

To the oxidised sample prepared according to 5.3.1 add 25 ml of hydrolysis mixture (3.20) taking care to wash down any sample residue adhering to the sides of the vessel and the spatula.

Depending on the hydrolysis procedure being used, proceed according to 5.3.2.3 or 5.3.2.4.

5.3.2.2. *Hydrolysis of unoxidised samples*

Weigh into either a 100 ml or a 250 ml round-bottom flask (4.1) or a 100 ml bottle fitted with a screw cap (4.2), to the nearest 0,2 mg, from 0,1 to 1 g of the prepared sample (5.1). The weighed sample portion must have a nitrogen content of about 10 mg. Add carefully 25 ml of hydrolysis mixture (3.20) and mix with the sample. Proceed according to either 5.3.2.3 or 5.3.2.4.

5.3.2.3. *Open hydrolysis*

Add 3 glass beads to the mixture in the flask (prepared in accordance with 5.3.2.1 or 5.3.2.2) and boil with continuous bubbling under reflux for 23 hours. On completion of hydrolysis, wash the condenser down with 5 ml of citrate buffer (3.24). Disconnect the flask and cool it in an ice bath.

Proceed according to 5.3.3.

5.3.2.4. *Closed Hydrolysis*

Place the bottle containing the mixture prepared in accordance with 5.3.2.1 or 5.3.2.2 in an oven (4.3) at 110 °C. During the first hour in order to prevent a build up of pressure (due to the evolution of gaseous substances) and to avoid explosion, place the screw cap over the top of the vessel. Do not close the vessel with the cap. After one hour close the vessel with the cap and leave in the oven (4.3) for 23 hours. On completion of hydrolysis, remove the bottle from the oven, carefully open the cap of the bottle and place the bottle in an ice-water bath. Leave to cool.

Depending on the procedure for pH adjustment (5.3.3), quantitatively transfer the contents of the bottle to a 250 ml beaker or a 250 ml round-bottom flask, using citrate buffer (3.24).

Proceed according to 5.3.3.

5.3.3. Adjustment of pH

Depending on the sodium tolerance of the amino acid analyser (4.9) proceed according to 5.3.3.1 or 5.3.3.2 for the pH adjustment.

5.3.3.1. *For Chromatographic Systems (4.9) requiring a low sodium concentration*

It is advisable to use an internal stock standard solution (3.27.3) when amino acid analysers requiring a low sodium concentration are employed (when the acid volume has to be reduced).

In this case add 2,00 ml of the internal stock standard solution (3.27.3) to the hydrolysate before the evaporation.

Add 2 drops of 1-octanol (3.15) to the hydrolysate obtained in accordance with paragraph 5.3.2.3 or 5.3.2.4.

Using a rotary evaporator (4.7) reduce the volume to 5-10 ml under vacuum at 40 °C. If the volume is accidentally reduced to less than 5 ml the hydrolysate must be discarded and the analysis recommenced.

Adjust the pH to 2,20 with sodium hydroxide solution (3.18) and proceed to paragraph 5.3.4.

5.3.3.2. *For all other Amino Acid Analysers (4.9)*

Take the hydrolysates obtained in accordance with 5.3.2.3 or 5.3.2.4 and partly neutralise them by carefully adding with stirring, 17 ml of sodium hydroxide solution (3.17), ensuring that the temperature is kept below 40 °C.

Adjust the pH to 2,20 at room temperature using sodium hydroxide solution (3.17) and finally sodium hydroxide solution (3.18). Proceed to 5.3.4.

5.3.4. Sample solution for chromatography

Quantitatively transfer the pH adjusted hydrolysate (5.3.3.1 or 5.3.3.2) with citrate buffer (3.24) to a 200 ml graduated flask, and make up to the mark with buffer (3.24).

If an internal standard has not already been used, add 2,00 ml of internal standard (3.27.3) and make up to the mark with citrate buffer (3.24). Mix thoroughly.

Proceed to the chromatography step (5.4).

If the sample solutions are not being examined the same day they must be stored below 5 °C.

5.4. *Chromatography*

Before chromatography bring the extract (5.2) or hydrolysate (5.3.4) to room temperature. Shake the mixture and filter a suitable amount through a 0,22 µm membrane filter (4.5). The resulting clear solution is subjected to ion exchange chromatography, using an amino acid analyser (4.9).

The injection may be performed manually or automatically. It is important that the same quantity of solution ± 0,5 % is added to the column for the analysis of standards and samples except when an internal standard is used, and that the sodium:amino acid ratios in the standard and sample solutions are as similar as is practicable.

In general the frequency of calibration runs depends on the stability of the ninhydrin reagent and the analytical system. The standard or sample is diluted with citrate buffer (3.24) to give a peak area of the standard of 30 %-200 % of the sample amino acid peak area.

The chromatography of amino acids will vary slightly according to the type of analyser employed and resin used. The chosen system must be capable of separating the amino acids from each other and from the ninhydrin-positive materials. In the range of operation the chromatographic system must give a linear response to changes in the amounts of amino acids added to the column.

During the chromatography step the valley:peak height ratios mentioned below apply, when an equimolar solution (of the amino acids being determined) is analysed. This equimolar solution must contain at least 30 % of the maximum load of each amino acid which can be accurately measured with the amino acid analyser system (4.9).

For separation of threonine-serine the valley:peak height ratio of the lower of the two overlapping amino acids on the chromatogram must not exceed 2:10. (if only cyst(e)ine, methionine, threonine and lysine are determined, insufficient separation from adjoining peaks will adversely influence the determination). For all other amino acids the separation must be better than 1:10.

The system must ensure that lysine is separated from 'lysine artifacts' and ornithine.

6. Calculation of results

The area of the sample and standard peaks is measured for each individual amino acid and the amount (X), in g amino acid per kg sample, is calculated as follows:

$$X = \frac{A \times c \times M \times V}{B \times m \times 1\,000}$$

If an internal standard is used multiply by: $\frac{D}{C}$

A = peak area, hydrolysate or extract

B = peak area, calibration standard solution

C = peak area, internal standard in hydrolysate or extract

D = peak area, internal standard, calibration standard solution

M = molar weight of the amino acid being determined

c = concentration of standard in $\mu\text{mol/ml}$

m = sample weight (g) (corrected to original weight if dried or defatted)

V = ml total hydrolysate (5.3.4) or ml calculated total dilution volume of extract (6.1)

Cystine and cysteine are both determined as cysteic acid in hydrolysates of oxidised sample, but calculated as cystine ($\text{C}_6\text{H}_{12}\text{N}_2\text{O}_4\text{S}_2$, M 240,30 g/mol) by using M 120,15 g/mol (= 0,5 x 240,30 g/mol).

Methionine is determined as methionine sulphone in hydrolysates of oxidised sample, but calculated as methionine by using M of methionine: 149,21 g/mol.

Added free methionine is determined after extraction as methionine, for the calculation the same M is used.

6.1. The total dilution volume of extracts (F) for determination of free amino acids (5.2) is calculated as follows:

$$F = \frac{100 \text{ ml} \times (10 \text{ ml} + 5 \text{ ml})}{10 \text{ ml}} \times \frac{V}{10}$$

V = Volume of final extract

7. Evaluation of the method

The method has been tested in an intercomparison made at international level in 1990 using four different feed (mixed pig feed, broiler compound, protein concentrate, premixture). The results, after elimination of outliers, of mean and standard deviation are given in the tables in this point:

Means in g/kg

Reference material	Amino Acid			
	Threonine	Cyst(e)ine	Methionine	Lysine
Mixed Pig Feed	6,94 n = 15	3,01 n = 17	3,27 n = 17	9,55 n = 13
Broiler Compound	9,31 n = 16	3,92 n = 18	5,08 n = 18	13,93 n = 16
Protein Concentrate	22,32 n = 16	5,06 n = 17	12,01 n = 17	47,74 n = 15
Premixture	58,42 N = 16	—	90,21 n = 16	98,03 n = 16

n = Number of participating laboratories.

7.1. Repeatability

The repeatability expressed as 'within laboratory standard deviation' of the abovementioned intercomparison is given in the tables below:

Within Laboratory Standard Deviation (S_r) in g/kg

Reference material	Amino Acid			
	Threonine	Cyst(e)ine	Methionine	Lysine
Mixed Pig Feed	0,13 n = 15	0,10 n = 17	0,11 n = 17	0,26 n = 13
Broiler Compound	0,20 n = 16	0,11 n = 18	0,16 n = 18	0,28 n = 16
Protein Concentrate	0,48 n = 16	0,13 n = 17	0,27 n = 17	0,99 n = 15
Premixture	1,30 N = 16	—	2,19 n = 16	2,06 n = 16

n = Number of participating laboratories.

Coefficient of Variation (%) for Within Laboratory Standard Deviation (S_r)

Reference material	Amino Acid			
	Threonine	Cyst(e)ine	Methionine	Lysine
Mixed Pig Feed	1,9 n = 15	3,3 n = 17	3,4 n = 17	2,8 n = 13
Broiler Compound	2,1 n = 16	2,8 n = 18	3,1 n = 18	2,1 n = 16
Protein Concentrate	2,7 n = 16	2,6 n = 17	2,2 n = 17	2,4 n = 15

Reference material	Amino Acid			
	Threonine	Cyst(e)ine	Methionine	Lysine
Premixture	2,2 n = 16	—	2,4 n = 16	2,1 n = 16

n = Number of participating laboratories.

7.2 Reproducibility

The results for between laboratory standard deviation by the abovementioned intercomparison are given in the table below:

Between Laboratory Standard Deviation (S_R) in g/kg

Reference material	Amino Acid			
	Threonine	Cyst(e)ine	Methionine	Lysine
Mixed Pig Feed	0,28 n = 15	0,30 n = 17	0,23 n = 17	0,30 n = 13
Broiler Compound	0,48 n = 16	0,34 n = 18	0,55 n = 18	0,75 n = 16
Protein Concentrate	0,85 n = 16	0,62 n = 17	1,57 n = 17	1,24 n = 15
Premixture	2,49 n = 16	—	6,20 n = 16	6,62 n = 16

n = Number of participating laboratories.

Coefficient of Variation (%) for Between Laboratory Standard Deviation (S_R)

Reference material	Amino Acid			
	Threonine	Cyst(e)ine	Methionine	Lysine
Mixed Pig Feed	4,1 n = 15	9,9 n = 17	7,0 n = 17	3,2 n = 13
Broiler Compound	5,2 n = 16	8,8 n = 18	10,9 n = 18	5,4 n = 16
Protein Concentrate	3,8 n = 16	12,3 n = 17	13,0 n = 17	3,0 n = 15
Premixture	4,3 n = 16	—	6,9 n = 16	6,7 n = 16

n = Number of participating laboratories.

8. Use of reference materials

The correct application of the method shall be verified by making replicate measurements of certified reference materials when available. Calibration with certified amino acid calibration solution is recommended.

9. Observations

- 9.1. Because of differences between amino acid analysers the final concentrations of the calibration solutions of standard amino acids (see 3.27.4 and 3.27.5) and of the hydrolysate (see 5.3.4) shall be taken as a guideline.

The range of linear response of the apparatus has to be checked for all amino acids.

The standard solution is diluted with citrate buffer to give peak areas in the middle of the range.

- 9.2. Where high performance liquid chromatographic equipment is used to analyse the hydrolysates, the experimental conditions must be optimised in accordance with the manufacturer's recommendations.
- 9.3. By applying the method to feed containing more than 1 % chloride (concentrate, mineral feeds, supplementary feeds) underestimation of methionine could occur and special treatment has to be done.

G. DETERMINATION OF TRYPTOPHAN

1. Purpose and scope

The method makes the determination possible of the total and free tryptophan in feed. It does not distinguish between D- and L- forms.

2. Principle

For the determination of the total tryptophan, the sample is hydrolysed under alkaline conditions with saturated barium hydroxide solution and heated to 110 °C for 20 hours. After hydrolysis internal standard is added.

For the determination of free tryptophan, the sample is extracted under mild acidic conditions in the presence of internal standard.

The tryptophan and the internal standard in the hydrolysate or in the extract are determined by HPLC with fluorescence detection.

3. Reagents

- 3.1. Double distilled water or water of equivalent quality must be used (conductivity < 10 µS/cm).
- 3.2. Standard substance: tryptophan (purity/content ≥ 99 %) dried under vacuum over phosphorous pentoxide.
- 3.3. Internal standard substance: α-methyl-tryptophan (purity/content ≥ 99 %), dried under vacuum over phosphorous pentoxide.
- 3.4. Barium hydroxide octa-hydrate (care shall be taken not to expose the Ba(OH)₂ · 8 H₂O excessively to air in order to avoid formation of BaCO₃, which could disturb the determination) (see observation 9.3).
- 3.5. Sodium hydroxide.
- 3.6. Ortho-phosphoric acid, w (w/w) = 85 %.
- 3.7. Hydrochloric acid, ρ₂₀ 1,19 g/ml.
- 3.8. Methanol, equivalent to HPLC grade.
- 3.9. Light petroleum, boiling range 40-60 °C.
- 3.10. Sodium hydroxide solution, c = 1 mol/l:

Dissolve 40,0 g NaOH (3.5) in water and make up to 1 litre with water (3.1).
- 3.11. Hydrochloric acid, c = 6 mol/l:

Take 492 ml HCl (3.7) and make up to 1 litre with water.

- 3.12. Hydrochloric acid, $c = 1 \text{ mol/l}$:
Take 82 ml HCl (3.7) and make up to 1 litre with water.
- 3.13. Hydrochloric acid, $c = 0,1 \text{ mol/l}$:
Take 8,2 ml HCl (3.7) and make up to 1 litre with water.
- 3.14. Ortho-phosphoric acid, $c = 0,5 \text{ mol/l}$:
Take 34 ml ortho-phosphoric acid (3.6) and make up to 1 litre with water (3.1).
- 3.15. Concentrated solution of tryptophan (3.2), $c = 2,50 \text{ } \mu\text{mol/ml}$:
In a 500 ml volumetric flask dissolve 0,2553 g tryptophan (3.2) in hydrochloric acid (3.13) and make up to the mark with hydrochloric acid (3.13). Store at $-18 \text{ }^\circ\text{C}$ for a maximum of 4 weeks.
- 3.16. Concentrated internal standard solution, $c = 2,50 \text{ } \mu\text{mol/ml}$:
In a 500 ml volumetric flask dissolve 0,2728 g α -methyl-tryptophan (3.3) in hydrochloric acid (3.13) and make up to the mark with hydrochloric acid (3.13). Store at $-18 \text{ }^\circ\text{C}$ for a maximum of 4 weeks.
- 3.17. Calibration standard solution of tryptophan and internal standard:
Take 2,00 ml concentrated solution of tryptophan (3.15), and 2,00 ml of concentrated internal standard (α -methyl-tryptophan) solution (3.16). Dilute with water (3.1) and methanol (3.8) to approximately the same volume and to approximately the same concentration of methanol (10 %-30 %) as the finished hydrolysate.

This solution must be prepared freshly before use.

Protect from direct sunlight during preparation.
- 3.18. Acetic acid
- 3.19. 1,1,1-trichloro-2-methyl-2-propanol.
- 3.20. Ethanolamine w (w/w) > 98 %.
- 3.21. Solution of 1 g 1,1,1-trichloro-2-methyl-2-propanol (3.19) in 100 ml methanol (3.8).
- 3.22. Mobile phase for HPLC: 3,00 g acetic acid (3.18) + 900 ml water (3.1) + 50,0 ml solution (3.21) of 1,1,1-trichloro-2-methyl-2-propanol (3.19) in methanol (3.8) (1g/100ml). Adjust pH to 5,00 using ethanolamine (3.20). Make up to 1 000 ml with water (3.1).
4. **Apparatus**
- 4.1. HPLC equipment with a spectrofluorometric detector.
- 4.2. Liquid chromatographic column, 125 mm x 4 mm, C_{18} , 3 μm packing, or equivalent.
- 4.3. pH-meter.
- 4.4. Polypropylene flask, capacity 125 ml, with wide neck and screw cap.
- 4.5. Membrane filter, 0,45 μm .
- 4.6. Autoclave, 110 (± 2) $^\circ\text{C}$, 1,4 ($\pm 0,1$) bar.
- 4.7. Mechanical shaker or magnetic stirrer.
- 4.8. Vortex mixer.

5. Procedure

5.1. Preparation of samples

The sample is ground to pass through a 0,5 mm sieve. Samples high in moisture must be either air-dried at a temperature not exceeding 50 °C or freeze dried prior to grinding. Samples with high fat content shall be extracted with light petroleum (3.9) prior to grinding.

5.2. Determination of free tryptophan (extract)

Weigh to the nearest 1 mg an appropriate amount (1-5 g) of the prepared sample (5.1), into a conical flask. Add 100,0 ml hydrochloric acid, (3.13) and 5,00 ml concentrated internal standard solution (3.16). Shake or mix for 60 min. using a mechanical shaker or a magnetic stirrer (4.7). Allow the sediment to settle and pipette 10,0 ml of the supernatant solution into a beaker. Add 5 ml ortho-phosphoric acid (3.14). Adjust the pH to 3 using sodium hydroxide (3.10). Add sufficient methanol (3.8) to give a concentration of between 10 % and 30 % of methanol in the final volume. Transfer to a volumetric flask of appropriate volume and dilute with water to a volume necessary for the chromatography (approx. the same volume as the calibration standard solution (3.17)).

Filter a few ml of the solution through a 0,45 µm membrane filter (4.5) before injection on the HPLC column. Proceed to the chromatography step according to paragraph 5.4.

Protect standard solution and extracts against direct sunlight. If it is not possible to analyse the extracts the same day, the extracts may be stored at 5 °C for a maximum of 3 days.

5.3. Determination of total tryptophan (hydrolysate)

Weigh to the nearest 0,2 mg from 0,1 to 1 g of the prepared sample (5.1) into the polypropylene flask (4.4). The weighed sample portion shall have a nitrogen content of about 10 mg. Add 8,4 g barium hydroxide octa-hydrate (3.4) and 10 ml water. Mix on a vortex mixer (4.8) or magnetic stirrer (4.7). Leave the teflon coated magnet in the mixture. Wash down the walls of the vessel with 4 ml water. Put on the screw cap and close the flask loosely. Transfer to an autoclave (4.6) with boiling water and steam for 30-60 minutes. Close the autoclave and autoclave at 110 (± 2) °C for 20 hours.

Before opening the autoclave reduce the temperature to just under 100 °C. In order to avoid crystallisation of $\text{Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}$, add to the warm mixture 30 ml water which is at room temperature. Shake or stir gently. Add 2,00 ml concentrated internal standard (α -methyl-tryptophan) solution (3.16). Cool the vessels on water/ice bath for 15 minutes.

Then, add 5 ml ortho-phosphoric acid (3.14). Keep the vessel in the cooling bath and neutralise with HCl (3.11) whilst stirring and adjust the pH to 3,0 using HCl (3.12). Add sufficient methanol to give a concentration of between 10 % and 30 % of methanol in the final volume. Transfer to a volumetric flask of appropriate volume and dilute with water to the defined volume necessary for the chromatography (for example 100 ml). The addition of methanol shall not cause precipitation.

Filter a few ml of the solution through a 0,45 µm membrane filter (4.5) before injection on the HPLC column. Proceed to the chromatography step according to paragraph 5.4.

Protect standard solution and hydrolysates against direct sunlight. If it is not possible to analyse the hydrolysates the same day, they may be stored at 5 °C for a maximum of 3 days.

5.4. HPLC determination

The following conditions for isocratic elution are offered for guidance; other conditions may be used, provided they yield equivalent results (see also observations 9.1 and 9.2):

Liquid chromatographic column (4.2):	125 mm x 4 mm, C ₁₈ , 3 µm packing or equivalent
Column temperature:	Room temperature
Mobile phase (3.22):	3,00 g acetic acid (3.18) + 900 ml water (3.1) + 50,0 ml solution (3.21) of 1,1,1-trichloro-2- methyl-2-propanol (3.19) in methanol (3.8) (1 g/100 ml). Adjust pH to 5,00 using ethanolamine (3.20). Make up to 1 000 ml with water (3.1)
Flow rate:	1 ml/min.
Total run time:	approx. 34 min.
Detection wavelength:	excitation: 280 nm, emission: 356 nm.
Injection volume	20 µl

6. Calculation of results

The amount of tryptophane (X), in g per 100g sample, is calculated as follows:

$$X = \frac{A \times B \times V_1 \times c \times V_2 \times M}{C \times D \times V_3 \times 10\,000 \times m}$$

A = peak area of internal standard, calibration standard solution (3.17)

B = peak area of tryptophan, extract (5.2) or hydrolysate (5.3)

V₁ = volume in ml (2 ml) of concentrated tryptophan solution (3.15) added to the calibration solution (3.17)

c = concentration in µmol/ml (= 2,50) of concentrated tryptophan solution (3.15) added to calibration solution (3.17)

V₂ = volume in ml of concentrated internal standard solution (3.16) added at the extraction (5.2) (= 5,00 ml) or to the hydrolysate (5.3) (= 2,00 ml)

C = peak area of internal standard, extract (5.2) or hydrolysate (5.3)

D = peak area of tryptophan, calibration standard solution (3.17)

V₃ = volume in ml (= 2,00 ml) of concentrated internal standard solution (3.16) added to calibration standard solution (3.17)

m = sample weight in g (corrected to original weight if dried and/or defatted)

M = molar weight of tryptophan (= 204,23 g/mol)

7. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed 10 % relative to the highest result.

8. Results of a collaborative study

An EC collaborative study (4th intercomparison) was arranged in which three samples were analysed by up to 12 laboratories to certify the method for hydrolysis. Replicate (5) analyses were performed on each sample. The results are given in the following table:

	Sample 1 Pig feed	Sample 2 Pig feed supplemented with L-tryptophan	Sample 3 Feed concentrate for pigs
L	12	12	12
n	50	55	50
Mean [g/kg]	2,42	3,40	4,22
s _r [g/kg]	0,05	0,05	0,08
r [g/kg]	0,14	0,14	0,22
CV _r [%]	1,9	1,6	1,9
S _R [g/kg]	0,15	0,20	0,09
R [g/kg]	0,42	0,56	0,25
CV _R [%]	6,3	6,0	2,2

L = number of laboratories submitting results

n = number of single results retained eliminating outliers (identified by Cochran, Dixon outlier test)

s_r = standard deviation of repeatability

S_R = standard deviation of reproducibility

r = repeatability

R = reproducibility

CV_r = coefficient of variation of repeatability, %

CV_R = coefficient of variation of reproducibility, %

Another EC collaborative study (3rd intercomparison) was arranged in which two samples were analysed by up to 13 laboratories to certify the method for extraction of free tryptophan. Replicate (5) analyses were performed on each sample. The results are given in the following table:

	Sample 4 Wheat and soya mixture	Sample 5 Wheat and soya mixture (= sample 4) with added tryptophan (0,457g/kg1)
L	12	12
n	55	60
Mean [g/kg]	0,391	0,931
s_r [g/kg]	0,005	0,012
r [g/kg]	0,014	0,034
CV_r [%]	1,34	1,34
S_R [g/kg]	0,018	0,048
R [g/kg]	0,050	0,134
CV_R [%]	4,71	5,11

L = number of laboratories submitting results

n = number of single results retained after eliminating outliers (identified by Cochran, Dixon outlier test)

s_r = standard deviation of repeatability

S_R = standard deviation of reproducibility

r = repeatability

R = reproducibility

CV_r = coefficient of variation of repeatability, %

CV_R = coefficient of variation of reproducibility, %

Another EC intercomparison study was arranged in which four samples were analysed by up to 7 laboratories with the aim of a tryptophan certification for hydrolysis. The results are given below. Replicate (5) analyses were performed on each sample.

	Sample 1 Mixed pig feed (CRM 117)	Sample 2 Low fat fish meal (CRM 118)	Sample 3 Soybean meal (CRM 119)	Sample 4 Skimmed milk powder (CRM 120)
L	7	7	7	7
n	25	30	30	30
Mean [g/kg]	2,064	8,801	6,882	5,236
s_r [g/kg]	0,021	0,101	0,089	0,040
r [g/kg]	0,059	0,283	0,249	0,112
CV_r [%]	1,04	1,15	1,30	0,76
S_R [g/kg]	0,031	0,413	0,283	0,221
R [g/kg]	0,087	1,156	0,792	0,619
CV_R [%]	1,48	4,69	4,11	4,22

L = number of laboratories submitting results

n = number of single results retained after eliminating outliers (identified by Cochran, Dixon outlier test)

s_r = standard deviation of repeatability

S_R = standard deviation of reproducibility

r = repeatability

R = reproducibility

CV_r = coefficient of variation of repeatability, %

CV_R = coefficient of variation of reproducibility, %

9. Observations

- 9.1. Following special chromatographic conditions may give better separation between tryptophan and α -methyl-tryptophan.

Isocratic elution followed by gradient column cleaning:

Liquid chromatographic column:	125 mm x 4 mm, C ₁₈ , 5 µm packing or equivalent		
Column temperature:	32 °C		
Mobile phase:	A: 0,01 mol/l KH ₂ PO ₄ /méthanol, 95+5 (V+V). B: methanol		
Gradient program:	0 min.	100 % A	0 % B
	15 min.	100 % A	0 % B
	17 min.	60 % A	40 % B
	19 min.	60 % A	40 % B
	21 min.	100 % A	0 % B
	33 min.	100 % A	0 % B
Flow rate:	1,2 ml/min.		
Total run time:	approx. 33 min.		

- 9.2. The chromatography will vary according to the type of HPLC and column packing material used. The chosen system must be capable of giving baseline separation between the tryptophan and the internal standard. Moreover it is important that degradation products are well separated from the tryptophan and the internal standard. Hydrolysates without internal standard shall be run in order to check the base line under the internal standard for impurities. It is important that the run time is sufficiently long for the elution of all the degradation products, otherwise late eluting peaks may interfere with subsequent chromatographic runs.

In the range of operation, the chromatographic system shall give linear response. The linear response shall be measured with a constant (the normal) concentration of the internal standard and varying concentrations of tryptophan. It is of importance that the size of both the tryptophan and internal standard peaks are within the linear range of the HPLC/fluorescence system. If either the tryptophan and/or the internal standard peak(s) is (are) too small or too high the analysis shall be repeated with another sample size and/or a changed final volume.

- 9.3. *Barium hydroxide*

With age barium hydroxide becomes more difficult to dissolve. This results in an unclear solution for the HPLC determination, which may produce low results for tryptophan.

H. DETERMINATION OF CRUDE OILS AND FATS

1. Purpose and scope

This method is for the determination of crude oils and fats in feed. It does not cover the analysis of oil seeds and oleaginous fruit.

The use of the two procedures described below depends on the nature and composition of the feed and the reason for carrying out the analysis.

- 1.1. *Procedure A — Directly extractable crude oils and fats*

This method is applicable to feed materials of plant origin, except those included within the scope of Procedure B.

- 1.2. *Procedure B — Total crude oils and fats*

This method is applicable to feed materials of animal origin and to all compound feeds. It is to be used for all materials from which the oils and fats cannot be completely extracted without prior hydrolysis (e.g. glutens, yeast, potato proteins and products subjected to processes such as extrusion, flaking and heating).

- 1.3. *Interpretation of results*

In all cases where a higher result is obtained by using Procedure B than by Procedure A, the result obtained by Procedure B shall be accepted as the true value.

2. Principle

2.1. Procedure A

The sample is extracted with light petroleum. The solvent is distilled off and the residue dried and weighed.

2.2. Procedure B

The sample is treated under heating with hydrochloric acid. The mixture is cooled and filtered. The residue is washed and dried and submitted to the determination according to Procedure A.

3. Reagents

3.1. Light petroleum, boiling range: 40 to 60 °C. The bromine value must be less than 1 and the residue on evaporation less than 2 mg/100 ml.

3.2. Sodium sulfate, anhydrous.

3.3. Hydrochloric acid, $c = 3 \text{ mol/l}$

3.4. Filtration aid, e.g. Kieselguhr, Hyflo-supercel.

4. Apparatus

4.1. Extraction apparatus. If fitted with a siphon (Soxhlet apparatus), the reflux rate shall be such as to produce about 10 cycles per hour; if of the non-siphoning type, the reflux rate shall be about 10 ml per minute.

4.2. Extraction thimbles, free of matter soluble in light petroleum and having a porosity consistent with the requirements of point 4.1.

4.3. Drying oven, either a vacuum oven set at $75 \pm 3 \text{ °C}$ or an air-oven set at $100 \pm 3 \text{ °C}$.

5. Procedure

5.1. Procedure A (see point 8.1)

Weigh 5 g of the sample to the nearest 1 mg, transfer it to an extraction thimble (4.2) and cover with a fat-free wad of cotton wool.

Place the thimble in an extractor (4.1) and extract for six hours with light petroleum (3.1). Collect the light petroleum extract in a dry, weighed flask containing fragments of pumice stone ⁽¹⁾.

Distil off the solvent. Dry the residue maintaining the flask for one and a half hours in the drying oven (4.3). Leave to cool in a desiccator and weigh. Dry again for 30 minutes to ensure that the weight of the oils and fats remains constant (loss in weight between two successive weighings must be less than or equal to 1 mg).

5.2. Procedure B

Weigh 2,5 g of the sample to the nearest 1 mg (see point 8.2), place in a 400 ml beaker or a 300 ml conical flask and add 100 ml of hydrochloric acid (3.3) and fragments of pumice stone. Cover the beaker with a watch glass or fit the conical flask with a reflux condenser. Bring the mixture to a gentle boil over a low flame or a hot-plate and keep it there for one hour. Do not allow the product to stick to the sides of the container.

Cool and add a quantity of filtration aid (3.4) sufficient to prevent any loss of oil and fat during filtration. Filter through a moistened, fat-free, double filter paper. Wash the residue in cold water until a neutral filtrate is obtained. Check that the filtrate does not contain any oil or fats. Their presence indicates that the sample must be extracted with light petroleum, using Procedure A, before hydrolysis.

⁽¹⁾ Where the oil or fat has to undergo subsequent quality tests, replace the fragments of pumice stone by glass beads.

Place the double filter paper containing the residue on a watch glass and dry for one and a half hours in the air oven (4.3) at 100 ± 3 °C.

Place the double filter paper containing the dry residue in an extraction thimble (4.2) and cover with a fat-free wad of cotton wool. Place the thimble in an extractor (4.1) and proceed as indicated in the second and third paragraphs of point 5.1.

6. **Expression of result**

Express the weight of the residue as a percentage of the sample.

7. **Repeatability**

The difference between the results of two parallel determinations carried out on the same sample by the same analyst shall not exceed:

- 0,2 %, in absolute value, for contents of crude oils and fats lower than 5 %,
- 4,0 % relative to the highest result for contents of 5 % to 10 %,
- 0,4 %, in absolute value, for contents above 10 %.

8. **Observations**

8.1. For products with a high content of oils and fats, which are difficult to crush or unsuitable for drawing a homogeneous reduced test sample, proceed as follows.

Weigh 20 g of the sample to the nearest 1 mg and mix with 10 g or more of anhydrous sodium sulfate (3.2). Extract with light petroleum (3.1) as indicated in point 5.1. Make up the extract obtained to 500 ml with light petroleum (3.1) and mix. Take 50 ml of the solution and place in a small, dry, weighed flask containing fragments of pumice stone. Distil off the solvent, dry and proceed as indicated in the last paragraph of point 5.1.

Eliminate the solvent from the extraction residue left in the thimble, crush the residue to a fineness of 1 mm, return it to the extraction thimble (do not add sodium sulfate) and proceed as indicated in the second and third paragraphs of point 5.1.

Calculate the content of oils and fats as a percentage of the sample by using the following formula:

$$(10m_1 + m_2) \times 5$$

where:

m_1 = weight in grams of the residue after the first extraction (aliquot part of the extract),
 m_2 = weight in grams of the residue after the second extraction.

- 8.2. For products low in oils and fats the test sample may be increased to 5 g.
- 8.3. Pet foods containing a high content of water may need to be mixed with anhydrous sodium sulfate prior to hydrolysis and extraction as per Procedure B.
- 8.4. In paragraph 5.2 it may be more effective to use hot water in place of cold water to wash the residue after filtration.
- 8.5. The drying time of 1,5 h may need to be extended for some feed. Excessive drying shall be avoided as this can lead to low results. A microwave oven can also be used.
- 8.6. Pre-extraction by Procedure A prior to hydrolysis and re-extraction by Procedure B is recommended if the crude oil/fat content is greater than 15 %. To some extent this depends on the nature of the feed and the nature of the oil/fat in the feed.

I. DETERMINATION OF CRUDE FIBRE

1. Purpose and scope

This method makes it possible to determine fat-free organic substances in feed which are insoluble in acid and alkaline media and are conventionally described as crude fibre.

2. Principle

The sample, defatted where necessary, is treated successively with boiling solutions of sulphuric acid and potassium hydroxide of specified concentrations. The residue is separated by filtration on a sintered-glass filter washed, dried, weighed and ashed within a range of 475 to 500 °C. The loss of weight resulting from ashing corresponds to the crude fibre present in the test sample.

3. Reagents

- 3.1. Sulphuric acid, $c = 0,13$ mol/l.
- 3.2. Anti-foaming agent (e.g. n-octanol).
- 3.3. Filter aid (Celite 545 or equivalent), heated at 500 °C for four hours (8.6).
- 3.4. Acetone.
- 3.5. Light petroleum boiling-range 40 to 60 °C.
- 3.6. Hydrochloric acid, $c = 0,5$ mol/l.
- 3.7. Potassium hydroxide solution, $c = 0,23$ mol/l.

4. Apparatus

- 4.1. Heating unit for digestion with sulphuric acid and potassium hydroxide solution, equipped with a support for the filter crucible (4.2) and provided with an outlet tube with a tap to the liquid outlet and vacuum, possibly with compressed air. Before use each day preheat the unit with boiling water for five minutes.
- 4.2. Glass filter crucible with fused sintered glass filter plate pore size 40-90 µm. Before first use, heat to 500 °C for a few minutes and cool (8.6).
- 4.3. Cylinder of at least 270 ml with a reflux condenser, suitable for boiling.
- 4.4. Drying oven with thermostat.
- 4.5. Muffle furnace with thermostat.
- 4.6. Extraction unit consisting of a support plate for the filter crucible (4.2) and with a discharge pipe with a tap to the vacuum and liquid outlet.
- 4.7. Connecting rings to assemble the heating unit (4.1), crucible (4.2) and cylinder (4.3) and to connect the cold extraction unit (4.6) and crucible.

5. Procedure

Weigh out 1 g of the prepared sample to the nearest 1 mg and place it in the crucible (4.2), (see observations 8.1, 8.2 and 8.3) and add 1 g of filter aid (3.3).

Assemble the heating unit (4.1) and the filter crucible (4.2), then attach the cylinder (4.3) to the crucible. Pour 150 ml of boiling sulphuric acid (3.1) into the assembled cylinder and crucible and if necessary add a few drops of anti-foaming agent (3.2).

Bring the liquid to the boil within 5 ± 2 minutes and boil vigorously for exactly 30 minutes.

Open the tap to the discharge pipe (4.1) and, under vacuum, filter the sulphuric acid through the filter crucible and wash the residue with three consecutive 30 ml portions of boiling water, ensuring that the residue is filtered dry after each washing.

Close the outlet tap and pour 150 ml boiling potassium hydroxide solution (3.7) to the assembled cylinder and crucible and add a few drops of anti-foaming agent (3.2). Bring the liquid to boiling point within 5 ± 2 minutes and boil vigorously for exactly 30 minutes. Filter and repeat the washing procedure used for the sulphuric acid step.

After the final washing and drying, disconnect the crucible and its contents and reconnect it to the cold extraction unit (4.6). Apply the vacuum and wash the residue in the crucible with three consecutive 25 ml portions of acetone (3.4) ensuring that the residue is filtered dry after each washing.

Dry the crucible to constant weight in the oven at 130 °C. After each drying cool in the desiccator and weigh rapidly. Place the crucible in a muffle furnace and ash to constant weight (loss in weight between two successive weightings must be less than or equal to 2 mg) at 475 °C to 500 °C for at least 30 minutes.

After each heating cool first in the furnace and then in the desiccator before weighing.

Carry out a blank test without the sample. Loss of weight resulting from ashing must not exceed 4 mg.

6. Calculation of results

The crude fibre content as a percentage of the sample is given by the expression:

$$X = \frac{(m_0 - m_1) \times 100}{m}$$

where:

m = weight of sample in g,

m₀ = loss of weight after ashing during the determination, in g,

m₁ = loss of weight after ashing during the blank test, in g.

7. Repeatability

The difference between two parallel determinations carried out on the same sample must not exceed:

- 0,6 % in absolute value for crude fibre contents lower than 10 %,
- 6 % relative to the higher result, for crude fibre contents equal to or greater than 10 %.

8. Observations

- 8.1. Feed containing more than 10 % crude fat must be defatted prior to analysis with light petroleum (3.5). Connect the filter crucible (4.2) and its contents to the cold extraction unit (4.6) and apply vacuum and wash the residue with three consecutive 30 ml portions of light petroleum, ensuring that the residue is dry. Connect the crucible and its contents to the heating unit (4.1) and continue as described under 5.
- 8.2. Feed containing fats which cannot be extracted directly with light petroleum (3.5) must be defatted as shown in 8.1 and defatted once more after boiling with acid. After boiling with acid and the subsequent washing connect the crucible and its contents to the cold extraction unit (4.6) and wash three times with 30 ml acetone followed by three further washings with 30 ml portions of light petroleum. Filter under vacuum until dry and continue the analysis as described under 5, beginning with potassium hydroxide treatment.

- 8.3. If the feed contains over 5 % of carbonates, expressed as calcium carbonate, connect the crucible (4.2) with the weighed sample to the heating unit (4.1). Wash the sample three times with 30 ml hydrochloric acid (3.6). After each addition let the sample stand for about one minute before filtering. Wash once with 30 ml water and then continue as described under 5.
- 8.4. If an apparatus in the form of a stand is used (several crucibles attached to the same heating unit) no two individual determinations on the same sample for analysis may be carried out in the same series.
- 8.5. If after boiling it is difficult to filter the acidic and basic solutions, use compressed air through the discharge pipe of the heating unit and then continue filtering.
- 8.6. The temperature for ashing shall not be higher than 500 °C in order to extend the lifetime of the glass filter crucibles. Care must be taken to avoid excessive thermal shock during heating and cooling cycles.

J. DETERMINATION OF SUGAR

1. Purpose and scope

This method makes it possible to determine the amount of reducing sugars and total sugars after inversion, expressed as glucose or where appropriate as sucrose, converting by the factor 0,95. It is applicable to compound feed. Special methods are provided for other feed. Where necessary, lactose shall be measured separately and taken into account when calculating the results.

2. Principle

The sugars are extracted in dilute ethanol; the solution is clarified with Carrez solutions I and II. After eliminating the ethanol, the quantities before and after inversion are determined by the Luff-Schoorl method.

3. Reagents

- 3.1. Ethanol solution 40 % (v/v) density: 0,948 g/ml at 20 °C, neutralised to phenolphthalein.
- 3.2. Carrez solution I: dissolve in water 21,9 g of zinc acetate $Zn(CH_3COO)_2 \cdot 2H_2O$ and 3 g of glacial acetic acid. Make up to 100 ml with water.
- 3.3. Carrez solution II: dissolve in water 10,6 g of potassium ferrocyanide $K_4Fe(CN)_6 \cdot 3H_2O$. Make up to 100 ml with water.
- 3.4. Methyl orange, solution 0,1 % (w/v).
- 3.5. Hydrochloric acid 4 mol/litre.
- 3.6. Hydrochloric acid 0,1 mol/litre.
- 3.7. Sodium hydroxide solution 0,1 mol/litre.
- 3.8. Luff-Schoorl reagent:

Stirring carefully, pour the citric acid solution (3.8.2) into the sodium carbonate solution (3.8.3). Add the copper sulphate solution (3.8.1) and make up to 1 litre with water. Leave to settle overnight and filter.

Check the concentration of the reagent thus obtained (Cu 0,05 mol/litre; Na_2CO_3 1 mol/litre), see (5.4) last paragraph. The solution's pH shall be approximately 9,4.

- 3.8.1. Copper sulphate solution: dissolve 25 g of copper sulphate, $CuSO_4 \cdot 5H_2O$, free from iron, in 100 ml of water.

- 3.8.2. Citric acid solution: dissolve 50 g of citric acid, $C_6H_8O_7 \cdot H_2O$ in 50 ml of water.
- 3.8.3. Sodium carbonate solution: dissolve 143,8 g of anhydrous sodium carbonate in approximately 300 ml of warm water. Leave to cool.
- 3.9. Sodium thiosulphate solution 0,1 mol/litre.
- 3.10. Starch solution: add a mixture of 5 g of soluble starch in 30 ml of water to 1 litre of boiling water. Boil for three minutes, leave to cool and if necessary add 10 mg of mercuric iodide as a preservative.
- 3.11. Sulphuric acid 3 mol/litre.
- 3.12. Potassium iodide, solution 30 % (w/v).
- 3.13. Granulated pumice stone boiled in hydrochloric acid, washed in water and dried.
- 3.14. 3-methylbutan-1-ol.

4. Apparatus

Mixer (tumbler): approximately 35 to 40 r.p.m.

5. Procedure

5.1. Extraction of sample

Weigh 2,5 g of the sample to the nearest mg and place in a 250 ml volumetric flask. Add 200 ml of ethanol (3.1) and mix in the tumbler for one hour. Add 5 ml of Carrez solution I (3.2) and stir for approximately 30 seconds. Add 5 ml of Carrez solution II (3.3) and again stir for one minute. Make up to volume with ethanol (3.1), homogenise and filter. Remove 200 ml of the filtrate and evaporate to approximately half volume in order to eliminate most of the ethanol. Transfer the evaporation residue quantitatively to a 200 ml volumetric flask using warm water, cool, bring up to volume with water, homogenise and filter if necessary. This solution will be used to determine the amount of reducing sugars and, after inversion, of total sugars.

5.2. Determination of reducing sugars

Using a pipette, remove not more than 25 ml of the solution containing less than 60 mg of reducing sugars expressed as glucose. If necessary, make up to 25 ml with distilled water and determine the content of reducing sugars by the Luff-Schoorl method. The result is expressed as the percentage content of glucose in the sample.

5.3. Determination of total sugars after inversion

Using a pipette take 50 ml of the solution and transfer to a 100 ml volumetric flask. Add a few drops of methyl orange solution (3.4) then, carefully and stirring continuously, add hydrochloric acid (3.5) until the liquid turns a definite red. Add 15 ml of hydrochloric acid (3.6), immerse the flask in a fast boiling water bath and keep there for 30 minutes. Cool rapidly to approximately 20 °C and add 15 ml of sodium hydroxide solution (3.7). Make up to 100 ml with water and homogenise. Remove not more than 25 ml containing less than 60 mg of reducing sugars expressed as glucose. If necessary, make up to 25 ml with distilled water and determine the content of reducing sugars by the Luff-Schoorl method. The result is expressed as the percentage of glucose or, where appropriate, sucrose, by multiplying by the factor 0,95.

5.4. Titration by the Luff-Schoorl method

Using a pipette, take 25 ml of Luff-Schoorl reagent (3.8) and transfer to a 300 ml Erlenmeyer flask; add exactly 25 ml of the clarified sugar solution. Add 2 granules of pumice stone (3.13), heat, stirring by hand, over a free flame of medium height and bring the liquid to the boil in approximately two minutes. Place the Erlenmeyer immediately on an asbestos-coated wire gauze with a hole approximately 6 cm in diameter under which a flame has been lit. The flame shall be regulated in such a way that only the base of the Erlenmeyer is heated. Fit a reflux condenser to the Erlenmeyer flask. Boil for exactly 10 minutes. Cool immediately in cold water and after approximately five minutes titrate as follows:

Add 10 ml of potassium iodide solution (3.12) and immediately afterwards (carefully, because of the risk of abundant foaming), add 25 ml of sulphuric acid (3.11). Titrate with sodium thiosulphate solution (3.9) until a dull yellow colour appears, add the starch indicator (3.10) and complete titration.

Carry out the same titration on an accurately measured mixture of 25 ml of Luff-Schoorl reagent (3.8) and 25 ml of water, after adding 10 ml of potassium iodide solution (3.12) and 25 ml of sulphuric acid (3.11) without boiling.

6. Calculation of results

Using the table establish the amount of glucose in mg which corresponds to the difference between the values of the two titrations, expressed in mg of sodium thiosulphate 0,1 mol/litre. Express the result as a percentage of the sample.

7. Special procedures

- 7.1. In the case of feed which are rich in molasses and other feed which are not particularly homogeneous, weigh out 20 g and place with 500 ml of water in a 1 litre volumetric flask. Mix for one hour in the tumbler. Clarify using Carrez I (3.2) and II (3.3) reagents as described under 5.1, this time however using four times the quantities of each reagent. Bring up to volume with 80 % ethanol (v/v).

Homogenise and filter. Eliminate the ethanol as described under 5.1. If there is no dextrinised starch, bring up to volume with distilled water.

- 7.2. In the case of molasses and feed materials which are rich in sugar and almost starch-free (carobs, dried beetroot cassettes etc.), weigh out 5 g, place in a 250 ml volumetric flask, add 200 ml of distilled water and mix in the tumbler for one hour, or more if necessary. Clarify using Carrez I (3.2) and II (3.3) reagents as described under 5.1. Bring up to volume with cold water, homogenise and filter. In order to determine the amount of total sugars, continue as described under 5.3.

8. Observations

- 8.1. In order to prevent foaming it is advisable to add (irrespective of the volume) approximately 1 ml of 3-methylbutan-1-ol (3.14) before boiling with Luff-Schoorl reagent.

- 8.2. The difference between the content of total sugars after inversion, expressed as glucose, and the content of reducing sugars, expressed as glucose, multiplied by 0,95, gives the percentage content of sucrose.

- 8.3. In order to determine the content of reducing sugars, excluding lactose, two methods may be adopted:

- 8.3.1. For an approximate calculation, multiply by 0,675 the lactose content established by a different method of analysis and subtract the result obtained from the content of reducing sugars.

- 8.3.2. For an accurate calculation of reducing sugars, excluding lactose, the same sample must be used for the two final determinations. One of the analyses is carried out on part of the solution obtained under 5.1, the other on part of the solution obtained during the determination of lactose by the method laid down for that purpose (after fermenting the other types of sugar and clarifying).

In both cases the amount of sugar present is determined by the Luff-Schoorl method and calculated in mg of glucose. One of the values is subtracted from the other and the difference is expressed as a percentage of the sample.

Example:

The two volumes taken correspond, for each determination, to a sample of 250 mg.

In the first case 17 ml of sodium thiosulphate solution 0,1 mol/litre corresponding to 44,2 mg of glucose is consumed; in the second, 11 ml, corresponding to 27,6 mg of glucose.

The difference is 16,6 mg of glucose.

The content of reducing sugars (excluding lactose), calculated as glucose, is therefore:

$$\frac{4 \times 16,6}{10} = 6,64 \%$$

Table of values for 25 ml of Luff-Schoorl reagent

ml of Na₂ S₂ O₃ 0,1 mol/litre, two minutes' heating, 10 minutes' boiling

Na ₂ S ₂ O ₃ 0,1 mol/litre	Glucose, fructose invert sugars C ₆ H ₁₂ O ₆		Lactose C ₁₂ H ₂₂ O ₁₁		Maltose C ₁₂ H ₂₂ O ₁₁		Na ₂ S ₂ O ₃ 0,1 mol/litre
	ml	mg	difference	mg	difference	mg	
1	2,4	2,4	3,6	3,7	3,9	3,9	1
2	4,8	2,4	7,3	3,7	7,8	3,9	2
3	7,2	2,5	11,0	3,7	11,7	3,9	3
4	9,7	2,5	14,7	3,7	15,6	4,0	4
5	12,2	2,5	18,4	3,7	19,6	3,9	5
6	14,7	2,5	22,1	3,7	23,5	4,0	6
7	17,2	2,6	25,8	3,7	27,5	4,0	7
8	19,8	2,6	29,5	3,7	31,5	4,0	8
9	22,4	2,6	33,2	3,8	35,5	4,0	9
10	25,0	2,6	37,0	3,8	39,5	4,0	10
11	27,6	2,7	40,8	3,8	43,5	4,0	11
12	30,3	2,7	44,6	3,8	47,5	4,1	12
13	33,0	2,7	48,4	3,8	51,6	4,1	13
14	35,7	2,8	52,2	3,8	55,7	4,1	14
15	38,5	2,8	56,0	3,9	59,8	4,1	15
16	41,3	2,9	59,9	3,9	63,9	4,1	16
17	44,2	2,9	63,8	3,9	68,0	4,2	17
18	47,1	2,9	67,7	4,0	72,2	4,3	18
19	50,0	3,0	71,7	4,0	76,5	4,4	19
20	53,0	3,0	75,7	4,1	80,9	4,5	20
21	56,0	3,1	79,8	4,1	85,4	4,6	21
22	59,1	3,1	83,9	4,1	90,0	4,6	22
23	62,2		88,0		94,6		23

K. DETERMINATION OF LACTOSE

1. Purpose and scope

This method makes it possible to determine the level of lactose in feed containing more than 0,5 % of lactose.

2. Principle

The sugars are dissolved in water. The solution is subjected to fermentation by the yeast *Saccharomyces cerevisiae* which leaves the lactose intact. After clarification and filtration the lactose content of the filtrate is determined by the Luff-Schoorl method.

3. Reagents

- 3.1. Suspension of *Saccharomyces cerevisiae*: suspend 25 g of fresh yeast in 100 ml of water. The suspension will keep for a maximum period of one week in a refrigerator.
- 3.2. Carrez solution I: dissolve in water 21,9 g of zinc acetate, Zn (CH₃ COO)₂ 2H₂O and 3 g of glacial acetic acid. Make up to 100 ml with water.
- 3.3. Carrez solution II: dissolve in water 10,6 g of potassium ferrocyanide K₄Fe (CN)₆ 3H₂O. Make up to 100 ml with water.
- 3.4. Luff-Schoorl reagent:

Stirring carefully, pour the citric acid solution (3.4.2) into the sodium carbonate solution (3.4.3). Add the copper sulphate solution (3.4.1) and make up to 1 litre with water. Leave to settle overnight and filter. Check the concentration of the reagent thus obtained (Cu 0,05 mol/litre; Na₂ CO₃ 1 mol/litre). The solution's pH shall be approximately 9,4.

- 3.4.1. Copper sulphate solution: dissolve 25 g of copper sulphate $\text{Cu SO}_4 \cdot 5\text{H}_2\text{O}$, free from iron, in 100 ml of water.
- 3.4.2. Citric acid solution: dissolve 50 g of citric acid $\text{C}_6\text{H}_8\text{O}_7 \cdot \text{H}_2\text{O}$ in 50 ml of water.
- 3.4.3. Sodium carbonate solution: dissolve 143,8 g of anhydrous sodium carbonate in approximately 300 ml of warm water. Leave to cool.
- 3.5. Granulated pumice stone boiled in hydrochloric acid, washed in water and dried.
- 3.6. Potassium iodide, solution 30 % (w/v).
- 3.7. Sulphuric acid 3 mol/litre.
- 3.8. Solution of sodium thiosulphate 0,1 mol/litre.
- 3.9. Starch solution: add a mixture of 5 g of soluble starch in 30 ml of water to 1 litre of boiling water. Boil for three minutes, leave to cool, and if necessary add 10 mg of mercuric iodide as a preservative.

4. Apparatus

Water bath with thermostat set at 38-40 °C.

5. Procedure

Weigh 1 g of the sample to the nearest mg and place this portion of the sample in a 100 ml volumetric flask. Add 25 to 30 ml of water. Place the flask in a boiling water bath for 30 minutes and then cool to approximately 35 °C. Add 5 ml of yeast suspension (3.1) and homogenise. Leave the flask to stand for two hours in a water bath, at a temperature of 38-40° C. Cool to approximately 20 °C.

Add 2,5 ml of Carrez solution I (3.2) and stir for 30 seconds, then add 2,5 ml of Carrez solution II (3.3) and again stir for 30 seconds. Make up to 100 ml with water, mix and filter. Using a pipette, remove an amount of filtrate which does not exceed 25 ml and which preferably contains from 40 to 80 mg of lactose and transfer it to a 300 ml Erlenmeyer flask. If necessary, make up to 25 ml with water.

Carry out a blank test in the same way with 5 ml of yeast suspension (3.1). Determine the lactose content according to Luff-Schoorl, as follows: add exactly 25 ml of Luff-Schoorl reagent (3.4) and two granules of pumice stone (3.5). Stir by hand-while heating over a free flame of medium height and bring the liquid to the boil in approximately two minutes. Place the Erlenmeyer immediately on an asbestos-coated wire gauze with a hole approximately 6 cm in diameter under which a flame has been lit. The flame shall be regulated in such a way that only the base of the Erlenmeyer is heated. Fit a reflux condenser to the Erlenmeyer flask. Boil for exactly 10 minutes. Cool immediately in cold water and after approximately five minutes titrate as follows:

Add 10 ml of potassium iodide solution (3.6) and immediately afterwards (carefully, because of the risk of abundant foaming) add 25 ml of sulphuric acid (3.7). Titrate with sodium thiosulphate solution (3.8) until a dull yellow colour appears, add the starch indicator (3.9) and complete titration.

Carry out the same titration on an accurately measured mixture of 25 ml of Luff-Schoorl reagent (3.4) and 25 ml of water, after adding 10 ml of potassium iodide solution (3.6) and 25 ml of sulphuric acid (3.7) without boiling.

6. Calculation of results

Using the attached table, establish the amount of lactose in mg which corresponds to the difference between the results of the two titrations, expressed in ml of sodium thiosulphate 0,1 mol/litre.

Express the result of anhydrous lactose as a percentage of the sample.

7. Observation

For products containing more than 40 % of fermentable sugar, use more than 5 ml of yeast suspension (3.1).

Table of values for 25 ml of Luff-Schoorl reagentml of Na₂ S₂ O₃ 0,1 mol/litre, two minutes' heating, 10 minutes' boiling

Na ₂ S ₂ O ₃ 0,1 mol/litre	Glucose, fructose invert sugars C ₆ H ₁₂ O ₆		Lactose C ₁₂ H ₂₂ O ₁₁		Maltose C ₁₂ H ₂₂ O ₁₁		Na ₂ S ₂ O ₃ 0,1 mol/litre
	ml	mg	difference	mg	difference	mg	
1	2,4	2,4	3,6	3,7	3,9	3,9	1
2	4,8	2,4	7,3	3,7	7,8	3,9	2
3	7,2	2,5	11,0	3,7	11,7	3,9	3
4	9,7	2,5	14,7	3,7	15,6	4,0	4
5	12,2	2,5	18,4	3,7	19,6	3,9	5
6	14,7	2,5	22,1	3,7	23,5	4,0	6
7	17,2	2,6	25,8	3,7	27,5	4,0	7
8	19,8	2,6	29,5	3,7	31,5	4,0	8
9	22,4	2,6	33,2	3,8	35,5	4,0	9
10	25,0	2,6	37,0	3,8	39,5	4,0	10
11	27,6	2,7	40,8	3,8	43,5	4,0	11
12	30,3	2,7	44,6	3,8	47,5	4,1	12
13	33,0	2,7	48,4	3,8	51,6	4,1	13
14	35,7	2,8	52,2	3,8	55,7	4,1	14
15	38,5	2,8	56,0	3,9	59,8	4,1	15
16	41,3	2,9	59,9	3,9	63,9	4,1	16
17	44,2	2,9	63,8	3,9	68,0	4,2	17
18	47,1	2,9	67,7	4,0	72,2	4,3	18
19	50,0	3,0	71,7	4,0	76,5	4,4	19
20	53,0	3,0	75,7	4,1	80,9	4,5	20
21	56,0	3,1	79,8	4,1	85,4	4,6	21
22	59,1	3,1	83,9	4,1	90,0	4,6	22
23	62,2		88,0		94,6		23

L. DETERMINATION OF STARCH

POLARIMETRIC METHOD**1. Purpose and scope**

This method makes it possible to determine the levels of starch and of high molecular weight starch degradation products in feed for the purpose of checking compliance with the declared energy value (provisions in Annex VII) and Council Directive 96/25/EC ⁽¹⁾.

2. Principle

The method comprises two determinations. In the first, the sample is treated with dilute hydrochloric acid. After clarification and filtration the optical rotation of the solution is measured by polarimetry.

In the second, the sample is extracted with 40 % ethanol. After acidifying the filtrate with hydrochloric acid, clarifying and filtering, the optical rotation is measured as in the first determination.

The difference between the two measurements, multiplied by a known factor, gives the starch content of the sample.

3. Reagents

3.1. Hydrochloric acid, solution 25 % (w/w) density: 1,126 g/ml.

⁽¹⁾ OJ L 125, 23.5.1996, p. 35.

- 3.2. Hydrochloric acid. solution 1,13 % (w/v)

The concentration must be checked by titration using a sodium hydroxide solution 0,1 mol/litre in the presence of 0,1 % (w/v) methyl red in 94 % (v/v) ethanol. For the neutralisation of 10 ml, 30,94 ml of NaOH 0,1 mol/litre is needed.

- 3.3. Carrez solution I: dissolve 21,9 g of zinc acetate $Zn(CH_3COO)_2 \cdot 2H_2O$ and 3 g of glacial acetic acid in water. Make up to 100 ml with water.
- 3.4. Carrez solution II: dissolve 10,6 g of potassium ferrocyanide $K_4Fe(CN)_6 \cdot 3H_2O$ in water. Make up to 100 ml with water.
- 3.5. Ethanol, solution 40 % (v/v), density: 0,948 g/ml at 20 °C.

4. Apparatus

- 4.1. 250 ml Erlenmeyer flask with standard ground-glass joint and with reflux condenser.
- 4.2. Polarimeter or saccharimeter.

5. Procedure

- 5.1. *Preparation of the sample*

Crush the sample until it is fine enough for all of it to pass through a 0,5 mm round-meshed sieve.

- 5.2. *Determination of the total optical rotation (P or S) (see observation 7.1)*

Weigh 2,5 g of the crushed sample to the nearest mg and place in a 100 ml graduated flask. Add 25 ml of hydrochloric acid (3.2), shake to obtain even distribution of the test sample and add a further 25 ml of hydrochloric acid (3.2). Immerse the flask in a boiling water bath shaking vigorously and steadily for the first three minutes to prevent the formation of agglomerates. The quantity of water in the water bath must be sufficient for the bath to remain at boiling point when the flask is introduced into it. The flask must not be taken out of the bath whilst being shaken. After exactly 15 minutes, remove from the bath, add 30 ml of cold water and cool immediately to 20 °C.

Add 5 ml of Carrez solution I (3.3) and shake for approximately 30 seconds. Then add 5 ml of Carrez solution II (3.4) and shake again for approximately 30 seconds. Make up to volume with water, mix and filter. If the filtrate is not perfectly clear (which is rare), repeat the determination using a larger quantity of Carrez solutions I and II, for example 10 ml.

Measure the optical rotation of the solution in a 200 mm tube with the polarimeter or saccharimeter.

- 5.3. *Determination of the optical rotation (P' or S') of substances soluble in 40 % ethanol*

Weigh 5 g of the sample to the nearest mg, place in a 100 ml graduated flask and add about 80 ml of ethanol (3.5) (see observation 7.2). Leave the flask to stand for 1 hour at room temperature; during this time, shake vigorously on six occasions so that the test sample is thoroughly mixed with the ethanol. Make up to volume with ethanol (3.5), mix and filter.

Pipette 50 ml of the filtrate (corresponds to 2,5 g of the sample) into a 250 ml Erlenmeyer flask, add 2,1 ml of hydrochloric acid (3.1) and shake vigorously. Fit a reflux condenser to the Erlenmeyer flask and immerse the latter in a boiling water bath. After exactly 15 minutes, remove the Erlenmeyer flask from the bath, transfer the contents to a 100 ml graduated flask, rinsing with a little cold water, and cool to 20 °C.

Clarify using Carrez solutions I (3.3) and II (3.4), make up to volume with water, mix, filter and measure the optical rotation as indicated in the 2nd and 3rd paragraphs of 5.2.

6. Calculation of results

The starch content (%) is calculated as follows:

- 6.1. *Measurement by polarimeter*

$$\text{Starch content (\%)} = \frac{2\,000(P - P')}{[\alpha]_D^{20}}$$

P = Total optical rotation in angle degrees

- P' = Optical rotation in angle degrees of the substances soluble in 40 % (V/V) ethanol
- $[\alpha]_D^{20}$ = Specific optical rotation of pure starch. The numerical values conventionally accepted for this factor are the following:
- + 185,9°: rice starch
 - + 185,7°: potato starch
 - + 184,6°: maize starch
 - + 182,7°: wheat starch
 - + 181,5°: barley starch
 - + 181,3°: oat starch
 - + 184,0°: other types of starch and starch mixtures in compound feed

6.2. Measurement by saccharimeter

$$\text{Starch content (\%)} = \frac{2\,000}{[\alpha]_D^{20}} \times \frac{(2\,N \times 0,665) \times (S - S')}{100} - \frac{26,6\,N \times (S - S')}{[\alpha]_D^{20}}$$

- S = Total optical rotation in saccharimeter degrees
- S' = Optical rotation in saccharimeter degrees of the substances soluble in 40 % (v/v) ethanol
- N = weight (g) of saccharose in 100 ml of water yielding an optical rotation of 100 saccharimeter degrees when measured using a 200 mm tube
- 16,29 g for the French saccharimeters
 - 26,00 g for the German saccharimeters
 - 20,00 g for mixed saccharimeters.
- $[\alpha]_D^{20}$ = Specific optical rotation of pure starch (see 6.1)

6.3. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed 0,4 in absolute value for a starch content lower than 40 % and 1 % relative for starch contents equal to or greater than 40 %.

7. Observations

- 7.1. If the sample contains more than 6 % of carbonates, calculated in terms of calcium carbonate, they must be destroyed by treatment with an exactly appropriate quantity of dilute sulphuric acid before determination of the total optical rotation.
- 7.2. In the case of products with a high lactose content, such as powdered milk serum or skimmed milk powder, proceed as follows after adding 80 ml of ethanol (3.5). Fit a reflux condenser to the flask and immerse the latter in a water bath at 50 °C for 30 minutes. Leave to cool and continue the analysis as indicated in 5.3.
- 7.3. The following feed materials, where they are present in significant amounts in feed, are known to give rise to interferences when determining the starch content by the polarimetric method and thereby incorrect results could be yielded:
- (sugar) beet products such as (sugar)beet pulp, (sugar) beet molasses, (sugar) beet pulp — molassed, (sugar) beet vinasse, (beet) sugar,
 - citrus pulp,
 - linseed; linseed expeller; linseed extracted,
 - rape seed; rape seed expeller; rape seed extracted; rape seed hulls,
 - sunflower seed; sunflower seed extracted; sunflower seed, partially decorticated, extracted,
 - copra expeller; copra extracted,
 - potato pulp,
 - dehydrated yeast,

- products rich in inulin (e.g. Chips and meal of Jerusalem artichokes),
- greaves.

M. DETERMINATION OF CRUDE ASH

1. Purpose and Scope

This method makes it possible to determine the crude ash content of feed.

2. Principle

The sample is ashed at 550 °C; the residue is weighed.

3. Reagents

Ammonium nitrate, solution 20 % (w/v).

4. Apparatus

4.1. Hot-plate.

4.2. Electric muffle-furnace with thermostat.

4.3. Crucibles for ashing made of silica, porcelain or platinum either rectangular (approx. 60 × 40 × 25 mm) or circular (diameter: 60 to 75 mm, height: 20 to 40 mm).

5. Procedure

Weigh out to the nearest mg approximately 5 g of the sample (2,5 in the case of products which have a tendency to swell) and place in a crucible for ashing which has first been heated at 550 °C, cooled down and tared. Place the crucible on the hot-plate and heat gradually until the substance carbonises. Ash according to 5.1 or 5.2.

5.1. Put the crucible into the calibrated muffle furnace set at 550 °C. Keep at this temperature until white, light grey or reddish ash is obtained which appears to be free from carbonaceous particles. Place the crucible in a desiccator, leave to cool and weigh immediately.

5.2. Put the crucible into the calibrated muffle-furnace set at 550 °C. Ash for 3 hours. Place the crucible in a desiccator, leave to cool and weigh immediately. Ash again for 30 minutes to ensure that the weight of the ash remains constant (loss in weight between two successive weightings must be less than or equal to 1 mg).

6. Calculation of results

Calculate the weight of the residue by deducting the tare.

Express the result as a percentage of the sample.

7. Observations

7.1. The ash of *substances which are difficult to ash* must be subjected to an initial ashing of at least three hours, cooled and then a few drops of 20 % solution of ammonium nitrate or water added to it (carefully, to avoid dispersal of the ash or the formation of lumps). Continue calcining after drying in the oven. Repeat the operation as necessary until ashing is complete.

7.2. In the case of *substances resistant to the treatment* described under 7.1, proceed as follows: after ashing for three hours, place the ash in warm water and filter through a small, ash-free filter. Ash the filter and its contents in the original crucible. Place the filtrate in the cooled crucible, evaporate until dry, ash and weigh.

- 7.3. In the case of *oils and fats*, weigh accurately a sample of 25 g in a suitably sized crucible. Carbonise by setting light to the substance with a strip of ash-free filter paper. After combustion, moisten with as little water as possible. Dry and ash as described under 5.

N. DETERMINATION OF ASH WHICH IS INSOLUBLE IN HYDROCHLORIC ACID

1. Purpose and Scope

This method makes it possible to determine the level in feed of mineral substances which are insoluble in hydrochloric acid. Two methods can be used, depending on the nature of the sample.

- 1.1. *Method A*: applicable to organic feed materials and to most compound feed.
- 1.2. *Method B*: applicable to mineral compounds and mixtures and to compound feed, whose content in substances insoluble in hydrochloric acid, as determined by Method A, is greater than 1 %.

2. Principle

- 2.1. *Method A*: the sample is ashed, the ash boiled in hydrochloric acid and the insoluble residue filtered and weighed.
- 2.2. *Method B*: the sample is treated with hydrochloric acid. The solution is filtered, the residue ashed and the ash thus obtained treated in accordance with Method A.

3. Reagents

- 3.1. Hydrochloric acid 3 mol/litre.
- 3.2. Trichloroacetic acid, solution 20 % solution (w/v).
- 3.3. Trichloroacetic acid, solution 1 % (w/v).

4. Apparatus

- 4.1. Hot plate.
- 4.2. Electric muffle-furnace with thermostat.
- 4.3. Crucibles for ashing made of silica, porcelain or platinum, either rectangular (approx. 60 × 40 × 25 mm) or circular (diameter: 60 to 75 mm, height: 20 to 40 mm).

5. Procedure

5.1. Method A

Ash the sample using the method described for the determination of crude ash. Ash obtained from that analysis may also be used.

Place the ash in a 250 to 400 ml beaker using 75 ml of hydrochloric acid (3.1). Bring slowly to the boil and boil gently for 15 minutes. Filter the warm solution through an ash-free filter paper and wash the residue with warm water until the acid reaction is no longer visible. Dry the filter containing the residue and ash in a tared crucible at a temperature of not less than 550 °C and not more than 700 °C. Cool in a desiccator and weigh.

5.2. Method B

Weigh 5 g of the sample to the nearest mg and place in a 250 to 400 ml beaker. Add 25 ml of water and 25 ml of hydrochloric acid (3.1) successively, mix and wait for effervescence to cease. Add a further 50 ml of hydrochloric acid (3.1). Wait for any release of gas to cease then place the beaker in a boiling water bath and keep it there for 30 minutes or longer, if necessary, in order to hydrolyse thoroughly any starch which may be present.

Filter while warm through an ash-free filter and wash the filter in 50 ml of warm water (see observation 7). Place the filter containing the residue in a crucible for ashing, dry and ash at a temperature of not less than 550 °C and not more than 700 °C. Place the ash in a 250 to 400 ml beaker using 75 ml of hydrochloric acid (3.1); continue as described in the second subparagraph of 5.1.

6. **Calculation of results**

Calculate the weight of the residue by deducting the tare. Express the result as a percentage of the sample.

7. **Observation**

If filtration proves difficult recommence the analysis, replacing the 50 ml of hydrochloric acid (3.1) by 50 ml of 20 % trichloroacetic acid (3.2) and washing the filter in a warm solution of 1 % trichloroacetic acid (3.3).

O. DETERMINATION OF CARBONATES

1. **Purpose and Scope**

This method makes it possible to determine the amount of carbonates, conventionally expressed as calcium carbonate, in most feed.

However in certain cases (for example, with iron carbonate) a special method must be used.

2. **Principle**

The carbonates are decomposed in hydrochloric acid; the carbon dioxide released is collected in a graduated tube, and its volume compared with that released under the same conditions by a known quantity of calcium carbonate.

3. **Reagents**

- 3.1. Hydrochloric acid, density 1,10 g/ml.
- 3.2. Calcium carbonate.
- 3.3. Sulphuric acid, approximately 0,05 mol/litre, coloured with methyl red.

4. **Apparatus**

Scheibler-Dietrich apparatus (see diagram) or equivalent apparatus.

5. **Procedure**

According to the sample's carbonate content, weigh a portion of the sample as shown below:

- 0,5 g for products containing from 50 % to 100 % of carbonates, expressed as calcium carbonate,
- 1 g for products containing from 40 % to 50 % of carbonates, expressed as calcium carbonate,
- 2 to 3 g for other products.

Place the portion of the sample in the special flask (4) of the apparatus, fitted with a small tube of unbreakable material containing 10 ml of hydrochloric acid (3.1), and connect the flask to the apparatus. Turn the three-way cock (5) so that the tube (1) connects with the outside. Using the mobile tube (2), which is filled with coloured sulphuric acid (3.3) and connected to the graduated tube (1), bring the level of the liquid up to the zero mark. Turn the cock (5) in order to connect up tubes (1) and (3) and check that the level is at zero.

Run the hydrochloric acid (3.1) slowly over the portion of the sample, tilting the flask (4). Make the pressure equal by lowering the tube (2). Shake the flask (4) until the release of carbon dioxide has stopped completely.

Restore pressure by bringing the liquid back to the same level in tubes (1) and (2). After a *few minutes*, when the volume of gas has become constant, take the reading.

Carry out a control test in the same conditions on 0,5 g of calcium carbonate (3.2).

6. **Calculation of results**

The content of carbonates, expressed as calcium carbonate, is calculated by using the formula:

$$X = \frac{V \times 100}{V_1 \times 2m}$$

where:

X = % (w/w) of carbonates in the sample, expressed as calcium carbonate

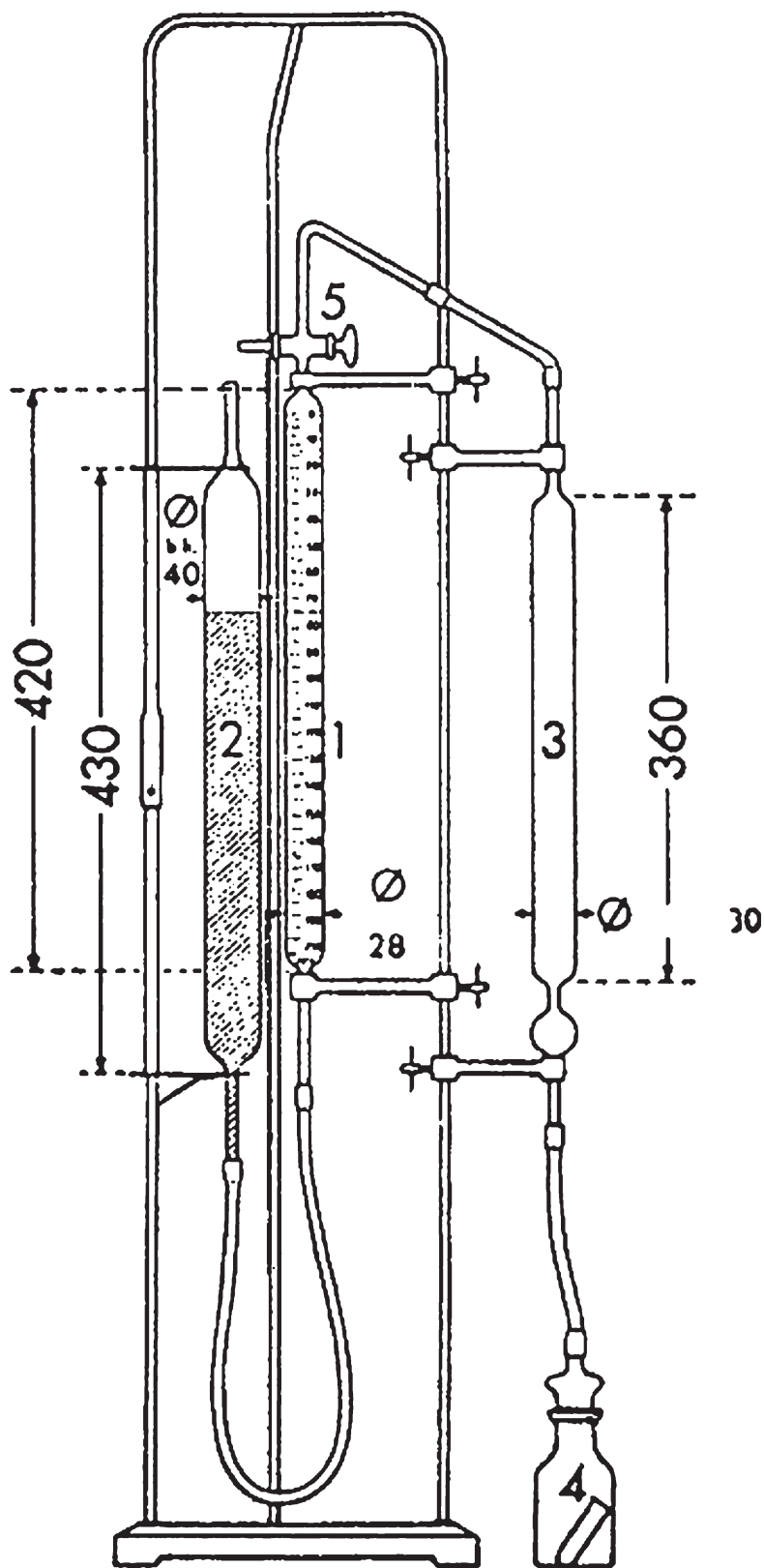
V = ml of CO₂ released by the portion of the sample.

V₁ = ml of CO₂ released by 0,5 g of CaCO₃.

m = weight, in grammes, of the portion of the sample.

7. **Observations**

- 7.1. When the portion of the sample weighs more than 2 g, first place 15 ml of distilled water in the flask (4) and mix before beginning the test. Use the same volume of water for the control test.
- 7.2. If the apparatus used has a different volume from that of the Scheibler-Dietrich apparatus, the portions taken from the sample and from the control substance and the calculation of the results must be adapted accordingly.

SCHEIBER-DIETRICH APPARATUS FOR THE DETERMINATION OF CO₂

(measured in mm)

P. DETERMINATION OF TOTAL PHOSPHORUS

PHOTOMETRIC METHOD**1. Purpose and Scope**

This method makes it possible to determine the content of total phosphorus in feed. It is particularly appropriate for the analysis of products low in phosphorus. In certain cases (product rich in phosphorus), a gravimetric method may be used.

2. Principle

The sample is mineralised, either by dry combustion (in the case of organic feed) or by acid digestion (in the case of mineral compounds and liquid feed), and placed in an acid solution. The solution is treated with molybdovanadate reagent. The optical density of the yellow solution thus formed is measured in a spectrophotometer at 430 nm.

3. Reagents

- 3.1. Calcium carbonate.
- 3.2. Hydrochloric acid, $\rho_{20} = 1,10$ g/ml (approx 6 mol/litre).
- 3.3. Nitric acid, $\rho_{20} = 1,045$ g/ml.
- 3.4. Nitric acid, $\rho_{20} = 1,38$ to 1,42 g/ml.
- 3.5. Sulphuric acid, $\rho_{20} = 1,84$ g/ml.
- 3.6. Molybdovanadate reagent: mix 200 ml of ammonium heptamolybdate solution (3.6.1), 200 ml of ammonium monovanadate solution (3.6.2) and 134 ml of nitric acid (3.4) in a 1 litre graduated flask. Make up to volume with water.
 - 3.6.1. Ammonium heptamolybdate solution: dissolve in hot water 100 g of ammonium heptamolybdate (NH_4) $6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}$. Add 10 ml of ammonia (density 0,91 g/ml) and make up to 1 litre with water.
 - 3.6.2. Ammonium monovanadate solution: dissolve 2,35 g of ammonium monovanadate NH_4VO_3 in 400 ml of hot water. Stirring constantly, slowly add 20 ml of dilute nitric acid (7 ml of HNO_3 (3.4) + 13 ml of H_2O) and make up to 1 litre with water.
- 3.7. Standard solution of 1 mg phosphorus per ml: dissolve 4,387 g of potassium dihydrogen phosphate KH_2PO_4 in water. Make up to 1 litre with water.

4. Apparatus

- 4.1. Silica, porcelain or platinum ashing crucibles.
- 4.2. Electric muffle-furnace with thermostat set at 550 °C.
- 4.3. 250 ml Kjeldahl flask.
- 4.4. Graduated flasks and precision pipettes.
- 4.5. Spectrophotometer.
- 4.6. Test tubes about 16 mm in diameter, with stoppers graded to a diameter of 14,5 mm; capacity: 25 to 30 ml.

5. Procedure**5.1. Preparation of the solution**

According to the nature of the sample, prepare a solution as indicated in 5.1.1 or 5.1.2.

5.1.1. Usual procedure

Weigh 1 g or more of the sample to the nearest 1 mg. Place the test sample in a Kjeldahl flask, add 20 ml of sulphuric acid (3.5), shake to impregnate the substance completely with acid and to prevent it from sticking to the sides of the flask, heat and keep at boiling point for 10 minutes. Leave to cool slightly, add 2 ml of nitric acid (3.4), heat gently, leave to cool slightly, add a little more nitric acid (3.4) and bring back to boiling point. Repeat this procedure until a colourless solution is obtained. Cool, add a little water, decant the liquid into a 500 ml graduated flask, rinsing the Kjeldahl flask with hot water. Leave to cool, make up to volume with water, homogenise and filter.

5.1.2. Samples containing organic substances and free from calcium and magnesium dihydrogen phosphates

Weigh about 2,5 g of the sample to the nearest 1 mg in an ashing crucible. Mix the test sample until completely merged with 1 g of calcium carbonate (3.1). Ash in the oven at 550 °C until white or grey ash is obtained (a little charcoal does not matter). Transfer the ash into a 250 ml beaker. Add 20 ml of water and hydrochloric acid (3.2) until effervescence ceases. Add a further 10 ml of hydrochloric acid (3.2). Place the beaker on a sand bath and evaporate until dry to make the silica insoluble. Redissolve the residue in 10 ml of nitric acid (3.3) and boil on the sand bath or hot plate for 5 minutes without evaporating until dry. Decant the liquid into a 500 ml graduated flask, rinsing the beaker several times with hot water. Leave to cool, make up to volume with water, homogenise and filter.

5.2. Development of coloration and measurement of optical density

Dilute an aliquot part of the filtrate obtained by 5.1.1 or 5.1.2 to obtain a phosphorus concentration of not more than 40 µg/ml. Place 10 ml of this solution in a test tube (4.6) and add 10 ml of molybdovanadate reagent (3.6). Homogenise and leave to stand for at least 10 minutes at 20 °C. Measure the optical density in a spectrophotometer at 430 nm against a solution obtained by adding 10 ml of the molybdovanadate reagent (3.6) to 10 ml of water.

5.3. Calibration curve

From the standard solution (3.7) prepare solutions containing respectively 5, 10, 20, 30 and 40 µg of phosphorus per ml. Take 10 ml of each of these solutions and add thereto 10 ml of molybdovanadate reagent (3.6). Homogenise and leave to stand for at least 10 minutes at 20 °C. Measure the optical density as indicated in 5.2. Trace the calibration curve by plotting the optical densities against the corresponding quantities of phosphorus. For concentrations between 0 and 40 µg/ml, the curve will be linear.

6. Calculation of results

Determine the amount of phosphorus in the test sample by using the calibration curve.

Express the result as a percentage of the sample.

Repeatability

The difference between the results of two parallel determinations carried out on the same sample shall not exceed:

- 3 %, relative to the higher result, for phosphorus contents of less than 5 %,
- 0,15 % in absolute value, for phosphorus contents of 5 % or more.

Q. DETERMINATION OF CHLORINE FROM CHLORIDES

1. Purpose and Scope

This method makes it possible to determine the amount of chlorine in chlorides which are soluble in water, conventionally expressed as sodium chloride. It is applicable to all feed.

2. Principle

The chlorides are dissolved in water. If the product contains organic matter it is clarified. The solution is slightly acidified with nitric acid and the chlorides precipitated in the form of silver chloride by means of a solution of silver nitrate. The excess silver nitrate is titrated with a solution of ammonium thiocyanate, by Volhard's method.

3. Reagents

- 3.1. Solution of ammonium thiocyanate 0,1 mol/litre.
- 3.2. Solution of silver nitrate 0,1 mol/litre.
- 3.3. Saturated solution of ammonium ferric sulphate $(\text{NH}_4)\text{Fe}(\text{SO}_4)_2$.
- 3.4. Nitric acid, density: 1,38 g/ml.
- 3.5. Diethyl ether.
- 3.6. Acetone.
- 3.7. Carrez I solution: dissolve in water 21,9 g of zinc acetate, $\text{Zn}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$ and 3 g of glacial acetic acid. Make up to 100 ml with water.
- 3.8. Carrez II solution: dissolve in water 10,6 g of potassium ferrocyanide $\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$. Make up to 100 ml with water.
- 3.9. Active carbon, free from chlorides and not absorbing them.

4. Apparatus

Mixer (tumbler): approximately 35 to 40 r.p.m.

5. Procedure

5.1. Preparation of the solution

According to the nature of the sample, prepare a solution as shown under 5.1.1, 5.1.2 or 5.1.3.

At the same time carry out a *blank test* omitting the sample to be analysed.

5.1.1. Samples free from organic matter

Weigh to the nearest mg a sample of not more than 10 g and containing not more than 3 g of chlorine in the form of chlorides. Place with 400 ml of water in a 500 ml volumetric flask at approximately 20 °C. Mix for 30 minutes in the tumbler, bring up to volume, homogenise and filter.

5.1.2. Samples containing organic matter, excluding the products listed under 5.1.3.

Weigh approximately 5 g of the sample to the nearest mg and place with 1 g of active carbon in a 500 ml volumetric flask. Add 400 ml of water at approximately 20 °C and 5 ml of Carrez solution I (3.7), stir for 30 seconds then add 5 ml of Carrez solution II (3.8). Mix for 30 minutes in the tumbler, bring up to volume, homogenise and filter.

5.1.3. Cooked feed, flax cakes and flour, products rich in flax flour and other products rich in mucilage or in colloidal substances (for example, dextrinated starch)

Prepare the solution as described under 5.1.2 but do not filter. Decant (if necessary centrifuge), remove 100 ml of the supernatant liquid and transfer to a 200 ml measuring flask. Mix with acetone (3.6) and bring up to volume with this solvent, homogenise and filter.

5.2. Titration

Using a pipette, transfer to an Erlenmeyer flask from 25 ml to 100 ml of the filtrate (according to the assumed chlorine content) obtained as described under 5.1.1, 5.1.2 or 5.1.3. The aliquot portion must not contain more than 150 mg of chlorine (Cl). Dilute if necessary to not less than 50 ml with water, add 5 ml of nitric acid (3.4), 20 ml of saturated solution of ammonium ferric sulphate (3.3) and two drops of ammonium thiocyanate solution (3.1) transferred by means of a burette filled up to the zero mark. Using a burette, transfer the silver nitrate solution (3.2) in such a way that an excess of 5 ml is obtained. Add 5 ml of diethyl ether (3.5) and shake hard to coagulate the precipitate. Titrate the excess silver nitrate with the ammonium thiocyanate solution (3.1) until the reddish-brown tint has lasted for one minute.

6. Calculation of results

The amount of chlorine (X), expressed as % sodium chloride is calculated by using the following formula:

$$X = \frac{5,845 \times (V_1 - V_2)}{m}$$

where:

V_1 = ml of silver nitrate solution 0,1 mol/l added

V_2 = ml of ammonium thiocyanate solution 0,1 mol/l used for titration

m = weight of sample.

If the blank test indicates that silver nitrate solution 0,1 mol/l has been consumed deduct this value from the volume ($V_1 - V_2$).

7. Observations

- 7.1. Titration may also be carried out by potentiometry.
 - 7.2. In the case of products which are very rich in oils and fats, first de-fat with diethyl ether or light petroleum.
 - 7.3. In the case of fish-meal, titration may be carried out by Mohr's method.
-

ANNEX IV

METHODS OF ANALYSIS TO CONTROL THE LEVEL OF AUTHORISED ADDITIVES IN FEED

A. DETERMINATION OF VITAMIN A

1. Purpose and Scope

This method makes it possible to determine the level of vitamin A (retinol) in feed and premixtures. Vitamin A includes all-*trans*-retinyl alcohol and its *cis*-isomers which are determined by this method. The content of vitamin A is expressed in International Units (IU) per kg. One IU corresponds to the activity of 0,300 µg all-*trans*-vitamin A alcohol or 0,344 µg all-*trans*-vitamin A acetate or 0,550 µg all-*trans*-vitamin A palmitate.

The limit of quantification is 2 000 IU vitamin A/kg.

2. Principle

The sample is hydrolysed with ethanolic potassium hydroxide solution and the vitamin A is extracted into light petroleum. The solvent is removed by evaporation and the residue is dissolved in methanol and, if necessary, diluted to the required concentration. The content of vitamin A is determined by reversed phase high performance liquid chromatography (RP-HPLC) using a UV or a fluorescence detector. The chromatographic parameters are chosen so that there is no separation between the all-*trans*-vitamin A alcohol and its *cis* isomers.

3. Reagents

- 3.1. Ethanol, $\sigma = 96 \%$
- 3.2. Light petroleum, boiling range 40 °C-60 °C
- 3.3. Methanol
- 3.4. Potassium hydroxide solution, $c = 50 \text{ g}/100 \text{ ml}$
- 3.5. Sodium ascorbate solution, $c = 10 \text{ g}/100 \text{ ml}$ (see 7.7 observations)
- 3.6. Sodium sulphide, $\text{Na}_2\text{S} \cdot x \text{ H}_2\text{O}$ ($x = 7-9$)
 - 3.6.1. Sodium sulphide solution, $c = 0,5 \text{ mol}/\text{l}$ in glycerol, $\beta = 120 \text{ g}/\text{l}$ (for $x = 9$) (see 7.8 observations)
- 3.7. Phenolphthalein solution, $c = 2 \text{ g}/100 \text{ ml}$ in ethanol (3.1)
- 3.8. 2-Propanol
- 3.9. Mobile phase for HPLC: mixture of methanol (3.3) and water, e.g. 980 + 20 (v + v). The exact ratio will be determined by the characteristics of the column employed.
- 3.10. Nitrogen, oxygen free
- 3.11. All-*trans*-vitamin A acetate, extra pure, of certified activity, e.g. $2,80 \times 10^6 \text{ IU}/\text{g}$
 - 3.11.1. Stock solution of all-*trans*-vitamin A acetate: Weigh to the nearest 0,1 mg, 50 mg of vitamin A acetate (3.11) into a 100 ml graduated flask. Dissolve in 2-propanol (3.8) and make up to the mark with the same solvent. The nominal concentration of this solution is 1 400 IU vitamin A per ml. The exact content has to be determined according to 5.6.3.1.
- 3.12. All-*trans*-vitamin A palmitate, extra pure, of certified activity, e.g. $1,80 \times 10^6 \text{ IU}/\text{g}$
 - 3.12.1. Stock solution of all-*trans*-vitamin A palmitate: Weigh to the nearest 0,1 mg, 80 mg of vitamin A palmitate (3.12) into a 100 ml graduated flask. Dissolve in 2-propanol (3.8) and make up to the mark with the same solvent. The nominal concentration of this solution is 1 400 IU vitamin A per ml. The exact content has to be determined according to 5.6.3.2.

- 3.1.3. 2,6-Di-*tert*-butyl-4-methylphenol (BHT) (see 7.5 observations)

4. Apparatus

- 4.1. Vacuum rotary evaporator
- 4.2. Amber glassware
- 4.2.1. Flat bottom or conical flasks, 500 ml, with ground-glass socket
- 4.2.2. Graduated flasks with ground-glass stoppers, narrow-necked, 10, 25, 100 and 500 ml
- 4.2.3. Separating funnels, conical, 1 000 ml, with ground-glass stoppers
- 4.2.4. Pear shaped flasks, 250 ml, with ground-glass sockets
- 4.3. Allihn condenser, jacket length 300 mm, with ground-glass joint, with adapter for gas feed pipe
- 4.4. Pleated filter paper for phase separation, diameter 185 mm (e.g. Schleicher & Schuell 597 HY 1/2)
- 4.5. HPLC equipment with injection system
- 4.5.1. Liquid chromatographic column, 250 mm x 4 mm, C₁₈, 5 or 10 µm packing, or equivalent (performance criterion: only a single peak for all retinol isomers under the HPLC-conditions)
- 4.5.2. UV or fluorescence detector, with variable wavelength adjustment
- 4.6. Spectrophotometer with 10 mm quartz cells
- 4.7. Water-bath with magnetic stirrer
- 4.8. Extraction apparatus (see figure 1) consisting of:
- 4.8.1. Glass cylinder of 1 l capacity fitted with a ground glass neck and stopper
- 4.8.2. Ground glass insert equipped with a side-arm and an adjustable tube passing through the centre. The adjustable tube shall have a U-shaped lower end and a jet at the opposite end so that the upper liquid layer in the cylinder may be transferred into a separating funnel.

5. Procedure

Note: Vitamin A is sensitive to (UV-) light and to oxidation. All operations shall be carried out in the absence of light (using amber glassware, or glassware protected with aluminium foil) and oxygen (flush with nitrogen). During extraction air above the liquid shall be replaced by nitrogen (avoid excess pressure by loosening the stopper from time to time).

5.1. Preparation of the sample

Grind the sample so that it passes a 1 mm mesh sieve, taking care to avoid generation of heat. Grinding must be carried out **immediately** before weighing and saponification otherwise there may be losses of vitamin A.

5.2. Saponification

Depending on the vitamin A content weigh, to the nearest 1 mg, 2 g to 25 g of the sample into a 500 ml flat bottom or conical flask (4.2.1). Add successively with swirling 130 ml ethanol (3.1), approximately 100 mg BHT (3.1.3), 2 ml sodium ascorbate solution (3.5) and 2 ml sodium sulphide solution (3.6). Fit a condenser (4.3) to the flask and immerse the flask in a water-bath with magnetic stirrer (4.7). Heat to boiling and allow to reflux for 5 minutes. Then add 25 ml potassium hydroxide solution (3.4) through the condenser (4.3) and allow to reflux for a further 25 min., with stirring under a slow stream of nitrogen. Then rinse the condenser with approximately 20 ml water and cool the content of the flask to room temperature.

5.3. *Extraction*

Transfer by decantation the saponification solution quantitatively by rinsing with a total volume of 250 ml water to a 1 000 ml separating funnel (4.2.3) or to the extraction apparatus (4.8). Rinse the saponification flask successively with 25 ml ethanol (3.1) and 100 ml light petroleum (3.2) and transfer the rinsings to the separating funnel or to the extraction apparatus. The proportion of water and ethanol in the combined solutions must be about 2:1. Shake vigorously for 2 min. and allow to settle for 2 minutes.

5.3.1. *Extraction using a separating funnel (4.2.3)*

When the layers have separated (see observation 7.3) transfer the light petroleum layer to another separating funnel (4.2.3). Repeat this extraction twice, with 100 ml light petroleum (3.2) and twice, with 50 ml light petroleum (3.2).

Wash the combined extracts in the separating funnel twice by gently swirling (to avoid formation of emulsions) with 100 ml portions of water and then by repeated shaking with further 100 ml portions of water until the water remains colourless on addition of phenolphthalein solution (3.7) (washing four times is usually sufficient). Filter the washed extract through a dry pleated filter for phase separation (4.4) to remove any suspended water into a 500 ml graduated flask (4.2.2). Rinse the separating funnel and the filter with 50 ml light petroleum (3.2), make up to the mark with light petroleum (3.2) and mix well.

5.3.2. *Extraction using an extraction apparatus (4.8)*

When the layers have separated (see observation 7.3) replace the stopper of the glass cylinder (4.8.1) by the ground glass insert (4.8.2) and position the U-shaped lower end of the adjustable tube so that it is just above the level of the interface. By application of pressure from a nitrogen line to the side-arm, transfer the upper light petroleum-layer to a 1 000 ml separating funnel (4.2.3). Add 100 ml light petroleum (3.2) to the glass cylinder, stopper and shake well. Allow the layers to separate and transfer the upper layer to the separating funnel as before. Repeat the extraction procedure with further 100 ml of light petroleum (3.2), then twice with 50 ml portions of light petroleum (3.2) and add the light petroleum layers to the separating funnel.

Wash the combined light petroleum extracts as described in 5.3.1 and proceed as described there.

5.4. *Preparation of the sample solution for HPLC*

Pipette an aliquot portion of the light petroleum solution (from 5.3.1 or 5.3.2) into a 250 ml pear shaped flask (4.2.4). Evaporate the solvent nearly to dryness on the rotary evaporator (4.1) with reduced pressure at a bath temperature not exceeding 40 °C. Restore atmospheric pressure by admitting nitrogen (3.10) and remove the flask from the rotary evaporator. Remove the remaining solvent with a stream of nitrogen (3.10) and dissolve the residue immediately in a known volume (10-100 ml) of methanol (3.3) (the concentration of vitamin A must be in the range of 5 IU/ml to 30 IU/ml).

5.5. *Determination by HPLC*

Vitamin A is separated on a C₁₈ reversed phase column (4.5.1) and the concentration is measured by means of a UV detector (325 nm) or a fluorescence detector (excitation: 325 nm, emission: 475 nm) (4.5.2).

Inject an aliquot portion (e.g. 20 µl) of the methanolic solution obtained in 5.4 and elute with the mobile phase (3.9). Calculate the mean peak height (area) of several injections of the same sample solution and the mean peak heights (areas) of several injections of the calibration solutions (5.6.2).

HPLC conditions

The following conditions are offered for guidance; other conditions may be used provided that they give equivalent results.

Liquid chromatographic column (4.5.1): 250 mm × 4 mm, C₁₈, 5 or 10 µm packing, or equivalent

Mobile phase (3.9): Mixture of methanol (3.3) and water e.g. 980 + 20 (v + v).

Flow rate: 1-2 ml/min.

Detector (4.5.2): UV detector (325 nm) or fluorescence detector (excitation: 325 nm/emission: 475 nm)

5.6. Calibration

5.6.1. Preparation of the working standard solutions

Pipette 20 ml of the vitamin A acetate stock solution (3.11.1) or 20 ml of the vitamin A palmitate stock solution (3.12.1) into a 500 ml flat bottom or conical flask (4.2.1) and hydrolyse as described under 5.2, but without addition of BHT. Subsequently extract with light petroleum (3.2) according to 5.3 and make up to 500 ml with light petroleum (3.2). Evaporate 100 ml of this extract on the rotary evaporator (see 5.4) nearly to dryness, remove the remaining solvent with a stream of nitrogen (3.10) and redissolve the residue in 10,0 ml of methanol (3.3). The nominal concentration of this solution is 560 IU vitamin A per ml. The exact content has to be determined according to 5.6.3.3. The working standard solution has to be freshly prepared before use.

Pipette 2,0 ml of this working standard solution into a 20 ml graduated flask, make up to the mark with methanol (3.3) and mix. The nominal concentration of this **diluted** working standard solution is 56 IU vitamin A per ml.

5.6.2. Preparation of the calibration solutions and calibration graph

Transfer 1,0, 2,0, 5,0 and 10,0 ml of the **diluted** working standard solution into a series of 20 ml graduated flasks, make up to the mark with methanol (3.3) and mix. The nominal concentrations of these solutions are 2,8, 5,6, 14,0 and 28,0 IU vitamin A per ml.

Inject 20 µl of each calibration solution several times and determine the mean peak heights (areas). Using the mean peak heights (areas) plot a calibration graph considering the results of the UV control (5.6.3.3).

5.6.3. UV standardisation of the standard solutions

5.6.3.1. Vitamin A acetate stock solution

Pipette 2,0 ml of the vitamin A acetate stock solution (3.11.1) into a 50 ml graduated flask (4.2.2) and make up to the mark with 2-propanol (3.8). The nominal concentration of this solution is 56 IU vitamin A per ml. Pipette 3,0 ml of this diluted vitamin A acetate solution into a 25 ml graduated flask and make up to the mark with 2-propanol (3.8). The nominal concentration of this solution is 6,72 IU vitamin A per ml. Measure the UV spectrum of this solution against 2-propanol (3.8) in the spectrophotometer (4.6) between 300 nm and 400 nm. The extinction maximum must be between 325 nm and 327 nm.

Calculation of the vitamin A content:

$$\text{IU vitamin A/ml} = E_{326} \times 19,0$$

$$(E_{1\text{ cm}}^{1\%} \text{ for vitamin A acetate} = 1\,530 \text{ at } 326 \text{ nm in 2-propanol})$$

5.6.3.2. Vitamin A palmitate stock solution

Pipette 2,0 ml of the vitamin A palmitate stock solution (3.12.1) into a 50 ml graduated flask (4.2.2) and make up to the mark with 2-propanol (3.8). The nominal concentration of this solution is 56 IU vitamin A per ml. Pipette 3,0 ml of this diluted vitamin A palmitate solution into a 25 ml graduated flask and make up to the mark with 2-propanol (3.8). The nominal concentration of this solution is 6,72 IU vitamin A per ml. Measure the UV spectrum of this solution against 2-propanol (3.8) in the spectrophotometer (4.6) between 300 nm and 400 nm. The extinction maximum must be between 325 nm and 327 nm.

Calculation of the vitamin A content:

$$\text{IU vitamin A/ml} = E_{326} \times 19,0$$

$$(E_{1\text{ cm}}^{1\%} \text{ for vitamin A palmitate} = 957 \text{ at } 326 \text{ nm in 2-propanol})$$

5.6.3.3. Vitamin A working standard solution

Pipette 3,0 ml of the **undiluted** vitamin A working standard solution, prepared according to 5.6.1 into a 50 ml graduated flask (4.2.2) and make up to the mark with 2-propanol (3.8). Pipette 5,0 ml of this solution into a 25 ml graduated flask and make up to the mark with 2-propanol (3.8). The nominal concentration of this solution is 6,72 IU vitamin A per ml. Measure the UV spectrum of this solution against 2-propanol (3.8) in the spectrophotometer (4.6) between 300 nm and 400 nm. The extinction maximum must be between 325 nm and 327 nm.

Calculation of the vitamin A content:

$$\text{IU vitamin A/ml} = E_{325} \times 18,3$$

$$(E_{1\text{ cm}}^{1\%} \text{ for vitamin A alcohol} = 1\,821 \text{ at } 325 \text{ nm in 2-propanol})$$

6. Calculation of the results

From the mean height (area) of the vitamin A peaks of the sample solution determine the concentration of the sample solution in IU/ml by reference to the calibration graph (5.6.2).

The vitamin A content w in IU/kg of the sample is given by the following formula:

$$w = \frac{500 \times c \times V_2 \times 1\,000}{V_1 \times m} \text{ [IU/kg]}$$

in which:

c = vitamin A concentration of the sample solution (5.4) in IU/ml

V_1 = volume of sample solution (5.4) in ml

V_2 = volume of aliquot taken in 5.4 in ml

m = weight of the test portion in g

7. Observations

- 7.1. For samples with low vitamin A concentration it may be useful to combine the light petroleum-extracts of two saponification-charges (amount weighed: 25 g) to one sample solution for HPLC-determination.
- 7.2. The weight of the sample taken for the analysis shall not contain more than 2 g fat.
- 7.3. If phase separation does not occur add approximately 10 ml ethanol (3.1) to break the emulsion.
- 7.4. With cod-liver oil and other pure fats the saponification time shall be extended to 45-60 minutes.
- 7.5. Hydroquinone can be used instead of BHT.
- 7.6. Using a normal phase-column the separation of retinol isomers is possible. But in that case, the heights (areas) of all cis and trans isomers peaks have to be summed for calculations.
- 7.7. Approximately 150 mg ascorbic acid can be used instead of sodium ascorbate solution.
- 7.8. Approximately 50 mg EDTA can be used instead of sodium sulphide solution.
- 7.9. In cases of analysis of vitamin A in milk replacers, specific attention has to be paid
 - at saponification (5.2): due to the amount of fat present in the sample, increasing of potassium hydroxide solution amount (3.4) may be necessary,
 - at extraction (5.3): due to the presence of emulsions, adaptation of the water/ethanol 2:1 ratio may be necessary.

To check if the applied method of analysis generates reliable results on this specific matrix (milk replacer), a recovery test shall be applied on an additional test portion. If the recovery rate is lower than 80 %, the analytical result has to be corrected for recovery.

8. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed 15 % relative to the higher result.

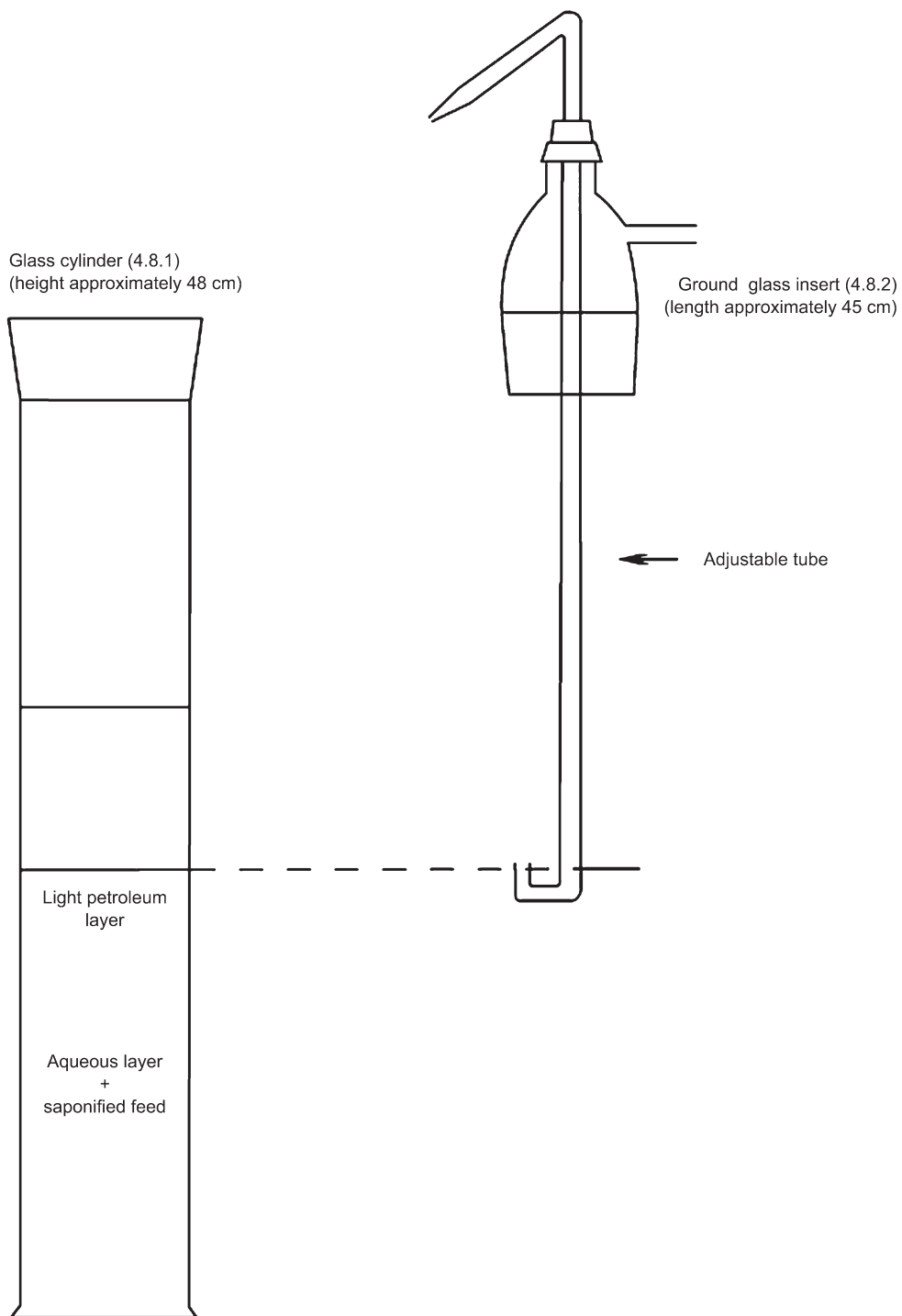
9. **Results of a collaborative study ⁽¹⁾**

	Premix	Premix feed	Mineral concen- trate	Protein feed	Piglet
L	13	12	13	12	13
n	48	45	47	46	49
mean [IU/kg]	17,02 x 10 ⁶	1,21 x 10 ⁶	537 100	151 800	18 070
S _r [IU/kg]	0,51 x 10 ⁶	0,039 x 10 ⁶	22 080	12 280	682
r [IU/kg]	1,43 x 10 ⁶	0,109 x 10 ⁶	61 824	34 384	1 910
CV _r [%]	3,0	3,5	4,1	8,1	3,8
S _R [IU/kg]	1,36 x 10 ⁶	0,069 x 10 ⁶	46 300	23 060	3 614
R [IU/kg]	3,81 x 10 ⁶	0,193 x 10 ⁶	129 640	64 568	10 119
CV _R [%]	8,0	6,2	8,6	15	20

L = number of laboratories
 n = number of single values
 s_r = standard deviation of repeatability
 S_R = standard deviation of reproducibility
 r = repeatability
 R = reproducibility
 CV_r = coefficient of variation of repeatability
 CV_R = coefficient of variation of reproducibility.

⁽¹⁾ Conducted by the Feed Working Group of Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten (VDLUFA).

Figure 1: Extraction apparatus (4.8)



B. DETERMINATION OF VITAMIN E**1. Purpose and Scope**

This method makes it possible to determine the level of vitamin E in feed and premixtures. The content of vitamin E is expressed as mg DL- α -tocopherol acetate per kg. 1 mg DL- α -tocopherol acetate corresponds to 0,91 mg DL- α -tocopherol (vitamin E).

The limit of quantification is 2 mg vitamin E/kg. This limit of quantification is only achievable with fluorescence detector. With an UV detector the limit of quantification is 10 mg/kg.

2. Principle

The sample is hydrolysed with ethanolic potassium hydroxide solution and the vitamin E is extracted into light petroleum. The solvent is removed by evaporation and the residue is dissolved in methanol and, if necessary, diluted to the required concentration. The content of vitamin E is determined by reversed phase high performance liquid chromatography (RP-HPLC) using a fluorescence or a UV detector.

3. Reagents

- 3.1. Ethanol, $\sigma = 96 \%$.
- 3.2. Light petroleum, boiling range 40 °C-60 °C.
- 3.3. Methanol.
- 3.4. Potassium hydroxide solution, $c = 50 \text{ g}/100 \text{ ml}$.
- 3.5. Sodium ascorbate solution, $c = 10 \text{ g}/100 \text{ ml}$ (see 7.7 observations).
- 3.6. Sodium sulphide, $\text{Na}_2\text{S} \cdot x \text{ H}_2\text{O}$ ($x = 7-9$).
- 3.6.1. Sodium sulphide solution, $c = 0,5 \text{ mol/l}$ in glycerol, $\beta = 120 \text{ g/l}$. (for $x = 9$) (see 7.8 observations)
- 3.7. Phenolphthalein solution, $c = 2 \text{ g}/100 \text{ ml}$ in ethanol (3.1).
- 3.8. Mobile phase for HPLC: mixture of methanol (3.3) and water, e.g. 980 + 20 ($v + v$). The exact ratio will be determined by the characteristics of the column employed.
- 3.9. Nitrogen, oxygen free.
- 3.10. DL- α -tocopherol acetate, extra pure, of certified activity.
- 3.10.1. Stock solution of DL- α -tocopherol acetate: Weigh to the nearest 0,1 mg, 100 mg of DL- α -tocopherol acetate (3.10) into a 100 ml graduated flask. Dissolve in ethanol (3.1) and make up to the mark with the same solvent. 1 ml of this solution contains 1 mg DL- α -tocopherol acetate. (UV control see 5.6.1.3; stabilisation see 7.4 observations).
- 3.11. DL- α -tocopherol, extra pure, of certified activity.
- 3.11.1. Stock solution of DL- α -tocopherol: Weigh to the nearest 0,1 mg, 100 mg of DL- α -tocopherol (3.10) into a 100 ml graduated flask. Dissolve in ethanol (3.1) and make up to the mark with the same solvent. 1 ml of this solution contains 1 mg DL- α -tocopherol. (UV control see 5.6.2.3; stabilisation see 7.4 observations).
- 3.12. 2,6-Di-*tert*-butyl-4-methylphenol (BHT) (see 7.5 observations).

4. Apparatus

- 4.1. Rotary film evaporator.
- 4.2. Amber glassware.
- 4.2.1. Flat bottom or conical flasks, 500 ml, with ground-glass socket.

- 4.2.2. Graduated flasks with ground-glass stoppers, narrow-necked, 10, 25, 100 and 500 ml.
- 4.2.3. Separating funnels, conical, 1 000 ml, with ground-glass stoppers.
- 4.2.4. Pear shaped flasks, 250 ml, with ground-glass sockets.
- 4.3. Allihn condenser, jacket length 300 mm, with ground-glass joint, with adapter for gas feed pipe.
- 4.4. Pleated filter paper for phase separation, diameter 185 mm (e.g. Schleicher & Schuell 597 HY 1/2).
- 4.5. HPLC equipment with injection system.
- 4.5.1. Liquid chromatographic column, 250 mm × 4 mm, C₁₈, 5 or 10 µm packing, or equivalent.
- 4.5.2. Fluorescence or UV detector, with variable wavelength adjustment.
- 4.6. Spectrophotometer with 10 mm quartz cells.
- 4.7. Water-bath with magnetic stirrer.
- 4.8. Extraction apparatus (see figure 1) consisting of:
 - 4.8.1. Glass cylinder of 1 l capacity fitted with a ground glass neck and stopper.
 - 4.8.2. Ground glass insert equipped with a side-arm and an adjustable tube passing through the centre. The adjustable tube shall have a U-shaped lower end and a jet at the opposite end so that the upper liquid layer in the cylinder may be transferred into a separating funnel.

5. Procedure

Note: Vitamin E is sensitive to (UV-) light and to oxidation. All operations shall be carried out in the absence of light (using amber glassware, or glassware protected with aluminium foil) and oxygen (flush with nitrogen). During extraction air above the liquid shall be replaced by nitrogen (avoid excess pressure by loosening the stopper from time to time).

5.1. Preparation of the sample

Grind the sample so that it passes a 1 mm mesh sieve, taking care to avoid generation of heat. Grinding must be carried out **immediately** before weighing and saponification otherwise there may be losses of vitamin E.

5.2. Saponification

Depending on the vitamin E content weigh, to the nearest 0,01 g, 2 g to 25 g of the sample into a 500 ml flat bottom or conical flask (4.2.1). Add successively with swirling 130 ml ethanol (3.1), approximately 100 mg BHT (3.12), 2 ml sodium ascorbate solution (3.5) and 2 ml sodium sulphide solution (3.6). Fit the condenser (4.3) to the flask and immerse the flask in a water-bath with magnetic stirrer (4.7). Heat to boiling and allow to reflux for 5 minutes. Then add 25 ml potassium hydroxide solution (3.4) through the condenser (4.3) and allow to reflux for a further 25 min. with stirring under a slow stream of nitrogen. Then rinse the condenser with approximately 20 ml water and cool the content of the flask to room temperature.

5.3. Extraction

Transfer by decantation the saponification solution quantitatively by rinsing with a total volume of 250 ml water to a 1 000 ml separating funnel (4.2.3) or to the extraction apparatus (4.8). Rinse the saponification flask successively with 25 ml ethanol (3.1) and 100 ml light petroleum (3.2) and transfer the rinsings to the separating funnel or to the extraction apparatus. The proportion of water and ethanol in the combined solutions must be about 2:1. Shake vigorously for 2 min. and allow to settle for 2 minutes.

5.3.1. Extraction using a separating funnel (4.2.3)

When the layers have separated (see observation 7.3) transfer the light petroleum layer to another separating funnel (4.2.3). Repeat this extraction twice, with 100 ml light petroleum (3.2) and twice, with 50 ml light petroleum (3.2).

Wash the combined extracts in the separating funnel twice by gently swirling (to avoid formation of emulsions) with 100 ml portions of water and then by repeated shaking with further 100 ml portions of water until the water remains colourless on addition of phenolphthalein solution (3.7) (washing four times is usually sufficient). Filter the washed extract through a dry pleated filter for phase separation (4.4) to remove any suspended water into a 500 ml graduated flask (4.2.2). Rinse the separating funnel and the filter with 50 ml light petroleum (3.2), make up to the mark with light petroleum (3.2) and mix well.

5.3.2. Extraction using an extraction apparatus (4.8)

When the layers have separated (see observation 7.3) replace the stopper of the glass cylinder (4.8.1) by the ground glass insert (4.8.2) and position the U-shaped lower end of the adjustable tube so that it is just above the level of the interface. By application of pressure from a nitrogen line to the side-arm, transfer the upper light petroleum-layer to a 1 000 ml separating funnel (4.2.3). Add 100 ml light petroleum (3.2) to the glass cylinder, stopper and shake well. Allow the layers to separate and transfer the upper layer to the separating funnel as before. Repeat the extraction procedure with further 100 ml of light petroleum (3.2), then twice with 50 ml portions of light petroleum (3.2) and add the light petroleum layers to the separating funnel.

Wash the combined light petroleum extracts as described in 5.3.1 and proceed as described there.

5.4. Preparation of the sample solution for HPLC

Pipette an aliquot portion of the light petroleum solution (from 5.3.1 or 5.3.2) into a 250 ml pear shaped flask (4.2.4). Evaporate the solvent nearly to dryness on the rotary evaporator (4.1) with reduced pressure at a bath temperature not exceeding 40 °C. Restore atmospheric pressure by admitting nitrogen (3.9) and remove the flask from the rotary evaporator. Remove the remaining solvent with a stream of nitrogen (3.9) and dissolve the residue immediately in a known volume (10-100 ml) of methanol (3.3) (the concentration of DL- α -tocopherol must be in the range 5 μ g/ml to 30 μ g/ml).

5.5. Determination by HPLC

Vitamin E is separated on a C₁₈ reversed phase column (4.5.1) and the concentration is measured using a fluorescence detector (excitation: 295 nm, emission: 330 nm) or a UV detector (292 nm) (4.5.2).

Inject an aliquot portion (e.g. 20 μ l) of the methanolic solution obtained in 5.4 and elute with the mobile phase (3.8). Calculate the mean peak heights (areas) of several injections of the same sample solution and the mean peak heights (areas) of several injections of the calibration solutions (5.6.2).

HPLC conditions

The following conditions are offered for guidance; other conditions may be used provided that they give equivalent results.

Liquid chromatographic 250 mm \times 4 mm, C₁₈, 5 or 10 μ m packing, or equivalent column (4.5.1):

Mobile phase (3.8): Mixture of methanol (3.3) and water e.g. 980 + 20 (v + v).

Flow rate: 1-2 ml/min.

Detector (4.5.2) Fluorescence detector
(excitation: 295 nm/emission: 330 nm) or UV detector (292 nm)

5.6. Calibration (DL- α -tocopherol acetate or DL- α -tocopherol)

5.6.1. DL- α -tocopherol acetate standard

5.6.1.1. Preparation of the working standard solution

Transfer by pipette 25 ml of the DL- α -tocopherol acetate stock solution (3.10.1) into a 500 ml flat bottom or conical flask (4.2.1) and hydrolyse as described under 5.2. Subsequently extract with light petroleum (3.2) according to 5.3 and make up to 500 ml with light petroleum. Evaporate 25 ml of this extract on the rotary evaporator (see 5.4) nearly to dryness, remove the remaining solvent with a stream of nitrogen (3.9) and redissolve the residue in 25,0 ml of methanol (3.3). The nominal concentration of this solution is 45,5 μ g DL- α -tocopherol per ml, equivalent to 50 μ g DL- α -tocopherol acetate per ml. The working standard solution has to be freshly prepared before use.

5.6.1.2. *Preparation of the calibration solutions and calibration graph*

Transfer 1,0, 2,0, 4,0 and 10,0 ml of the working standard solution into a series of 20 ml graduated flasks, make up to the mark with methanol (3.3) and mix. The nominal concentrations of these solutions are 2,5, 5,0, 10,0 and 25,0 µg/ml DL- α -tocopherol acetate, i.e. 2,28, 4,55, 9,10 µg/ml and 22,8 µg/ml DL- α -tocopherol.

Inject 20 µl of each calibration solution several times and determine the mean peak heights (areas). Using the mean peak heights (areas) plot a calibration graph.

5.6.1.3. *UV standardisation of the DL- α -tocopherol acetate stock solution (3.10.1)*

Dilute 5,0 ml of the DL- α -tocopherol acetate stock solution (3.10.1) to 25,0 ml with ethanol and measure the UV spectrum of this solution against ethanol (3.1) in the spectrophotometer (4.6) between 250 nm and 320 nm.

The absorption maximum shall be at 284 nm:

$$E_{1\text{ cm}}^{1\%} = 43,6 \text{ at } 284 \text{ nm in ethanol}$$

At this dilution an extinction value of 0,84 to 0,88 must be obtained.

5.6.2. DL- α -tocopherol standard

5.6.2.1. *Preparation of the working standard solution*

Transfer by pipette 2 ml of the DL- α -tocopherol stock solution (3.11.1) into a 50 ml graduated flask, dissolve in methanol (3.3) and make up to the mark with methanol. The nominal concentration of this solution is 40 µg DL- α -tocopherol per ml, equivalent to 44,0 µg DL- α -tocopherol acetate per ml. The working standard solution has to be freshly prepared before use.

5.6.2.2. *Preparation of the calibration solutions and calibration graph*

Transfer 1,0, 2,0, 4,0 and 10,0 ml of the working standard solution into a series of 20 ml graduated flasks, make up to the mark with methanol (3.3) and mix. The nominal concentrations of these solutions are 2,0, 4,0, 8,0 and 20,0 µg/ml DL- α -tocopherol, i.e. 2,20, 4,40, 8,79 µg/ml and 22,0 µg/ml DL- α -tocopherol acetate.

Inject 20 µl of each calibration solution several times and determine the mean peak heights (areas). Using the mean peak heights (areas) plot a calibration graph.

5.6.2.3. *UV standardisation of the DL- α -tocopherol stock solution (3.11.1)*

Dilute 2,0 ml of the DL- α -tocopherol stock solution (3.11.1) to 25,0 ml with ethanol and measure the UV spectrum of this solution against ethanol (3.1) in the spectrophotometer (4.6) between 250 nm and 320 nm. The absorption maximum shall be at 292 nm:

$$E_{1\text{ cm}}^{1\%} = 75,8 \text{ at } 292 \text{ nm in ethanol}$$

At this dilution an extinction value of 0,6 must be obtained.

6. Calculation of the results

From the mean height (area) of the vitamin E peaks of the sample solution determine the concentration of the sample solution in µg/ml (calculated as α -tocopherol acetate) by reference to the calibration graph (5.6.1.2 or 5.6.2.2).

The vitamin E content w in mg/kg of the sample is given by the following formula:

$$w = \frac{500 \times c \times V_2}{V_1 \times m} \text{ [mg/kg]}$$

in which:

c = vitamin E concentration (as α -tocopherol acetate) of the sample solution (5.4) in µg/ml

V_1 = volume of sample solution (5.4), in ml

V_2 = volume of aliquot taken in (5.4), in ml

m = weight of the test portion in g

7. Observations

- 7.1. For samples with low vitamin E concentration it may be useful to combine the light petroleum-extracts of two saponification-charges (amount weighed: 25 g) to one sample solution for HPLC-determination.
- 7.2. The weight of the sample taken for the analysis shall not contain more than 2 g fat.
- 7.3. If phase separation does not occur add approximately 10 ml ethanol (3.1) to break the emulsion.
- 7.4. After the spectrophotometric measurement of the DL- α -tocopherol acetate or DL- α -tocopherol solution according to 5.6.1.3 or 5.6.2.3 respectively add approximately 10 mg BHT (3.12) to the solution (3.10.1 or 3.10.2) and keep the solution in a refrigerator (storage life max. 4 weeks).
- 7.5. Hydroquinone can be used instead of BHT.
- 7.6. Using a normal phase-column the separation of α -, β -, γ - and δ -tocopherol is possible.
- 7.7. Approximately 150 mg ascorbic acid can be used instead of sodium ascorbate solution.
- 7.8. Approximately 50 mg EDTA can be used instead of sodium sulphide solution.
- 7.9. Vitamin E acetate hydrolyses very fast under alkaline conditions and is therefore very sensitive to oxidation, especially in the presence of trace elements like iron or copper. In case of the determination of vitamin E in premixtures at levels higher than 5 000 mg/kg, a degradation of vitamin E could be the consequence. Therefore a HPLC method including an enzymatic digestion of the vitamin E formulation without an alkaline saponification step is to be recommended for confirmation.

8. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed 15 % relative to the higher result.

9. Results of a collaborative study ⁽¹⁾

	Premix	Premix feed	Mineral concentrate	Protein feed	Piglet
L	12	12	12	12	12
n	48	48	48	48	48
mean [mg/kg]	17 380	1 187	926	315	61,3
S_r [mg/kg]	384	45,3	25,2	13,0	2,3
r [mg/kg]	1 075	126,8	70,6	36,4	6,4
CV_r [%]	2,2	3,8	2,7	4,1	3,8
S_R [mg/kg]	830	65,0	55,5	18,9	7,8
R [mg/kg]	2 324	182,0	155,4	52,9	21,8
CV_R [%]	4,8	5,5	6,0	6,0	12,7

L = number of laboratories

n = number of single values

s_r = standard deviation of repeatability

s_R = standard deviation of reproducibility

r = repeatability

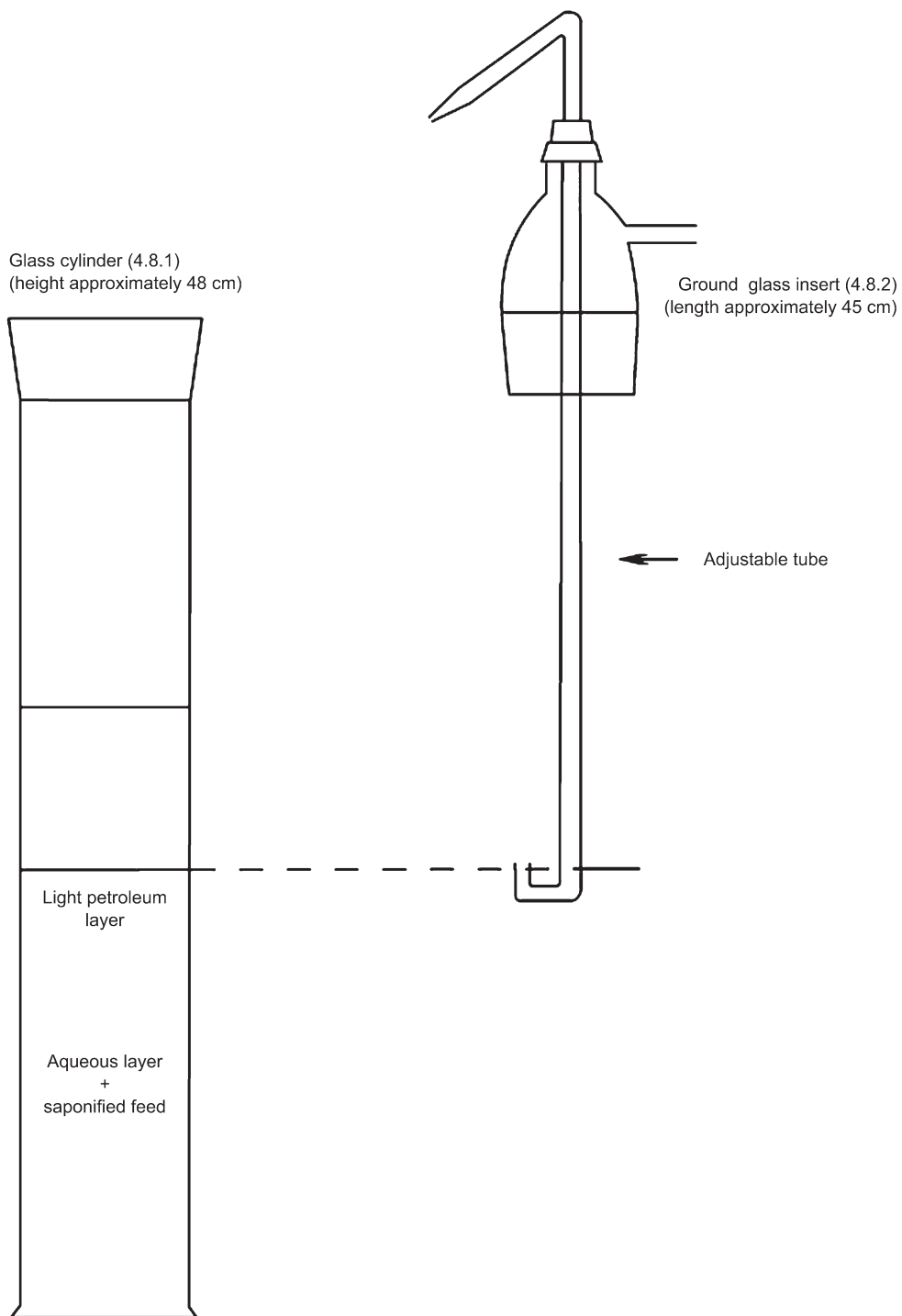
R = reproducibility

CV_r = coefficient of variation of repeatability

CV_R = coefficient of variation of reproducibility

⁽¹⁾ Conducted by the Feed Working Group of Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten (VDLUFA).

Figure 1: Extraction apparatus (4.8)



C. DETERMINATION OF THE TRACE ELEMENTS IRON, COPPER, MANGANESE AND ZINC

1. **Purpose and scope**

The method makes it possible to determine the trace elements iron, copper, manganese and zinc in feed. The limits of quantification are:

- iron (Fe): 20 mg/kg
- copper (Cu): 10 mg/kg
- manganese (Mn): 20 mg/kg
- zinc (Zn): 20 mg/kg.

2. **Principle**

The sample is brought into solution in hydrochloric acid after destruction of organic matter, if any. The elements iron, copper, manganese and zinc are determined, after appropriate dilution, by atomic absorption spectrometry.

3. **Reagents***Introductory comments*

For preparation of the reagents and analytical solutions use water free from the cations to be determined, obtained either by double distilling water in a borosilicate glass or quartz still or by double treatment on ion exchange resin.

The reagents must be of at least analytical grade. Freedom from the element to be determined must be checked in a blank experiment. If necessary, the reagents must be further purified.

In place of the standard solutions described below, commercial standard solutions may be used provided that they are guaranteed and have been checked before use.

- 3.1. Hydrochloric acid (d:1,19 g/ml).
- 3.2. Hydrochloric acid (6 mol/litre).
- 3.3. Hydrochloric acid (0,5 mol/litre).
- 3.4. Hydrofluoric acid 38 % to 40 % (v/v) having an iron (Fe) content of less than 1 mg/litre and a residue after evaporation of less than 10 mg (as sulphate)/litre.
- 3.5. Sulphuric acid (d: 1,84 g/ml).
- 3.6. Hydrogen peroxide (approximately 100 volumes of oxygen (30 % by weight)).
- 3.7. Standard iron solution (1 000 µg Fe/ml) prepared as follows or equivalent commercially available solution: dissolve 1 g of iron wire in 200 ml of 6 mol/litre hydrochloric acid (3.2), add 16 ml of hydrogen peroxide (3.6) and make up to one litre with water.
 - 3.7.1. Working standard iron solution (100 µg Fe/ml) prepared by diluting one part of the standard solution (3.7) with 9 parts of water.
- 3.8. Standard copper solution (1 000 µg Cu/ml) prepared as follows or equivalent commercially available solution:
 - dissolve 1 g of copper in powder form in 25 ml of 6 mol/litre hydrochloric acid (3.2), add 5 ml of hydrogen peroxide (3.6) and make up to one litre with water.

- 3.8.1. Working standard copper solution (10 µg Cu/ml) prepared by diluting 1 part of the standard solution (3.8) with 9 parts of water and then diluting 1 part of the resulting solution with 9 parts of water.
- 3.9. Standard manganese solution (1 000 µg Mn/ml) prepared as follows or equivalent commercially available solution:
- dissolve 1 g of manganese in powder form in 25 ml of 6 mol/litre hydrochloric acid (3.2) and make up to one litre with water.
- 3.9.1. Working standard manganese solution (10 µg Mn/ml) prepared by diluting 1 part of the standard solution (3.9) with 9 parts of water and then diluting 1 part of the resulting solution with 9 parts of water.
- 3.10. Standard zinc solution (1 000 µg Zn/ml) prepared as follows or equivalent commercially available solution:
- dissolve 1 g of zinc in strip or leaf form in 25 ml of 6 mol/litre hydrochloric acid (3.2) and make up to one litre with water.
- 3.10.1. Working standard zinc solution (10 µg Zn/ml) prepared by diluting 1 part of the standard solution (3.10) with 9 parts of water and then diluting 1 part of the resulting solution with 9 parts of water.
- 3.11. Lanthanum chloride solution: dissolve 12 g of lanthanum oxide in 150 ml of water, add 100 ml of 6 mol/litre hydrochloric acid (3.2) and make up to one litre with water.

4. Apparatus

- 4.1. Muffle furnace with temperature regulation and preferably recorder.
- 4.2. Glassware must be of resistant borosilicate type and it is recommended to use apparatus which is reserved exclusively for trace element determinations.
- 4.3. Atomic absorption spectrophotometer meeting the requirements of the method with regard to sensitivity and precision in the required range.

5. Procedure ⁽¹⁾

5.1. *Samples containing organic matter*

5.1.1. Ashing and preparation of the solution for analysis ⁽²⁾

- 5.1.1.1. Place 5 to 10 g of sample weighed to the nearest 0,2 mg in a quartz or platinum crucible (see Note (b)), dry in an oven at 105 °C and introduce the crucible into the cold muffle furnace (4.1). Close the furnace (see Note (c)) and gradually raise the temperature to 450 to 475 °C over about 90 minutes. Maintain this temperature for 4 to 16 hours (e.g. overnight) to remove carbonaceous material and then open the furnace and allow to cool (see Note (d)).

Moisten the ashes with water and transfer these in a beaker of 250 ml. Wash the crucible out with a total of about 5 ml of hydrochloric acid (3.1) and add the latter slowly and carefully to the beaker (there may be a vigorous reaction due to CO₂ formation). Add hydrochloric acid (3.1) dropwise with agitation until all effervescence has stopped. Evaporate to dryness, occasionally stirring with a glass rod.

⁽¹⁾ Other methods of digestion may be used provided they have been demonstrated to have similar results (such as microwave pressure digestion).

⁽²⁾ Green fodder (fresh or dried) is liable to contain large amounts of vegetable silica, which may retain trace elements and must be removed. For samples of these feed, therefore, the following modified procedure must be followed. Carry out operation 5.1.1.1. as far as the filtration. Wash the filter paper containing the insoluble residue twice with boiling water and place it in a quartz or platinum crucible. Ignite in the muffle furnace (4.1) at a temperature below 550 °C until all carbonaceous material has completely disappeared. Allow to cool, add a few drops of water followed by 10 to 15 ml of hydrofluoric acid (3.4) and evaporate to dryness at about 150 °C. If any silica remains in the residue, redissolve it in a few millilitres of hydrofluoric acid (3.4) and evaporate to dryness. Add five drops of sulphuric acid (3.5) and heat until no more white fumes are given off. After the addition of 5 ml of 6 mol/litre hydrochloric acid (3.2) and about 30 ml of water, heat, filter the solution into the 250 ml volumetric flask and make up to the mark with water (HCl concentration about 0,5 mol/l). Proceed then with the determination from point 5.1.2.

Next add 15 ml of 6 mol/litre hydrochloric acid (3.2) to the residue followed by about 120 ml of water. Stir with the glass rod, which shall be left in the beaker, and cover the beaker with a watch-glass. Bring gently to the boil and maintain at boiling point until no more ash can be seen to dissolve. Filter on ash-free filter paper and collect the filtrate in a 250 ml volumetric flask. Wash the beaker and filter with 5 ml of hot 6 mol/litre hydrochloric acid (3.2) and twice with boiling water. Fill the volumetric flask up to the mark with water (HCl concentration about 0,5 mol/litre).

- 5.1.1.2. If the residue in the filter appears black (carbon), put it back in the furnace and ash again at 450 to 475 °C. This ashing, which only requires a few hours (about three to five hours), is complete when the ash appears white or nearly white. Dissolve the residue with about 2 ml of hydrochloric acid (3.1), evaporate to dryness and add 5 ml of 6 mol/litre hydrochloric acid (3.2). Heat, filter the solution into the volumetric flask and make up to the mark with water (HCl concentration about 0,5 mol/litre).

Notes:

- (a) In determining trace elements it is important to be alert to the risks of contamination, particularly by zinc, copper and iron. For this reason, the equipment used in preparing the samples must be free of these metals.

To reduce the general risk of contamination, work in a dust-free atmosphere with scrupulously clean equipment and carefully washed glassware. The determination of zinc is particularly sensitive to many types of contamination, e.g. from glassware, reagents, dust, etc.

- (b) The weight of sample to be ashed is calculated from the approximate trace element content of the feed in relation to the sensitivity of the spectrophotometer used. For certain feed low in trace elements it may be necessary to start with a 10 to 20 g sample and make up the final solution to only 100 ml.
- (c) Ashing must be carried out in a closed furnace without injection of air or oxygen.
- (d) The temperature indicated by the pyrometer must not exceed 475 °C.

5.1.2. Spectrophotometric determination

5.1.2.1. Preparation of calibration solutions

For each of the elements to be determined, prepare from the working standard solutions given in points 3.7.1, 3.8.1, 3.9.1 and 3.10.1 a range of calibration solutions, each calibration solution having an HCl concentration of about 0,5 mol/litre (and (in the cases of iron, manganese and zinc) a lanthanum chloride concentration equivalent to 0,1 % La (w/v).

The trace element concentrations selected must lie within the range of sensitivity of the spectrophotometer used. The tables below show, by way of example, the compositions of typical ranges of calibration solutions; depending, however, on the type and sensitivity of spectrophotometer used it may be necessary to select other concentrations.

Iron

µg Fe/ml	0	0,5	1	2	3	4	5
ml working standard solution (3.7.1) (1 ml = 100 µg Fe)	0	0,5	1	2	3	4	5
ml HCl (3.2)	7	7	7	7	7	7	7
+ 10 ml of lanthanum chloride solution (3.11) and make up to 100 ml with water							

Copper

µg Cu/ml	0	0,1	0,2	0,4	0,6	0,8	1,0
ml working standard solution (3.8.1) (1 ml = 10 µg Cu)	0	1	2	4	6	8	10
ml HCl (3.2)	8	8	8	8	8	8	8

Manganese

µg Mn/ml	0	0,1	0,2	0,4	0,6	0,8	1,0
ml working standard solution (3.9.1) (1 ml = 10 µg Mn)	0	1	2	4	6	8	10
ml HCl (3.2)	7	7	7	7	7	7	7
+ 10 ml of lanthanum chloride solution (3.11) and make up to 100 ml with water							

Zinc

µg Zn/ml	0	0,05	0,1	0,2	0,4	0,6	0,8
ml working standard solution (3.10.1) (1 ml = 10 µg Zn)	0	0,5	1	2	4	6	8
ml HCl (3.2)	7	7	7	7	7	7	7
+ 10 ml of lanthanum chloride solution (3.11) and make up to 100 ml with water							

5.1.2.2. *Preparation of solution for analysis*

For the determination of copper, the solution prepared from point 5.1.1 can normally be used directly. If necessary to bring its concentration within the range of the calibration solutions, an aliquot portion may be pipetted into a 100 ml volumetric flask and made up to the mark with 0,5 mol/litre hydrochloric acid (3.3).

For the determination of iron, manganese and zinc, pipette an aliquot portion of the solution prepared from point 5.1.1 into a 100 ml volumetric flask, add 10 ml of lanthanum chloride solution (3.11) and make up to the mark with 0,5 mol/litre hydrochloric acid (3.3) (see also point 8 'Observation').

5.1.2.3. *Blank experiment*

The blank experiment must include all the prescribed steps of the procedure except that the sample material is omitted. The calibration solution '0' must not be used as the blank.

5.1.2.4. *Measurement of the atomic absorption*

Measure the atomic absorption of the calibration solutions and of the solution to be analysed using an oxidising air-acetylene flame at the following wavelengths:

Fe: 248,3 nm

Cu: 324,8 nm

Mn: 279,5 nm

Zn: 213,8 nm

Carry out each measurement four times.

5.2. *Mineral feed*

If the sample contains no organic matter, prior ashing is unnecessary. Proceed as described in point 5.1.1.1 starting from the second paragraph. Evaporation with hydrofluoric acid may be omitted.

6. Calculation of results

Using a calibration curve, calculate the trace element concentration in the solution to be analysed and express the result in milligrams of trace element per kilogram of sample (ppm).

7. Repeatability

The difference between the results of two parallel determinations carried out on the same sample by the same analyst shall not exceed:

- 5 mg/kg, in absolute value, for contents of the trace element concerned up to 50 mg/kg,
- 10 % of the higher result for contents of the trace element concerned from 50 and up to 100 mg/kg,
- 10 mg/kg, in absolute value, for contents of the trace element concerned from 100 and up to 200 mg/kg,
- 5 % of the higher result for contents of the trace element concerned above 200 mg/kg.

8. Observation

The presence of large quantities of phosphates may interfere with the determination of iron, manganese and zinc. Such interference must be corrected by addition of lanthanum chloride solution (3.11). If, however, in the sample the weight ratio Ca + Mg/P is > 2, addition of lanthanum chloride solution (3.11) to the solution for analysis and to the calibration solutions may be omitted.

D. DETERMINATION OF HALOFUGINONE

DL-trans-7-bromo-6-chloro-3-[3-(3-hydroxy-2-piperidyl)acetyl]-quinazolin-4-(3H)-one hydrobromide

1. Purpose and scope

The method makes it possible to determine the level of halofuginone in feed. The limit of quantification is 1 mg/kg.

2. Principle

After treatment with hot water, halofuginone is extracted as the free base into ethyl acetate and subsequently partitioned as the hydrochloride into an aqueous acid solution. The extract is purified by ion-exchange chromatography. The content of halofuginone is determined by reversed-phase high performance liquid chromatography (HPLC) using an UV detector.

3. Reagents

- 3.1. Acetonitrile, equivalent to HPLC grade.
- 3.2. Amberlite XAD-2 resin.
- 3.3. Ammonium acetate.
- 3.4. Ethyl acetate.
- 3.5. Acetic acid, glacial.
- 3.6. Halofuginone standard substance (DL-trans-7-bromo-6-chloro-3-[3-(3-hydroxy-2-piperidyl)acetyl] quinazolin-4-(3H)-one hydrobromide, E 764).
- 3.6.1. Halofuginone stock standard solution, 100 µg/ml

Weight to the nearest 0,1 mg, 50 mg of halofuginone (3.6) in a 500 ml graduated flask, dissolve in ammonium acetate buffer solution (3.18), make up to the mark with the buffer solution and mix. This solution is stable for three weeks at 5 °C if stored in the dark.

3.6.2. Calibration solutions

Into a series of 100 ml graduated flasks transfer 1,0, 2,0, 3,0, 4,0 and 6,0 ml of the stock standard solution (3.6.1). Make up to the mark with mobile phase (3.21) and mix. These solutions have concentrations of 1,0, 2,0, 3,0, 4,0 and 6,0 µg/ml of halofuginone respectively. These solutions must be freshly prepared before use.

- 3.7. Hydrochloric acid (ρ_{20} approximately 1,16 g/ml).
- 3.8. Methanol.
- 3.9. Silver nitrate.
- 3.10. Sodium ascorbate.
- 3.11. Sodium carbonate.
- 3.12. Sodium chloride.
- 3.13. EDTA (ethylenediaminetetraacetic acid, disodium salt).
- 3.14. Water, equivalent to HPLC grade.
- 3.15. Sodium carbonate solution, $c = 10$ g/100 ml.
- 3.16. Sodium chloride-saturated sodium carbonate solution, $c = 5$ g/100 ml.
- Dissolve 50 g of sodium carbonate (3.11) in water, dilute to 1 litre and add sodium chloride (3.12) until the solution is saturated.
- 3.17. Hydrochloric acid, approximately 0,1 mol/l.
- Dilute 10 ml of HCl (3.7) with water to 1 litre.
- 3.18. Ammonium acetate buffer solution, approximately 0,25 mol/l.
- Dissolve 19,3 g of ammonium acetate (3.3) and 30 ml of acetic acid (3.5) in water (3.14) and dilute to 1 litre.
- 3.19. Amberlite XAD-2 resin preparation.
- Wash an appropriate quantity of Amberlite (3.2) with water until all chloride ions have been removed, as indicated by a silver nitrate (3.20) test performed on the discarded aqueous phase. Then wash the resin with 50 ml of methanol (3.8), discard the methanol and store the resin under fresh methanol.
- 3.20. Silver nitrate solution, approximately 0,1 mol/l.
- Dissolve 0,17 g of silver nitrate (3.9) in 10 ml of water.
- 3.21. HPLC Mobile phase.
- Mix 500 ml of acetonitrile (3.1) with 300 ml of ammonium acetate buffer solution (3.18) and 1 200 ml of water (3.14). Adjust the pH to 4,3 using acetic acid (3.5). Filter through a 0,22 μm filter (4.8) and degas the solution (e.g. by ultrasonification for 10 minutes). This solution is stable for one month, if stored in the dark in a closed container.
4. **Apparatus**
- 4.1. Ultrasonic bath
- 4.2. Rotary film evaporator
- 4.3. Centrifuge
- 4.4. HPLC equipment with variable wavelength ultraviolet detector or diode-array detector
- 4.4.1. Liquid chromatographic column, 300 mm x 4 mm, C_{18} , 10 μm packaging, or an equivalent column
- 4.5. Glass column (300 mm x 10 mm) fitted with a sintered-glass filter and a stopcock
- 4.6. Glass-fibre filters, diameter 150 mm

4.7. Membrane filters, 0,45 µm

4.8. Membrane filters, 0,22 µm

5. Procedure

Note: Halofuginone as the free base is unstable in alkaline and ethyl acetate solutions. It shall not remain in ethyl acetate for more than 30 minutes.

5.1. General

5.1.1. A blank feed shall be analysed to check that neither halofuginone nor interfering substances are present.

5.1.2. A recovery test shall be carried out by analysing the blank feed which has been fortified by addition of a quantity of halofuginone, similar to that present in the sample. To fortify at a level of 3 mg/kg, add 300 µl of the stock standard solution (3.6.1) to 10 g of the blank feed, mix and wait for 10 minutes before proceeding with the extraction step (5.2).

Note: for the purpose of this method, the blank feed shall be similar in type to that of the sample and on analysis halofuginone shall not be detected.

5.2. Extraction

Weigh to the nearest 0,1 g, 10 g of the prepared sample, into a 200 ml centrifuge tube, add 0,5 g of sodium ascorbate (3.10), 0,5 g of EDTA (3.13) and 20 ml of water and mix. Place the tube for 5 minutes in a water bath (80 °C). After cooling down to room temperature, add 20 ml of sodium carbonate solution (3.15) and mix. Add immediately 100 ml of ethyl acetate (3.4) and shake vigorously by hand for 15 seconds. Then place the tube for three minutes in the ultrasonic bath (4.1) and loosen the stopper. Centrifuge for two minutes and decant the ethyl acetate phase through a glass fibre filter (4.6), into a 500 ml separating funnel. Repeat the extraction of the sample with a second portion of 100 ml of ethyl acetate. Wash the combined extracts for one minute with 50 ml of sodium chloride saturated sodium carbonate solution (3.16) and discard the aqueous layer.

Extract the organic layer for 1 min. with 50 ml of hydrochloric acid (3.17). Run the lower acid layer into a 250 ml separating funnel. Re-extract the organic layer for 1,5 minutes with a further 50 ml of hydrochlorid acid and combine with the first extract. Wash the combined acid extracts by swirling for approximately 10 seconds with 10 ml of ethyl acetate (3.4).

Quantitatively transfer the aqueous layer into a 250 ml round-bottomed flask and discard the organic phase. Evaporate all the remaining ethyl acetate from the acid solution using a rotary film evaporator (4.2). The temperature of the water bath must not exceed 40 °C. Under a vacuum of approximately 25 mbar all of the residual ethyl acetate will be removed within 5 minutes at 38 °C.

5.3. Clean up

5.3.1. Preparation of the Amberlite column

An XAD-2 column is prepared for each sample extract. Transfer 10 g of prepared Amberlite (3.19) into a glass column (4.5) with methanol (3.8). Add a small plug of glass-wool to the top of the resin bed. Drain the methanol from the column and wash the resin with 100 ml of water, stopping the flow as the liquid reaches the top of the resin bed. Allow the column to equilibrate for 10 minutes before use. Never allow the column to run dry.

5.3.2. Sample clean up

Transfer the extract (5.2) quantitatively to the top of the prepared Amberlite column (5.3.1) and elute, discarding the eluate. The rate of elution must not exceed 20 ml/min. Rinse the round-bottomed flask with 20 ml of hydrochlorid acid (3.17) and use this to wash the resin column. Blow through any remaining acid solution with a stream of air. Discard the washings. Add 100 ml of methanol (3.8) to the column and allow 5 to 10 ml to elute, collecting the eluate in a 250 ml round-bottomed flask. Leave the remaining methanol for 10 minutes to equilibrate with the resin and continue the elution at a rate not exceeding 20 ml/min. collecting the eluate in the same round-bottomed flask. Evaporate the methanol on the rotary film evaporator (4.2), the temperature of the water bath must not exceed 40 °C. Transfer the residue quantitatively into a 10 ml calibrated flask using the mobile phase (3.21). Make up to the mark with mobile phase and mix. An aliquot is filtered through a membrane filter (4.7). Reserve this solution for the HPLC determination (5.4).

5.4. HPLC determination

5.4.1. Parameters

The following conditions are offered for guidance, other conditions may be used provided they yield equivalent results.

Liquid chromatographic column (4.4.1)

HPLC Mobile phase (3.21)

Flow rate: 1,5 to 2 ml/min.

Detection wavelength: 243 nm

Injection volume: 40 to 100 µl.

Check the stability of the chromatographic system, injecting the calibration solution (3.6.2) containing 3,0 µg/ml several times, until constant peak heights (or areas) and retention times are achieved.

5.4.2. Calibration graph

Inject each calibration solution (3.6.2) several times and measure the peak heights (areas) for each concentration. Plot a calibration graph using the mean peak heights or areas of the calibration solutions as the ordinates and the corresponding concentrations in µg/ml as the abscissae.

5.4.3. Sample solution

Inject the sample extract (5.3.2) several times, using the same volume as taken for the calibration solutions and determine the mean peak height (area) of the halofuginone peaks.

6. Calculation of results

Determine the concentration of the sample solution in µg/ml, from the mean height (area) of the halofuginone peaks of the sample solution by reference to the calibration graph (5.4.2).

The content of halofuginone w (mg/kg) of the sample is given by the following formula:

$$w = \frac{c \times 10}{m}$$

in which:

c = halofuginone concentration of the sample solution in µg/ml,

m = weight of the test portion in grams.

7. Validation of the results

7.1. Identity

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract and the calibration solution (3.6.2) containing 6,0 µg/ml are compared.

7.1.1. Co-chromatography

A sample extract is fortified by addition of an appropriate amount of a calibration solution (3.6.2). The amount of added halofuginone must be similar to the estimated amount of halofuginone found in the sample extract.

Only the height of the halofuginone peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its maximum height, must be within $\pm 10\%$ of the original width.

7.1.2. Diode-array detection

The results are evaluated according to the following criteria:

- (a) the wavelength of maximum absorption of the sample and of the standard spectra, recorded at the peak apex on the chromatogram, must be the same within a margin determined by the resolving power of the detection system. For diode-array detection, this is typically within ± 2 nm;
- (b) between 225 and 300 nm, the sample and standard spectra recorded at the peak apex on the chromatogram, must not be different for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte;
- (c) between 225 and 300 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and when at all observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the apex.

If one of these criteria is not met the presence of the analyte has not been confirmed.

7.2. Repeatability

The difference between results of two parallel determinations carried out on the same sample must not exceed 0,5 mg/kg for halofuginone contents up to 3 mg/kg.

7.3. Recovery

For the fortified blank sample the recovery shall be at least 80 %.

8. Results of a collaborative study

A collaborative study ⁽¹⁾ was arranged in which three samples were analysed by eight laboratories.

Results

	Sample A (blank) On receipt	Sample B (Meal)		Sample C (Pellets)	
		On receipt	After two months	On receipt	After two months
Mean [mg/kg]	ND	2,80	2,42	2,89	2,45
S _R [mg/kg]	—	0,45	0,43	0,40	0,42
CV _R [%]	—	16	18	14	17
Rec. [%]		86	74	88	75

ND = not detected

S_R = standard deviation of reproducibility

CV_R = coefficient of variation of reproducibility (%)

Rec. = recovery (%)

E. DETERMINATION OF ROBENIDINE

1,3-bis [(4-chlorobenzylidene)amino]guanidine — hydrochloride

1. Purpose and scope

This method makes it possible to determine the levels of robenidine in feed. The limit of quantification is 5 mg/kg.

⁽¹⁾ The Analyst 108, 1983, pp. 1252 to 1256.

2. Principle

The sample is extracted with acidified methanol. The extract is dried and an aliquot portion subjected to a clean-up on an aluminium oxide column. Robenidine is eluted from the column with methanol, concentrated, and made up to a suitable volume with mobile phase. The content of robenidine is determined by reversed-phase high-performance liquid chromatography (HPLC) using an UV detector.

3. Reagents

3.1. Methanol.

3.2. Acidified methanol.

Transfer 4,0 ml hydrochloric acid ($\rho_{20} = 1,18$ g/ml) into a 500 ml graduated flask, make up to the mark with methanol (3.1) and mix. This solution shall be freshly prepared before use.

3.3. Acetonitrile, equivalent to HPLC grade.

3.4. Molecular sieve.

Type 3A, 8 to 12 mesh beads (1,6-2,5 mm beads, crystalline alumino-silicate, diameter of pores 0,3 mm).

3.5. Aluminium oxide acidic activity grade I for column chromatography.

Transfer 100 g aluminium oxide into a suitable container and add 2,0 ml of water. Stopper and shake for approximately 20 minutes. Store in a well stoppered container.

3.6. Potassium dihydrogen phosphate solution, $c = 0,025$ mol/l.

Dissolve 3,40 g of potassium dihydrogen phosphate in water (HPLC grade) in a 1 000 ml graduated flask, make up to the mark and mix.

3.7. Di-sodium hydrogen phosphate solution, $c = 0,025$ mol/l.

Dissolve 3,55 g of anhydrous (or 4,45 g of dihydrate or 8,95 g of dodecahydrate) di-sodium hydrogen phosphate in water (equivalent to HPLC grade) in a 1 litre graduated flask, make up to the mark and mix.

3.8. HPLC mobile phase.

Mix together the following reagents:

650 ml acetonitrile (3.3),

250 ml water (equivalent to HPLC-grade),

50 ml potassium di-hydrogen phosphate solution (3.6),

50 ml di-sodium hydrogen phosphate solution (3.7).

Filter through a 0,22 μ m filter (4.6) and degas the solution, (e.g. by ultrasonification for 10 minutes).

3.9. Standard substance.

Pure robenidine: 1,3-bis [(4-chlorobenzylidene)amino]guanidine — hydrochloride.

3.9.1. Robenidine stock standard solution: 300 μ g/ml

Weigh to the nearest 0,1 mg, 30 mg of robenidine standard substance (3.9). Dissolve in acidified methanol (3.2) in a 100 ml graduated flask, make up to the mark with the same solvent and mix. Wrap the flask with aluminium foil and store in a dark place.

3.9.2. Robenidine intermediate standard solution: 12 µg/ml

Transfer 10,0 ml of the stock standard solution (3.9.1) into a 250 ml graduated flask, make up to the mark with the mobile phase (3.8) and mix. Wrap the flask with aluminium foil and store in a dark place.

3.9.3. Calibration solutions

Into a series of 50 ml calibrated flasks, transfer 5,0, 10,0, 15,0, 20,0 and 25,0 ml of the intermediate standard solution (3.9.2). Make up to the mark with mobile phase (3.8) and mix. These solutions correspond to 1,2, 2,4, 3,6, 4,8 and 6,0 µg/ml of robenidine respectively. These solutions must be freshly prepared before use.

3.10. Water equivalent to HPLC grade.

4. Apparatus

4.1. Glass column.

Constructed of amber glass fitted with a stopcock and a reservoir of approximately 150 ml capacity, internal diameter 10 to 15 mm, length 250 mm.

4.2. Mechanical shaker or magnetic stirrer.

4.3. Rotary film evaporator.

4.4. HPLC equipment with variable wavelength ultraviolet detector or diode array detector operating in the range of 250 to 400 nm.

4.4.1. Liquid chromatographic column: 300 mm x 4 mm, C₁₈ 10 µm packing or equivalent.

4.5. Glass fibre filter paper (Whatman GF/A or equivalent).

4.6. Membrane filters, 0,22 µm.

4.7. Membrane filters, 0,45 µm.

5. Procedure

Note: Robenidine is light-sensitive. Amber glassware shall be used in all operations.

5.1. *General*

5.1.1. A blank feed shall be analysed to check that neither robenidine nor interfering substances are present.

5.1.2. A recovery test shall be carried out by analysing the blank feed (5.1.1) which has been fortified by addition of a quantity of robenidine, similar to that present in the sample. To fortify at a level of 60 mg/kg, transfer 3,0 ml of the stock standard solution (3.9.1) to a 250 ml conical flask. Evaporate the solution to ca. 0,5 ml in a stream of nitrogen. Add 15 g of the blank feed, mix and wait for 10 minutes before proceeding with the extraction step (5.2).

Note: For the purpose of this method, the blank feed shall be similar in type to that of the sample and on analysis robenidine shall not be detected.

5.2. *Extraction*

Weigh to the nearest 0,01 g, approximately 15 g of the prepared sample. Transfer to a 250 ml conical flask and add 100,0 ml of acidified methanol (3.2), stopper and shake for one hour on the shaker (4.2). Filter the solution through a glass fibre filter paper (4.5) and collect the whole filtrate in a 150 ml conical flask. Add 7,5 g molecular sieve (3.4), stopper and shake for five minutes. Filter immediately through a glass-fibre filter paper. Retain this solution for the purification step (5.3).

5.3. Purification

5.3.1. Preparation of the aluminium-oxide column

Insert a small glass-wool plug into the lower end of a glass column (4.1) and tamp it down using a glass rod. Weigh out 11,0 g of the prepared aluminium oxide (3.5) and transfer to the column. Care shall be taken to minimise the exposure to the atmosphere during this stage. Gently tap the loaded column at its lower end to settle the aluminium oxide.

5.3.2. Sample purification

Transfer onto the column by pipette 5,0 ml of the sample extract prepared in (5.2) Rest the pipette tip close to the column wall and allow the solution to be absorbed onto the aluminium oxide. Elute the robenidine from the column using 100 ml methanol (3.1), at a flow rate of 2 to 3 ml/minute and collect the eluate in a 250 ml round bottomed flask. Evaporate the methanol solution to dryness under reduced pressure at 40 °C by means of a rotary film evaporator (4.3). Re-dissolve the residue in 3 to 4 ml of mobile phase (3.8) and transfer quantitatively to a 10 ml graduated flask. Rinse the flask with several 1 to 2 ml portions of mobile phase and transfer these rinsings to the graduated flask. Make up to the mark with the same solvent and mix. An aliquot is filtered through a 0,45 µm membrane filter (4.7). Reserve this solution for HPLC determination (5.4).

5.4. HPLC determination

5.4.1. Parameters

The following conditions are offered for guidance, other conditions may be used provided they yield equivalent results:

Liquid chromatographic column (4.4.1),

HPLC mobile phase (3.8),

Flow rate: 1,5 to 2 ml/minute,

Detector wavelength: 317 nm,

Injection volume: 20 to 50 µl.

Check the stability of the chromatographic system, injecting the calibration solution (3.9.3) containing 3,6 µg/ml several times, until constant peak heights and retention times are achieved.

5.4.2. Calibration graph

Inject each calibration solution (3.9.3) several times and measure the peak heights (areas) for each concentration. Plot a calibration curve using the mean peak heights or areas of the calibration solutions as the ordinates and corresponding concentrations in µg per ml as abscissae.

5.4.3. Sample solution

Inject the sample extract (5.3.2) several times, using the same volume as taken for the calibration solutions and determine the mean peak height (area) of the robenidine peaks.

6. Calculation of results

From the mean height (area) of the robenidine peaks of the sample solution determine the concentration of the sample solution in µg/ml by reference to the calibration graph (5.4.2).

The content of robenidine w (mg/kg) in the sample is given by the following formula:

$$w = \frac{c \times 200}{m}$$

in which:

c = robenidine concentration of the sample solution in µg/ml,

m = weight of the test portion in grams.

7. Validation of the results

7.1. Identity

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract and the calibration solution (3.9.3) containing 6 µg/ml are compared.

7.1.1. Co-chromatography

A sample extract is fortified by addition of an appropriate amount of calibration solution (3.9.3). The amount of added robenidine must be similar to the estimated amount of robenidine found in the sample extract.

Only the height of the robenidine peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its maximum height, must be within approximately 10 % of the original width.

7.1.2. Diode-array detection

The results are evaluated according to the following criteria:

- the wavelength of maximum absorption of the sample and of the standard spectra, recorded at the peak apex on the chromatogram, must be the same within a margin determined by the resolving power of the detection system. For diode-array detection, this is typically within approximately 2 nm;
- between 250 and 400 nm, the sample and standard spectra recorded at the peak apex on the chromatogram, must not be different for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte;
- between 250 and 400 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and when at all observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the apex.

If one of these criteria is not met the presence of the analyte has not been confirmed.

7.2. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed 10 % of the higher result for robenidine content higher than 15 mg/kg.

7.3. Recovery

For a fortified blank sample the recovery shall be at least 85 %.

8. Results of a collaborative study

An EC collaborative study was arranged in which four samples of poultry and rabbit feed, in meal or pelleted form were analysed by 12 laboratories. Duplicate analyses were performed on each sample. The results are given in the table below:

	Poultry		Rabbit	
	Meal	Pellet	Meal	Pellet
Mean [mg/kg]	27,00	27,99	43,6	40,1
s_r [mg/kg]	1,46	1,26	1,44	1,66
CV_r [%]	5,4	4,5	3,3	4,1
S_R [mg/kg]	4,36	3,36	4,61	3,91
CV_R [%]	16,1	12,0	10,6	9,7
Recovery [%]	90,0	93,3	87,2	80,2

s_r = standard deviation of repeatability,

CV_r = coefficient of variation of repeatability, %

S_R = standard deviation of reproducibility,

CV_R = coefficient of variation of reproducibility. %

F. DETERMINATION OF DICLAZURIL

(+)-4-chlorophenyl [2,6-dichloro-4-(2,3,4,5-tetrahydro-3,5-dioxo-1,2,4-triazin-2-yl)phenyl] acetonitrile

1. **Purpose and scope**

The method makes it possible to determine the level of diclazuril in feed and premixtures. The limit of detection is 0,1 mg/kg, the limit of quantification is 0,5 mg/kg.

2. **Principle**

After addition of an internal standard, the sample is extracted with acidified methanol. For feed, an aliquot of the extract is purified on a C₁₈ solid phase extraction cartridge. Diclazuril is eluted from the cartridge with a mixture of acidified methanol and water. After evaporation, the residue is dissolved in DMF/water. For premixtures, the extract is evaporated and the residue is dissolved in DMF/water. The content of diclazuril is determined by ternary gradient reversed-phase high-performance liquid chromatography (HPLC) using a UV detector.

3. **Reagents**

3.1. Water, equivalent to HPLC-grade

3.2. Ammonium acetate

3.3. Tetrabutylammonium hydrogen sulphate (TBHS)

3.4. Acetonitrile, equivalent to HPLC grade

3.5. Methanol, equivalent to HPLC grade

3.6. N, N-dimethylformamide (DMF)

3.7. Hydrochloric acid, $\rho_{20} = 1,19$ g/ml

3.8. Standard substance: diclazuril II-24: (+)-4-chlorophenyl [2,6-dichloro-4-(2,3,4,5-tetrahydro-3,5-dioxo-1,2,4-triazin-2-yl) phenyl] acetonitrile with guaranteed purity, E771

3.8.1. Diclazuril stock standard solution, 500 μ g/ml

Weigh to the nearest 0,1 mg, 25 mg of diclazuril standard substance (3.8) in a 50 ml graduated flask. Dissolve in DMF (3.6), make up to the mark with DMF (3.6) and mix. Wrap the flask with aluminium foil or use amber flask and store in the refrigerator. At a temperature of ≤ 4 °C the solution is stable for 1 month.

3.8.2. Diclazuril standard solution, 50 μ g/ml

Transfer 5,00 ml of the stock standard solution (3.8.1) into a 50 ml graduated flask, make up to the mark with DMF (3.6) and mix. Wrap the flask with aluminium foil or use amber flask and store in the refrigerator. At a temperature of ≤ 4 °C the solution is stable for 1 month.

3.9. Internal standard substance: 2,6 dichloro- α -(4-chlorophenyl)-4-(4,5 dihydro-3,5-dioxo-1,2,4-triazine-2 (3H) —yl) α -methylbenzene-acetonitrile

3.9.1. Internal stock standard solution, 500 μ g/ml

Weigh to the nearest 0,1 mg 25 mg of internal standard substance (3.9) in a 50 ml graduated flask. Dissolve in DMF (3.6), make up to the mark with DMF (3.6) and mix. Wrap the flask with aluminium foil or use amber flask and store in the refrigerator. At a temperature of ≤ 4 °C the solution is stable for 1 month.

3.9.2. Internal standard solution, 50 μ g/ml

Transfer 5,00 ml of the internal stock standard solution (3.9.1) into a 50 ml graduated flask, make up to the mark with DMF (3.6) and mix. Wrap the flask with aluminium foil or use amber flask and store in the refrigerator. At a temperature of ≤ 4 °C the solution is stable for 1 month.

3.9.3. Internal standard solution for premixtures, p/1 000 mg/ml

(p = nominal content of diclazuril in the premixture in mg/kg)

Weigh to the nearest 0,1 mg p/10 mg of the internal standard substance in a 100 ml graduated flask, dissolve in DMF (3.6) in a ultrasonic bath (4.6), make up to the mark with DMF and mix. Wrap the flask with aluminium foil or use amber flask and store in a refrigerator. At a temperature of $\leq 4^{\circ}\text{C}$ the solution is stable for 1 month.

3.10. Calibration solution, 2 $\mu\text{g}/\text{ml}$.

Pipet 2,00 ml diclazuril standard solution (3.8.2) and 2,00 ml internal standard solution (3.9.2) into a 50 ml graduated flask. Add 16 ml DMF (3.6), make up to the mark with water and mix. This solution must be prepared freshly before use.

3.11. C_{18} solid phase extraction cartridge, e.g. Bond Elut, size: 1 cc, sorbent weight: 100 mg.

3.12. Extraction solvent: acidified methanol.

Pipet 5,0 ml hydrochloric acid (3.7) into 1 000 ml of methanol (3.5), and mix.

3.13. Mobile phase for HPLC

3.13.1. Eluent A: ammonium acetate — tetrabutylammonium hydrogen sulphate solution.

Dissolve 5 g ammonium acetate (3.2) and 3,4 g TBHS (3.3) in 1 000 ml water (3.1) and mix.

3.13.2. Eluent B: acetonitrile (3.4).

3.13.3. Eluent C: methanol (3.5).

4. **Apparatus**

4.1. Mechanical shaker

4.2. Equipment for ternary gradient HPLC

4.2.1. Liquid chromatographic column, Hypersil ODS, 3 μm packing, 100 mm x 4,6 mm, or equivalent

4.2.2. UV detector with variable wavelength adjustment or diode array detector

4.3. Rotary film evaporator

4.4. Membrane filter, 0,45 μm

4.5. Vacuum manifold

4.6. Ultrasonic bath

5. **Procedure**

5.1. *General*

5.1.1. Blank feed

A blank feed shall be analysed to check that neither diclazuril nor interfering substances are present. The blank feed shall be similar in type to that of the sample and on analysis diclazuril or interfering substances shall not be detected.

5.1.2. Recovery test

A recovery test shall be carried out by analysing the blank feed which has been fortified by addition of a quantity of diclazuril similar to that present in the sample. To fortify at a level of 1 mg/kg add 0,1 ml of the stock standard solution (3.8.1) to 50 g of a blank feed, mix thoroughly and leave for 10 min. mixing again several times before proceeding (5.2).

Alternatively, if a blank feed similar in type to that of the sample is not available (see 5.1.1), a recovery test can be performed by means of the standard addition method. In this case, the sample to be analysed is fortified with a quantity of diclazuril, similar to that already present in the sample. This sample is analysed, together with the unfortified sample and the recovery can be calculated by subtraction.

5.2. Extraction

5.2.1. Feed

Weigh to the nearest 0,01 g approximately 50 g of the sample. Transfer to a 500 ml conical flask, add 1,00 ml internal standard solution (3.9.2), 200 ml extraction solvent (3.12) and stopper the flask. Shake the mixture on the shaker (4.1) overnight. Allow to settle for 10 minutes. Transfer a 20 ml aliquot of the supernatant to a suitable glass container and dilute with 20 ml water. Transfer this solution on an extraction cartridge (3.11), and pass through by applying vacuum (4.5). Wash the cartridge with 25 ml of a mixture of extraction solvent (3.12) and water, 65 + 35 (V + V). Discard the collected fractions and elute the compounds with 25 ml of a mixture of extraction solvent (3.12) and water, 80 + 20 (V + V). Evaporate this fraction until it had just reached dryness by means of the rotary evaporator (4.3) at 60 °C. Dissolve the residue in 1,0 ml DMF (3.6), add 1,5 ml of water (3.1) and mix. Filter through a membrane filter (4.4). Proceed to the HPLC determination (5.3).

5.2.2. Premixtures

Weigh to the nearest 0,001 g approximately 1 g of the sample. Transfer to a 500 ml conical flask, add 1,00 ml internal standard solution (3.9.3), 200 ml extraction solvent (3.12) and stopper the flask. Shake the mixture overnight on the shaker (4.1). Allow to settle for 10 minutes. Transfer an aliquot of 10 000/p ml (p = nominal content of diclazuril in the premix in mg/kg) of the supernatant to a round bottomed flask of suitable size. Evaporate until it had just reached dryness, under reduced pressure at 60 °C by means of the rotary evaporator (4.3). Redissolve the residue in 10,0ml DMF (3.6), add 15,0 ml water (3.1) and mix. Proceed to the HPLC determination (5.3).

5.3. HPLC determination

5.3.1. Parameters

The following conditions are offered for guidance, other conditions may be used provided that they give equivalent results.

Liquid chromatographic column (4.2.1)	100 mm × 4,6 mm, Hypersil ODS, 3 µm packing, or equivalent
Mobile phase:	Eluent A (3.13.1): Aqueous solution of ammonium acetate and tetrabutyl-ammonium hydrogen sulphate
	Eluent B (3.13.2): acetonitrile
	Eluent C (3.13.3): methanol
Elution mode:	— linear gradient — initial conditions: A + B + C = 60 + 20 + 20 (V + V + V) — after 10 min. gradient elution during 30 min. to: A + B + C = 45 + 20 + 35 (V + V + V) Flush with B during 10 min.
Flow rate:	1,5-2 ml/min.
Injection volume:	20 µl
Detector wavelength:	280 nm.

Check the stability of the chromatographic system, injecting several times the calibration solution (3.10), containing 2 µg/ml, until constant peak heights and retention times are achieved.

5.3.2. Calibration solution

Inject 20 µl of the calibration solution (3.10) several times and determine the mean peak height (area) of the diclazuril and internal standard peaks.

5.3.3. Sample solution

Inject 20 µl of the sample solution (5.2.1 or 5.2.2) several times and determine the mean peak height (area) of the diclazuril and internal standard peaks.

6. Calculation of the results

6.1. Feeds

The diclazuril content w (mg/kg) in the sample is given by the following formula:

$$w = \frac{h_{d,s} \times h_{i,c}}{h_{i,s} \times h_{d,c}} \times \frac{c_{d,c} \times 10 V}{m} \text{ [mg/kg]}$$

where:

- $h_{d,s}$ = peak height (area) of diclazuril in the sample solution (5.2.1)
- $h_{i,s}$ = peak height (area) of the internal standard in the sample solution (5.2.1)
- $h_{d,c}$ = peak height (area) of diclazuril in the calibration solution (3.10)
- $h_{i,c}$ = peak height (area) of the internal standard in the calibration solution (3.10)
- $c_{d,c}$ = diclazuril concentration in the calibration solution in $\mu\text{g/ml}$ (3.10)
- m = weight of the test portion in g
- V = volume of the sample extract according to 5.2.1 (i.e. 2,5 ml)

6.2. Premixtures

The diclazuril content w (mg/kg) in the sample is given by the following formula:

$$w = \frac{h_{d,s} \times h_{i,c}}{h_{i,s} \times h_{d,c}} \times \frac{c_{d,c} \times 0,02V \times p}{m} \text{ [mg/kg]}$$

where:

- $h_{d,c}$ = peak height (area) of diclazuril in the calibration solution (3.10)
- $h_{i,c}$ = peak height (area) of the internal standard in the calibration solution (3.10)
- $h_{d,s}$ = peak height (area) of diclazuril in the sample solution (5.2.2)
- $h_{i,s}$ = peak height (area) of the internal standard in the sample solution (5.2.2)
- $c_{d,c}$ = diclazuril concentration in the calibration solution in $\mu\text{g/ml}$ (3.10)
- m = weight of the test portion in g
- V = volume of the sample extract according to 5.2.2 (i.e. 25 ml)
- p = nominal content of diclazuril in mg/kg in the premixture

7. Validation of the results

7.1. Identity

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract (5.2.1 or 5.2.2) and the calibration solution (3.10) are compared.

7.1.1. Co-chromatography

A sample extract (5.2.1 or 5.2.2) is fortified by addition of an appropriate amount of calibration solution (3.10). The amount of added diclazuril must be similar to the amount of diclazuril found in the sample extract.

Only the height of the diclazuril peak and the internal standard peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its height, must be within $\pm 10\%$ of the original width of the diclazuril peak or the internal standard peak of the unfortified sample extract.

7.1.2. Diode-array detection

The results are evaluated according to the following criteria:

- (a) The wavelength of maximum absorption of the sample and of the standard spectra, recorded at the peak apex on the chromatogram, must be the same within a margin determined by the resolving power of the detection system. For diode-array detection this is typically within ± 2 nm.
- (b) Between 230 and 320 nm, the sample and standard spectra recorded at the peak apex of the chromatogram, must not be different for those parts of the spectrum within the range 10 % 100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte.

- (c) Between 230 and 320 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 % 100 % of relative absorbance. This criterion is met when the same maxima are present and when at all observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the peak apex.

If one of these criteria is not met the presence of the analyte has not been confirmed.

7.2. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed:

- 30 % relative, to the higher value for diclazuril contents from 0,5 mg/kg to 2,5 mg/kg,
- 0,75 mg/kg for diclazuril contents between 2,5 mg/kg and 5 mg/kg,
- 15 % relative to the higher value for diclazuril contents of more than 5 mg/kg.

7.3. Recovery

For a fortified (blank) sample the recovery shall be at least 80 %.

8. Results of a collaborative study

A collaborative study was arranged in which 5 samples were analysed by 11 laboratories. These samples consisted of two premixtures; one was mixed with an organic matrix (O 100) and the other with an inorganic matrix (A 100). The theoretical content is 100 mg diclazuril per kg. The three mixed feeds for poultry were made by 3 different producers (NL) (L1/Z1/K1). The theoretical content is 1 mg diclazuril per kg. The laboratories were instructed to analyse each of the samples once or in duplicate. (More detailed information on this collaborative study can be found in the *Journal of AOAC International*, Volume 77, No 6, 1994, p. 1359-1361). The results are given in the following table.

	Sample 1 A 100	Sample 2 O 100	Sample 3 L1	Sample 4 Z1	Sample 5 K1
L	11	11	11	11	6
n	19	18	19	19	12
Mean	100,8	103,5	0,89	1,15	0,89
S _r (mg/kg)	5,88	7,64	0,15	0,02	0,03
CV _r (%)	5,83	7,38	17,32	1,92	3,34
S _R (mg/kg)	7,59	7,64	0,17	0,11	0,12
CV _R (%)	7,53	7,38	18,61	9,67	13,65
Nominal content (mg/kg)	100	100	1	1	1

- L = number of laboratories
n = number of single values
S_r = standard deviation of repeatability
CV_r = coefficient of variation of repeatability
S_R = standard deviation of reproducibility
CV_R = coefficient of variation of reproducibility

9. Observations

The diclazuril response must have been previously demonstrated to be linear over the range of concentrations being measured.

G. DETERMINATION OF LASALOCID SODIUM

Sodium salt of a polyether monocarboxylic acid produced by Streptomyces lasaliensis

1. Purpose and scope

The method makes it possible to determine the level of lasalocid sodium in feed and premixtures. The limit of detection is 5 mg/kg, the limit of quantification is 10 mg/kg.

2. Principle

Lasalocid sodium is extracted from the sample into acidified methanol and determined by reversed-phase high performance liquid chromatography (HPLC) using a spectrofluorometric detector.

3. Reagents

3.1. Potassium dihydrogen phosphate (KH_2PO_4).

3.2. Orthophosphoric acid, w (w/w) = 85 %.

3.3. Orthophosphoric acid solution, c = 20 %.

Dilute 23,5 ml of orthophosphoric acid (3.2) to 100 ml with water.

3.4. 6-Methyl-2-heptylamine (1,5-dimethylhexylamine), w (w/w) = 99 %.

3.5. Methanol, equivalent to HPLC grade.

3.6. Hydrochloric acid, density = 1,19 g/ml.

3.7. Phosphate buffer solution, c = 0,01 mol/l.

Dissolve 1,36 g of KH_2PO_4 (3.1) in 500 ml of water (3.11), add 3,5 ml of orthophosphoric acid (3.2) and 10,0 ml of 6-methyl-2-heptylamine (3.4). Adjust the pH to 4,0 with orthophosphoric acid solution (3.3) and dilute to 1 000 ml with water (3.11).

3.8. Acidified methanol.

Transfer 5,0 ml of hydrochloric acid (3.6) into a 1 000 ml graduated flask, make up to the mark with methanol (3.5) and mix. This solution must be prepared freshly before use.

3.9. HPLC mobile phase, phosphate buffer-methanol solution 5 + 95 (V + V).

Mix 5 ml of phosphate buffer solution (3.7) with 95 ml of methanol (3.5).

3.10. Lasalocid sodium standard substance with guaranteed purity, $\text{C}_{34}\text{H}_{53}\text{O}_8\text{Na}$ (sodium salt of a polyether monocarboxylic acid produced by *Streptomyces lasaliensis*), E763.

3.10.1. Lasalocid sodium stock standard solution, 500 $\mu\text{g}/\text{ml}$

Weigh to the nearest 0,1 mg, 50 mg of lasalocid sodium (3.10) into a 100 ml graduated flask, dissolve in acidified methanol (3.8), make up to the mark with the same solvent and mix. This solution must be freshly prepared before use.

3.10.2. Lasalocid sodium intermediate standard solution, 50 $\mu\text{g}/\text{ml}$

Pipette 10,0 ml of stock standard solution (3.10.1) into a 100 ml graduated flask, make up to the mark with acidified methanol (3.8) and mix. This solution must be prepared freshly before use.

3.10.3. Calibration solutions

Into a series of 50 ml graduated flasks transfer 1,0, 2,0, 4,0, 5,0 and 10,0 ml of the intermediate standard solution (3.10.2). Make up to the mark with acidified methanol (3.8) and mix. These solutions correspond to 1,0, 2,0, 4,0, 5,0 and 10,0 µg of lasalocid sodium per ml respectively. These solutions must be prepared freshly before use.

3.11. Water, equivalent to HPLC grade.

4. Apparatus

4.1. Ultrasonic bath (or shaking water-bath) with temperature control.

4.2. Membrane filters, 0,45 µm.

4.3. HPLC equipment with injection system, suitable for injecting volumes of 20 µl.

4.3.1. Liquid chromatographic column 125 mm x 4 mm, reversed-phase C₁₈, 5 µm packing or equivalent.

4.3.2. Spectrofluorometer with variable wavelength adjustment of excitation and emission wavelengths.

5. Procedure

5.1. *General*

5.1.1. Blank feed

For the performance of the recovery test (5.1.2) a blank feed shall be analysed to check that neither lasalocid sodium nor interfering substances are present. The blank feed shall be similar in type to that of the sample and lasalocid sodium or interfering substances shall not be detected.

5.1.2. Recovery test

A recovery test shall be carried out by analysing the blank feed which has been fortified by addition of a quantity of lasalocid sodium, similar to that present in the sample. To fortify at a level of 100 mg/kg, transfer 10,0 ml of the stock standard (3.10.1) to a 250 ml conical flask and evaporate the solution to approximately 0,5 ml. Add 50 g of the blank feed, mix thoroughly and leave for 10 minutes mixing again several times before proceeding with the extraction step (5.2).

Alternatively, if a blank feed similar in type to that of the sample is not available (see 5.1.1), a recovery test can be performed by means of the standard addition method. In this case the sample to be analysed is fortified with a quantity of lasalocid sodium similar to that already present in the sample. This sample is analysed together with the unfortified sample and the recovery calculated by subtraction.

5.2. *Extraction*

5.2.1. Feed

Weigh to the nearest 0,01 g, from 5 g to 10 g of the sample into a 250 ml conical flask with stopper. Add 100,0 ml of acidified methanol (3.8) by pipette. Stopper loosely and swirl to disperse. Place the flask in an ultrasonic bath (4.1) at approximately 40 °C for 20 minutes, then remove and cool to room temperature. Allow to stand for about 1 hour until the suspended matter has settled, then filter an aliquot portion through a 0,45 µm membrane filter (4.2) into a suitable vessel. Proceed to the HPLC determination (5.3).

5.2.2. Premixtures

Weigh to the nearest 0,001 g about 2 g of the unground premix into a 250 ml graduated flask. Add 100,0 ml of acidified methanol (3.8) and swirl to disperse. Place the flask and contents in an ultrasonic bath (4.1) at approximately 40 °C for 20 minutes, then remove and cool to room temperature. Dilute to the mark with acidified methanol (3.8) and mix thoroughly. Allow to stand for 1 hour until the suspended matter has settled, then filter an aliquot portion through a 0,45 µm membrane filter (4.2). Dilute an appropriate volume of the clear filtrate with acidified methanol (3.8) to produce a final test solution containing about 4 µg/ml of lasalocid sodium. Proceed to the HPLC determination (5.3).

5.3. *HPLC determination*5.3.1. *Parameters*

The following conditions are offered for guidance; other conditions may be used, provided they yield equivalent results:

Liquid chromatographic column (4.3.1): 125 mm × 4 mm, reversed-phase C₁₈, 5 µm packing or equivalent

Mobile phase (3.9): Mixture of phosphate buffer solution (3.7) and methanol (3.5), 5+95 (V+V)

Flow rate: 1,2 ml/min.

Detection wavelengths:

Excitation: 310 nm

Emission: 419 nm

Injection volume: 20 µl

Check the stability of the chromatographic system, injecting the calibration solution (3.10.3) containing 4,0 µg/ml several times, until constant peak heights (or areas) and retention times are achieved.

5.3.2. *Calibration graph*

Inject each calibration solution (3.10.3) several times and determine the mean peak heights (areas) for each concentration. Plot a calibration graph using the mean peak heights (areas) as the ordinates and the corresponding concentrations in µg/ml as the abscissae.

5.3.3. *Sample solution*

Inject the sample extracts obtained in 5.2.1 or 5.2.2 several times, using the same volume as taken for the calibration solution and determine the mean peak heights (areas) of the lasalocid sodium peaks.

6. **Calculation of results**

From the mean peak height (area) produced by injection of the sample solution (5.3.3) determine the concentration of lasalocid sodium (µg/ml) by reference to the calibration graph.

6.1. *Feed*

The lasalocid sodium content, *w* (mg/kg) in the sample is given by the following formula:

$$w = \frac{c \times V_1}{m} \text{ [mg/kg]}$$

where:

c = lasalocid sodium concentration of the sample solution (5.2.1) in µg/ml

*V*₁ = volume of the sample extract according to 5.2.1 in ml (i.e. 100)

m = weight of the test portion in g

6.2. *Premixtures*

The lasalocid sodium content, *w* (mg/kg) in the sample is given by the following formula:

$$w = \frac{c \times V_2 \times f}{m} \text{ [mg/kg]}$$

where:

c = lasalocid sodium concentration of the sample solution (5.2.2) in µg/ml

*V*₂ = volume of the sample extract according to 5.2.2 in ml (i.e. 250)

f = dilution factor according to 5.2.2

m = weight of the test portion in g

7. **Validation of the results**7.1. *Identity*

Methods based on spectrofluorometry are less subject to interference than those in which UV detection is used. The identity of the analyte can be confirmed by co-chromatography.

7.1.1. Co-chromatography

A sample extract (5.2.1 or 5.2.2) is fortified by the addition of an appropriate amount of a calibration solution (3.10.3). The amount of added lasalocid sodium must be similar to the amount of lasalocid sodium found in the sample extract. Only the height of the lasalocid sodium peak shall be enhanced after taking into account the amount of lasalocid sodium added and the dilution of the extract. The peak width, at half height, must be within $\pm 10\%$ of the original peak width produced by the unfortified sample extract.

7.2. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed:

- 15 % relative to the higher value for lasalocid sodium contents from 30 mg/kg to 100 mg/kg,
- 15 mg/kg for lasalocid sodium contents from 100 mg/kg to 200 mg/kg,
- 7,5 % relative to the higher value for lasalocid sodium contents of more than 200 mg/kg.

7.3. Recovery

For the fortified (blank) feed sample, the recovery shall be at least 80 %. For the fortified premixture samples, the recovery shall be at least 90 %.

8. Results of a collaborative study

A collaborative study (*) was arranged in which 2 premixtures (samples 1 and 2) and 5 feeds (samples 3-7) were analysed by 12 laboratories. Duplicate analyses were performed on each sample. The results are given in the following table:

	Sample 1 Chicken premix	Sample 2 Turkey premix	Sample 3 Turkey pel- lets	Sample 4 Chicken crumbs	Sample 5 Turkey Feed	Sample 6 Poultry Feed A	Sample 7 Poultry Feed B
L	12	12	12	12	12	12	12
n	23	23	23	23	23	23	23
Mean [mg/kg]	5 050	16 200	76,5	78,4	92,9	48,3	32,6
s_r [mg/kg]	107	408	1,71	2,23	2,27	1,93	1,75
CV_r [%]	2,12	2,52	2,24	2,84	2,44	4,00	5,37
s_R [mg/kg]	286	883	3,85	7,32	5,29	3,47	3,49
CV_R [%]	5,66	5,45	5,03	9,34	5,69	7,18	10,70
Nominal con- tent [mg/kg]	5 000 (*)	16 000 (*)	80 (*)	105 (*)	120 (*)	50 (**)	35 (**)

(*) Content declared by manufacturer.

(**) Feed prepared in the laboratory.

L = number of laboratories
n = number of single results
 s_r = standard deviation of repeatability
 s_R = standard deviation of reproducibility
 CV_r = coefficient of variation of repeatability, %
 CV_R = coefficient of variation of reproducibility, %.

ANNEX V

METHODS OF ANALYSIS TO CONTROL UNDESIRABLE SUBSTANCES IN FEED

A. DETERMINATION OF FREE AND TOTAL GOSSYPOL

1. **Purpose and scope**

This method makes it possible to determine the levels of free gossypol, total gossypol and chemically related substances in cottonseed, cottonseed meal and cottonseed cake and in compound feed containing these feed materials where more than 20 mg/kg of free gossypol, total gossypol and chemically related substances are present.

2. **Principle**

The gossypol is extracted in the presence of 3-aminopropan-1-ol, either with a mixture of propan-2-ol and hexane, for the determination of free gossypol, or with dimethylformamide, for the determination of total gossypol. The gossypol is converted by aniline into gossypol-dianiline, the optical density of which is measured at 440 nm.

3. **Reagents**

- 3.1. Propan-2-ol-hexane mixture: mix 60 parts by volume of propan-2-ol with 40 parts by volume of *n*-hexane.
- 3.2. Solvent A: Place in a 1 litre graduated flask approximately 500 ml of propan-2-ol-hexane mixture (3.1), 2 ml of 3-aminopropan-1-ol, 8 ml of glacial acetic acid and 50 ml of water. Make up to volume with the propan-2-ol-hexane mixture (3.1). This reagent is stable for one week.
- 3.3. Solvent B: Pipette 2 ml of 3-aminopropan-1-ol and 10 ml of glacial acetic acid into a 100 ml graduated flask. Cool to room temperature and make up to volume with N, N-dimethylformamide. This reagent is stable for one week.
- 3.4. Aniline: *If the optical density in the blank test exceeds 0,022*, distil the aniline over zinc dust, discarding the first and last 10 % fractions of the distillate. Refrigerated and stored in a brown, stoppered glass flask, this reagent will keep for several months.
- 3.5. Standard gossypol solution A: Place 27,9 mg of gossypol acetate in a 250 ml graduated flask. Dissolve and make up to volume with solvent A (3.2). Pipette 50 ml of this solution into a 250 ml graduated flask and make up to volume with solvent A. The gossypol concentration of this solution is 0,02 mg/ml. Leave to stand for one hour at room temperature before use.
- 3.6. Standard gossypol solution B: Place 27,9 mg of gossypol acetate in a 50 ml graduated flask, Dissolve and make up to volume with solvent B (3.3). The gossypol concentration of this solution is 0,5 mg/ml.

Standard gossypol solutions A and B will remain stable for 24 hours if protected from the light.

4. **Apparatus**

- 4.1. Mixer (tumbler): approximately 35 r.p.m.
- 4.2. Spectrophotometer.

5. **Procedure**5.1. *Test sample*

The amount of test sample used depends on the presumed gossypol content of the sample. It is preferable to work with a small test sample and a relatively large aliquot part of the filtrate, so as to obtain sufficient gossypol for precise photometric measurement to be possible. *For the determination of free gossypol* in cottonseed, cottonseed meal and cottonseed cake, the test sample shall not exceed 1 g; for compound feed, it may be as much as 5 g. A 10 ml aliquot part of filtrate is suitable in most cases; it shall contain 50 to 100 µg of gossypol. *For the determination of total gossypol*, the test sample shall be between 0,5 and 5 g, that a 2 ml aliquot part of filtrate will contain 40 to 200 µg of gossypol.

The analysis shall be carried out at a room temperature of about 20 °C.

5.2. *Determination of free gossypol*

Place the test sample in a ground-necked 250 ml flask, the bottom of the flask having been covered with crushed glass. Using a pipette, add 50 ml of solvent A (3.2), stopper the flask and mix for one hour in the mixer. Filter through a dry filter and collect the filtrate in a small ground-necked flask. During filtration, cover the funnel with a watch glass.

Pipette identical aliquot parts of filtrate containing 50 to 100 µg of gossypol into each of two 25 ml graduated flasks (A and B). If necessary, make up the volume to 10 ml with solvent A (3.2). Then make the contents of flask (A) up to volume with the propan-2-ol-hexane mixture (3.1). This solution will be used as a reference solution against which to measure the sample solution.

Pipette 10 ml of solvent A (3.2) into each of two other 25 ml graduated flasks (C and D). Make the contents of flask (C) up to volume with the propan-2-ol-hexane mixture (3.1). This solution will be used as a reference solution against which to measure the blank test solution.

Add 2 ml of aniline (3.4) to each of flasks (D) and (B). Heat for 30 minutes over a boiling water bath to develop the colour. Cool to room temperature, make up to volume with the propan-2-ol-hexane mixture (3.1), homogenise and leave to stand for one hour.

Determine the optical density of the blank test solution (D) by comparison with the reference solution (C), and the optical density of the sample solution (B) by comparison with the reference solution (A), in the spectrophotometer at 440 nm using 1 cm glass cells.

Subtract the optical density of the blank test solution from that of the sample solution (= corrected optical density). From this value calculate the free gossypol content as indicated in 6.

5.3. *Determination of total gossypol*

Place a test sample containing 1 to 5 mg of gossypol in a 50 ml graduated flask and add 10 ml of solvent B (3.3). At the same time, prepare a blank test, placing 10 ml of solvent B (3.3) in another 50 ml graduated flask. Heat the two flasks for 30 minutes over a boiling water bath. Cool to room temperature and make the contents of each flask up to volume with the propan-2-ol-hexane mixture (3.1). Homogenise and leave to settle for 10 to 15 minutes, then filter and collect the filtrates in ground-necked flasks.

Pipette 2 ml of the sample filtrate into each of two 25 ml graduated flasks, and 2 ml of the blank test filtrate into each of two other 25 ml flasks. Make the contents of one flask from each series up to 25 ml with the propan-2-ol-hexane mixture (3.1). These solutions will be used as reference solutions.

Add 2 ml of aniline (3.4) to each of the other two flasks. Heat for 30 minutes over a boiling water bath to develop the colour. Cool to room temperature, make up to 25 ml with the propan-2-ol-hexane mixture (3.1), homogenise and leave to stand for one hour.

Determine the optical density as indicated in 5.2 for free gossypol. From this value calculate the total gossypol content as indicated in 6.

6. **Calculation of results**

Results may be calculated either from the specific optical density (6.1), or by reference to a calibration curve (6.2).

6.1. *From the specific optical density*

The specific optical densities, under the conditions described, will be the following:

$$\text{Free gossypol: } E \frac{1\%}{1 \text{ cm}} = 625$$

$$\text{Total gossypol: } E \frac{1\%}{1 \text{ cm}} = 600$$

The free or total gossypol content of the sample is calculated by using the following formula:

$$\% \text{ gossypol} : \frac{E \times 1\ 250}{E_{1\text{cm}}^{1\%} \times p \times a}$$

where:

E = corrected optical density, determined as indicated in 5.2,

p = test sample in g,

a = aliquot part of the filtrate in ml.

6.2. From a calibration curve

6.2.1. Free gossypol

Prepare 2 series of five 25 ml graduated flasks. Pipette aliquots of 2,0, 4,0, 6,0, 8,0 and 10,0 ml of standard gossypol solution A (3.5) into each series of flasks. Make up the volumes to 10 ml with solvent A (3.2). Complete each series with a 25 ml graduated flask containing only 10 ml of solvent A (3.2) (blank test).

Make the volume of the flasks in the first series (including the flask for the blank test) up to 25 ml with the propan-2-ol-hexane mixture (3.1) (reference series).

Add 2 ml of aniline (3.4) to each flask in the second series (including the flask for the blank test). Heat for 30 minutes over a boiling water bath to develop the colour. Cool to room temperature, make up to volume with the propan-2-ol-hexane mixture (3.1), homogenise and leave to stand for one hour (standard series).

Determine as indicated in 5.2 the optical density of the solutions in the standard series by comparison with the corresponding solutions in the reference series. Trace the calibration curve by plotting the optical densities against the quantities of gossypol (in µg).

6.2.2. Total gossypol

Prepare six 50 ml graduated flasks. In the first flask place 10 ml of solvent B (3.3), and in the others 2,0, 4,0, 6,0, 8,0 and 10,0 ml of standard gossypol solution B (3.6) respectively. Make the contents of each flask up to 10 ml with solvent B (3.3). Heat for 30 minutes over a boiling water bath. Cool to room temperature, make up to volume with the propan-2-ol-hexane mixture (3.1) and homogenise.

Place 2,0 ml of these solutions in each of two series of six 25 ml graduated flasks. Make the contents of the flasks in the first series up to 25 ml with the propan-2-ol-hexane mixture (3.1) (reference series).

Add 2 ml of aniline (3.4) to each flask in the second series. Heat for 30 minutes over a boiling water bath. Cool to room temperature, make up to volume with the propan-2-ol-hexane mixture (3.1), homogenise and leave to stand for one hour (standard series).

Determine as indicated in 5.2 the optical density of the solutions in the standard series by comparison with the corresponding solutions in the reference series. Trace the calibration curve by plotting the optical densities against the quantities of gossypol (in µg).

6.3. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed:

- 15 %, in relative value to the higher level, for gossypol contents of less than 500 ppm,
- 75 ppm, in absolute value, for contents of not less than 500 ppm and not more than 750 ppm,
- 10 %, in relative value to the higher value, for contents of more than 750 ppm.

(B) DETERMINATION OF THE LEVELS OF DIOXINS (PCDD/PCDF) AND DIOXIN-LIKE PCBs

I. METHODS OF SAMPLING AND INTERPRETATION OF ANALYTICAL RESULTS

1. Purpose and scope

The samples intended for the official control of the levels of dioxins (polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)) and dioxin-like polychlorinated biphenyls (PCBs) ⁽¹⁾ in feed, shall be taken in accordance with the provisions of Annex I. The quantitative requirements in relation to the control of substances or products uniformly distributed throughout the feed as provided for in point 5.A. of the Annex I have to be applied. Aggregate samples thus obtained shall be considered as representative for the lots or sublots from which they are taken. Compliance with maximum levels laid down in Directive 2002/32/EC of the European Parliament and of the Council ⁽²⁾ shall be established on the basis of the levels determined in the laboratory samples.

2. Compliance of the lot or subplot with the specification

The lot is accepted if the analytical result of a single analysis does not exceed the respective maximum level as laid down in Directive 2002/32/EC taking into account the measurement uncertainty.

The lot is non-compliant with the maximum level as laid down in Directive 2002/32/EC, if the upperbound ⁽³⁾ analytical result, confirmed by duplicate analysis ⁽⁴⁾, exceeds the maximum level beyond reasonable doubt taking into account the measurement uncertainty.

⁽¹⁾ Table of TEF (= toxic equivalency factors) for dioxins, furans and dioxin-like PCBs:

Congener	TEF value	Congener	TEF value
Dibenzo-p-dioxins ('PCDDs')		'Dioxin-like' PCBs:	
2,3,7,8-TCDD	1		
1,2,3,7,8-PeCDD	1	Non-ortho PCBs	
1,2,3,4,7,8-HxCDD	0,1	PCB 77	0,0001
1,2,3,6,7,8-HxCDD	0,1	PCB 81	0,0001
1,2,3,7,8,9-HxCDD	0,1	PCB 126	0,1
1,2,3,4,6,7,8-HpCDD	0,01	PCB 169	0,01
OCDD	0,0001	Mono-ortho PCBs	
		PCB 105	0,0001
Dibenzofurans ('PCDFs')		PCB 114	0,0005
2,3,7,8-TCDF	0,1	PCB 118	0,0001
1,2,3,7,8-PeCDF	0,05	PCB 123	0,0001
2,3,4,7,8-PeCDF	0,5	PCB 156	0,0005
1,2,3,4,7,8-HxCDF	0,1	PCB 157	0,0005
1,2,3,6,7,8-HxCDF	0,1	PCB 167	0,00001
1,2,3,7,8,9-HxCDF	0,1	PCB 189	0,0001
2,3,4,6,7,8-HxCDF	0,1		
1,2,3,4,6,7,8-HpCDF	0,01		
1,2,3,4,7,8,9-HpCDF	0,01		
OCDF	0,0001		

Abbreviations used: «T» = tetra; «Pe» = penta; «Hx» = hexa; «Hp» = hepta; «O» = octa; «CDD» = chlorodibenzo-p-dioxin; «CDF» = chlorodibenzofuran; «CB» = chlorobiphenyl.

⁽²⁾ OJ L 140, 30.5.2002, p. 10.

⁽³⁾ The concept of 'upperbound' requires using the limit of quantification for the contribution of each non-quantified congener to the Toxic Equivalent (TEQ).

The concept of 'lowerbound' requires using zero for the contribution of each non-quantified congener to the TEQ.

The concept of 'mediumbound' requires using half of the limit of quantification calculating the contribution of each non-quantified congener to the TEQ.

⁽⁴⁾ The duplicate analysis is necessary to exclude the possibility of internal cross-contamination or an accidental mix-up of samples. The first analysis, taking into account the measurement uncertainty is used for verification of compliance.

In case the analysis is performed in the frame of a dioxin contamination incident, confirmation by duplicate analysis might be omitted in the case the samples selected for analysis are through traceability linked to the dioxin contamination incident.

Measurement uncertainty may be taken into account according to one of the following approaches:

- by calculating the expanded uncertainty, using a coverage factor of 2 which gives a level of confidence of approximately 95 %. A lot is non-compliant if the measured value minus U is above the maximum level. In case of a separate determination of dioxins and dioxin-like-PCBs the sum of the estimated expanded uncertainty of the separate analytical results of dioxins and dioxin-like PCBs has to be used for the sum of dioxins and dioxin-like PCBs,
- by establishing the decision limit (CC_α) in accordance with Commission Decision 2002/657/EC ⁽¹⁾ (point 3.1.2.5 of the Annex — the case of substances with established permitted level). A lot is non-compliant if the measured value is equal to or above the CC_α.

The present interpretation rules apply for the analytical result obtained on the sample for official control. It does not affect the right of Member States to apply national rules to analyses for defence or referee purposes.

II. *SAMPLE PREPARATION AND REQUIREMENTS FOR METHODS OF ANALYSIS USED IN OFFICIAL CONTROL OF THE LEVELS OF DIOXINS (PCDD/PCDF) AND DIOXIN-LIKE PCBs*

1. **Objective and field of application**

These requirements shall be applied where feed materials and feed are analysed for the determination of the dioxins (polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)) and dioxin-like polychlorinated biphenyls (PCBs).

Monitoring for the presence of dioxins in feed can be performed by a strategy involving a screening method in order to select those samples with levels of dioxins and dioxin-like PCBs that are less than 25 % below or exceed the level of interest. The concentration of dioxins in those samples with significant levels needs to be determined/confirmed by a confirmatory method.

Screening methods are methods that are used to detect the presence of dioxins and dioxin-like PCBs at the level of interest. These methods have a capacity for a high sample throughput and are used to sift large numbers of samples for potential positives. They are specifically designed to avoid false negatives.

Confirmatory methods are methods that provide full or complementary information enabling the dioxins and dioxin-like PCBs to be identified and quantified unequivocally at the level of interest.

2. **Background**

Because environmental and biological samples (including samples of feed materials/feed) in general contain complex mixtures of different dioxin congeners, the concept of Toxic Equivalency Factors (TEFs) has been developed to facilitate risk assessment. These TEFs have been established to express concentrations of mixtures of 2,3,7,8-substituted PCDDs and PCDFs and some non-ortho and mono-ortho chlorine substituted PCBs which possess dioxin-like activity in toxic equivalents (TEQs) of 2,3,7,8-TCDD. The concentrations of the individual substances in a given sample are multiplied by their respective TEF and subsequently summed to give the total concentration of dioxin-like compounds expressed in TEQs.

For the purposes of this Regulation only, the accepted specific limit of quantification of an individual congener is the concentration of an analyte in the extract of a sample which produces an instrumental response at two different ions to be monitored with an S/N (signal/noise) ratio of 3:1 for the less sensitive signal and fulfilment of the basic requirements such as e.g. retention time and isotope ratio according to the determination procedure as described in EPA method 1613 revision B.

3. **Quality assurance requirements to be complied with for sample preparation**

The general provisions on the preparation of samples for analysis as laid down in the Annex II are applicable.

In addition following requirements have to be complied with:

- The samples must be stored and transported in glass, aluminium, polypropylene or polyethylene containers. Traces of paper dust must be removed from the sample container. Glassware shall be rinsed with solvents previously controlled for the presence of dioxins.

⁽¹⁾ OJ L 221, 17.8.2002, p. 8.

- Perform a blank analysis by carrying out the entire analytical procedure omitting only the sample.
- Sample weight used for the extraction must be sufficient to fulfil the requirements with respect to sensitivity.

4. Requirements for laboratories

- Laboratories shall demonstrate the performance of a method in the range of the level of interest, e.g. 0,5x, 1x and 2x the level of interest with an acceptable coefficient of variation for repeated analysis. For details of acceptance criteria, see point 5.
- Limit of quantification for a confirmatory method shall be in the range of about one fifth of the level of interest, to make sure that acceptable coefficients of variations are met in the range of the level of interest.
- Regular blank controls and spiking experiments or analysis of control samples (preferably, if available, certified reference material) shall be performed as internal quality control measures.
- Successful participation in interlaboratory studies that assess laboratory proficiency is the best way to prove the competence in specific analyses. However successful participation in interlaboratory studies for e.g. soil or sewage samples does not necessarily prove the competence also in the field of food or feed samples, which present lower contamination levels. Therefore, the continuous participation in interlaboratory studies for the determination of dioxins and dioxin-like PCBs in the relevant feed/food matrices is mandatory.
- Laboratories shall be accredited by a recognised body operating in accordance with ISO Guide 58 to ensure that they are applying analytical quality assurance. Laboratories shall be accredited following the ISO/IEC/17025 standard.

5. Requirements for the analytical procedures for dioxins and dioxin-like PCBs

Basic requirements for acceptance of analytical procedures:

- **High sensitivity and low limits of detection.** For PCDDs and PCDFs, detectable quantities have to be in the picogram TEQ (10^{-12} g) range because of extreme toxicity of some of these compounds. PCBs are known to occur at higher levels than the PCDDs and PCDFs. For most PCB congeners sensitivity in nanogram (10^{-9} g) range is already sufficient. However, for the measurement of the more toxic dioxin-like PCB congeners (in particular non-ortho substituted congeners), the same sensitivity must be reached as for the PCDDs and PCDFs.
- **High selectivity (specificity).** A distinction is required for PCDDs, PCDFs and dioxin-like PCBs from a multitude of other, coextracted and possibly interfering compounds present at concentrations up to several orders of magnitude higher than those of the analytes of interest. For gas chromatography/mass spectrometry (GC/MS) methods, a differentiation among various congeners is necessary, such as between toxic (e.g. the 17 2,3,7,8-substituted PCDDs and PCDFs and dioxin-like PCBs) and other congeners. Bioassays must be able to determine TEQ values selectively as the sum of PCDDs, PCDFs and dioxin-like PCBs.
- **High accuracy (trueness and precision).** The determination shall provide a valid and reliable estimate of the true concentration in a sample. High accuracy (accuracy of the measurement: the closeness of agreement between the result of a measurement with the true or assigned value of the measurand) is necessary to avoid the rejection of a sample analysis result on the basis of poor reliability of the estimate of TEQ. Accuracy is expressed as trueness (difference between the mean value measured for an analyte in a certified material and its certified value, expressed as percentage of this value) and precision (RSD_R , relative standard deviation calculated from results generated under reproducibility conditions).

Screening methods can comprise bioassays and GC/MS methods; confirmatory methods are high-resolution gas-chromatography/high-resolution mass-spectrometry (HRGC/HRMS) methods.

Following criteria have to be complied with on total TEQ value:

	Screening methods	Confirmatory methods
False negative rate	< 1 %	
Trueness		- 20 % to + 20 %
Precision RSD _R	< 30 %	< 15 %

6. Specific requirements for gc/ms methods to be complied with for screening or confirmatory purposes.

- Addition of ¹³C-labelled 2,3,7,8-chlorine substituted internal PCDD/F standards and of ¹³C-labelled internal dioxin-like PCB standards must be carried out at the very beginning or start of the analytical method, e.g. prior to extraction in order to validate the analytical procedure. At least one congener for each of the tetra to octa-chlorinated homologous groups for PCDD/F and at least one congener for each of the homologous groups for dioxin-like PCBs must be added (alternatively, at least one congener for each mass spectrometric selected ion recording function used for monitoring PCDD/F and dioxin-like PCBs). There shall be a clear preference, certainly in case of confirmatory methods, of using all 17 ¹³C-labelled 2,3,7,8-substituted internal PCDD/F standards and all 12 ¹³C-labelled internal dioxin-like PCB standards.
- Relative response factors shall also be determined for those congeners for which no ¹³C-labelled analogue is added by using appropriate calibration solutions.
- For feed of plant origin and feed of animal origin containing less than 10 % fat, the addition of the internal standards is mandatory prior to extraction. For feed of animal origin containing more than 10 % fat, the internal standards can be added either before extraction or after fat extraction. An appropriate validation of the extraction efficiency shall be carried out, depending on the stage at which internal standards are introduced and on whether results are reported on a product or fat basis.
- Prior to GC/MS analysis, 1 or 2 recovery (surrogate) standard(s) must be added.
- Control of recovery is necessary. For confirmatory methods, the recoveries of the individual internal standards must be in the range of 60 % to 120 %. Lower or higher recoveries for individual congeners, in particular for some hepta- and octa- chlorinated dibenzodioxins and dibenzofurans, are acceptable on the condition that their contribution to the TEQ value does not exceed 10 % of the total TEQ value (based on sum of PCDD/F and dioxin-like PCBs). For screening methods, the recoveries must be in the range of 30 % to 140 %.
- Separation of dioxins from interfering chlorinated compounds such as non-dioxin-like PCBs and chlorinated diphenyl ethers shall be carried out by suitable chromatographic techniques (preferably with a florisil, alumina and/or carbon column).
- Gaschromatographic separation of isomers shall be sufficient (< 25 % peak to peak between 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF).
- Determination shall be performed according to EPA Method 1613 revision B: Tetra- through octa-chlorinated dioxins and furans by isotope dilution HRGC/HRMS or another with equivalent performance criteria.
- The difference between upperbound level and lower bound level must not exceed 20 % for feed with a dioxin contamination in the range or above the maximum level. For feed with contamination levels well below the maximum level, the difference may be in the range of 25 %-40 %.

7. Screening methods of analysis

7.1. Introduction

Different analytical approaches can be performed using a screening method: a pure screening approach and a quantitative approach.

Screening approach

The response of samples is compared to that of a reference sample at the level of interest. Samples with a response less than the reference are declared negative, those with a higher response are suspected positives. Requirements:

- A blank and a reference sample(s) have to be included in each test series, which is extracted and tested at the same time under identical conditions. The reference sample must show a clearly elevated response in comparison to a blank.
- Additional reference samples at 0,5x and 2x the level of interest shall be included to demonstrate the proper performance of the test in the range of interest for the control of the level of interest.
- When testing other matrices, the suitability of the reference sample(s) has to be demonstrated, preferentially by including samples shown by HRGC/HRMS to contain a TEQ level around that of the reference sample or else a blank spiked at this level.
- Since no internal standards can be used in bioassays, tests on repeatability are very important to obtain information on the standard deviation within one test series. The coefficient of variation must be below 30 %.
- For bioassays, the target compounds, possible interferences, and maximum tolerable blank levels shall be defined.

Quantitative approach

The quantitative approach requires standard dilution series, duplicate or triplicate clean up and measuring as well as blank and recovery controls. The result may be expressed as TEQ, thereby assuming that the compounds responsible for the signal correspond to the TEQ principle. This can be performed by using TCDD (or a dioxin/furan/dioxin-like PCB standard mixture) to produce a calibration curve to calculate the TEQ level in the extract and thus in the sample. This is subsequently corrected for the TEQ level calculated for a blank sample (to account for impurities from solvents and chemicals used), and a recovery (calculated from the TEQ level in a quality control sample around the limit of interest). It is essential to note that part of the apparent recovery loss may be due to matrix effects and/or differences between the TEF values in the bioassays and the official TEF values set by WHO.

7.2. *Requirements for methods of analysis used for screening*

- GC/MS methods of analysis and bioassays may be used for screening. For GC/MS methods the requirements as laid down in point 6 are to be used. For cell based bioassays specific requirements are laid down in point 7.3 and for kit-based bioassays in point 7.4.
- Information on the number of false-positive and false-negative results of a large set of samples below and above the maximum level or action level is necessary, in comparison to the TEQ content as determined by a confirmatory method of analysis. Actual false negative rates must be under 1 %. The rate of false positive samples shall be low enough to make the use of a screening tool advantageous.
- Positive results have always to be confirmed by a confirmatory method of analysis (HRGC/HRMS). In addition, samples from a wide TEQ-range shall be confirmed by HRGC/HRMS (approximately 2 %-10 % of the negative samples). Information on correspondence between bioassay and HRGC/HRMS results shall be made available.

7.3. *Specific requirements for cell based bioassays*

- When performing a bioassay, every test run requires a series of reference concentration of TCDD or a dioxin/furan mixture (full dose-response curve with a $R^2 > 0,95$). However, for screening purposes, an expanded low level curve for analysing low-level samples could be used.
- A TCDD reference concentration (about 3 x limit of quantification) on a quality control sheet shall be used for the outcome of the bioassay over a constant time period. An alternative could be the relative response of a reference sample in comparison to the TCDD calibration line since the response of the cells may depend on many factors.
- Quality control (QC) charts for each type of reference material shall be recorded and checked to make sure the outcome is in accordance with the stated guidelines.

- In particular for quantitative calculations, the induction of the sample dilution used must be within the linear portion of the response curve. Samples above the linear portion of the response curve must be diluted and re-tested. Therefore, at least 3 or more dilutions at one time are recommended to be tested.
- The per cent standard deviation shall not be above 15 % in a triplicate determination for each sample dilution and not above 30 % between three independent experiments.
- The limit of detection may be set as 3x the standard deviation of the solvent blank or of the background response. Another approach is to apply a response that is above the background (induction factor 5x the solvent blank) calculated from the calibration curve of the day. The limit of quantification may be set as 5 to 6x the standard deviation of the solvent blank or of the background response or to apply a response that is clearly above the background (induction factor 10x the solvent blank) calculated from the calibration curve of the day.

7.4. *Specific requirements for kit based bioassays*

- It shall be ensured that the kit-based bioassays have sufficient sensitivity and reliability to be applied for feed.
- Manufacturer's instructions for sample preparation and analyses have to be followed.
- Test kits shall not be used after the expiration date.
- Materials or components designed for use with other kits shall not be used.
- Test kits shall be kept within the specified range of storage temperature and used at the specified operating temperature.
- The limit of detection for immunoassays is determined as the sum of the mean and 3x the standard deviation, based on 10 replicate analysis of the blank, to be divided by the slope value of the linear regression equation.
- Reference standards shall be used for tests at the laboratory to make sure that the responsiveness to the standard is within an acceptable range.

8. **Reporting of results**

In so far as the used analytical procedure makes it possible, the analytical results shall contain the levels of the individual PCDD/F and PCB congeners and the analytical results have to be reported as lowerbound, upperbound and medium-bound in order to include a maximum of information in the reporting of the results and thereby enabling the interpretation of the results according to specific requirements.

The report shall also include the lipid content of the sample as well the method used for lipid extraction.

The recoveries of the individual internal standards must be made available in case the recoveries are outside the range mentioned in point 6, in case the maximum level is exceeded and in the other cases upon request.

As the uncertainty of the measurement is to be taken into account when deciding about the compliance of a sample, this parameter shall also be made available. Thus, analytical results shall be reported as $x \pm U$ whereby x is the analytical result and U is the expanded measurement uncertainty using a coverage factor of 2 which gives a level of confidence of approximately 95 %. In case of a separate determination of dioxins and dioxin-like-PCBs the sum of the estimated expanded uncertainty of the separate analytical results of dioxins and dioxin-like PCBs has to be used for the sum of dioxins and dioxin-like PCBs.

If the uncertainty of measurement would be taken into account by applying a CC α (as described in I.2 of this Part B) this parameter shall be reported.

ANNEX VI

METHODS OF ANALYSIS FOR THE DETERMINATION OF CONSTITUENTS OF ANIMAL ORIGIN FOR THE OFFICIAL CONTROL OF FEED**Conditions for the microscopic detection, identification or estimation of constituents of animal origin in feed****1. Objective and field of application**

These conditions shall be used when detection of constituents of animal origin (defined as products from processing bodies and body-parts of mammals, poultry and fish) in feed is carried out by means of microscopic examination in the framework of the coordinated inspection programme in the field of animal nutrition in accordance with Regulation (EC) 882/2004 of the European Parliament and of the Council ⁽¹⁾. Provided that the methods in this Annex are used in all official tests, a second test may also be carried out using variant or alternative methods, in order to improve the detection of certain types of animal constituents or to further specify the origin of the animal constituents. Furthermore, a variant protocol may be used when examining certain specific animal constituents such as plasma or bones in tallow (see also point 9), provided that these analyses are made in addition to the analyses foreseen in the coordinated inspection programme.

2. Sensitivity

Dependent on the nature of the constituents of animal origin, very small amounts (< 0,1 %) in feed can be detected.

3. Principle

A representative sample, taken in accordance with the provisions laid down in Annex I which has undergone suitable preparation is used for the identification. The following protocol is fit for handling feed with low moisture content. Feed with an amount of moisture higher than 14 % shall be dried (condensed) prior to handling. Special feed or feed materials (e.g. fats, oils) need dedicated treatment (see point 9). The constituents of animal origin are identified on the basis of typical, microscopically identifiable characteristics (i.e. muscle fibres and other meat particles, cartilage, bones, horn, hair, bristles, blood, feathers, egg shells, fish bones, scales). The identification has to be done both on the sieve fraction (6.1) and the concentrated sediment (6.2) of the sample.

4. Reagents**4.1. Embedding agent**

4.1.1. Chloral hydrate (aqueous, 60 % w/v)

4.1.2. Lye (NaOH 2,5 % w/v or KOH 2,5 % w/v) for sieve fractions

4.1.3. Paraffin oil or glycerol (viscosity: 68-81) for microscopic observations in the sediment

4.2. Rinsing agents

4.2.1. Alcohol, 96 %

4.2.2. Acetone

4.3. Concentrating agent

4.3.1. Tetrachloroethylene (density 1,62)

⁽¹⁾ OJ L 165, 30.4.2004 p. 1; corrected by OJ L 191, 28.5.2004, p. 1.

4.4. Staining reagents

- 4.4.1. Iodine/potassium iodide solution (Dissolve 2 g potassium iodide in 100 ml water and add 1 g iodine while frequently shaking)
- 4.4.2. Alizarin Red (Dilute 2,5 ml 1M hydrochloric acid in 100 ml water and add 200 mg alizarine red to this solution)
- 4.4.3. Cystine reagent (2 g lead acetate, 10 g NaOH/100 ml H₂O)
- 4.4.4. Iodine/potassium iodide solution (dissolved in 70 % ethanol)

4.5. Bleaching reagent

- 4.5.1 Commercial sodium hypochlorite solution (9,6 % active chlorine)

5. Equipment and accessories

- 5.1. Analytical balance (accuracy of 0,01 g except for the concentrated sediment: 0,001 g).
- 5.2. Material for grinding (grinding mill or a mortar, especially for feed containing > 15 % fat on analysis).
- 5.3. Sieve fitted with sieve mesh with square meshes of width of 0,50 mm maximum.
- 5.4. Separation funnel or conical bottomed settling beaker.
- 5.5. Stereomicroscope (minimum 40' magnification).
- 5.6. Compound microscope (minimum 400' magnification), transmitted light or polarised light.
- 5.7. Standard laboratory glassware.

All equipment shall be thoroughly cleaned. Separation funnels and glassware need washing in a washing machine. Sieves need cleaning by using a brush with stiff hairs.

6. Procedure

Pelleted feeds may be pre-sieved if both fractions are analysed as a separate sample.

At least 50 g of the sample shall be treated (ground with care using the suitable grinding equipment (5.2) if necessary in order to achieve an appropriate structure). From the grinded material two representative portions shall be taken, one for the sieve fraction (at least 5 g) (6.1) and one for the concentrated sediment (at least 5 g) (6.2). Colouring with staining reagents (6.3) can additionally be applied for the identification.

In order to indicate the nature of the animal proteins and the origin of the particles, a decision support system such as ARIES can be used and reference samples can be documented.

6.1. Identification of constituents of animal origin in the sieve fractions

At least 5 g of the sample is sieved through the sieve (5.3) in two fractions

The sieve fraction(s) with the large particles (or a representative part of the fraction) is applied as a thin layer to a suitable support and screened systematically under the stereomicroscope (5.5) at various magnifications for constituents of animal origin.

Slides made with the sieve fraction(s) with the fine particles are screened systematically under the compound microscope (5.6) at various magnifications for constituents of animal origin.

6.2. Identification of constituents of animal origin from the concentrated sediment

At least 5 g (accurate to 0,01 g) of the sample shall be transferred into a separation funnel or conical bottomed settling beaker and treated with at least 50 ml of tetrachloroethylene (4.3.1). The mixture shall be shaken or stirred repeatedly.

- If a closed separation funnel is used the sediment shall be left to stand for a sufficient time (at least 3 minutes) before the sediment is separated off. Shaking shall be repeated and the sediment shall be left to stand again at least 3 minutes. The sediment shall be separated off again.
- If an open beaker is used, the sediment shall be left to stand for at least 5 minutes before the sediment is separated off.

The total sediment shall be dried and subsequently weighed (accurate to 0,001 g). The weighing is only necessary in case an estimation is required. If the sediment consists of many large particles it may be sieved through a sieve (5.3) in two fractions. The dried sediment shall be examined for bone constituents under the stereomicroscope (5.5) and the compound microscope (5.6).

6.3. Use of embedding agents and staining reagents.

The microscopic identification of the constituents of animal origin can be supported by the use of special embedding agents and staining reagents.

Chloral hydrate (4.1.1): By carefully heating, cell structures can be seen more clearly because starch grains gelatinise and unwanted cell contents are removed.

Lye (4.1.2): either sodiumhydroxide or potassiumhydroxide clears the material of the feed, assisting the detection of muscle fibres, hairs and other keratin structures.

Paraffin oil and glycerol (4.1.3): Bone constituents can be well identified in this embedding agent because most lacunae remain filled with air and appear as black holes about 5-15 μm .

Iodine/potassium Iodide solution (4.4.1): Is used for the detection of starch (Blue-violet colour) and protein (yellow-orange colour). Solutions may be diluted if required.

Alizarin red solution (4.4.2): Red/pink colouring of bones, fish-bones and scales. Before drying the sediment (see section 6.2), the total sediment shall be transferred into a glass test tube and rinsed twice with approximately 5 ml alcohol (4.2.1) (each time a vortex shall be used, the solvent shall be let settle about one minute and poured off). Before using this staining reagent, the sediment shall be bleached by adding at least 1 ml sodium hypochlorite solution (4.5.1). The reaction shall be allowed continue during 10 minutes. The tube shall be filled with water, the sediment shall be let settle 2-3 minutes, and the water and the suspended particles shall be poured off. The sediment shall be rinsed twice more with about 10 ml of water (a vortex shall be used, let settle, and pour off the water each time). Two to 10 or more drops (depending on the amount of residue) of the alizarine red solution shall be added. The mixture shall be shaken and the reaction shall be let occur a few seconds. The coloured sediment shall be rinsed twice with approximately 5 ml alcohol (4.2.1) followed by one rinse with acetone (4.2.2) (each time a vortex shall be used, the solvent shall be let settle about one minute and poured off). The sediment is then ready to be dried.

Cystin reagent: (4.4.3): By carefully heating, cystin-containing constituents (hair, feathers, etc.) become black-brown.

6.4. Examination in feed possibly containing fishmeal

At least one slide shall be examined from the fine sieve fraction and from the fine fraction of the sediment under the compound microscope (see sections 6.1 and 6.2).

Where the label indicates that the ingredients include fishmeal, or if the presence of fishmeal is suspected or detected in the initial examination, at least two additional slides of the fine sieve fraction from the original sample, and the total sediment fraction shall be examined.

7. Calculation and evaluation

Member States shall ensure that the procedures described in this point are used where an official analysis is carried out with a view to estimate the amount (and not simply the presence) of animal constituents.

The calculation can only be made if the constituents of animal origin contain bone fragments.

Bone fragments of terrestrial warm-blooded species (i.e. mammals and birds) can be distinguished from the different types of fish bone on the microscopic slide by means of the typical lacunae. The proportion of constituents of animal origin in the sample material is estimated taking into consideration:

- the estimated proportion (weight %) of bone fragments in the concentrated sediment, and
- the proportion (weight %) of bone in the constituents of animal origin.

The estimate has to be based on at least three (if possible) slides and at least five fields per slide. In compound feed, the concentrated sediment as a rule contains not only terrestrial animal bone and fish bone fragments, but also other particles of high specific weight, e.g. minerals, sand, lignified plant fragments and the like.

7.1. *Estimated value of the percentage of bone fragments*

% terrestrial bone fragments = $(S \times c)/W$

% fish bone and scale fragments = $(S \times d)/W$

(S = sediment weight (mg), c = correction factor (%) for the estimated portion of terrestrial animal bones in the sediment, d = correction factor (%) for the estimated portion of fish bones and scale fragments in the sediment, W = weight of the sample material for the sedimentation (mg)).

7.2. *Estimated value of constituents of animal origin*

The proportion of bone in animal products can vary greatly. (The percentage of bone in the case of bone meals is of the order of 50 %-60 % and in the case of meat meals of the order of 20 %-30 %; in case of fish meals bone and scale contents vary according the category and origin of fish meal, normally in the order of 10-20 %).

If the type of animal meal present in the sample is known, it is possible to estimate the content:

Estimated content of constituents of terrestrial animal products (%) = $(S \times c)/(W \times f) \times 100$

Estimated content of constituents of fish products (%) = $(S \times d)/(W \times f) \times 100$

(S = sediment weight (mg), c = correction factor (%) for the estimated portion of terrestrial animal bone constituents in the sediment, d = correction factor (%) for the estimated portion of fish bones and scale fragments in the sediment, f = correction factor for the proportion of bone in the constituents of animal origin in the sample examined, W = weight of the sample material for the sedimentation (mg)).

8. **Expression of the result of the examination**

The report shall at least contain information on the presence of constituents derived from terrestrial animals and from fishmeal. The different cases shall be reported in the following way:

8.1. With regard to the presence of constituents derived from terrestrial animals:

- as far as was discernible using a microscope, no constituents derived from terrestrial animals were found in the submitted sample,

or

- as far as was discernible using a microscope, constituents derived from terrestrial animals were found in the submitted sample.

8.2. and, with regard to the presence of fishmeal:

- as far as was discernible using a microscope, no constituents derived from fish were found in the submitted sample,

or

- as far as was discernible using a microscope, constituents derived from fish were found in the submitted sample.

In case constituents derived from fish or terrestrial animals are found, the report of the examination result, if required, can further indicate an estimation of the amount of constituents detected (x %, < 0,1 %, 0,1-0,5 %, 0,5-5 % or > 5 %), further specification of the type of terrestrial animal if possible and the animal constituents identified (muscle fibres, cartilage, bones, horn, hair, bristles, feathers, blood, egg shells, fish bones, scales).

For the case where the amount of animal ingredients is estimated the correction factor *f* used shall be mentioned.

For the cases where bone constituents from terrestrial animals are identified, the report shall contain the additional clause:

'The possibility that the above constituents are derived from mammals cannot be excluded.'

This additional clause is not necessary in cases where the bone fragments from terrestrial animals have been specified as bone fragments from poultry or mammals.

9. **Optional protocol for analysing fat or oil**

The following protocol may be used for the analysis of fat or oil:

- If the fat is solid, it is warmed for example in a microwave oven until it is liquid.
 - By using a pipette, 40 ml of fat is transferred from the bottom of the sample to a centrifugation tube.
 - Centrifugate during 10 minutes at 4 000 r.p.m.
 - If the fat is solid after centrifugation, it is warmed once more in an oven until it is liquid. Repeat the centrifugation during 5 minutes at 4 000 r.p.m.
 - By using a small spoon or a spatula one half of the decanted impurities is transferred to a small Petri dish or a microscopic slide for microscopic identification of a possible content of animal constituents (meat fibres, feathers, bone fragments, ...). As embedding agent for microscopy paraffin oil or glycerol is recommended.
 - The remaining impurities are used for sedimentation as described in point 6.2.
-

ANNEX VII

METHOD OF CALCULATING THE ENERGY VALUE OF POULTRYFEED**1. Method of calculation and expression of energy value**

The energy value of compound poultry feed must be calculated in accordance with the formula set out below on the basis of the percentages of certain analytical components of the feed. This value is to be expressed in megajoules (MJ) of metabolisable energy (ME), corrected for nitrogen, per kilogram of compound feed:

$\text{MJ/kg of ME} = 0,1551 \times \% \text{ crude protein} + 0,3431 \times \% \text{ crude fat} + 0,1669 \times \% \text{ starch} + 0,1301 \times \% \text{ total sugar}$
(expressed as sucrose).

2. Tolerances applicable to declared values

If the official inspection reveals a discrepancy (increased or reduced energy value of the feed) between the result of the inspection and the declared energy value, a minimum tolerance of 0,4 MJ/kg of ME shall be permitted.

3. Expression of result

After application of the above formula, the result obtained must be given to one decimal place.

4. Sampling and analysis methods

Sampling of the compound feed and determination of the content of analytical components indicated in the method of calculation must be performed in accordance with the Community sampling methods and analysis methods for the official control of feed respectively.

The following are to be applied:

- for determining the crude fat content: procedure B of the method for the determination of crude oils and fats, laid down in Part H of Annex III.
 - for determining the starch content: the polarimetric method, laid down in Part L of Annex III.
-

ANNEX VIII

METHODS OF ANALYSIS TO CONTROL ILLEGAL PRESENCE OF NO LONGER AUTHORISED ADDITIVES IN FEED

Important notes:

More sensitive methods of analysis than the methods of analysis mentioned in this Annex can be used to detect the illegal presence of no longer authorised additives in feed.

The methods of analysis mentioned in this Annex shall be used for confirmatory purposes.

A. DETERMINATION OF METHYL BENZOQUATE

7-benzyloxy-6-butyl-3-methoxycarbonyl-4-quinolone

1. **Purpose and scope**

This method makes it possible to determine the level of methyl benzoate in feed. The limit of quantification is 1 mg/kg.

2. **Principle**

Methyl benzoate is extracted from the sample with methanolic methanesulfonic acid solution. The extract is purified with dichloromethane, by ion-exchange chromatography and then again with dichloromethane. The methyl benzoate content is determined by reversed-phase high-performance liquid chromatography (HPLC) with an UV detector.

3. **Reagents**

3.1. Dichloromethane

3.2. Methanol, equivalent to HPLC grade

3.3. HPLC mobile phase

Mixture of methanol (3.2) and water (equivalent to HPLC grade) 75 + 25 (v + v).

Filter through a 0,22 µm filter (4.5) and degas the solution (e.g. by ultrasonification for 10 minutes).

3.4. Methanesulfonic acid solution, c = 2 %

Dilute 20,0 ml methanesulfonic acid to 1 000 ml with methanol (3.2).

3.5. Hydrochloric acid solution, c = 10 %

Dilute 100 ml hydrochloric acid (ρ_{20} 1,18 g/ml) to 1 000 ml with water.

3.6. Cation-exchange resin Amberlite CG-120 (Na), 100 to 200 mesh

The resin is pretreated before use. Slurry 100 g resin with 500 ml hydrochloric acid solution (3.5) and heat on a hot plate to boiling, stirring continuously. Allow to cool and decant off the acid. Filter through a filter paper under vacuum. Wash the resin twice with 500 ml portions of water and then with 250 ml of methanol (3.2). Rinse the resin with a further 250 ml portion of methanol and dry by passing air through the filter cake. Store the dried resin in a stoppered bottle.

- 3.7. Standard substance: pure methyl benzoate (7-benzyloxy-6-butyl-3-methoxycarbonyl-4-quinolone)
- 3.7.1. Methyl benzoate stock standard solution, 500 µg/ml
- Weigh to the nearest 0,1 mg, 50 mg of standard substance (3.7), dissolve in methanesulfonic acid solution (3.4) in a 100 ml graduated flask, make up to the mark and mix.
- 3.7.2. Methyl benzoate intermediate standard solution, 50 µg/ml
- Transfer 5,0 ml of methyl benzoate stock standard solution (3.7.1) into a 50 ml graduated flask, make up to the mark with methanol (3.2) and mix.
- 3.7.3. Calibration solutions
- Transfer 1,0, 2,0, 3,0, 4,0 and 5,0 ml of methyl benzoate intermediate standard solution (3.7.2) into a series of 25 ml graduated flasks. Make up to the mark with the mobile phase (3.3) and mix. These solutions have concentrations of 2,0, 4,0, 6,0, 8,0 and 10,0 µg/ml methyl benzoate respectively. These solutions must be freshly prepared before use.
4. **Apparatus**
- 4.1. Laboratory shaker
- 4.2. Rotary film evaporator
- 4.3. Glass column (250 mm × 15 mm) fitted with a stopcock and reservoir of approximately 200 ml capacity
- 4.4. HPLC equipment with variable wavelength ultraviolet detector or diode-array detector
- 4.4.1. Liquid chromatographic column: 300 mm × 4 mm, C₁₈, 10 µm packing or equivalent
- 4.5. Membrane filters, 0,22 µm
- 4.6. Membrane filters, 0,45 µm
5. **Procedure**
- 5.1. *General*
- 5.1.1. A blank feed shall be analysed to check that neither methyl benzoate nor interfering substances are present.
- 5.1.2. A recovery test shall be carried out by analysing the blank feed which has been fortified by addition of a quantity of methyl benzoate, similar to that present in the sample. To fortify at a level of 15 mg/kg, add 600 µl of the stock standard solution (3.7.1) to 20 g of the blank feed, mix and wait for 10 minutes before proceeding with the extraction step (5.2).
- Note for the purpose of this method, the blank feed shall be similar in type to that of the sample and on analysis methyl benzoate must not be detected.
- 5.2. *Extraction*
- Weigh to the nearest 0,01 g, approximately 20 g of the prepared sample and transfer to a 250 ml conical flask. Add 100,0 ml of methanesulfonic acid solution (3.4) and shake mechanically (4.1) for 30 minutes. Filter the solution through a filter paper and retain the filtrate for the liquid-liquid partition step (5.3).
- 5.3. *Liquid-liquid partition*
- Transfer into a 500 ml separating funnel containing 100 ml of hydrochloric acid solution (3.5), 25,0 ml of the filtrate obtained in (5.2). Add 100 ml dichloromethane (3.1) to the funnel and shake for one minute. Allow the layers to separate and run off the lower (dichloromethane) layer into a 500 ml round-bottomed flask. Repeat the extraction of the aqueous phase with two further 40-ml portions of dichloromethane and combine these with the first extract in the round-bottomed flask. Evaporate the dichloromethane extract down to dryness on the rotary evaporator (4.2) operating under reduced pressure at 40 °C. Dissolve the residue in 20 to 25 ml methanol (3.2), stopper the flask and retain the whole of the extract for ion-exchange chromatography (5.4).

5.4. *Ion-exchange chromatography*

5.4.1. Preparation of the cation-exchange column

Insert a plug of glass wool into the lower end of a glass column (4.3). Prepare a slurry of 5.0 g of the treated cation-exchange resin (3.6) with 50 ml of hydrochloric acid (3.5), pour into the glass column and allow to settle. Run out the excess acid to just above the resin surface and wash the column with water until the effluent is neutral to litmus. Transfer 50 ml methanol (3.2) onto the column and allow to drain down to the resin surface.

5.4.2. Column chromatography

By means of a pipette, carefully transfer the extract obtained in (5.3) onto the column. Rinse the round-bottomed flask with two portions of 5 to 10 ml methanol (3.2) and transfer these washings to the column. Run the extract down to the resin surface and wash the column with 50 ml methanol, ensuring that the flow rate does not exceed 5 ml per minute. Discard the effluent. Elute the methyl benzoate from the column using 150 ml of methanesulfonic acid solution (3.4) and collect the column eluate in a 250 ml conical flask.

5.5. *Liquid-liquid partition*

Transfer the eluate obtained in (5.4.2) into a 1 litre separating funnel. Rinse the conical flask with 5 to 10 ml methanol (3.2) and combine the washings with the contents of the separating funnel. Add 300 ml of hydrochloric acid solution (3.5) and 130 ml of dichloromethane (3.1). Shake for 1 minute and allow the phases to separate. Run off the lower (dichloromethane) layer into a 500 ml round bottomed flask. Repeat the extraction of the aqueous phase with two further 70 ml portions of dichloromethane and combine these extracts with the first in the round-bottomed flask.

Evaporate the dichloromethane extract down to dryness on the rotary evaporator (4.2) operating under reduced pressure at 40 °C. Dissolve the residue in the flask with approximately 5 ml of methanol (3.2) and transfer this solution quantitatively to a 10 ml graduated flask. Rinse the round-bottomed flask with a further two portions of 1 to 2 ml of methanol and transfer these to the graduated flask. Make up to the mark with methanol and mix. An aliquot portion is filtered through a membrane filter (4.6). Reserve this solution for HPLC-determination (5.6).

5.6. *HPLC determination*

5.6.1. Parameters

The following conditions are offered for guidance, other conditions may be used provided that they give equivalent results:

- liquid chromatographic column (4.4.1),
- HPLC mobile phase: methanol-water mixture (3.3),
- flow rate: 1 to 1,5 ml/minute,
- detection wavelength: 265 nm,
- Injection volume: 20 to 50 µl.

Check the stability of the chromatographic system, injecting the calibration solution (3.7.3) containing 4 µg/ml several times, until constant peak heights or areas and retention times are achieved.

5.6.2. Calibration graph

Inject each calibration solution (3.7.3) several times and measure the peak heights (areas) for each concentration. Plot a calibration graph using the mean peak heights or areas of the calibration solutions as the ordinates and the corresponding concentrations in µg/ml as the abscissae.

5.6.3. Sample solution

Inject the sample extract (5.5) several times, using the same volume as taken for the calibration solutions and determine the mean peak height (area) of the methyl benzoate peaks.

6. **Calculation of results**

Determine the concentration of the sample solution in µg/ml from the mean height (area) of the methyl benzoate peaks of the sample solution by reference to the calibration graph (5.6.2).

The content of methyl benzoate w (mg/kg) of the sample is given by the following formula:

$$w = \frac{c \times 40}{m}$$

in which:

c = methyl benzoate concentration of the sample solution in $\mu\text{g/ml}$,

m = weight of the test portion in grams.

7. Validation of the results

7.1. Identity

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract and the calibration solution (3.7.3) containing 10 $\mu\text{g/ml}$ are compared.

7.1.1. Co-chromatography

A sample extract is fortified by addition of an appropriate amount of the intermediate standard solution (3.7.2). The amount of added methyl benzoate must be similar to the estimated amount of methyl benzoate in the sample extract.

Only the height of the methyl-benzoate peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its maximum height, must be within approximately 10 % of the original width.

7.1.2. Diode-array detection

The results are evaluated according to the following criteria:

- the wavelength of maximum absorption of the sample and of the standard spectra recorded at the peak apex on the chromatogram must be the same within a margin determined by the resolving power of the detection system. For diode-array detection, this is typically within approximately 2 nm;
- between 220 and 350 nm, the sample and standard spectra recorded at the peak apex on the chromatogram must not be different for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte;
- between 220 and 350 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and when at no observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the apex.

If one of these criteria is not met the presence of the analyte has not been confirmed.

7.2. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed: 10 % relative to the higher result for methyl benzoate contents between 4 and 20 mg/kg.

7.3. Recovery

For a fortified blank sample the recovery shall be at least 90 %.

8. Results of a collaborative study

Five samples were analysed by 10 laboratories. Duplicate analyses were performed on each sample.

	Blank	Meal 1	Pellet 1	Meal 2	Pellet2
Mean [mg/kg]	ND	4,50	4,50	8,90	8,70
s_r [mg/kg]	—	0,30	0,20	0,60	0,50

	Blank	Meal 1	Pellet 1	Meal 2	Pellet2
CV _r [%]	—	6,70	4,40	6,70	5,70
s _R [mg/kg]	—	0,40	0,50	0,90	1,00
CV _R [%]	—	8,90	11,10	10,10	11,50
Recovery [%]	—	92,00	93,00	92,00	89,00

ND = Not detected

s_r = standard deviation of repeatability

CV_r = coefficient of variation of repeatability, %

s_R = standard deviation of reproducibility

CV_R = coefficient of variation of reproducibility, %.

B. DETERMINATION OF OLAQUINDOX

2-[N-2'-(hydroxyethyl)carbamoyl]-3-methylquinoxaline-N¹,N⁴-dioxide

1. Purpose and scope

This method makes it possible to determine the level olaquinox in feed. The limit of quantification is 5 mg/kg.

2. Principle

The sample is extracted by a water-methanol mixture. The content of olaquinox is determined by reversed-phase high-performance liquid chromatography (HPLC) using an UV detector.

3. Reagents

3.1. Methanol.

3.2. Methanol, equivalent to HPLC grade.

3.3. Water, equivalent to HPLC grade.

3.4. Mobile phase for HPLC.

Water (3.3)-methanol (3.2) mixture, 900 +100 (V + V).

3.5. Standard substance: pure olaquinox 2-[N-2'-(hydroxyethyl)carbamoyl]-3-methylquinoxaline-N¹,N⁴-dioxide, E 851.

3.5.1. Olaquinox stock standard solution, 250 µg/ml

Weigh to the nearest 0,1 mg 50 mg of olaquinox (3.5) in a 200 ml graduated flask and add ca. 190 ml water. Then place the flask for 20 min. into an ultrasonic bath (4.1). After ultrasonic treatment bring the solution to room temperature, make up to the mark with water and mix. Wrap the flask with aluminium foil and store in a refrigerator. This solution must be prepared fresh each month.

3.5.2. Olaquinox intermediate standard solution, 25 µg/ml

Transfer 10,0 ml of the stock standard solution (3.5.1) into a 100 ml graduated flask, make up to the mark with the mobile phase (3.4) and mix. Wrap the flask with aluminium foil and store in a refrigerator. This solution must be prepared fresh each day.

3.5.3. Calibration solutions

Into a series of 50 ml graduated flasks transfer 1,0, 2,0, 5,0, 10,0, 15,0 and 20,0 ml of the intermediate standard solution (3.5.2). Make up to the mark with the mobile phase (3.4) and mix. Wrap the flasks with aluminium foil. These solutions correspond to 0,5, 1,0, 2,5, 5,0, 7,5 and 10,0 µg of olaquinox per ml respectively.

These solutions must be prepared fresh each day.

4. Apparatus

- 4.1. Ultrasonic bath
- 4.2. Mechanical shaker
- 4.3. HPLC equipment with variable wavelength ultraviolet detector or diode array detector
- 4.3.1. Liquid chromatographic column, 250 mm × 4 mm, C₁₈, 10 µm packing, or equivalent
- 4.4. Membrane filters, 0,45 µm

5. Procedure

Note: Olaquinox is light sensitive. Carry out all procedures under subdued light or use amber glassware.

5.1. General

- 5.1.1. A blank feed shall be analysed to check that neither olaquinox nor interfering substances are present.
- 5.1.2. A recovery test shall be carried out by analysing the blank feed which has been fortified by addition of a quantity of olaquinox, similar to that present in the sample. To fortify at a level of 50 mg/kg, transfer 10,0 ml of the stock standard solution (3.5.1) to a 250 ml conical flask and evaporate the solution to ca. 0,5 ml. Add 50 g of the blank feed, mix thoroughly and leave for 10 min. mixing again several times before proceeding with the extraction step (5.2).

Note: For the purpose of this method the blank feed shall be similar in type to that of the sample and olaquinox must not be detected.

5.2. Extraction

Weigh to the nearest 0,01 g, approximately 50 g of the sample. Transfer to a 1 000 ml conical flask, add 100 ml of methanol (3.1) and place the flask for 5 min. in the ultrasonic bath (4.1). Add 410 ml water and leave in the ultrasonic bath for further 15 min. Remove the flask from the ultrasonic bath, shake it for 30 min. on the shaker (4.2) and filter through a folded filter. Transfer 10,0 ml of the filtrate into a 20 ml graduated flask, make up to the mark with water and mix. An aliquot is filtered through a membrane filter (4.4). (see 9. Observation) Proceed to the HPLC determination (5.3).

5.3. HPLC determination

5.3.1. Parameters:

The following conditions are offered for guidance, other conditions may be used provided that they give equivalent results.

Analytical column
(4.3.1)

Mobile Phase (3.4): water (3.3)-methanol (3.2) mixture, 900 + 100 (V + V)

Flow rate: 1,5-2 ml/min.

Detection wavelength: 380 nm

Injection volume: 20 µl –100 µl

Check the stability of the chromatographic system, injecting several times the calibration solution (3.5.3) containing 2,5 µg/ml, until constant peak heights and retention times are achieved.

5.3.2. Calibration graph

Inject each calibration solution (3.5.3) several times and determine the mean peak heights (areas) for each concentration. Plot a calibration graph using the mean peak heights (areas) of the calibration solutions as the ordinates and the corresponding concentrations in µg/ml as the abscissae.

5.3.3. Sample solution

Inject the sample extract (5.2) several times using the same volume as taken for the calibration solutions and determine the mean peak height (area) of the olaquinox peaks.

6. Calculation of the results

From the mean height (area) of the olaquinox peaks of the sample solution determine the concentration of the sample solution in µg/ml by reference to the calibration graph (5.3.2).

The olaquinox content w in mg/kg of the sample is given by the following formula:

$$w = \frac{c \times 1000}{m}$$

in which:

c = olaquinox concentration of the sample extract (5.2) in µg/ml

m = weight of the test portion in g (5.2).

7. Validation of the results

7.1. Identity

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract (5.2) and the calibration solution (3.5.3) containing 5,0 µg/ml are compared.

7.1.1. Co-chromatography

A sample extract (5.2) is fortified by addition of an appropriate amount of calibration solution (3.5.3). The amount of added olaquinox must be similar to the amount of olaquinox found in the sample extract.

Only the height of the olaquinox peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its height, must be within $\pm 10\%$ of the original width of the olaquinox peak of the unfortified sample extract.

7.1.2. Diode array detection

The results are evaluated according to the following criteria:

- (a) The wavelength of maximum absorption of the sample and of the standard spectra, recorded at the peak apex on the chromatogram, must be the same within a margin determined by the resolving power of the detection system. For diode-array detection this is typically within ± 2 nm.
- (b) Between 220 and 400 nm, the sample and standard spectra recorded at the peak apex of the chromatogram, must not be different for those parts of the spectrum within the range 10 %-100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte.
- (c) Between 220 and 400 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 %-100 % of relative absorbance. This criterion is met when the same maxima are present and when at all observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the peak apex.

If one of these criteria is not met the presence of the analyte has not been confirmed.

7.2. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed 15 % relative to the higher result for olaquinox contents between 10 and 200 mg/kg.

7.3. Recovery

For a fortified blank sample the recovery shall be at least 90 %.

8. Results of a collaborative study

An EC collaborative study was arranged in which four piglet feed samples including one blank feed were analysed by up to 13 laboratories. The results are given below:

	Sample 1	Sample 2	Sample 3	Sample 4
L	13	10	11	11
n	40	40	44	44
mean [mg/kg]	—	14,6	48,0	95,4
S _r [mg/kg]	—	0,82	2,05	6,36
S _R [mg/kg]	—	1,62	4,28	8,42
CV _r [%]	—	5,6	4,3	6,7
CV _R [%]	—	11,1	8,9	8,8
Nominal content [mg/kg]	—	15	50	100
recovery %	—	97,3	96,0	95,4

L = number of laboratories

n = number of single values

S_r = standard deviation of repeatability

S_R = standard deviation of reproducibility

CV_r = coefficient of variation of repeatability

CV_R = coefficient of variation of reproducibility.

9. Observation

Although the method has not been validated for feeds containing more than 100 mg/kg of olaquinox, it may be possible to obtain satisfactory results by taking a smaller sample weight and/or diluting the extract (5.2) to reach a concentration within the range of the calibration graph (5.3.2).

C. DETERMINATION OF AMPROLIUM

1-[(4-amino-2-propylpyrimidin-5-yl)methyl]-2-methyl-pyridinium chloride hydrochloride

1. Purpose and Scope

This method makes it possible to determine the level of amprolium in feed and premixtures. The detection limit is 1 mg/kg, the limit of quantification is 5 mg/kg.

2. Principle

The sample is extracted with a methanol-water mixture. After dilution with the mobile phase and membrane filtration the content of amprolium is determined by cation exchange high performance liquid chromatography (HPLC) using a UV detector.

3. Reagents

3.1. Methanol.

3.2. Acetonitrile, equivalent to HPLC grade.

3.3. Water, equivalent to HPLC grade.

3.4. Sodium dihydrogen phosphate solution, c = 0,1 mol/l.

Dissolve 13,80 g of sodium dihydrogen phosphate monohydrate in water (3.3) in a 1 000 ml graduated flask, make up to the mark with water (3.3) and mix.

- 3.5. Sodium perchlorate solution, $c = 1,6 \text{ mol/l}$.
- Dissolve 224,74 g of sodium perchlorate monohydrate in water (3.3) in a 1 000 ml graduated flask, make up to the mark with water (3.3) and mix.
- 3.6. Mobile phase for HPLC (see observation 9.1).
- Mixture of acetonitrile (3.2), sodium dihydrogen phosphate solution (3.4) and sodium perchlorate solution (3.5), 450+450+100 (v+v+v). Prior to use filter through a 0,22 μm membrane filter (4.3) and degas the solution (e.g. in the ultrasonic bath (4.4) for at least 15 minutes).
- 3.7. Standard substance: pure amprolium, 1-[(4-amino-2-propylpyrimidin-5-yl)methyl]-2-methyl-pyridinium chloride hydrochloride, E 750 (see 9.2).
- 3.7.1. Amprolium stock standard solution, 500 $\mu\text{g/ml}$
- Weigh to the nearest 0,1 mg, 50 mg of amprolium (3.7) in a 100 ml graduated flask, dissolve in 80 ml methanol (3.1) and place the flask for 10 min. in an ultrasonic bath (4.4). After ultrasonic treatment bring the solution to room temperature, make up to the mark with water and mix. At a temperature of $\leq 4 \text{ }^\circ\text{C}$ the solution is stable for 1 month.
- 3.7.2. Amprolium intermediate standard solution, 50 $\mu\text{g/ml}$
- Pipette 5,0 ml of the stock standard solution (3.7.1) into a 50 ml graduated flask, make up to the mark with the extraction solvent (3.8) and mix. At a temperature of $\leq 4 \text{ }^\circ\text{C}$ the solution is stable for 1 month.
- 3.7.3. Calibration solutions
- Transfer 0,5, 1,0 and 2,0 ml of the intermediate standard solution (3.7.2) into a series of 50 ml graduated flasks. Make up to the mark with the mobile phase (3.6) and mix. These solutions correspond to 0,5, 1,0 and 2,0 μg of amprolium per ml respectively. These solutions must be prepared freshly before use.
- 3.8. Extraction solvent.
- Methanol (3.1)-water mixture 2+1 (v+v).
4. **Apparatus**
- 4.1. HPLC equipment with injection system, suitable for injection volumes of 100 μl .
- 4.1.1. Liquid chromatographic column 125 mm \times 4 mm, cation exchange Nucleosil 10 SA, 5 or 10 μm packing, or equivalent.
- 4.1.2. UV detector with variable wavelength adjustment or diode array detector.
- 4.2. Membrane filter, PTFE material, 0,45 μm .
- 4.3. Membrane filter, 0,22 μm .
- 4.4. Ultrasonic bath.
- 4.5. Mechanical shaker or magnetic stirrer.
5. **Procedure**
- 5.1. *General*
- 5.1.1. Blank feed

For the performance of the recovery test (5.1.2) a blank feed shall be analysed to check that neither amprolium nor interfering substances are present. The blank feed shall be similar in type to that of the sample and amprolium or interfering substances must not be detected.

5.1.2. Recovery test

A recovery test shall be carried out by analysing the blank feed which has been fortified by addition of a quantity of amprolium, similar to that present in the sample. To fortify at a level of 100 mg/kg, transfer 10,0 ml of the stock standard solution (3.7.1) to a 250 ml conical flask and evaporate the solution to approximately 0,5 ml. Add 50 g of the blank feed, mix thoroughly and leave for 10 min. mixing again several times before proceeding with the extraction step (5.2).

Alternatively, if a blank feed similar in type to that of the sample is not available (see 5.1.1), a recovery test can be performed by means of the standard addition method. In this case, the sample to be analysed is fortified with a quantity of amprolium similar to that already present in the sample. This sample is analysed together with the unfortified sample and the recovery can be calculated by subtraction.

5.2. Extraction

5.2.1. Premixtures (content < 1 % amprolium) and feed

Weigh to the nearest 0,01 g, 5-40 g of the sample depending on the amprolium content into a 500 ml conical flask and add 200 ml extraction solvent (3.8). Place the flask in the ultrasonic bath (4.4) and leave for 15 minutes. Remove the flask from the ultrasonic bath and shake it for 1 h on the shaker or stir on the magnetic stirrer (4.5). Dilute an aliquot of the extract with the mobile phase (3.6) to an amprolium content of 0,5-2 µg/ml and mix (see observation 9.3). Filter 5-10 ml of this diluted solution on a membrane filter (4.2). Proceed to the HPLC determination (5.3).

5.2.2. Premixtures (content ≥ 1 % amprolium)

Weigh to the nearest 0,001 g, 1-4 g of the premixture depending on the amprolium content into a 500 ml conical flask and add 200 ml extraction solvent (3.8). Place the flask in the ultrasonic bath (4.4) and leave for 15 minutes. Remove the flask from the ultrasonic bath and shake it for 1 h on the shaker or stir on the magnetic stirrer (4.5). Dilute an aliquot of the extract with the mobile phase (3.6) to an amprolium content of 0,5-2 µg/ml and mix. Filter 5-10 ml of this diluted solution on a membrane filter (4.2). Proceed to the HPLC determination (5.3).

5.3. HPLC determination

5.3.1. Parameters:

The following conditions are offered for guidance, other conditions may be used provided that they give equivalent results.

Liquid chromatographic

column (4.1.1):	125 mm × 4 mm, cation exchange Nucleosil 10 SA, 5 or 10 µm packing, or equivalent
Mobile phase (3.6):	Mixture of acetonitrile (3.2), sodium dihydrogen phosphate solution (3.4) and sodium perchlorate solution (3.5), 450+450+100 (v+v+v).
Flow rate:	0,7-1 ml/min
Detection wavelength:	264 nm
Injection volume:	100 µl

Check the stability of the chromatographic system, injecting several times the calibration solution (3.7.3) containing 1,0 µg/ml, until constant peak heights and retention times are achieved.

5.3.2. Calibration graph

Inject each calibration solution (3.7.3) several times and determine the mean peak heights (areas) for each concentration. Plot a calibration graph using the mean peak heights (areas) of the calibration solutions as the ordinates and the corresponding concentrations in µg/ml as the abscissae.

5.3.3. Sample solution

Inject the sample extract (5.2) several times using the same volume as taken for the calibration solutions and determine the mean peak height (area) of the amprolium peaks.

6. Calculation of the results

From the mean height (area) of the amprolium peaks of the sample solution determine the concentration of the sample solution in µg/ml by reference to the calibration graph (5.3.2).

The amprolium content w in mg/kg of the sample is given by the following formula:

$$w = \frac{V \times c \times f}{m} \text{ [mg/kg]}$$

in which:

V = volume of the extraction solvent (3.8) in ml according to 5.2 (i.e. 200 ml)

c = amprolium concentration of the sample extract (5.2) in $\mu\text{g/ml}$

f = dilution factor according to 5.2

m = weight of the test portion in g.

7. Validation of the results

7.1. Identity

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract (5.2) and the calibration solution (3.7.3) containing 2,0 $\mu\text{g/ml}$ are compared.

7.1.1. Co-chromatography

A sample extract (5.2) is fortified by addition of an appropriate amount of calibration solution (3.7.3). The amount of added amprolium must be similar to the amount of amprolium found in the sample extract.

Only the height of the amprolium peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its height, must be within $\pm 10\%$ of the original width of the amprolium peak of the unfortified sample extract.

7.1.2. Diode array detection

The results are evaluated according to the following criteria:

- (a) The wavelength of maximum absorption of the sample and of the standard spectra, recorded at the peak apex on the chromatogram, must be the same within a margin determined by the resolving power of the detection system. For diode-array detection this is typically within ± 2 nm.
- (b) Between 210 and 320 nm, the sample and standard spectra recorded at the peak apex of the chromatogram, must not be different for those parts of the spectrum within the range 10 %-100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte.
- (c) Between 210 and 320 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 %-100 % of relative absorbance. This criterion is met when the same maxima are present and when at all observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the peak apex.

If one of these criteria is not met, the presence of the analyte has not been confirmed.

7.2. Repeatability

The difference between the results of two parallel determinations carried out on the same sample must not exceed:

- 15 % relative to the higher value for amprolium contents from 25 mg/kg to 500 mg/kg,
- 75 mg/kg for amprolium contents between 500 mg/kg and 1 000 mg/kg,
- 7,5 % relative to the higher value for amprolium contents of more than 1 000 mg/kg.

7.3. Recovery

For a fortified (blank) sample the recovery shall be at least 90 %.

8. Results of a collaborative study

A collaborative study was arranged in which three poultry feeds (sample 1-3), one mineral feed (sample 4) and one premix (sample 5) were analysed. The results are given in the following table:

	Sample 1 (blank feed)	Sample 2	Sample 3	Sample 4	Sample 5
L	14	14	14	14	15
n	56	56	56	56	60
mean [mg/kg]	—	45,5	188	5 129	25 140
s _r [mg/kg]	—	2,26	3,57	178	550
CV _r [%]	—	4,95	1,90	3,46	2,20
s _R [mg/kg]	—	2,95	11,8	266	760
CV _R [%]	—	6,47	6,27	5,19	3,00
nominal content [mg/kg]	—	50	200	5 000	25 000

L = number of laboratories

n = number of single values

s_r = standard deviation of repeatability

CV_r = coefficient of variation of repeatability

s_R = standard deviation of reproducibility

CV_R = coefficient of variation of reproducibility.

9. Observations

- 9.1. If the sample contains thiamine, the thiamine peak in the chromatogram appears shortly before the amprolium peak. Following this method amprolium and thiamine must be separated. If the amprolium and thiamine are not separated by the column (4.1.1) used in this method, replace up to 50 % of the acetonitrile portion of the mobile phase (3.6) by methanol.
- 9.2. According to the British Pharmacopoeia, the spectrum of an amprolium solution (c = 0,02 mol/l) in hydrochloric acid (c = 0,1 mol/l) shows maxima at 246 nm and 262 nm. The absorbance shall amount to 0,84 at 246 nm and 0,80 at 262 nm.
- 9.3. The extract must always be diluted with the mobile phase, because otherwise the retention time of the amprolium peak may shift significantly, due to changes in the ionic strength.

D. DETERMINATION OF CARBADOX

Methyl 3-(2-quinoxalinylmethylene)carbazate N¹,N⁴-dioxide

1. Purpose and scope

This method makes it possible to determine the level of carbadox in feed, premixtures and preparations. The detection limit is 1 mg/kg. The limit of quantification is 5 mg/kg.

2. Principle

The sample is equilibrated with water and extracted with methanol-acetonitrile. For feed, an aliquot portion of the filtered extract is subjected to clean-up on an aluminium oxide column. For premixtures and preparations an aliquot portion of the filtered extract is diluted to an appropriate concentration with water, methanol and acetonitrile. The content of carbadox is determined by reversed-phase high-performance liquid chromatography (HPLC) using a UV detector.

3. Reagents

- 3.1. Methanol.
- 3.2. Acetonitrile, equivalent to HPLC grade.

- 3.3. Acetic acid, w = 100 %.
- 3.4. Aluminium oxide: neutral, activity grade I.
- 3.5. Methanol-acetonitrile 1 + 1 (v + v).
Mix 500 ml of methanol (3.1) with 500 ml of acetonitrile (3.2).
- 3.6. Acetic acid, σ = 10 %.
Dilute 10 ml acetic acid (3.3) to 100 ml with water.
- 3.7. Sodium acetate.
- 3.8. Water, equivalent to HPLC grade.
- 3.9. Acetate buffer solution, c = 0,01 mol/l, pH = 6,0.
Dissolve 0,82 g of sodium acetate (3.7) in 700 ml of water (3.8) and adjust the pH to 6,0 with acetic acid (3.6). Transfer to a 1 000 ml graduated flask, make up to the mark with water (3.8) and mix.
- 3.10. Mobile phase for HPLC.
Mix 825 ml of acetate buffer solution (3.9) with 175 ml of acetonitrile (3.2).
Filter through a 0,22 μ m filter (4.5) and degas the solution (e.g. by ultrasonification for 10 minutes).
- 3.11. Standard substance.
Pure carbadox: Methyl 3-(2-quinoxalinylmethylene)carbazate N¹,N⁴-dioxide, E 850.
- 3.11.1. Carbadox stock standard solution, 100 μ g/ml (see *Note 5. Procedure*):
Weigh to the nearest 0,1 mg, 25 mg of carbadox standard substance (3.11) into a 250 ml graduated flask. Dissolve in methanol-acetonitrile (3.5) by ultrasonification (4.7). After ultrasonic treatment bring the solution to room temperature, make up to the mark with methanol-acetonitrile (3.5) and mix. Wrap the flask with aluminium foil or use amber glassware and store in a refrigerator. At a temperature of ≤ 4 °C the solution is stable for 1 month.
- 3.11.2. Calibration solutions
Transfer 2,0, 5,0, 10,0, and 20,0 ml of the stock standard solution (3.11.1) into a series of 100 ml calibrated flasks. Add 30 ml of water, make up to the mark with methanol-acetonitrile (3.5) and mix. Wrap the flasks with aluminium foil. These solutions correspond to 2,0, 5,0, 10,0 and 20,0 μ g/ml of carbadox respectively.
Calibration solutions must be freshly prepared before use.
Note: For the determination of carbadox in feed containing less than 10 mg/kg, calibration solutions with a concentration below 2,0 μ g/ml must be prepared.
- 3.12. Water-[methanol-acetonitrile] (3.5) mixture, 300 + 700 (v + v).
Mix 300 ml of water with 700 ml of the mixture of methanol-acetonitrile (3.5).
4. **Apparatus**
- 4.1. Laboratory shaker or magnetic stirrer.
- 4.2. Glass fibre filter paper (Whatman GF/A or equivalent).

- 4.3. Glass column (length 300 to 400 mm, internal diameter approximately 10 mm) with sintered glass frit and draw-off valve.

Note: a glass column fitted with a stopcock or a glass column with a tapered end may also be used; in this case, a small glass-wool plug is inserted into the lower end and it is tamped down using a glass rod.

- 4.4. HPLC equipment with injection system, suitable for injection volumes of 20 µl.

- 4.4.1. Liquid chromatographic column: 300 mm x 4 mm, C₁₈, 10 µm packing or equivalent.

- 4.4.2. UV detector with variable wavelength adjustment or diode array detector operating in the range of 225 to 400 nm.

- 4.5. Membrane filter, 0,22 µm.

- 4.6. Membrane filter, 0,45 µm.

- 4.7. Ultrasonic bath.

5. Procedure

Note: Carbadox is light-sensitive. Carry out all procedures under subdued light or use amber glassware or glassware wrapped in aluminium foil.

5.1. General

5.1.1. Blank feed

For the performance of the recovery test (5.1.2) a blank feed shall be analysed to check that neither carbadox nor interfering substances are present. The blank feed shall be similar in type to that of the sample and on analysis carbadox or interfering substances must not be detected.

5.1.2. Recovery test

A recovery test shall be carried out by analysing the blank feed (5.1.1) which has been fortified by the addition of a quantity of carbadox, similar to that present in the sample. To fortify at a level of 50 mg/kg, transfer 5,0 ml of the stock standard solution (3.11.1) to a 200 ml conical flask. Evaporate the solution to approximately 0,5 ml in a stream of nitrogen. Add 10 g of the blank feed, mix and wait for 10 minutes before proceeding with the extraction step (5.2).

Alternatively, if a blank feed similar in type to that of the sample is not available (see 5.1.1), a recovery test can be performed by means of the standard addition method. In this case, the sample is fortified with a quantity of carbadox, similar to that already present in the sample. This sample is analysed, together with the unfortified sample and the recovery can be calculated by subtraction.

5.2. Extraction

5.2.1. Feed

Weigh to the nearest 0,01 g, 10 g of the sample and transfer to a 200 ml conical flask. Add 15,0 ml of water, mix, and equilibrate for 5 min. Add 35,0 ml of methanol-acetonitrile (3.5), stopper and shake for 30 min. on the shaker or stir on the magnetic stirrer (4.1). Filter the solution through a glass fibre filter paper (4.2). Retain this solution for the purification step (5.3).

5.2.2. Premixtures (0,1 %-2,0 %)

Weigh to the nearest 0,001 g, 1 g of the unground sample and transfer to a 200 ml conical flask. Add 15,0 ml of water, mix, and equilibrate for 5 min. Add 35,0 ml of methanol-acetonitrile (3.5), stopper and shake for 30 min. on the shaker or stir on the magnetic stirrer (4.1). Filter the solution through a glass fibre filter paper (4.2).

Pipet an aliquot of filtrate into a 50 ml calibrated flask. Add 15,0 ml of water, make up to the mark with methanol-acetonitrile (3.5) and mix. The carbadox concentration of the final solution shall be approximately 10 µg/ml. An aliquot is filtered through a 0,45 µm filter (4.6).

Proceed to the HPLC determination (5.4).

5.2.3. Preparations (> 2 %)

Weigh to the nearest 0,001 g, 0,2 g of the unground sample and transfer to a 250 ml conical flask. Add 45,0 ml of water, mix, and equilibrate for 5 min. Add 105,0 ml of methanol-acetonitrile (3.5), stopper and homogenise. Sonicate (4.7) the sample for 15 min. followed by shaking or stirring for 15 min. (4.1). Filter the solution through a glass fibre filter paper (4.2).

Dilute an aliquot of filtrate with the mixture of water-methanol-acetonitrile (3.12) to a final carbadox concentration of 10-15 µg/ml (for a 10 % preparation, the dilution factor is 10). An aliquot is filtered through a 0,45 µm filter (4.6).

Proceed to the HPLC determination (5.4).

5.3. Purification

5.3.1. Preparation of the aluminium oxide column

Weigh 4 g of aluminium oxide (3.4) and transfer it to the glass column (4.3).

5.3.2. Sample purification

Apply 15 ml of the filtered extract (5.2.1) to the aluminium oxide column and discard the first 2 ml of eluate. Collect the next 5 ml and filter an aliquot through a 0,45 µm filter (4.6).

Proceed to the HPLC determination (5.4).

5.4. HPLC determination

5.4.1. Parameters

The following conditions are offered for guidance, other conditions may be used provided they yield equivalent results:

Liquid chromatographic

column (4.4.1): 300 mm × 4 mm, C₁₈, 10 µmpacking or equivalent

Mobile phase (3.10): Mixture of acetate buffer solution (3.9) and acetonitrile (3.2), 825 + 175 (v+v)

Flow rate: 1,5-2 ml/min.

Detection wavelength: 365 nm

Injection volume: 20 µl

Check the stability of the chromatographic system, injecting the calibration solution (3.11.2) containing 5,0 µg/ml several times, until constant peak heights (areas) and retention times are achieved.

5.4.2. Calibration graph

Inject each calibration solution (3.11.2) several times and measure the peak heights (areas) for each concentration. Plot a calibration curve using the mean peak heights or areas of the calibration solutions as the ordinates and corresponding concentrations in µg/ml as the abscissae.

5.4.3. Sample solution

Inject the sample extract [(5.3.2) for feed, (5.2.2) for premixtures and (5.2.3) for preparations] several times and determine the mean peak height (area) of the carbadox peaks.

6. Calculation of the results

From the mean height (area) of the carbadox peaks of the sample solution determine the carbadox concentration of the sample solution in µg/ml by reference to the calibration graph (5.4.2).

6.1. *Feed*

The content of carbadox w (mg/kg) in the sample is given by the following formula:

$$w = \frac{c \times V_1}{m} \text{ [mg/kg]}$$

in which:

c = carbadox concentration of the sample extract (5.3.2) in µg/ml

V₁ = extraction volume in ml (i.e. 50)

m = weight of the test portion in g.

6.2. *Premixtures and preparations*

The content of carbadox w (mg/kg) in the sample is given by the following formula:

$$w = \frac{c \times V_2 \times f}{m} \text{ [mg/kg]}$$

in which:

c = carbadox concentration of the sample extract (5.2.2 or 5.2.3) in µg/ml

V₂ = extraction volume in ml (i.e. 50 for premixtures; 150 for preparations)

f = dilution factor according to 5.2.2 (premixtures) or 5.2.3 (preparations)

m = weight of the test portion in g.

7. **Validation of the results**7.1. *Identity*

The identity of the analyte can be confirmed by co-chromatography, or by using a diode-array detector by which the spectra of the sample extract and the calibration solution (3.11.2) containing 10,0 µg/ml are compared.

7.1.1. *Co-chromatography*

A sample extract is fortified by addition of an appropriate amount of calibration solution (3.11.2). The amount of added carbadox must be similar to the estimated amount of carbadox found in the sample extract.

Only the height of the carbadox peak shall be enhanced after taking into account both the amount added and the dilution of the extract. The peak width, at half of its maximum height, must be within approximately 10 % of the original width.

7.1.2. *Diode-array detection*

The results are evaluated according to the following criteria:

- (a) the wavelength of maximum absorption of the sample and of the standard spectra, recorded at the peak apex on the chromatogram, must be the same within a margin determined by the resolving power of the detection system. For diode-array detection, this is typically within + 2 nm;
- (b) between 225 and 400 nm, the sample and standard spectra recorded at the peak apex on the chromatogram, must not be different for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and at no observed point the deviation between the two spectra exceeds 15 % of the absorbance of the standard analyte;
- (c) between 225 and 400 nm, the spectra of the upslope, apex and downslope of the peak produced by the sample extract must not be different from each other for those parts of the spectrum within the range 10 % to 100 % of relative absorbance. This criterion is met when the same maxima are present and when at all observed points the deviation between the spectra does not exceed 15 % of the absorbance of the spectrum of the apex.

If one of these criteria is not met the presence of the analyte has not been confirmed.

7.2. *Repeatability*

For contents of 10 mg/kg and higher, the difference between the results of two parallel determinations carried out on the same sample must not exceed 15 % relative to the higher result.

7.3. *Recovery*

For a fortified (blank) sample the recovery shall be at least 90 %.

8. **Results of a collaborative study**

A collaborative study was arranged in which 6 feed, 4 premixtures and 3 preparations were analysed by 8 laboratories. Duplicate analyses were performed on each sample. (More detailed information on this collaborative study can be found in the *Journal of the AOAC, Volume 71, 1988, p. 484-490*). The results (excluding outliers) are shown below:

Table 1

Results of the collaborative study for feed

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
L	8	8	8	8	8	8
n	15	14	15	15	15	15
Mean (mg/kg)	50,0	47,6	48,2	49,7	46,9	49,7
Sr (mg/kg)	2,90	2,69	1,38	1,55	1,52	2,12
CVr (%)	5,8	5,6	2,9	3,1	3,2	4,3
SR (mg/kg)	3,92	4,13	2,23	2,58	2,26	2,44
CVR (%)	7,8	8,7	4,6	5,2	4,8	4,9
Nominal content (mg/kg)	50,0	50,0	50,0	50,0	50,0	50,0

Table 2

Results of the collaborative study for premixtures and preparations

	Premixtures				Preparations		
	A	B	C	D	A	B	C
L	7	7	7	7	8	8	8
n	14	14	14	14	16	16	16
Mean (g/kg)	8,89	9,29	9,21	8,76	94,6	98,1	104
Sr (g/kg)	0,37	0,28	0,28	0,44	4,1	5,1	7,7
CVr (%)	4,2	3,0	3,0	5,0	4,3	5,2	7,4
SR (g/kg)	0,37	0,28	0,40	0,55	5,4	6,4	7,7
CVR (%)	4,2	3,0	4,3	6,3	5,7	6,5	7,4
Nominal content (g/kg)	10,0	10,0	10,0	10,0	100	100	100

L = number of laboratories
n = number of single values
Sr = standard deviation of repeatability
CVr = coefficient of variation of repeatability
SR = standard deviation of reproducibility
CVR = coefficient of variation of reproducibility.

ANNEX IX

CORRELATION TABLES REFERRED TO IN ARTICLE 6

1. Directive 71/250/EEC

Directive 71/250/EEC	This Regulation
Article 1 first subparagraph	Article 3
Article 1 second subparagraph	Article 2
Article 2	—
Article 3	—
Annex, part 1	Annex II
Annex, part 2	—
Annex, part 3	—
Annex, part 4	Annex III, part O
Annex, part 5	Annex III, part M
Annex, part 6	Annex III, part N
Annex, part 7	Annex III, part Q
Annex, part 9	Annex III, part K
Annex, part 10	—
Annex, part 11	—
Annex, part 12	Annex III, part J
Annex, part 14	Annex III, part D
Annex, part 16	—

2. Directive 71/393/EEC

Directive 71/393/EEC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Annex, part I	Annex III, part A
Annex, part II	Annex III, part E
Annex, part III	Annex III, part P
Annex, part IV	Annex III, part H

3. Directive 72/199/EEC

Directive 72/199/EEC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Article 4	—
Annex I, part 1	Annex III, part L
Annex I, part 2	Annex III, part C
Annex I, part 3	—
Annex I, part 4	—
Annex I, part 5	Annex V, part A
Annex II	—

4. **Directive 73/46/EEC**

Directive 73/46/EEC	This Regulation
Article 1	Article 3
Article 3	—
Article 4	—
Annex I, part 1	Annex III, part B
Annex I, part 2	—
Annex I, part 3	Annex III, part I

5. **Directive 76/371/EEC**

Directive 76/371/EEC	This Regulation
Article 1	Article 1
Article 2	—
Article 3	—
Annex	Annex I

6. **Directive 76/372/EEC**

Directive 76/372/EEC	This Regulation
Article 1	—
Article 2	—
Article 3	—
Annex	—

7. **Directive 78/633/EEC**

Directive 78/633/EEC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Annex, part 1	—
Annex, part 2	—
Annex, part 3	Annex IV, part C

8. **Directive 81/715/EEC**

Directive 81/715/EEC	This Regulation
Article 1	—
Article 2	—
Article 3	—
Annex	—

9. **Directive 84/425/EEC**

Directive 84/425/EEC	This Regulation
Article 1	—
Article 2	—
Article 3	—
Annex	—

10. **Directive 86/174/EEC**

Directive 86/174/EEC	This Regulation
Article 1	Article 4
Article 2	—
Article 3	—
Annex	Annex VII

11. **Directive 93/70/EEC**

Directive 93/70/EEC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Annex	Annex IV, part D

12. **Directive 93/117/EC**

Directive 93/117/EC	This Regulation
Article 1	Articles 3 and 5
Article 2	—
Article 3	—
Annex, part 1	Annex IV, part E
Annex, part 2	Annex VIII, part A

13. **Directive 98/64/EC**

Directive 98/64/EC	This Regulation
Article 1	Articles 3 and 5
Article 2	—
Article 3	—
Article 4	—
Annex, part A	Annex III, part F
Annex, part C	Annex VIII, part B

14. **Directive 1999/27/EC**

Directive 1999/27/EC	This Regulation
Article 1	Articles 3 and 5
Article 2	—
Article 3	—
Article 4	—
Article 5	—
Article 6	—
Article 7	—
Annex, part A	Annex VIII, part C
Annex, part B	Annex IV, part F
Annex, part C	Annex VIII, part D

15. **Directive 1999/76/EC**

Directive 1999/76/EC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Article 4	—
Annex	Annex IV, part G

16. **Directive 2000/45/EC**

Directive 2000/45/EC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Article 4	—
Annex, part A	Annex IV, part A
Annex, part B	Annex IV, part B
Annex, part C	Annex III, part G

17. **Directive 2002/70/EC**

Directive 2002/70/EC	This Regulation
Article 1	Article 1
Article 2	Articles 2 and 3
Article 3	—
Article 4	—
Article 5	—
Annex I	Annex I and Annex V part B(I)
Annex II	Annex II and Annex V part B(II)

18. Directive 2003/126/EC

Directive 2003/126/EC	This Regulation
Article 1	Article 3
Article 2	—
Article 3	—
Article 4	—
Article 5	—
Article 6	—
Annex	Annex VI