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Microbiology of food and animal feeding stuffs — Guidelines for the estimation of measurement uncertainty for quantitative determinations

AMENDMENT 1: Measurement uncertainty for low counts

Microbiologie des aliments — Lignes directrices pour l'estimation de l'incertitude de mesure pour les déterminations quantitatives

AMENDEMENT 1: Incertitude de mesure sur les faibles taux

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Amendment 1 to ISO/TS 19036:2006 was prepared by Technical Committee ISO/TC 34, *Food products*, Subcommittee SC 9, *Microbiology*.

Microbiology of food and animal feeding stuffs — Guidelines for the estimation of measurement uncertainty for quantitative determinations

AMENDMENT 1: Measurement uncertainty for low counts

Page 1, Clause 1, paragraphs 3 and 4

Delete paragraphs 3 and 4 and insert,

“This Technical Specification is not applicable to enumeration using a most probable number technique.

In this Technical Specification, MU is estimated using a simplified approach taking into account the Poisson distribution and is then applicable to any result, including “low” counts and/or “low” numbers of organisms.”

Page 4, 4.1, paragraph 2

Delete “(4.2).” and insert “(4.2), combined with a component due to Poisson distribution.”

Page 4, 4.3

Delete “$= 2s_R$” from the equation.

Page 5, 5.2.1, paragraph 4, sentence 1

Delete “given that low levels are not considered here” and insert “provided that results based on low counts are not used in the calculations (see 5.3)”.

Page 7, 5.3

Add at the beginning of the subclause:

“Experiments should be performed to ensure that sufficiently large numbers of counted colonies can be used for the calculations. Enumeration results based on less than 10 counted colonies should be excluded. Enumerations results with 10 to 30 counted colonies may be included only if the standard deviation of reproducibility, s_R, that is being estimated is expected to be higher than 0,2 $\log_{10}$ (cfu/g) or 0,2 $\log_{10}$ (cfu/ml).

NOTE 1 This limit of 10 (or 30) colonies applies to the sum of the total numbers of counted colonies on all plates, ΣC.

NOTE 2 This limit only relates to the specific case of this experimental protocol for the intralaboratory standard deviation of reproducibility (i.e. experiments aiming specifically to assess the uncertainty) and not the use of this standard deviation to assess the measurement uncertainty for new samples (see Clause 8).”

Page 10

After Clause 7, insert a new Clause 8,

"8 Calculation of expanded uncertainty

8.1 Introduction

It is assumed that the number of colony-forming units in Petri dishes follows a Poisson distribution. This random error is taken into account in the estimation of the expanded uncertainty described in 8.2.

NOTE The calculations described for the estimation of the intralaboratory standard deviation of reproducibility (see 5.3) neglect the random error due to Poisson distribution, which means that they should exclude enumeration results based on low numbers of counted colonies.

8.2 Calculation

8.2.1 General case

Denoting the test result $y = \log_{10} x$, then the expanded uncertainty, U, with a coverage factor of 2 (corresponding approximately to a confidence level of 95 %) can be calculated using Equation (1):

$$U = 2\sqrt{s_R^2 + \frac{0{,}188\,61}{\sum C}} \qquad (1)$$

where

s_R is the standard deviation of reproducibility;

$0{,}188\,61/\Sigma C$ is the variance component due to the Poisson distribution, in which ΣC is the sum of the total numbers of colonies counted on all plates.

NOTE The numerator is derived by using a theoretical property of the Poisson distribution (equality of the expectation and the variance, which immediately leads to an estimated Poisson component coefficient of variation, CV = $1/\sqrt{\Sigma C}$), and the approximation that the Poisson variance component on a logarithmic scale is approximately equal to the coefficient of variation squared, $(\mathrm{CV})^2$, when a natural logarithmic scale is used, and therefore to $(\log_{10} e)^2 = 0{,}188\,61 \times (\mathrm{CV})^2$ when a decimal logarithmic scale is used.

Measurement uncertainty according to Equation (1) depends both on the reproducibility standard deviation estimated from an experiment with high counts, s_R, and on the total plate count for the sample under investigation, ΣC. It is recommended, for the sake of simplicity, to use Equation (1) wherever possible.

8.2.2 Differentiation between low and high counts (optional)

For high counts, the second term under the square root, the Poisson term depending on ΣC, can be ignored and Equation (1) simplifies to:

$$U = 2 s_R \qquad (2)$$

Given the limit value, $C_{\lim}$:

$$C_{\lim} = \frac{(\log_{10} e)^2}{s_R^2 \times \left((1 - 0{,}05)^{-2} - 1\right)} \approx \frac{1{,}75}{s_R^2} \qquad (3)$$

For all cases where $\Sigma C > C_{\lim}$, the difference between U calculated by Equations (1) and (2) is negligible (< 5 %).

Once s_R has been estimated, C_{lim} can be either calculated from Equation (3) or taken from Table B.1.

Two cases can be differentiated:

if $\sum C > C_{lim}$ use Equation (2) to derive U;

if $\sum C \leqslant C_{lim}$ use Equation (1) to derive U.

NOTE Calculation of C_{lim} is not necessary when Equation (1) is used in all cases."

Page 10

Delete Clause 8, and insert,

"9 Expression of measurement uncertainty in the test reports

Once the measurement uncertainty has been derived as explained in Clause 8, it may be expressed in the report, together with the test result, as an interval on the decimal logarithmic scale (see Note to 5.3) or as natural values (cfu per gram or cfu per millilitre), or as a percentage, as illustrated by the following possibilities.

The test result can be reported according to one of the following possibilities:

a) interval for log result:

$y \pm U$ [log$_{10}$ (cfu/g)] or

$y \pm U$ [log$_{10}$ (cfu/ml)];

b) decimal logarithmic result estimate with limits:

y [log$_{10}$ (cfu/g)] $[y - U, y + U]$ or

y [log$_{10}$ (cfu/ml)] $[y - U, y + U]$;

c) result estimate with absolute limits:

x cfu/g $[10^{y-U}, 10^{y+U}]$ or

x cfu/ml $[10^{y-U}, 10^{y+U}]$;

d) result estimate with relative limits:

x cfu/g $[-(1 - 10^{-U}) \times 100\ \%, +(-1 + 10^{U}) \times 100\ \%]$ or

x cfu/ml $[-(1 - 10^{-U}) \times 100\ \%, +(-1 + 10^{U}) \times 100\ \%]$.

NOTE 1 Relative limits depend only on U. Examples of relative limits are found in Table B.1.

NOTE 2 While x has either cfu/g or cfu/ml as a unit, as a logarithm, y is, like pH, dimensionless, and has none. To remind users of the unit of the raw data and the type of logarithm used, log$_{10}$ (cfu/g) or log$_{10}$ (cfu/ml) can be added in brackets after the numerical result.

EXAMPLE 1

The standard deviation of reproducibility, s_R, is 0,15 [log$_{10}$ (cfu/g)].

The test result is 100 000 cfu/g, i.e. $y = 5{,}00$ [$\log_{10}$ (cfu/g)], with $\Sigma C = 110$ (dilution −3: 102 colonies; dilution −4: 8 colonies).

Thus the expanded uncertainty, U, with a coverage factor of 2 (95 % confidence level) is, using Equation (1):

$$U = 2\sqrt{0{,}15^2 + \frac{0{,}188\,61}{110}} = 0{,}31$$

The test result may be reported according to one of the following possibilities:

5,0 ± 0,3 [$\log_{10}$ (cfu/g)];

5,0 [$\log_{10}$ (cfu/g)] [4,7; 5,3];

$1{,}0 \times 10^5$ cfu/g [$4{,}9 \times 10^4$; $2{,}0 \times 10^5$];

$1{,}0 \times 10^5$ cfu/g [−51 %; +100 %].

NOTE Applicable only if two formulae are used (see 8.2.2): $C_{\text{lim}} = 78$. Then, as $\Sigma C = 110 > C_{\text{lim}} = 78$, simplified Equation (2) for high counts $U = 2\,s_R = 0{,}30$ could have been used.

EXAMPLE 2

The standard deviation of reproducibility, s_R, is 0,25 [$\log_{10}$ (cfu/g)].

The test result is 280 cfu/g, i.e. $y = 2{,}45$ [$\log_{10}$ (cfu/g)], with $\Sigma C = 31$ (dilution −1, 1 ml on three plates: 9 + 9 + 9 colonies; dilution −2: 4 colonies).

Thus the expanded uncertainty, U, with a coverage factor of 2 (95 % confidence level) is, using Equation (1):

$$U = 2\sqrt{0{,}25^2 + \frac{0{,}188\,61}{31}} = 0{,}52$$

The test result may be reported according to one of the following possibilities:

2,4 ± 0,5 [$\log_{10}$ (cfu/g)];

2,4 [$\log_{10}$ (cfu/g)] [1,9; 3,0];

280 cfu/g [85; 930];

280 cfu/g [−70 %; +230 %].

NOTE Applicable only if two formulae are used (see 8.2.2): $C_{\text{lim}} = 28$. Then, as $\Sigma C = 31 > C_{\text{lim}} = 28$, simplified Equation (2) for high counts $U = 2\,s_R = 0{,}50$ could have been used.

EXAMPLE 3

The standard deviation of reproducibility, s_R, is 0,11 [$\log_{10}$ (cfu/g)].

The test result is 100 cfu/g, i.e. $y = 2{,}00$ [$\log_{10}$ (cfu/g)], with $\Sigma C = 11$ (dilution −1: 9 colonies; dilution −2: 2 colonies).

Thus the expanded uncertainty, U, with a coverage factor of 2 (95 % confidence level) is, using Equation (1):

$$U = 2\sqrt{0{,}11^2 + \frac{0{,}188\,61}{11}} = 0{,}34$$

The test result may be reported according to one of the following possibilities:

2,0 ± 0,3 [$\log_{10}$ (cfu/g)];

2,0 [$\log_{10}$ (cfu/g)] [1,7; 2,3];

100 cfu/g [46; 220];

100 cfu/g [–54 %; +120 %].

NOTE Applicable only if two formulae are used (see 8.2.2): $C_{\text{lim}} = 144$. Then, as $\Sigma C = 11 < C_{\text{lim}} = 144$, simplified Equation (2) for high counts cannot be used.

EXAMPLE 4 (applicable only if two formulae are used)

A standard deviation of reproducibility, s_R, of 0,22 [$\log_{10}$ (cfu/g)] has been found.

$C_{\text{lim}} = 36$. Then, if $\Sigma C > C_{\text{lim}} = 36$, simplified Equation (2) for high counts, $U = 2 \times 0{,}22 = 0{,}44$ applies.

A general rule, applicable only for results with $\Sigma C > 36$, may be stated according to one of the following possibilities:

log result ± 0,44 [$\log_{10}$ (cfu/g)];

log result [$\log_{10}$ (cfu/g)] [log result – 0,44; log result + 0,44];

result cfu/g [$10^{\text{log result} - 0{,}44}$; $10^{\text{log result} + 0{,}44}$];

result cfu/g [–64 %; +175 %].

If $\Sigma C \leqslant 36$, or if a single universally applicable equation is preferred, use Equation (1).”

Page 16

Add Annex B (overleaf) before the bibliography.