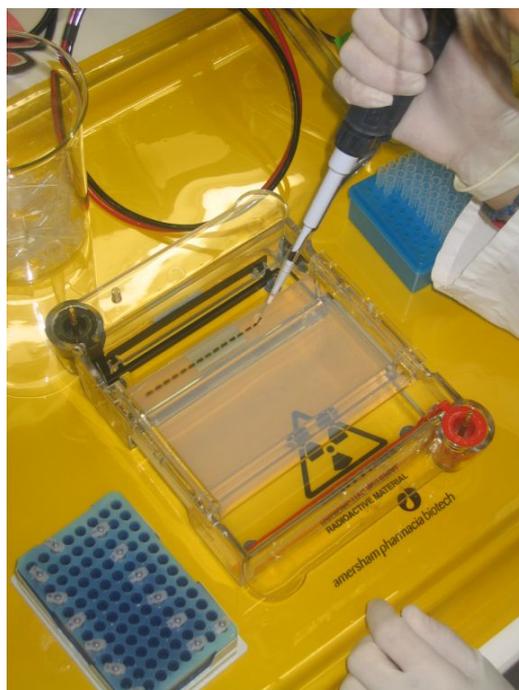




Event-specific Method for the Quantification of Maize Line MON 89034 Using Real-time PCR

Validation Report and Protocol

C. Savini, A. Bogni, E. Grazioli, B. Munaro, M. Mazzara, G. Van den Eede



EUR 23700 EN-2008

The mission of the JRC-IHCP is to protect the interests and health of the consumer in the framework of EU legislation on chemicals, food, and consumer products by providing scientific and technical support including risk-benefit assessment and analysis of traceability.

European Commission
Joint Research Centre
Institute for Health and Consumer Protection

Contact information

Address: Biotechnology and GMOs Unit
E-mail: JRC-BGMO@ec.europa.eu
Tel.: +39 0332 789378
Fax: +39 0332 786159

<http://ihcp.jrc.ec.europa.eu/>
<http://www.jrc.ec.europa.eu/>

Legal Notice

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication.

***Europe Direct is a service to help you find answers
to your questions about the European Union***

Freephone number (*):

00 800 6 7 8 9 10 11

(*) Certain mobile telephone operators do not allow access to 00 800 numbers or these calls may be billed.

A great deal of additional information on the European Union is available on the Internet. It can be accessed through the Europa server <http://europa.eu/>

JRC48921

EUR 23700 EN
ISBN 978-92-79-11166-2
ISSN 1018-5593
DOI 10.2788/68713
Luxembourg: Office for Official Publications of the European Communities

© European Communities, 2008

Reproduction is authorised provided the source is acknowledged

Printed in Italy



Event-specific Method for the Quantification of Maize Line MON 89034 Using Real-time PCR

Validation Report

21 October 2008

Joint Research Centre
Institute for Health and Consumer Protection
Biotechnology & GMOs Unit

Executive Summary

The JRC as Community Reference Laboratory for GM Food and Feed (CRL-GMFF), established by Regulation (EC) No 1829/2003, in collaboration with the European Network of GMO Laboratories (ENGL), has carried out a collaborative study to assess the performance of a quantitative event-specific method to detect and quantify the MON 89034 transformation event in maize DNA (unique identifier MON-89034-3). The collaborative trial was conducted according to internationally accepted guidelines^(1, 2).

In accordance with Regulation (EC) No 1829/2003 of 22 September 2003 on genetically modified food and feed and with Regulation (EC) No 641/2004 of 6 April 2004 on detailed rules for the implementation of Regulation (EC) No 1829/2003, Monsanto provided the detection method and the samples (genomic DNA extracted from conventional seeds and from 100% maize containing the event MON 89034). The JRC prepared the validation samples (calibration samples and blind samples at unknown GM percentage [DNA/DNA]). The collaborative trial involved twelve laboratories from nine European countries.

The results of the international collaborative trial met the ENGL performance requirements. The method is therefore considered applicable to the control samples provided, in accordance with the requirements of Annex I-2.C.2 to Commission Regulation (EC) No 641/2004.

The results of the collaborative study are made publicly available at <http://gmo-crl.jrc.ec.europa.eu/>.

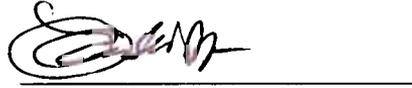
Drafted by:

C. Savini



Report Verification:

1) M. Ermolli



2) M. Querci



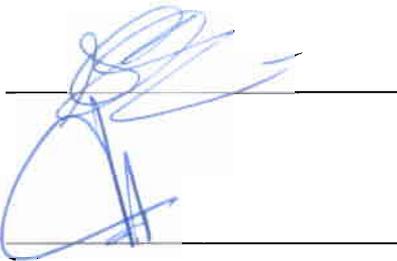
Scientific and technical approval:

M. Mazzara



Compliance with CRL Quality System:

S. Cordeil



Authorisation to publish:

G. Van den Eede



Address of contact laboratory:

European Commission, Joint Research Centre

Institute for Health and Consumer Protection (IHCP)

Biotechnology and GMOs Unit – Community Reference Laboratory for GM Food and Feed

Via Fermi 2749, 21027 Ispra (VA) - Italy

Report on Steps 1-3 of the Validation Process

Monsanto submitted the detection method and control samples for maize event MON 89034 (unique identifier MON-89034-3) under Article 5 and 17 of Regulation (EC) No 1829/2003 of the European Parliament and of the Council "on genetically modified food and feed".

The Community Reference Laboratory for GM Food and Feed (CRL-GMFF), following reception of the documentation and material, including control samples, (step 1 of the validation process) carried out the scientific assessment of documentation and data (step 2) in accordance with Commission Regulation (EC) No 641/2004 "on detailed rules for the implementation of Regulation (EC) No 1829/2003 of the European Parliament and of the Council as regards the application for the authorisation of new genetically modified food and feed, the notification of existing products and adventitious or technically unavoidable presence of genetically modified material which has benefited from a favourable risk evaluation" and according to its operational procedures ("Description of the CRL-GMFF Validation Process", <http://gmo-crl.jrc.ec.europa.eu/guidancedocs.htm>).

The scientific assessment focused on the method performance characteristics assessed against the method acceptance criteria set out by the European Network of GMO Laboratories and listed in the "Definition of Minimum Performance Requirements for Analytical Methods of GMO Testing" (<http://gmo-crl.jrc.ec.europa.eu/guidancedocs.htm>) (see Annex 1 for a summary of method acceptance criteria and method performance requirements). During step 2, four scientific assessments were performed and requests of complementary information addressed to the applicant. Upon reception of complementary information, the scientific evaluation of the detection method for maize MON 89034 was positively concluded in June 2007.

Between April and October 2007, the CRL-GMFF verified experimentally the method characteristics (step 3, experimental testing of samples and methods) by quantifying five blind GM-levels within the range 0.09%-8% on a copy number basis. The experiments were performed under repeatability conditions and demonstrated that the PCR efficiency, linearity, accuracy and precision of the quantifications were within the limits established by the ENGL.

A Technical Report summarising the results of tests carried out by the CRL-GMFF (step 3) is available on request.

Content

1. INTRODUCTION	5
2. LIST OF PARTICIPATING LABORATORIES	6
3. MATERIALS	7
4. EXPERIMENTAL DESIGN	8
5. METHOD	8
DESCRIPTION OF OPERATIONAL STEPS FOLLOWED	8
6. DEVIATIONS REPORTED	9
7. SUMMARY OF RESULTS	9
PCR EFFICIENCY AND LINEARITY	9
GMO QUANTIFICATION.....	10
8. METHOD PERFORMANCE REQUIREMENTS	12
9. CONCLUSIONS	13
10. QUALITY ASSURANCE	13
11. REFERENCES	13
12. ANNEX 1: METHOD ACCEPTANCE CRITERIA AND METHOD PERFORMANCE REQUIREMENTS AS SET BY THE EUROPEAN NETWORK OF GMO LABORATORIES (ENGL)	14

1. Introduction

Monsanto submitted the detection method and control samples for maize event MON 89034 (unique identifier MON-89034-3) under Article 5 and 17 of Regulation (EC) No 1829/2003 of the European Parliament and of the Council "on genetically modified food and feed".

The Joint Research Centre (JRC, Biotechnology and GMOs Unit of the Institute for Health and Consumer Protection) as Community Reference Laboratory for GM Food and Feed (see Regulation EC (No) 1829/2003) organised the international collaborative study for the event-specific method for the detection and quantification of MON 89034 maize. The study involved twelve laboratories from nine European countries, as listed in Annex II ("National reference laboratories assisting the CRL for testing and validation of methods for detection") of Commission Regulation (EC) No 1981/2006 of 22 December 2006.

Upon reception of method, samples and related data (step 1), the JRC carried out the assessment of the documentation (step 2) and the in-house evaluation of the method (step 3) according to the requirements of Regulation (EC) No 641/2004 and following its operational procedures.

The internal in-house experimental evaluation of the method was carried out between April and October 2007.

Following the evaluation of the data and the results of the in-house laboratory tests, the international collaborative study was organised (step 4) and took place in November 2007.

A method for DNA extraction from maize seeds, submitted by the applicant, was evaluated by the CRL-GMFF; laboratory testing of the method was carried out between April and October 2007 in order to confirm its performance characteristics. The protocol for DNA extraction and a report on method testing is available at <http://gmo-crl.jrc.ec.europa.eu/statusofdoss.htm>.

The operational procedure of the collaborative study included the following module:

- ✓ quantitative real-time PCR (Polymerase Chain Reaction). The methodology is an event-specific real-time quantitative TaqMan[®] PCR procedure for the determination of the relative content of maize line MON 89034 DNA to total maize DNA. The procedure is a simplex system, in which a maize *hmg* (high mobility group) endogenous assay (reference gene) and the target assay (MON 89034) are performed in separate wells.

The international collaborative study was carried out in accordance with the following internationally accepted guidelines:

- ✓ ISO 5725 (1994).
- ✓ The IUPAC "Protocol for the design, conduct and interpretation of method-performance studies" (Horwitz, 1995).

2. List of participating laboratories

As part of the international collaborative study the method was tested in twelve ENGL laboratories to determine its performance.

On 22nd October 2007 the CRL-GMFF invited all National Reference Laboratories nominated under Commission Regulation (EC) No 1981/2006 of 22 December 2006 and listed in Annex II ("National reference laboratories assisting the CRL for testing and validation of methods for detection") of that Regulation to express the availability to participate in the validation study of the quantitative real-time PCR method for the detection and quantification of soybean GM event DP-356043-5.

Thirty-six laboratories expressed in writing their willingness to participate, four declined the invitation, while thirty-three did not answer. The CRL-GMFF performed a random selection of twelve laboratories out of those that responded positively to the invitation, making use of a validated software application.

Clear guidance was given to the selected laboratories with regards to the standard operational procedures to follow for the execution of the protocol. The participating laboratories are listed in Table 1.

Table 1. Laboratories participating in the validation of the detection method for maize line MON 89034.

Laboratory	Country
Bavarian Health and Food Safety Authority	Germany
Central Agricultural Office, Directorate Food and Feed Safety, Central Feed Investigation Laboratory - National Reference Laboratory	Hungary
Crop Research Institute - Reference Laboratory for GMO Detection and DNA fingerprinting	Czech Rep.
Federal Environment Agency Austria	Austria
Finnish Customs Laboratory	Finland
Institute for Agricultural and Fisheries Research (ILVO)	Belgium
Institute for Consumer Protection. Department 3 – Food Safety	Germany
Institute for Hygiene and Environment	Germany
Institute of Biochemistry and Biophysics Polish Academy of Sciences	Poland
National Food Administration	Sweden
Scottish Agricultural Science Agency	UK
Walloon Agricultural Research Centre (CRA-W) - Department Quality of Agricultural Products	Belgium

3. Materials

For the validation of the quantitative event-specific method, samples were used consisting of:

- i) genomic DNA of maize harbouring the MON 89034 event in a hemizygous status (Lot number: GLP-0612-17873-S) and;
- ii) genomic DNA of conventional maize (Lot number: GLP-0612-17871-S)

Samples were provided by the applicant in accordance with the provisions of Regulation (EC) No 1829/2003, Art 2.11 [control sample defined as the GMO or its genetic material (positive sample) and the parental organism or its genetic material that has been used for the purpose of the genetic modification (negative sample)].

Samples containing mixtures of 100% MON 89034 maize DNA and non-GM maize genomic DNA at different GMO concentrations were prepared by the CRL-GMFF, using the control samples provided, in a constant amount of total maize DNA.

Participants received the following materials:

- ✓ Five calibration samples (160 µL of DNA solution each) for the preparation of the standard curve, labelled from S1 to S5.
- ✓ Twenty unknown DNA samples (80 µL of DNA solution each), labelled from U1 to U20.
- ✓ Reaction reagents:

<input type="checkbox"/> TaqMan [®] 2X PCR Master Mix, 2 vials:	5 mL each
<input type="checkbox"/> TaqMan [®] buffer A (10X), 1 vial:	800 µL
<input type="checkbox"/> MgCl ₂ (25 mM), 1 vial:	2.1 mL
<input type="checkbox"/> dNTP mix (10 mM each), 1 vial:	160 µL
<input type="checkbox"/> AmpliTaq Gold [®] polymerase (5U/ µL), 1 vial:	80 µL
<input type="checkbox"/> Sterile distilled water, 1 vial:	8 mL
- ✓ Primers and probes (1 tube each) as follows:

<i>hmg reference system</i>		
<input type="checkbox"/> hmg primer 1	(10 µM):	240 µL
<input type="checkbox"/> hmg primer 2	(10 µM):	240 µL
<input type="checkbox"/> hmg probe	(5 µM):	260 µL
 <i>MON 89034 system</i>		
<input type="checkbox"/> MON 89034 primer 1	(10 µM):	720 µL
<input type="checkbox"/> MON 89034 primer 2	(10 µM):	720 µL
<input type="checkbox"/> MON 89034 probe	(5 µM):	320 µL

4. Experimental design

Twenty unknown samples, representing five GM levels, were used in the validation study (Table 2). On each PCR plate, the samples were analyzed either for the MON 89034 specific system or the *hmg* specific system. In total, two plates were run per participating laboratory and four replicates for each GM level were analysed. PCR analysis was performed in triplicate for all samples. Participating laboratories carried out the determination of the GM% according to the instructions provided in the protocol and using the electronic tool provided (Excel spreadsheet).

Table 2. MON 89034 GM contents

MON 89034 GM% (GMO copy number/maize genome copy number x 100)
0.09
0.40
0.90
3.00
8.00

5. Method

Description of operational steps followed

For the specific detection of event MON 89034 DNA, a 77-bp fragment of the integration region of the construct inserted into the plant genome (that spans the 3' insert-to-plant junction) is amplified using two specific primers. PCR products are measured at each cycle (real-time) by means of a target-specific oligonucleotide probe labelled with FAM dye and a non fluorescent quencher MGBNFQ.

For the relative quantification of event MON 89034 DNA, a maize-specific reference system amplifies a 79-bp fragment of the maize endogenous gene *hmg* (*high mobility group*, accession number AJ131373), using a pair of *hmg* gene-specific primers and a *hmg* gene-specific probe labelled with FAM and TAMRA.

Standard curves are generated for both the MON 89034 and the *hmg* specific systems by plotting the Ct values measured for the calibration points against the logarithm of the DNA copy numbers and by fitting a regression line into these data. Thereafter, the standard curves are used to estimate the copy numbers in the unknown sample DNA by interpolation from the standard curves.

For relative quantification of maize line MON 89034 DNA in a test sample, the MON 89034 copy number is divided by the copy number of the maize reference gene (*hmg*) and multiplied by 100 to obtain the percentage value (GM% = MON 89034/*hmg* x 100).

Calibration sample S1 was prepared by mixing the appropriate amount of MON 89034 DNA in control non-GM maize DNA to obtain a 10% GM of MON 89034 maize line in a total of 200 ng

maize DNA. Samples S2 and S3 were prepared by 1:4 serial dilutions from the S1 sample and samples S4 and S5 were prepared by 1:3 serial dilutions from the S3 sample.

The absolute copy numbers in the calibration curve samples are determined by dividing the sample DNA weight (nanograms) by the published average 1C value for maize genome (2.725)⁽³⁾. The copy number values used in the quantification, the GM contents of the calibration samples and total DNA quantity used in PCR are provided in Table 3 (% GM calculated considering the 1C value for maize genome as 2.725 pg)⁽³⁾.

Table 3. % GM values of the standard curve samples.

Sample code	S1	S2	S3	S4	S5
Total amount of DNA in reaction (ng)	200	50	12.5	4.2	1.4
maize genome copies	73394	18349	4587	1529	510
MON 89034 maize line copies	7339	1835	459	153	51

6. Deviations reported

Ten laboratories reported no deviations from the protocol.

One laboratory performed twice run B as no amplification plot was observed for wells corresponding to reference sample S5 in the *hmg* system.

One laboratory did not get signals for one out of the three replicates for sample U3 with both the MON 89034 and the *hmg* system, likely due to a pipetting error.

7. Summary of results

PCR efficiency and linearity

The values of the slopes [from which the PCR efficiency is calculated using the formula $((10^{(-1/\text{slope})}-1) \times 100)$] of the reference curve and of the R^2 (expressing the linearity of the regression) reported by participating laboratories for the MON89034 system and the *hmg* reference system are summarised in Table 4.

Table 4. Values of reference curve slope, PCR efficiency and linearity (R^2)

Lab	Plate	MON 89034			<i>hmg</i>		
		Slope	PCR Efficiency (%)	R^2	Slope	PCR Efficiency (%)	R^2
1	A	-3.69	86.68	1.00	-3.28	101.65	1.00
	B	-3.50	92.95	1.00	-3.15	107.59	0.99
2	A	-3.70	86.47	0.99	-3.31	100.37	0.99
	B	-3.65	87.77	0.99	-3.29	101.20	0.99
3	A	-3.65	87.81	1.00	-3.34	99.42	1.00
	B	-3.64	88.38	1.00	-3.23	103.94	1.00
4	A	-3.65	87.82	1.00	-3.39	97.30	1.00
	B	-3.60	89.62	1.00	-3.21	105.04	0.99
5	A	-3.75	84.83	1.00	-3.52	92.45	1.00
	B	-3.68	87.10	1.00	-3.49	93.60	1.00
6	A	-3.61	89.13	0.99	-3.12	108.98	0.99
	B	-3.59	89.92	0.99	-3.23	104.20	1.00
7	A	-3.74	84.94	1.00	-3.24	103.70	0.99
	B	-3.66	87.60	1.00	-3.24	103.63	1.00
8	A	-3.53	91.91	1.00	-3.35	99.00	1.00
	B	-3.56	90.79	0.99	-3.26	102.70	1.00
9	A	-3.79	83.69	0.99	-3.40	96.78	1.00
	B	-3.58	90.11	1.00	-3.30	100.88	1.00
10	A	-3.39	97.32	0.98	-3.36	98.39	0.99
	B	-3.48	93.91	0.99	-3.31	100.29	0.99
11	A	-3.56	90.99	1.00	-3.23	104.03	0.99
	B	-3.67	87.40	1.00	-3.28	101.61	1.00
12	A	-3.71	85.90	0.99	-3.29	101.19	1.00
	B	-3.78	83.79	0.99	-3.33	99.74	1.00
Mean		-3.63	88.6	0.99	-3.30	101.1	1.00

The mean PCR efficiency was 88.6% for the MON 89034 system and 1001.1% for the *hmg* reference system. The linearity of the method was 0.99 and 1.00 for MON 89034 and *hmg*, respectively. Data reported confirm the appropriate performance characteristics of the method tested in terms of efficiency and linearity.

GMO quantification

Table 5 shows the mean values of the four replicates for each GM level as provided by all laboratories. Each mean value is the average of three PCR repetitions.

Table 5. GM% mean values determined by laboratories for unknown samples.

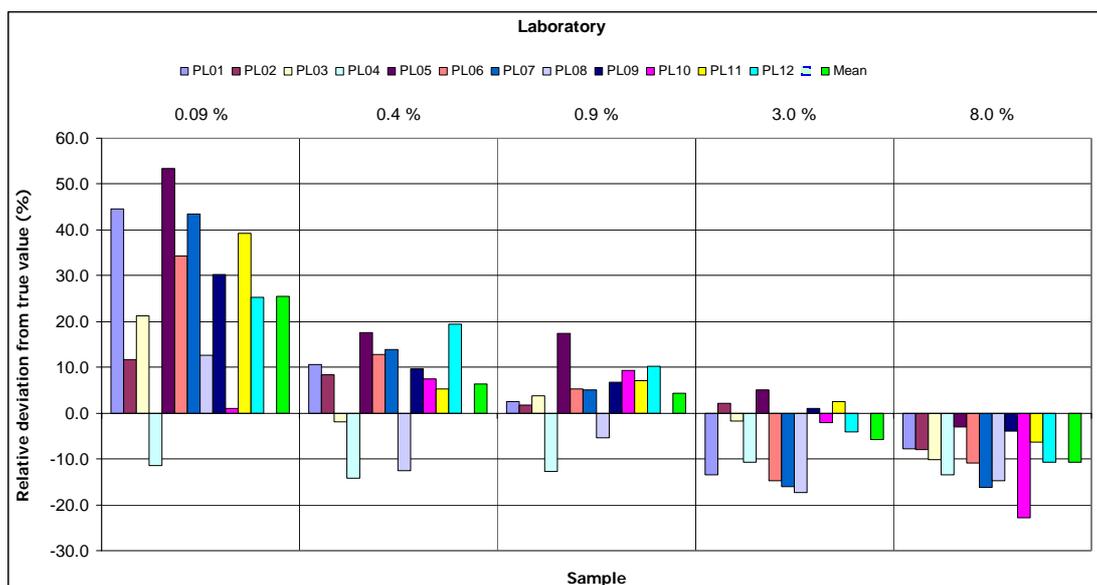
LAB	Sample GMO content (GM% = GMO copy number/maize genome copy number x 100)																			
	0.09				0.4				0.9				3.0				8.0			
	REP 1	REP 2	REP 3	REP 4	REP 1	REP 2	REP 3	REP 4	REP 1	REP 2	REP 3	REP 4	REP 1	REP 2	REP 3	REP 4	REP 1	REP 2	REP 3	REP 4
1	0.14	0.08	0.15	0.15	0.40	0.45	0.41	0.52	1.12	1.05	0.71	0.81	2.51	2.88	2.50	2.49	7.62	6.77	7.63	7.50
2	0.11	0.08	0.11	0.10	0.40	0.42	0.52	0.40	0.87	0.90	0.92	0.97	3.36	2.80	2.79	3.30	7.19	8.16	7.27	6.82
3	0.13	0.10	0.10	0.11	0.39	0.38	0.42	0.38	1.02	0.93	0.91	0.88	3.35	3.08	2.41	2.95	6.98	7.36	7.12	7.30
4	0.09	0.08	0.08	0.07	0.28	0.32	0.41	0.36	0.72	0.64	0.83	0.95	2.60	2.41	2.81	2.88	7.82	6.57	6.60	6.72
5	0.14	0.14	0.13	0.14	0.48	0.47	0.46	0.47	1.10	0.95	0.96	1.21	2.90	2.95	3.81	2.95	8.53	6.04	7.98	8.50
6	0.13	0.10	0.11	0.13	0.49	0.58	0.33	0.41	0.98	1.36	0.81	0.63	2.90	3.00	1.90	2.43	6.79	6.65	8.37	6.72
7	0.15	0.10	0.13	0.13	0.50	0.47	0.37	0.48	1.08	1.10	0.84	0.77	2.72	2.78	2.35	2.21	6.26	6.53	7.29	6.74
8	0.12	0.07	0.11	0.11	0.39	0.35	0.29	0.37	0.99	1.02	0.69	0.70	2.68	2.70	2.20	2.34	6.64	6.71	6.44	7.50
9	0.12	0.08	0.13	0.13	0.43	0.45	0.44	0.44	1.04	0.96	0.89	0.96	2.90	3.15	3.03	3.04	7.63	7.35	7.78	7.96
10	0.08	0.11	0.10	0.07	0.40	0.41	0.44	0.46	0.84	0.89	1.10	1.11	2.76	2.28	3.45	3.27	7.05	6.02	6.16	5.45
11	0.12	0.10	0.18	0.10	0.45	0.49	0.39	0.36	1.20	0.99	0.87	0.80	3.53	3.33	2.38	3.07	6.87	8.90	6.24	7.96
12	0.13	0.12	0.10	0.11	0.54	0.53	0.39	0.44	0.98	1.02	0.99	0.97	2.91	2.92	2.98	2.69	7.76	6.49	7.43	6.93

In Figure 1 the relative deviation from the true value for each GM level tested is shown for each laboratory. The coloured bars represent the relative GM quantification obtained by the participating laboratories as well as the mean value (represented by the green bar).

As observed in Figure 1, relative deviations from the true values are mainly positive for GM levels of 0.09% and 0.4% and negative at GM level of 3.0% and 8.0%, meaning that the GM content of unknown samples tends to be overestimated at the lowest GM levels and underestimated at the upper end of the dynamic range. More specifically, six laboratories overestimated significantly (> 25%) the true values at the 0.09% GM level.

Overall, the average deviation from true value, expressed as bias %, was limited and within the acceptance criterion of 25%.

Figure 1. Relative deviation (%) from the true value of MON 89034 for all laboratories



8. Method performance requirements

Among the performance criteria established by ENGL and adopted by the CRL-GMFF (<http://gmo-crl.jrc.it/guidancedocs.htm>, see also Annex 1), repeatability and reproducibility are assessed through an international collaborative trial, carried out with the support of ENGL laboratories (see Table 1). Table 6 illustrates the estimation of repeatability and reproducibility at various GM levels, according to the range of GM percentages tested during the collaborative trial.

The relative reproducibility standard deviation (RSD_R), that describes the inter-laboratory variation, should be below 33% at the target concentration and over the majority of the dynamic range, while it should be below 50% at the lower end of the dynamic range.

As it can be observed in Table 6, the method fully satisfies this requirement at all GM levels tested. In fact, the highest value of RSD_R (%) is 22% at the 0.09% level and below 20% over the other GM levels, thus within the acceptance criterion.

Table 6. MON 89034: summary of validation results.

Unknown sample GMO%	Expected value (GMO%)				
	0.09	0.4	0.9	3	8
Laboratories having returned results	12	12	12	12	12
Samples per laboratory	4	4	4	4	4
Number of outliers	-	-	-	-	-
Reason for exclusion	-	-	-	-	-
Mean value	0.11	0.43	0.94	2.83	7.15
Relative repeatability standard deviation, RSD_r (%)	18	13	17	12	9.5
Repeatability standard deviation	0.020	0.055	0.155	0.350	0.681
Relative reproducibility standard deviation, RSD_R (%)	22	15	17	14	10
Reproducibility standard deviation	0.025	0.064	0.155	0.390	0.740
Bias (absolute value)	0.02	0.03	0.04	-0.18	-0.86
Bias (%)	25	6.4	4.3	-5.8	-11

Bias is estimated according to ISO 5725 data analysis protocol.

Table 6 further documents the relative repeatability standard deviation (RSD_r), as estimated for each GM level. In order to accept methods for collaborative study evaluation, the CRL requires that RSD_r values be below 25%, as indicated by ENGL (Definition of Minimum Performance Requirements for Analytical Methods of GMO Testing" (<http://gmo-crl.jrc.it/guidancedocs.htm>)).

As it can be observed from the values reported in Table 6, the highest relative repeatability standard deviation is 18% at the 0.09% level, therefore well within the acceptance criterion.

The *trueness* of the method is estimated using the measures of the method bias for each GM level. According to ENGL method performance requirements, trueness should be $\pm 25\%$ across the entire dynamic range. The method satisfies this requirement across the dynamic range tested; in fact, the highest value of bias (%) is 25% at the 0.09% level.

9. Conclusions

The overall method performance has been evaluated with respect to the method acceptance criteria and method performance requirements recommended by the ENGL (as detailed under <http://gmo-crl.jrc.it/guidancedocs.htm>). The method acceptance criteria were reported by the applicant and used to evaluate the method prior to the international collaborative study (see Annex 1 for a summary of method acceptance criteria and method performance requirements).

The results obtained during the collaborative study indicate that the analytical module of the method submitted by the applicant complies with ENGL performance criteria, therefore the method is considered applicable to the control samples provided (see paragraph 3 "Materials"), in accordance with the requirements of Annex I-2.C.2 to Commission Regulation (EC) No 641/2004.

10. Quality assurance

The CRL-GMFF carries out its operations according to ISO 9001:2000 (certificate number: CH-32232) and ISO 17025:2005 (certificate number: DAC-PL-0459-06-00) [DNA extraction, qualitative and quantitative PCR in the area of Biology (DNA extraction and PCR method validation for the detection and identification of GMOs in food and feed materials)]

11. References

1. Horwitz, W., 1995. Protocol for the design, conduct and interpretation of method performance studies. *Pure and Appl. Chem*, 67: 331-343.
2. International Standard (ISO) 5725, 1994. Accuracy (trueness and precision) of measurement methods and results. International Organization for Standardization, Genève, Switzerland.
3. Arumuganathan K., Earle E.D., 1991. Nuclear DNA content of some important plant species. *Plant Molecular Biology Reporter* 9: 208-218.

12. Annex 1: method acceptance criteria and method performance requirements as set by the European Network of GMO Laboratories (ENGL)

Method Acceptance Criteria should be fulfilled at the moment of submission of a method (Phase 1: acceptance for the collaborative study).

Method Performance Requirements should be fulfilled in a collaborative study in order to consider the method as fit for its purpose (Phase 2: evaluation of the collaborative study results).

Method Acceptance Criteria

Applicability

Definition: The description of analytes, matrices, and concentrations to which a method can be applied.

Acceptance Criterion: The applicability statement should provide information on the scope of the method and include data for the indices listed below for the product/s for which the application is submitted. The description should also include warnings to known interferences by other analytes, or inapplicability to certain matrices and situations.

Practicability

Definition: The ease of operations, the feasibility and efficiency of implementation, the associated unitary costs (e.g. Euro/sample) of the method.

Acceptance Criterion: The practicability statement should provide indication on the required equipment for the application of the method with regards to the analysis *per se* and the sample preparation. An indication of costs, timing, practical difficulties and any other factor that could be of importance for the operators should be indicated.

Specificity

Definition: Property of a method to respond exclusively to the characteristic or analyte of interest.

Acceptance Criterion: The method should be event-specific and be functional only with the GMO or GM based product for which it was developed. This should be demonstrated by empirical results from testing the method with non-target transgenic events and non-transgenic material. This testing should include closely related events and cases where the limit of the detection is tested.

Dynamic Range

Definition: The range of concentrations over which the method performs in a linear manner with an acceptable level of accuracy and precision.

Acceptance Criterion: The dynamic range of the method should include the 1/10 and at least 5 times the target concentration. Target concentration is intended as the threshold relevant for legislative

requirements. The acceptable level of accuracy and precision are described below. The range of the standard curve(s) should allow testing of blind samples throughout the entire dynamic range, including the lower (10%) and upper (500%) end.

Accuracy

Definition: The closeness of agreement between a test result and the accepted reference value.

Acceptance Criterion: The accuracy should be within $\pm 25\%$ of the accepted reference value over the whole dynamic range.

Amplification Efficiency

Definition: The rate of amplification that leads to a theoretical slope of -3.32 with an efficiency of 100% in each cycle. The efficiency of the reaction can be calculated by the following equation: Efficiency = $[10^{(1/\text{slope})}] - 1$.

Acceptance Criterion: The average value of the slope of the standard curve should be in the range of $(-3.1 \geq \text{slope} \geq -3.6)$.

R² Coefficient

Definition: The R² coefficient is the correlation coefficient of a standard curve obtained by linear regression analysis.

Acceptance Criterion: The average value of R² should be ≥ 0.98 .

Repeatability Standard Deviation (RSD_r)

Definition: The standard deviation of test results obtained under repeatability conditions. Repeatability conditions are conditions where test results are obtained with the same method, on identical test items, in the same laboratory, by the same operator, using the same equipment within short intervals of time.

Acceptance Criterion: The relative repeatability standard deviation should be below 25% over the whole dynamic range of the method.

Note: Estimates of repeatability submitted by the applicant should be obtained on a sufficient number of test results, at least 15, as indicated in ISO 5725-3 (1994).

Limit of Quantitation (LOQ)

Definition: The limit of quantitation is the lowest amount or concentration of analyte in a sample that can be reliably quantified with an acceptable level of precision and accuracy.

Acceptance Criterion: LOQ should be less than 1/10th of the value of the target concentration with an RSD_r $\leq 25\%$. Target concentration should be intended as the threshold relevant for legislative requirements. The acceptable level of accuracy and precision are described below.

Limit of Detection (LOD)

Definition: The limit of detection is the lowest amount or concentration of analyte in a sample, which can be reliably detected, but not necessarily quantified, as demonstrated by single laboratory validation.

Acceptance Criterion: LOD should be less than $1/20^{\text{th}}$ of the target concentration. Experimentally, quantitative methods should detect the presence of the analyte at least 95% of the time at the LOD, ensuring $\leq 5\%$ false negative results. Target concentration should be intended as the threshold relevant for legislative requirements.

Robustness

Definition: The robustness of a method is a measure of its capacity to remain unaffected by small, but deliberate deviations from the experimental conditions described in the procedure.

Acceptance Criterion: The response of an assay with respect to these small variations should not deviate more than $\pm 30\%$. Examples of factors that a robustness test could address are: use of different instrument type, operator, brand of reagents, concentration of reagents, and temperature of reaction.

Method Performance Requirements

Dynamic Range

Definition: In the collaborative trial the dynamic range is the range of concentrations over which the reproducibility and the trueness of the method are evaluated with respect to the requirements specified below.

Acceptance Criterion: The dynamic range of the method should include the $1/10$ and at least five times the target concentration. Target concentration should be intended as the threshold relevant for legislative requirements.

Reproducibility Standard Deviation (RSD_R)

Definition: The standard deviation of test results obtained under reproducibility conditions. Reproducibility conditions are conditions where test results are obtained with the same method, on identical test items, in different laboratories, with different operators, using different equipment. Reproducibility standard deviation describes the inter-laboratory variation.

Acceptance Criterion: The relative reproducibility standard deviation should be below 35% at the target concentration and over the entire dynamic range. An $RSD_R < 50\%$ is acceptable for concentrations below 0.2%.

Trueness

Definition: The closeness of agreement between the average value obtained from a large series of test results and an accepted reference value. The measure of trueness is usually expressed in terms of bias.

Acceptance Criterion: The trueness should be within $\pm 25\%$ of the accepted reference value over the whole dynamic range.



Event-specific Method for the Quantification of Maize Line MON 89034 Using Real-time PCR

Protocol

21 October 2008

**Joint Research Centre
Institute for Health and Consumer Protection
Biotechnology & GMOs Unit**

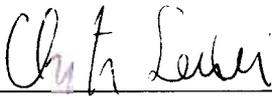
Method development:

Monsanto Company

Collaborative trial:

Community Reference Laboratory for GM Food and Feed (CRL-GMFF)
Biotechnology & GMOs Unit

Drafted by
C. Savini



Report Verification Team
1) M. Ermolli



2) M. Querci



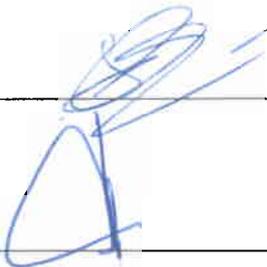
Scientific and technical approval
M. Mazzara



Compliance to CRL Quality System
S. Cordeil



Authorisation to publish
G. Van den Eede



Address of contact laboratory:

European Commission, Joint Research Centre
Institute for Health and Consumer Protection (IHCP)
Biotechnology and GMOs Unit – Community Reference Laboratory for GM Food and Feed
Via Fermi 2749, 21027 Ispra (VA) - Italy

Content

1. GENERAL INFORMATION AND SUMMARY OF THE METHOD	4
2. VALIDATION STATUS AND PERFORMANCE CHARACTERISTICS	4
2.1 GENERAL	4
2.2 COLLABORATIVE TRIAL	5
2.3 LIMIT OF DETECTION (LOD)	5
2.4 LIMIT OF QUANTIFICATION (LOQ)	5
2.5 MOLECULAR SPECIFICITY	5
3. PROCEDURE	6
3.1 GENERAL INSTRUCTIONS AND PRECAUTIONS	6
3.2 REAL-TIME PCR FOR QUANTITATIVE ANALYSIS OF MAIZE EVENT MON 89034	7
3.2.1 General	7
3.2.2 Calibration	7
3.2.3 Real-time PCR set-up	7
3.3 DATA ANALYSIS	9
3.4 CALCULATION OF RESULTS	9
4. MATERIALS	10
4.1 EQUIPMENT	10
4.2 REAGENTS	10
4.3 PRIMERS AND PROBES	10

1. General information and summary of the method

This protocol describes an event-specific real-time quantitative TaqMan[®] PCR procedure for the determination of the relative content of maize event MON 89034 DNA to total maize DNA in a sample.

The PCR assay was optimised for use in real-time PCR instruments for plastic reaction vessels.

Template DNA extracted by means of suitable methods should be tested for quality and quantity prior to use in PCR assay. Tests for the presence of PCR inhibitors (e.g. monitor run of diluted series, use of DNA spikes) are recommended.

For the specific detection of maize event MON 89034 DNA, a 77-bp fragment of the integration region of the construct inserted into the plant genome (located at the 3' insert-to-plant junction) is amplified using two specific primers. PCR products are measured during each cycle (real-time) by means of a target-specific oligonucleotide probe labelled with the fluorescent dye FAM as a reporter at its 5' end and with the non-fluorescent quencher MGBNFQ (minor groove binding non-fluorescent quencher) at its 3' end.

For the relative quantification of maize event MON 89034 DNA, a maize specific reference system amplifies a 79-bp fragment of the maize endogenous *hmg* gene (high mobility group), using a two specific primers and an *hmg* gene-specific probe labelled with FAM and TAMRA as described above.

The measured fluorescence signal passes a threshold value after a certain number of cycles. This threshold cycle is called the "Ct" value. For quantification of the amount of event MON 89034 DNA in a test sample, MON 89034 and *hmg* Ct values are determined for the sample. Standard curves are then used to estimate the relative amount of maize event MON 89034 DNA to total maize DNA.

2. Validation status and performance characteristics

2.1 General

The method was optimised for suitable DNA extracted from maize leaves, seeds and grains containing mixtures of genetically modified and conventional maize.

The reproducibility and trueness of the method were tested through an international collaborative ring trial using DNA samples at different GMO contents.

2.2 Collaborative trial

The method was validated in an international collaborative study by the Joint Research Centre (JRC) of the European Commission. The study was undertaken with twelve participating laboratories in November 2007.

Each participant received twenty blind samples containing maize MON 89034 genomic DNA at five GM contents, ranging from 0.09% to 8.0%.

Each test sample was analysed by PCR in three repetitions. The study was designed as a blind quadruplicate collaborative trial; each laboratory received each level of GM maize MON 89034 in four unknown samples. Four replicates of each GM level were analysed on the same PCR plate.

A detailed validation report can be found at <http://gmo-crl.jrc.it/statusofdoss.htm>

2.3 Limit of detection (LOD)

According to the method developer, the relative LOD of the method is at least 0.04% in 200 ng of total maize DNA. The relative LOD was not assessed in a collaborative study.

2.4 Limit of quantification (LOQ)

According to the method developer, the relative LOQ of the method is at least 0.085% in 200 ng of total maize DNA. The lowest relative GM content of the target sequence included in collaborative trial was 0.09 %.

2.5 Molecular specificity

According to the method developer, the method exploits a unique DNA sequence in the region of recombination between the insert and the plant genome. The sequence is specific to maize event MON 89034 and thus imparts event-specificity to the method.

The specificity of event-specific assay was experimentally tested in real-time PCR by the applicant against DNA extracted from plant materials containing the specific targets of Roundup Ready® canola (RT200), Roundup Ready® canola (RT73), conventional canola, Roundup Ready® maize (GA21), Roundup Ready® maize (NK603), YieldGard® corn borer maize (MON 810), YieldGard® Rootworm/Roundup Ready® maize (MON 88017) , YieldGard® Rootworm maize (MON 863), lysine maize (LY038), MON 89034 maize, conventional maize, Roundup Ready® cotton (MON 1445), Bollgard® cotton (MON 531), Bollgard® cotton (MON 757), BollgardII® cotton (MON 15985), MON 88913 cotton, conventional cotton, Roundup Ready® soybean 40-3-2, MON 89788 soybean, conventional soybean, Roundup Ready® wheat (MON71800), conventional wheat, lentil, quinoa, sunflower nuts, buckwheat, pinenuts, rye berries, millet, peanut (shelled).

None of the GM-lines tested, except the positive control maize line MON 89034, produced detectable amplification signals.

The specificity of the maize reference assay *hmg* was experimentally tested by the applicant against DNA extracted from plant materials containing Roundup Ready® canola (RT200), Roundup Ready® canola (RT73), conventional canola, Roundup Ready® maize (GA21), Roundup Ready® maize (NK603), YieldGard® corn borer maize (MON 810), YieldGard® Rootworm/Roundup Ready® maize (MON 88017), YieldGard® rootworm maize (MON863), lysine maize (LY038), MON 89034 maize, conventional maize, Roundup Ready® cotton (MON 1445), Bollgard® cotton (MON 531), Bollgard® cotton (MON 757), BollgardII® cotton (MON 15985), MON 88913 cotton, conventional cotton, Roundup Ready® soybean 40-3-2, MON 89788 soybean, conventional soybean, Roundup Ready® wheat (MON71800), conventional wheat, lentil, sunflower, buckwheat, rye berries, peanut.

None of the samples tested, except the control maize lines GA21, NK603, MON 810, MON 863, NON 88017, LY038, MON 89034 and conventional maize, produced detectable amplification signals.

3. Procedure

3.1 General instructions and precautions

- The procedures require experience of working under sterile conditions.
- Laboratory organisation, e.g. “forward flow direction” during PCR-setup, should follow the guidelines given by relevant authorities, e.g. ISO 24276:2006.
- PCR-reagents should be stored and handled in a separate room where no nucleic acids (with exception of PCR primers or probes) or DNA degrading or modifying enzymes have been handled previously. All handling of PCR reagents and controls requires dedicated equipment, especially pipettes.
- All the equipment used should be sterilised prior to use and any residue of DNA has to be removed. All material used (e.g. vials, containers, pipette tips, etc.) must be suitable for PCR and molecular biology applications. They must be DNase-free, DNA-free, sterile and unable to adsorb protein or DNA.
- Filter pipette tips protected against aerosol should be used.
- Powder-free gloves should be used and changed frequently.
- Laboratory benches and equipment should be cleaned periodically with 10% sodium hypochloride solution (bleach).
- Pipettes should be checked regularly for precision and calibrated, if necessary.
- All handling steps - unless specified otherwise - should be carried out at 0-4°C.
- In order to avoid repeated freeze/thaw cycles aliquots should be prepared.

3.2 Real-time PCR for quantitative analysis of maize event MON 89034

3.2.1 General

The PCR set-up for the taxon specific target sequence (*hmg*) and for the GMO (event MON 89034) target sequence should be carried out in separate vials. Multiplex PCR (using differential fluorescent labels for the probes) has not been tested or validated.

The use of maximum 200 ng of template DNA per reaction well is recommended.

The method is developed for a total volume of 50 µL for the MON 89034 reaction and of 25 µL for the *hmg* reaction mixture with the reagents as listed in Table 1 and Table 2.

3.2.2 Calibration

The calibration curves consist of five samples. The first point of the calibration curves is a 10% MON 89034 maize DNA in non-GM maize DNA for a total of 200 ng of DNA (corresponding to approximately 73394 maize genome copies with one genome assumed to correspond to 2.725 pg of haploid maize genomic DNA) ⁽¹⁾.

A calibration curve is produced by plotting the Ct values against the logarithm of the target copy number for the calibration points. This can be done e.g. by means of spreadsheet software, e.g. Microsoft Excel, or directly by options available with the sequence detection system software.

The copy number measured for the unknown sample DNA is obtained by interpolation from the standard curves.

3.2.3 Real-time PCR set-up

1. Thaw, mix gently and centrifuge the required amount of components needed for the run.
Keep thawed reagents at 1-4°C on ice.
2. In two reaction tubes (one for the MON 89034 system and one for the *hmg* system) on ice, add the following components (Tables 1 and 2) in the order mentioned below (except DNA) to prepare the master mixes.

Table 1. Amplification reaction mixture in the final volume/concentration per reaction well for the MON 89034 specific system.

Component	Final concentration	µL/reaction
TaqMan [®] 2x PCR Master Mix	1x	25
MON 89034 primer 1 (10 µM)	450 nM	2.25
MON 89034 primer 2 (10 µM)	450 nM	2.25
MON 89034 probe (5 µM)	100 nM	1.00
Nuclease free water	#	15.5
Template DNA (max 200 ng)	#	4.0
Total reaction volume:		50

Table 2. Amplification reaction mixture in the final volume/concentration per reaction well for the maize *hmg* reference system.

Component	Final concentration	µL/reaction
Nuclease free water	#	8.95
TaqMan [®] buffer A (10x)	1x	2.5
MgCl ₂ (25 mM)	6.5 mM	6.5
dNTP mix (10 mM each)	200 µM each	0.5
AmpliTaq Gold polymerase (5 U/µl)	1.25 U	0.25
<i>hmg</i> primer 1 (10 µM)	300 nM	0.75
<i>hmg</i> primer 2 (10 µM)	300 nM	0.75
<i>hmg</i> probe (5 µM)	160 nM	0.8
Template DNA (max 200 ng)	#	4.0
Total reaction volume:		25

- Mix gently and centrifuge briefly.
- Prepare two reaction tubes (one for the MON 89034 event and one for the *hmg* master mixes) for each DNA sample to be tested (standard curve samples, unknown samples and control samples).
- Add to each reaction tube the correct amount of master mix (e.g. 46 x 3 = 138 µL master mix for three PCR repetitions for the MON 89034 reactions and 21 x 3 = 63 µL for *hmg* reactions). Add to each tube the correct amount of DNA (e.g. 4 x 3 = 12 µL DNA for three PCR repetitions). Vortex each tubes for approx. 10 sec. This step is mandatory to reduce the variability among the repetitions of each sample to a minimum.
- Spin down the tubes in a microcentrifuge. Aliquot 50 µL (or 25 depending on the reaction mixture) in each well. Seal the reaction plate with optical cover or optical caps. Centrifuge the plate at low speed (e.g. approximately 250 x *g* for 1 minute at 4°C to room temperature) to spin down the reaction mixture.

7. Place the plate into the instrument.
8. Run the PCR with cycling conditions described in Table 3:

Table 3. Cycling program for maize MON 89034 and *hmg* systems

Step	Stage	T°C	Time (sec)	Acquisition	Cycles	
1	UNG	50°C	120	No	1	
2	Initial denaturation	95°C	600	No	1	
3	Amplification	Denaturation	95°C	15	No	45
		Annealing & Extension	60°C	60	Yes	

3.3 Data analysis

Subsequent to the real-time PCR, analyse the run following the procedure below:

- a) set the threshold: display the amplification curves of one system (e.g. MON 89034) in logarithmic mode. Locate the threshold line in the area where the amplification profiles are parallel (exponential phase of PCR) and where there is no “fork effect” between repetitions of the same sample. Press the “update” button to ensure changes affect Ct values. Switch to the linear view mode by clicking on the Y axis of the amplification plot, and check that the threshold previously set falls within the geometric phase of the curves.
- b) Set the baseline: determine the cycle number at which the threshold line crosses the first amplification curve and set the baseline three cycles before that value (e.g. earliest Ct = 25, set the baseline crossing at Ct = 25 – 3 = 22).
- c) Save the settings.
- d) Repeat the procedure described in a) and b) on the amplification plots of the other system (e.g. *hmg* system).
- e) Save the settings and export all the data to a text file for further calculations.

3.4 Calculation of results

After having defined a threshold value within the logarithmic phase of amplification as described above, the instrument’s software calculates the Ct values for each reaction.

The standard curves are generated both for the *hmg* and the MON 89034 specific systems by plotting the Ct values measured for the calibration points against the logarithm of the DNA copy numbers and by fitting a linear regression line into these data.

Thereafter, the standard curves are used to estimate the copy numbers in the unknown sample DNA.

For the determination of the amount of MON 89034 maize DNA in the unknown sample, the copy number of the GMO is divided by the copy number of the maize reference gene (*hmg*) and multiplied by 100 to obtain the percentage value ($GM\% = \text{MON 89034}/hmg \times 100$).

4. Materials

4.1 Equipment

- Real-time PCR instrument for plastic reaction vessels (glass capillaries are not recommended for the described buffer composition)
- Plastic reaction vessels suitable for real-time PCR instrument (enabling undisturbed fluorescence detection)
- Software for run analysis (mostly integrated in the software of the real-time PCR instrument)
- Microcentrifuge
- Micropipettes
- Vortex
- Rack for reaction tubes
- 1.5/2.0 mL reaction tubes

4.2 Reagents

- TaqMan® 2X PCR Master Mix, Applied Biosystems Part No 4304437
- TaqMan® 1000X Rxn Gold/Buffer A Pack (10x) Applied Biosystems Part No 4304441

4.3 Primers and Probes

Name	Oligonucleotide DNA Sequence (5' to 3')
MON 89034 target sequence	
MON 89034 primer 1	5' – TTC TCC ATA TTG ACC ATC ATA CTC ATT – 3'
MON 89034 primer 2	5' – CGG TAT CTA TAA TAC CGT GGT TTT TAA A – 3'
MON 89034 (Probe)	6-FAM 5' – ATC CCC GGA AAT TAT GTT – 3' MGBNFQ
Reference gene <i>hmg</i> target sequence	
<i>hmg</i> primer 1	5' – TTG GAC TAG AAA TCT CGT GCT GA – 3'
<i>hmg</i> primer 2	5' – GCT ACA TAG GGA GCC TTG TCC T – 3'
<i>hmg</i> (Probe)	6-FAM 5' – CAA TCC ACA CAA ACG CAC GCG TA – 3' TAMRA



Report on the Validation of a DNA Extraction Method for Maize Seeds and Grains

13 October 2008

**Joint Research Centre
Institute for Health and Consumer Protection
Biotechnology & GMOs Unit**

Method development:

Monsanto Company

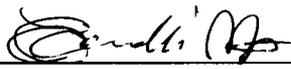
Method testing and single laboratory validation:

Community Reference Laboratory for GM Food and Feed (CRL-GMFF)
Biotechnology & GMOs Unit

Drafted by:
C. Savini



Report Verification Team:
1) M. Ermolli



2) M. Querci



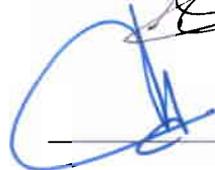
Scientific and technical approval:
M. Mazzara



Compliance with CRL Quality System:
S. Cordeil



Authorisation to publish:
G. Van den Eede



Address of contact laboratory:

European Commission, Joint Research Centre
Institute for Health and Consumer Protection (IHCP)
Biotechnology and GMOs Unit – Community Reference Laboratory for GM Food and Feed
Via Fermi 2749, 21027 Ispra (VA) - Italy

Content

1. INTRODUCTION.....	4
2. MATERIALS (EQUIPMENT/CHEMICALS/PLASTIC WARE).....	4
2.1. EQUIPMENT	4
2.2. CHEMICALS.....	4
2.3. SOLUTIONS.....	5
2.4. PLASTICWARE.....	5
2.5. PRECAUTIONS.....	5
2.6 ABBREVIATIONS:	6
3. DESCRIPTION OF THE METHODS.....	6
3.1 SAMPLING	6
3.2 SCOPE AND APPLICABILITY	6
3.3 PRINCIPLE	6
3.4 TISSUES CRUSHING PROCEDURE.....	6
3.5 EXTRACTION OF GENOMIC DNA FROM MAIZE SEEDS/GRAINS	7
4. TESTING OF THE DNA EXTRACTION METHOD BY THE COMMUNITY REFERENCE LABORATORY FOR GM FOOD AND FEED	8
4.1 PREPARATION OF SAMPLES	8
4.2 DNA EXTRACTION	8
4.3 DNA CONCENTRATION, YIELD AND REPEATABILITY	9
4.4 FRAGMENTATION STATE OF DNA	10
4.5 PURITY / ABSENCE OF PCR INHIBITORS.....	10
5. CONCLUSION.....	12
6. QUALITY ASSURANCE.....	13
7. REFERENCES.....	13

1. Introduction

This report describes the validation of a DNA extraction protocol to extract high quality genomic DNA from processed plant tissue (e.g., leaf, grain, or seed) and its applicability on the samples of food and feed provided by the applicant. This protocol can be used for the extraction of DNA from maize seeds and grains. It is a modified extraction method from Rogers and Bendich (1985)¹.

The purpose of the DNA extraction method described is to provide DNA with purity suitable for real-time PCR based detection methods.

This protocol is recommended to be executed by skilled laboratory personnel since hazardous chemicals and materials are exploited at some steps. It is strongly advised to take particular notice of all product safety recommendations and guidelines.

2. Materials (Equipment/Chemicals/Plastic ware)

2.1. Equipment

The following equipment is used in the DNA extraction procedure described (equivalents may be used):

1. Centrifuge (Beckman Coulter Avanti J-251)
2. Shaker (LabLine Enviro 3527)
3. Thermometer (VWR Cat. No. 61222-504)
4. Vacufuge (Eppendorf 5301 22 82 010-9)
5. Water bath (Precision Cat. No. 51220046)
6. Microcentrifuge (Any appropriate model)

2.2. Chemicals

The following chemicals are used in the DNA extraction procedure described (equivalents may be used):

1. 24:1 chloroform:isoamyl alcohol (Sigma Cat. No. C-0549)
2. 25:24:1 phenol:chloroform:isoamyl alcohol (Sigma Cat. No. P-3803)
3. Ammonium acetate 7.5 M (Sigma Cat. No. A-2706)
4. CTAB (Sigma Cat. No. H-6269)
5. 0.5 M EDTA, pH 8.0 (GibcoBRL Cat. no. 15575-038)
6. 100% ethanol (AAPER)
7. NaCl (Sigma Cat. No. S-5150)

8. 2-mercaptoethanol (Bio-Rad Cat. no. 161-0710)
9. RNase A (Roche Cat. No. 10 109 196 001)
10. Isopropanol (EM Science Cat. No. PX1835-9)
11. 1 M Tris HCl pH 8.0 (Sigma Cat. No. T-3038)
12. Proteinase K (Roche Cat. No. 03 115 836 001)
13. Polyethylene Glycol (MW 8000) (Sigma Cat. No. P2139)

2.3. Solutions

The following buffers and solutions are used in the DNA extraction procedure described:

- 1. CTAB Extraction Buffer (2%) (store at room temperature)**
 - 2% w/v CTAB
 - 100 mM Tris HCl pH 8.0
 - 20 mM EDTA pH 8.0
 - 1.4 M NaCl
- 2. Tris-EDTA buffer (TE 1X) (store at room temperature)**
 - 10 mM Tris HCl pH 8.0
 - 1 mM EDTA pH 8.0
- 3. Proteinase K (10 mg/mL) (store at -20 °C)**
- 4. RNase A (10 mg/mL) (store at -20 °C)**
- 5. PEG Precipitation Buffer (20% w/v) (store at room temperature)**
- 6. Ethanol (70% v/v) (store at room temperature)**
- 7. Ethanol (80% v/v) (store at room temperature)**

2.4. Plasticware

1. 50 mL conical tubes (Corning Cat. No. 430290)
2. 13 mL Sarstedt tubes (Sarstedt Cat. No. 60.540)
3. 1.5 mL microcentrifuge tubes
4. filter tips

Note: All plasticware has to be sterile and free of DNases, RNases and nucleic acids.

2.5. Precautions

- Phenol, chloroform, isoamyl alcohol, and isopropanol are hazardous chemicals;

therefore, all manipulations have to be performed according to safety guidelines, under fume hood.

- It is recommended to use clean containers for Waring blenders for grinding the seed bulk samples.
- All tubes and pipette tips have to be discarded as biological hazardous material.

2.6. Abbreviations

EDTA	ethylenediaminetetraacetic acid
PCR	polymerase chain reaction
RNase A	ribonuclease A
TE	Tris EDTA
Tris	Tris(hydroxymethyl)aminomethane

3. Description of the methods

3.1. Sampling

For sampling methods, it is referred to the technical guidance documents and protocols described in Commission Recommendation 2004/787/EC on technical guidance for sampling and detection of genetically modified organisms and material produced from genetically modified organisms as or in products in the context of Regulation (EC) N. 1830/2003.

3.2. Scope and applicability

The method for DNA extraction described below is suitable for the isolation of genomic DNA from a wide variety of maize tissues and derived matrices. However, validation data presented here are restricted to ground maize seeds and grains. Application of the method to other matrices may require adaptation and possible further specific validation.

3.3. Principle

The basic principle of the DNA extraction consists of first releasing the DNA present in the matrix into aqueous solution and further purifying the DNA from PCR inhibitors. The present method starts with a lysis step (thermal lysis in the presence of Tris HCl, EDTA, CTAB and β -mercaptoethanol) followed by removal of contaminants such as lipophilic molecules and proteins by extraction with phenol and chloroform.

A DNA precipitate is then generated by using isopropanol. The pellet is dissolved in TE buffer. Remaining inhibitors are removed by PEG precipitation and re-suspension in TE buffer.

3.4. Samples grinding procedure

Samples should be processed prior to extraction procedure. Possible methods of processing include a mortar and pestle with liquid nitrogen (leaf) or commercial blender (grain or seed).

3.5 Extraction of genomic DNA from maize seeds/grains

1. Weight out 6 g of processed tissue into a 50 mL conical tube appropriate for centrifugation. Note: For unprocessed tissue, weighing may occur prior to processing as long as entire processed sample is transferred to the conical tube.
2. For each 6 g sample add 25 mL of a solution consisting of 24.25 mL, pre-warmed CTAB extraction buffer, 0.5 mL 2- β -mercaptoethanol (2-ME), and 0.25 mL of 10 mg/mL proteinase K for a final concentration of 2% (2-ME) and 100 μ g/mL (proteinase K).
3. Mix the tube vigorously by inversion for 45-60 seconds.
4. Incubate for 60 minutes at 55 °C and mix the tube vigorously for 40-60 seconds every 20 minutes. Cool the tube on bench for 10 minutes.
5. Add 20 mL of phenol:chloroform:isoamyl alcohol (PCI 25:24:1, pH 6.7). Cap the tube and mix vigorously by inversion at least for 1 minute.
6. Centrifuge for 10 minutes at 13000 x g at room temperature to separate the aqueous and organic phases. Transfer upper aqueous phase to a clean 50 mL conical tube.
7. Repeat extraction twice for a total of three extractions (step 5-6).
8. Transfer upper aqueous phase to a new tube, add 2/3 volume of -20 °C isopropanol and gently mix the tube by inversion.
9. To precipitate the DNA place the tube at -20 °C for 30 minutes. (DNA may be stored as isopropanol precipitate at -20 °C for up to 1 year).
10. To pellet the DNA, centrifuge the tubes at approximately 13000 x g for 20 minutes at 4 °C. Pour off isopropanol by pipette, and then perform a quick spin in the centrifuge to bring down the isopropanol from the side of the tube. Remove remaining isopropanol by pipette and ensure all residual isopropanol is removed before proceeding to the next step without over drying the pellet.
11. Re-dissolve the pellet in 4 mL of TE pH 8.0. Note: it may be necessary to incubate the tube at 60°C to resuspend the pellet.
12. Transfer the resuspended pellet to a 13-mL tube, add 40 μ L of 10 mg/mL RNase and then incubate at 37°C for 30 minutes.
13. To extract the DNA, add 4 mL of chloroform:isoamyl alcohol (CIA 24:1), mix vigorously by inversion for 40-60 seconds and centrifuge for 10 minutes at 13000 x g at room temperature. Transfer the upper aqueous phase to a clean tube.
14. Repeat step 13 an additional time, then add half volume of 7.5 M ammonium acetate, gently mix by inversion and add 2 volumes of 100% ethanol. Mix by inversion and place at -20°C for 30 minutes. DNA may be stored as ethanol precipitate at -20 °C for up to 1 year.
15. Centrifuge at 13000 x g for 20 minutes at 4°C to pellet the DNA.
16. Rinse the DNA pellet twice with 10 mL of 70 % ethanol loosening the pellet from the side of the tube and remove residual ethanol by vacuum.
17. Re-suspend DNA in 1 mL TE, pH 8.0 and incubate at 65°C for at least 1 hour with periodic gentle mixing.
18. Centrifuge the DNA solution at 16000 x g for 10 minutes at 4°C. Transfer the aqueous portion to a clean tube without disturbing the pellet and store at 4°C.

19. Add equal volume of 20% PEG precipitation buffer (~1 mL) to the extracted DNA solution. Mix well by inversion.
20. Incubate the PEG/DNA mixture for 15 minutes at 37 °C.
21. Centrifuge the PEG/DNA mixture for 15 minutes at 15000 x g at room temperature.
22. Pour off supernatant. Wash the walls of the tube and DNA pellet with 1 mL of 80% ethanol loosening the pellet from the tube. Carefully pour off ethanol, centrifuge briefly and remove by pipetting any residual ethanol.
23. Repeat wash (step 22) for a total of two washes.
24. Completely dry any residual ethanol by vacufuge at low heat.
25. Re-suspend the pellet in 1 mL TE or H₂O. If necessary, incubate the sample at 60°C to dissolve the pellet.
26. Centrifuge the re-suspended DNA solution at 15000 x g for 15 minutes.
27. Transfer DNA solution to a clean tube without disturbing the pellet and store DNA at 4°C.

4. Testing of the DNA extraction method by the Community Reference Laboratory for GM Food and Feed

The aim of the experimental testing was to verify that the DNA extraction method provides DNA of suitable quantity and quality for the intended purpose. The DNA extraction method should allow preparation of the analyte in quality and quantity appropriate for the analytical method used to quantify the event-specific analyte versus the reference analyte.

The CRL-GMFF tested the method proposed by the applicant on samples of food and feed consisting of ground maize seeds provided by the applicant.

To assess the suitability of the DNA extraction method for real-time PCR analysis, the extracted DNA was tested using a qualitative PCR run on the real-time PCR equipment.

4.1. Preparation of samples

About 200 g of maize seed material were ground using a GRINDOMIX GM 200 (Retsch GmbH) mixer.

4.2. DNA extraction

DNA was extracted following the method described above (see paragraph 3. "Description of the methods"); the DNA extraction was carried out on 6 test portions (replicates) and repeated over three different days, giving a total of 18 DNA extractions.

4.3. DNA concentration, yield and repeatability

Concentration of the DNA extracted was determined by fluorescence detection using the PicoGreen dsDNA Quantitation Kit (Molecular Probes).

Each DNA extract was measured twice, and the two values were averaged. DNA concentration was determined on the basis of a five point standard curve ranging from 1 to 500 ng/ μ L using a Biorad VersaFluor fluorometer.

The DNA concentration for all samples is reported in the Table 1 below.

Table 1. DNA concentration (ng/ μ L) of eighteen samples extracted in three days: yellow boxes for samples extracted on day 1, green boxes for samples extracted on day 2 and blue boxes for samples extracted on day 3.

Sample	Concentration (ng/ μ L)
1	147.2
2	229.0
3	579.8
4	352.1
5	551.1
6	504.9
1	277.5
2	468.7
3	473.4
4	424.6
5	258.0
6	517.5
1	526.7
2	463.1
3	531.5
4	594.8
5	537.8
6	545.4

✓ DNA concentration (ng/ μ L)

Overall average	443.5 ng/ μ L
Standard deviation	133 ng/ μ L
Coefficient of variation	30%

✓ Yield (total volume of DNA solution: 1 mL)

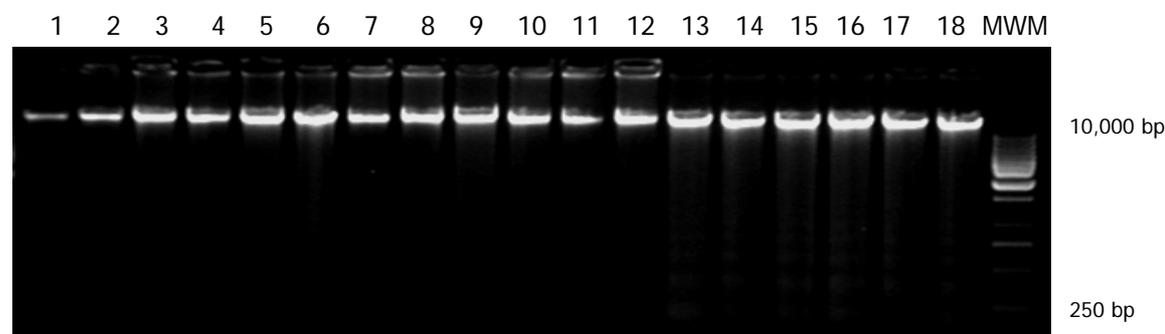
Overall average	443.5 μ g
Standard deviation	133 μ g
Coefficient of variation	30%

4.4. Fragmentation of DNA

The size of the extracted DNA was evaluated by agarose gel electrophoresis; 1 μ L of the DNA solution were analysed on a 1.0% agarose gel (Figure 1).

The eighteen genomic DNA samples extracted as described above appeared as distinct fluorescent banding patterns migrating through the gel corresponding to high molecular weight DNA. None of the DNA samples showed indications of significant degradation ('smearing').

Figure 1. Agarose gel electrophoresis of eighteen genomic DNA samples extracted from maize seeds. Lanes 1-6: samples extracted on day 1; lanes 7-12 samples extracted on day 2; lanes 13-18 samples extracted on day 3; lane 19: 1 kb DNA molecular weight marker (MWM).



4.5. Purity/Absence of PCR inhibitors

In order to assess the purity and to confirm the absence of PCR inhibitors, the extracted DNA solutions were adjusted to a concentration of 50 ng/ μ L (hereafter referred as "undiluted" samples).

Subsequently fourfold serial dilutions of each extract were prepared with 0.2x TE buffer (1:4, 1:16, 1:64, 1:256) and analysed using a real-time PCR system detecting the target sequence of the maize endogenous control gene, *hmg* (*high mobility group*). The Ct values obtained for "undiluted" and diluted DNA samples are reported in the Table 2.

Table 2. Ct values of undiluted and fourfold serially diluted DNA extracts after amplification of the maize endogenous gene, *hmg*. Yellow boxes for samples extracted on day 1, green boxes for samples extracted on day 2 and blue boxes for samples extracted on day 3.

DNA extract	Undiluted (50 ng/ μ L)	Diluted			
		1:4	1:16	1:64	1:256
1	23.88	25.64	27.65	29.44	31.43
2	23.56	25.70	27.59	29.26	31.38
3	23.53	25.46	27.71	29.68	31.52
4	23.89	25.56	27.43	29.75	31.49
5	24.10	25.78	27.59	29.06	31.43
6	23.89	25.74	27.52	29.18	31.70
1	23.72	25.30	27.35	28.97	31.08
2	23.51	25.82	27.73	29.48	31.51
3	23.61	25.37	27.99	29.87	31.78
4	23.55	25.26	27.20	29.52	31.55
5	23.77	25.67	27.51	29.37	31.93
6	23.41	25.86	27.31	29.24	31.23
1	23.49	25.09	27.62	29.71	31.72
2	23.79	25.95	27.90	29.76	31.77
3	23.71	25.47	27.73	29.50	31.47
4	23.73	25.44	27.45	29.92	31.81
5	23.88	25.64	27.42	29.23	31.75
6	23.58	25.89	27.96	30.12	32.03

Table 3 below reports the comparison of extrapolated Ct values versus measured Ct values for all samples and the values of linearity (R^2) and slope of all measurements.

To measure inhibition, the Ct values of the four diluted samples were plotted against the logarithm of the dilution and the Ct value for the “undiluted” sample (50 ng/ μ L) was extrapolated from the equation calculated by linear regression.

Subsequently the extrapolated Ct for the “undiluted” sample was compared with the measured Ct. The evaluation is carried out considering that PCR inhibitors are present if the measured Ct value for the “undiluted” sample is > 0.5 cycles compared the calculated Ct value ($\Delta Ct > 0.5$). In addition, the slope of the curve should be between -3.6 and -3.1.

Table 3. Comparison of extrapolated Ct values versus measured Ct values (amplification of maize *hmg* gene).

DNA extraction	R ²	Slope*	Ct extrapolated	mean Ct measured	ΔCt**
1	0.998	-3.18	23.75	23.88	0.13
2	0.995	-3.11	23.79	23.56	0.23
3	0.997	-3.35	23.55	23.53	0.03
4	0.996	-3.34	23.53	23.89	0.36
5	0.987	-3.10	23.76	24.10	0.33
6	0.989	-3.25	23.64	23.89	0.24
1	0.997	-3.149	23.43	23.72	0.28
2	0.999	-3.127	23.93	23.51	0.42
3	0.992	-3.507	23.47	23.61	0.13
4	0.997	-3.516	23.09	23.55	0.46
5	0.991	-3.427	23.46	23.77	0.31
6	0.995	-2.995	23.90	23.41	0.49
1	0.995	-3.598	23.15	23.49	0.35
2	0.999	-3.212	24.01	23.79	0.22
3	0.996	-3.278	23.61	23.71	0.10
4	0.996	-3.582	23.26	23.73	0.46
5	0.991	-3.345	23.47	23.88	0.41
6	0.998	-3.412	23.87	23.58	0.28

Note: In yellow boxes samples from 1 to 6 extracted on day 1; in green boxes samples from 1-6 extracted on day 2; in blue boxes samples from 1-6 extracted on day 3.

*The expected slope for a PCR with 100% efficiency is -3.32

**delta Ct = abs (Ct extrapolated - Ct measured)

All ΔCt values of extrapolated versus measured Ct are < 0.5.

R² of linear regression is > 0.99 for all DNA samples except two samples extracted on day 1: the sample 5 (0.987) and the sample number 6 (0.989). The slopes of the curve are all between -3.1 and -3.6, with one exception: the sample number 6 extracted on day 2, with a value of -2.995.

5. Conclusion

The data reported confirm that the extraction method, applied to samples of food and feed provided by the applicant, produces DNA of suitable quantity and quality for subsequent PCR based detection applications.

The method is consequently applicable to samples of maize seeds provided as samples of food and feed in accordance with the requirements of Annex I-2.C.2 to Commission Regulation (EC) No 641/2004.

6. Quality assurance

The CRL-GMFF carries out all operations according to ISO 9001:2000 (certificate number: CH-32232) and ISO 17025:2005 (certificate number: DAC-PL-0459-06-00) [DNA extraction, qualitative and quantitative PCR in the area of Biology (DNA extraction and PCR method validation for the detection and identification of GMOs in food and feed materials)]

7. References

1. Rogers S., Bendich A., 1985. Extraction of DNA from milligram amounts of fresh, herbarium and mummified plant tissues. *Plant Molecular Biology*, 69-76.
2. Sambrook J. and Russell D. W., 2001. *Molecular Cloning. A laboratory manual*. Third edition. Cold Spring Harbor Laboratory Press.

European Commission

EUR 23700 EN – Joint Research Centre – Institute for Health and Consumer Protection

Title: Event-specific Method for the Quantification of Maize Line MON 89034 Using Real-time PCR. Validation Report and Protocol

Author(s): C. Savini, A. Bogni, E. Grazioli, B. Munaro, M. Mazzara, G. Van den Eede

Luxembourg: Office for Official Publications of the European Communities

2008 – 39 pp. – 21 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1018-5593

ISBN 978-92-79-11166-2

DOI 10.2788/68713

Abstract

The JRC as Community Reference Laboratory for GM Food and Feed (CRL-GMFF), established by Regulation (EC) No 1829/2003, in collaboration with the European Network of GMO Laboratories (ENGL), has carried out a collaborative study to assess the performance of a quantitative event-specific method to detect and quantify the MON 89034 transformation event in maize DNA (unique identifier MON-89034-3). The collaborative trial was conducted according to internationally accepted guidelines.

In accordance with Regulation (EC) No 1829/2003 of 22 September 2003 on genetically modified food and feed and with Regulation (EC) No 641/2004 of 6 April 2004 on detailed rules for the implementation of Regulation (EC) No 1829/2003, Monsanto provided the detection method and the samples (genomic DNA extracted from conventional seeds and from 100% maize containing the event MON 89034). The JRC prepared the validation samples (calibration samples and blind samples at unknown GM percentage [DNA/DNA]). The collaborative trial involved twelve laboratories from nine European countries.

The results of the international collaborative trial met the ENGL performance requirements. The method is therefore considered applicable to the control samples provided, in accordance with the requirements of Annex I-2.C.2 to Commission Regulation (EC) No 641/2004.

How to obtain EU publications

Our priced publications are available from EU Bookshop (<http://bookshop.europa.eu>), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

