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European Union Reference laboratory
for Foodborne Viruses

Standard Operating Procedure

for

Qualitative detection of norovirus and hepatitis A virus in soft fruit

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1	2018-11-05	Based on the generic protocol issue 3 by date 25/08/15 produced at the European Union Reference Laboratory for monitoring bacteriological and viral contamination of bivalve molluscs at The Centre for Environment, Fisheries & Aquaculture Science, Weymouth Laboratory

1.0 Introduction

Norovirus and hepatitis A virus (HAV) are important agents of food-borne human viral illness. One of the food types associated with transmission of norovirus and HAV is soft fruit such as raspberries and strawberries. No routine methods exist to culture these viruses from food matrices. Detection is therefore reliant on molecular methods using the reverse-transcriptase polymerase chain reaction (RT-PCR). As many food matrices contain substances that are inhibitory to RT-PCR, it is necessary to use a virus/RNA extraction method that produces highly clean RNA preparations that are fit-for-purpose. Virus extraction from soft fruit is done by elution with agitation followed by precipitation with PEG/NaCl. RNA is extracted using a method based on virus capsid disruption with chaotropic reagents followed by adsorption of RNA to silica particles. Real-time RT-PCR monitors amplification throughout the PCR cycle by measuring the excitation of fluorescently labelled molecules. In the 5'-fluorogenic nuclease-based real-time RT-PCR assay the fluorescent labels are attached to a sequence-specific nucleotide probe (hydrolysis probe) that also enables simultaneous confirmation of target template. These modifications increase the sensitivity and specificity of the PCR method, and obviate the need for additional amplification product confirmation steps post PCR. Due to the complexity of the method, it is necessary to include a comprehensive suite of controls. The method described in this document enables qualitative detection of virus RNA in the test sample.

Note: The laboratory protocol given here is based on Technical Specification CEN/ISO TS 15216-2:2013 with some modifications.

2.0 Scope

This procedure describes liberation, concentration and detection of norovirus genogroups I (GI) and II (GII) and HAV, from soft fruit (including raspberries and strawberries). Viral RNA extraction is by lysis with guanidine thiocyanate and adsorption to silica. Extracted viral RNA is amplified and detected by real-time RT-PCR. This part of the procedure describes a method for qualitative detection of virus RNA in the test sample.

3.0 Principle

3.1 Virus extraction

Viruses are eluted from soft fruit under alkaline conditions. Viruses are then concentrated by PEG/NaCl precipitation and finally the virus extract is cleaned using chloroform:butanol. Details of addition of a spike process control (mengo virus) to the test samples are also described.

3.2 RNA extraction

It is necessary to extract RNA using a method that yields clean RNA preparations to reduce the effect of PCR inhibitors. In this protocol, the chaotropic agent guanidine thiocyanate is used to disrupt the viral capsid. RNA is then adsorbed to silica to assist purification through several washing steps. Purified viral RNA is released from the silica into a buffer prior to real-time RT-PCR.

3.3 Real-time reverse transcription polymerase chain reaction (real time RT-PCR)

This protocol uses one-step real-time RT-PCR using hydrolysis probes. In one-step real-time RT-PCR, reverse transcription and PCR amplification are carried out consecutively in the same tube. TaqMan® PCR utilises a short DNA probe with a fluorescent label and a fluorescence quencher attached at opposite ends.

The assay chemistry ensures that as the quantity of amplified product increases, the probe is broken down, and the fluorescent signal from the label increases proportionately. Fluorescence is measured at each cycle throughout the run. An increase of fluorescence above a threshold level is indicative of the presence of target RNA in the test sample.

4.0 Safety precautions

Standard microbiology safety precautions should be applied throughout. Laboratories should perform a full risk assessment before performing this procedure.

5.0 Recommended equipment

- Micropipettes.
- Micropipette tips of a range of sizes, 1000 µl, 200 µl, 20 µl and 5 µl.
- Pipettes of a range of sizes, 25 ml, 10 ml.
- Vortex mixer.
- Thermoshaker operating at 60 °C and 1400 rpm or equivalent.
- Aspirator or equivalent apparatus for removing supernatant.
- Mesh filter bags that can be fitted into a 250 ml beaker
- pH meter.
- Rocking platform(s) or equivalent for use at room temperature and 4°C at 60rpm.
- **Centrifuge(s) and rotor(s)** capable of the following run speeds, run temperatures, and rotor capacities:
 - 10 000 × *g* at (5 ± 3) °C with capacity for tubes of at least 35 ml volume;
 - 10 000 × *g* at (5 ± 3) °C with capacity for chloroform-resistant tubes with 2 ml volume;
- Centrifuge tubes/bottles of a range of sizes, 1.5 ml, 15 ml, 50 ml etc. narrow gauge (15 mm is too large) chloroform resistant tubes with 2 ml capacity are necessary.
- RNA extraction equipment suitable for extraction using guanidine thiocyanate disruption and silica adsorption-based method.
- If miniMAG/easyMAG extraction system is used; 1.5 ml tubes with screw caps suitable for this system.
- PCR machine with real-time capacity capable of supporting TaqMan[®] chemistry.
- Consumables for real-time PCR, e.g. optical plates and caps.

6.0 Reagents

6.1 Reagents used as purchased

- Polyethylene Glycol (PEG), MW 8000
- Sodium chloride (NaCl)
- Potassium chloride (KCl)
- Disodium hydrogen phosphate (Na_2HPO_4)
- Potassium dihydrogen phosphate (KH_2PO_4)
- Tris base
- Glycine
- Beef extract powder
- Pectinase from *Aspergillus niger* or *Aspergillus aculeatus*
- Chloroform
- Butanol
- Sodium hydroxide (NaOH)
- Hydrochloric acid (HCl)
- If NucliSens system is used; magnetic extraction reagents. **BioMerieux**.
See <http://www.biomerieux.com/>
- If NucliSens system is used; lysis buffer. **BioMerieux**.
See <http://www.biomerieux.com/> for information.
- RNA UltraSense™ One-Step Quantitative RT-PCR System. Applied Biosystems™.
- Nuclease free water.

6.2 Prepared solutions/buffers

Note: Taqman® PCR buffers must be prepared no more than 24 hours before use. Short-term storage (<24 hours) at 2-6 °C is appropriate. Always prepare enough buffer for at least one reaction more than required (for larger preparations a greater number of excess reactions may be necessary).

- **5x PEG/NaCl solution (50% (w/v) PEG 8000, 1.5M NaCl)**
Add 500g PEG 8000, 87g NaCl and 450ml molecular grade water to a bottle. Mix with gentle shaking/stirring, heating gently if necessary, until the solids are dissolved then adjust the volume to 1000ml. Sterilise by autoclaving.
- **Chloroform:Butanol**
Add together equal volumes of chloroform and butanol. Shake to mix.
- **Phosphate buffered saline (PBS)**
Add 8 g NaCl, 0.2 g KCl, 1.15 g Na_2HPO_4 , 0.2g KH_2PO_4 and 1000 ml molecular grade water to a bottle. Mix with stirring until the solids are dissolved. Sterilise by autoclaving. Adjust the pH to 7.3. Alternatively use PBS from a commercial source.
- **Tris glycine 1% beef extract (TGBE) buffer**
Add 12.1 g Tris base, 3.8 g glycine, 10 g beef extract powder and 1000 ml molecular grade water to a bottle. Mix with stirring until the solids are dissolved. Adjust the pH to 9.5. Sterilise by autoclaving.

- **Norovirus GI Taqman[®] PCR buffer**

Add the following reagents to a 1.5 ml microcentrifuge tube

5 µl/reaction	RNA Ultrasense 5X Reaction Mix (from RNA Ultrasense One-step qRT-PCR system)
1.25 µl/reaction	RNA Ultrasense Enzyme Mix (from Ultrasense system)
12.5 pmol/reaction	QNIF4 (FWD) primer
22.5 pmol/reaction	NV1LCR (REV) primer
6.25 pmol/reaction	NVGG1p or TM9 probe (see Appendix 1 for sequences)

Add nuclease free water to a total volume of 20 µl/reaction and mix by vortexing.

- **Norovirus GII Taqman[®] PCR buffer**

Add the following reagents to a 1.5 ml microcentrifuge tube

5 µl/reaction	RNA Ultrasense 5X Reaction Mix (from RNA Ultrasense One-step qRT-PCR system)
1.25 µl/reaction	RNA Ultrasense Enzyme Mix (from Ultrasense system)
12.5 pmol/reaction	QNIF2 (FWD) primer
22.5 pmol/reaction	COG2R (REV) primer
6.25 pmol/reaction	QNIFS probe (see Appendix 1 for sequences)

Add nuclease free water to a total volume of 20µl/reaction and mix by vortexing.

- **Hepatitis A virus Taqman[®] PCR buffer**

Add the following reagents to a 1.5ml microcentrifuge tube

5 µl/reaction	RNA Ultrasense 5X Reaction Mix (from RNA Ultrasense One-step qRT-PCR system)
1.25 µl/reaction	RNA Ultrasense Enzyme Mix (from Ultrasense system)
12.5 pmol/reaction	HAV68 (FWD) primer
22.5 pmol/reaction	HAV240 (REV) primer
6.25 pmol/reaction	HAV150 (-) probe (see Appendix 1 for sequences)

Add nuclease free water to a total volume of 20µl/reaction and mix by vortexing.

- **Mengo virus Taqman[®] PCR buffer**

Add the following reagents to a 1.5 ml microcentrifuge tube

5 µl/reaction	RNA Ultrasense 5X Reaction Mix (from RNA Ultrasense One-step qRT-PCR system)
1.25 µl/reaction	RNA Ultrasense Enzyme Mix (from Ultrasense system)
12.5 pmol/reaction	Mengo 110 (FWD) primer
22.5 pmol/reaction	Mengo 209 (REV) primer
6.25 pmol/reaction	Mengo 147 probe (see Appendix 1 for sequences)

Add nuclease free water to a total volume of 20µl/reaction and mix by vortexing.

6.3 Control materials

- **Mengo virus process control material**

Note: for preparation of this control material laboratories will require cell culture facilities including incubator(s), preferably with controllable CO₂ levels, cell culture consumables (flasks etc.) and media.

Mengo virus¹ should best be grown in a 5% CO₂ atmosphere (with open vessels) or an uncontrolled atmosphere (closed vessels) on 80-90% confluent monolayers of HeLa cells (ATCC CCL-2). Recommended cell culture medium for this cell line is

Eagle's minimum essential medium with

2 mM L-glutamine

Earle's BSS, adjusted to

1.5 g/l sodium bicarbonate

0.1mM non-essential amino acids

1.0 mM sodium pyruvate

1% streptomycin/penicillin

10% (growth) or 2 % (maintenance) foetal bovine serum

Alternatively virus can be grown on FRhK-4 cells (ATCC CRL-1688). Recommended cell culture medium for this cell line is

Dulbecco's modified Eagle's medium with

4 mM L-glutamine, adjusted to

1.5 g/l sodium bicarbonate

4.5 g/l glucose

1% streptomycin/penicillin

10% (growth) or 2% (maintenance) foetal bovine serum

¹ Mengo virus strain MC₀ is recommended. It is a genetically modified organism (GMO). MC₀ has the same growth properties as wild type but has an avirulent phenotype. In laboratories where use of GMO is prohibited or problematic, a different process control virus should be used.

To prepare mengo virus for process control, freeze and thaw a culture flask in which at least 75% cytopathic effect (CPE) has been reached, centrifuge flask contents at 3000 x g for 10min to clarify and retain supernatant. Dilute by a minimum factor of 10x in sample buffer, e.g. PBS, split into single use aliquots and store frozen at -70 °C. This dilution must allow for inhibition-free detection of the process control virus genome using real-time RT-PCR but still be sufficiently concentrated to allow reproducible determination of the lowest dilution used for the process control virus RNA standard curve.

- **External control RNA (EC RNA)**

Note: for preparation of these control materials laboratories will require capabilities for transformation and growth in solid and liquid media of *E. coli*, capabilities or kits for plasmid preparation, purification of DNA from reaction mixes (in addition to the listed products) and a spectrophotometer capable of measuring at 260nm or a fluorometer (for instance Qubit® 3.0 Fluorometer with a Qubit® dsDNA HS kit, Thermo Fisher Scientific, Waltham, United States).

Control plasmids used in the development of ISO/TS 15216-2 were developed by Prof. Albert Bosch (HAV; Costafreda et al., 2006) and Dr. Soizick LeGuyader (norovirus; Le Guyader et al., 2009). For HAV, control plasmid was constructed by ligating the target DNA sequence into the pGEM-3Zf(+) vector (Promega) at a *HincII* restriction site such that the target sequence was downstream of a promoter sequence for the SP6 RNA polymerase. GI and GII control plasmids were separately constructed by ligating the target DNA sequence into the pGEM-3Zf(+) vector at a *SmaI* restriction site such that in each case the target sequence was downstream of a promoter sequence for the T7 RNA polymerase.

Sofia Persson constructed control Plasmids that can be provided by the EURL. All plasmids contain synthesised target sequences with an upstream T7 promoter sequence and a downstream *HindIII* restriction site cloned into a pEX-A2 vector (Eurofins Genomics, Ebersberg, Germany).

- Inserted target sequence for HAV control plasmid corresponds to nucleotide 1 to 542 of the HAV genome (GeneBank accession number, NC001489) without any inserted *BamHI* restriction site.
- Inserted target sequence for norovirus GI control plasmid corresponds to nucleotide 5209-5454 of the Norwalk virus genome (GenBank accession number, M87661.2), with an inserted *BamHI* restriction site.
- Inserted target sequence for norovirus GII control plasmid corresponds to nucleotide 4935-5180 of the Lonsdale virus genome (GenBank accession number, X86557.1) with an inserted *BamHI* restriction site.

Alternatively, separate control plasmids for each target virus can be constructed by individual laboratories by ligating the target DNA sequence into a suitable plasmid vector such that the target sequence is downstream of a promoter sequence for RNA polymerase.

These plasmids should be transformed and maintained in, and purified from, *E. coli* cells using standard molecular and microbiology techniques. Following purification of plasmid by e.g. commercial miniprep, a small amount should be linearised using a suitable restriction enzyme (to enable linearization of the plasmid at a point shortly downstream of the target sequence) and buffers as recommended by the manufacturer of the enzyme.

For the plasmids used in the development of ISO/TS 15216-2, linearize using *EcoRI* enzyme (HAV EC RNA) or *XbaI* enzyme (norovirus GI and GII EC RNA). For

all plasmids used at the EURL linearize using HindIII enzyme. The reaction should then be cleaned up using e.g. a commercial PCR purification kit.

EC RNA should be transcribed from 1 µg of purified linearized plasmid DNA using an in-vitro RNA transcription reaction mix prepared as recommended by the manufacturer of the relevant RNA polymerase enzyme. Following incubation, digestion of the DNA template using RNase-free DNase should be carried out according to the manufacturer's protocol.

For the plasmids described in this document, EC RNA can be in vitro transcribed using the SP6/T7 Riboprobe combination system (**Promega**, see <http://www.promega.com/>. For information, cat no. P1460) as follows:

1. Add the following components at room temperature in the order listed:

5X transcription buffer	20 µl
100 mM DTT	10 µl
RNasin	2.5 µl
rATP,rGTP,rCTP,rUTP mix (2.5mM each)	20 µl
linearised template DNA (max 1µg/µl)	5 µl
T7 polymerase	3 µl
OR	
SP6 polymerase	3 µl
Nuclease free water	39.5 µl

Mix by pipetting

2. Incubate for 2 hours at 37 °C.
3. Add 5 µl RQ1 RNase-free DNase to the reaction.
4. Incubate for 15 mins at 37 °C.

Regardless of the method used for in vitro transcription, the RNA should then be purified using RNA purification reagents (e.g. **QIAGEN** RNeasy Mini Kit, see <http://www1.qiagen.com/>, using the manufacturer's RNA cleanup protocol) and eluting in 100µl RNase-free water.

The RNA preparation should be checked for freedom from significant contamination with DNA by assaying for target both with and without RT activity, for example by assaying with both TaqMan[®] mastermix where RT has been deactivated by heating at 95°C, and untreated mastermix. If levels of DNA contamination higher than 0.1% are found, the preparation should be subjected to further treatment(s) with DNase.

The concentration of RNA can then be calculated using spectral absorption at 260 nm or a fluorometer.

Multiplication of the A₂₆₀ value by 4x10⁻⁸ (and by any dilution factor involved) will give the concentration of RNA in g/µl. For fluorometer follow the instructions from the manufacturer.

Divide this number by the mass in g of a single EC RNA molecule to calculate the concentration of DNA in copies/µl (the mass of an individual RNA molecule can be calculated by multiplying the RNA length in ribonucleotides by 320.5 (the molecular weight of an average ribonucleotide) and dividing by the Avogadro constant (6.02 × 10²³) e.g. an RNA molecule of 200 ribonucleotides will have a mass of 1.06 × 10⁻¹⁹ g

Examples for masses of two of the RNA produced from plasmids described above:-

Norovirus GI ISO	$6.73 \times 10^{-20} \text{g}$	(126 b)
Norovirus GII EURL	$1.32 \times 10^{-19} \text{g}$	(246 b)

The preparation of RNA transcripts should then be diluted with a suitable buffer (e.g. TE buffer) to a concentration of approximately 1×10^4 - 1×10^5 transcripts/ μl , and frozen in single use aliquots.

NOTE: do not use water only to dilute RNA transcripts to working concentration.

7.0 Method

7.1 Virus extraction

Immediately before any batch of samples is processed, pool together sufficient aliquots of mengo virus process control material for use with all samples (allow 10 μl per sample plus 25 μl excess).

Retain a 20 μl subsample of pooled material for RNA extraction and preparation of the standard curve. Store at 4°C for a maximum of 24 hrs or at -20°C for longer periods.

Transfer 25 g of soft fruits to the sample compartment of a mesh filter bag. Large soft fruits should be coarsely chopped into pieces of approximately 2.5 cm \times 2.5 cm \times 2.5 cm (it is not recommended to chop if e.g. individual fruits are smaller than this).

Add 40 ml TGBE buffer with pectinase (30 units of pectinase from *Aspergillus niger*, or 1140 units of pectinase from *Aspergillus aculeatus*) and 10 μl of mengo virus process control virus material.

Incubate at room temperature with constant rocking at approximately 60rpm for 20 min. For acidic soft fruits, the pH of the eluate should be monitored at 10 min intervals during incubation. If the pH falls below 9.0 it should be adjusted to 9.5 with NaOH. Extend the period of incubation by 10 min for every time the pH is adjusted (do not make more than three such pH adjustments per sample). Decant the eluate from the filtered compartment into a centrifuge tube (use two tubes if necessary to accommodate volume).

Clarify by centrifugation at 10000 x g for 30 min at 4°C.

Decant the supernatant into a single clean tube/bottle and adjust the pH to 7.0 with HCl.

Add 0.25 volumes of 5 \times PEG/NaCl solution (to produce a final concentration of 10 % PEG 0.3M NaCl), homogenise by shaking for 60s then incubate with constant rocking at around 60 rpm at 5 °C for 60 min.

Centrifuge at 10000 x g for 30 min at 5 °C (split volume across two centrifuge tubes if necessary).

Decant and discard the supernatant, then centrifuge at 10000 x g for 5 min at 5 °C to compact pellet.

Discard the supernatant and resuspend pellet in 500 µl PBS. If a single sample has been split across two tubes resuspend both pellets stepwise in the same aliquot of PBS.

NOTE: for samples that produce large pellets after centrifugation, a larger volume of PBS up to 1000µl may be necessary in order to completely resuspend the pellet.

Transfer suspension to a narrow gauge chloroform resistant centrifuge tube. Add an equal volume (500-1000 µl) chloroform-butanol, vortex to mix, then incubate at room temperature for 5 min.

Centrifuge at 10000 x *g* for 15 min at 5 °C. Carefully transfer the aqueous phase to a fresh tube and retain for RNA extraction. Process immediately, or store at 4 °C for up to 48 hr. For long-term storage, a temperature of -20 °C is recommended.

It is recommended to run a negative process control (NPC) in parallel to the sample to measure for contamination.

7.2 RNA extraction

Note: for every set of samples a negative extraction control (NEC) consisting of 500µl water should be extracted in parallel unless a negative process control is not included.

Note: Below is the NucliSens protocol from bioMerieux described. If an equivalent method is used follow the manufacturer's instructions.

For each test sample, add 2 ml of NucliSens lysis buffer to a tube. Add the entire sample produced in 7.1 and mix by vortexing briefly.

In addition, for each batch of mengo virus process control material used with the samples under test, add 2 ml of NucliSens lysis buffer to a tube. Add 10 µl of process control material (retained in 7.1) and 500 µl of water and mix by vortexing briefly.

Incubate for 10 min at room temperature.

Add 50 µl of well-mixed magnetic silica solution to the tube and mix by vortexing briefly.

Incubate for 10 min at room temperature.

Centrifuge for 2 min at 1,500 x *g* then carefully discard supernatant by e.g. aspiration.

Add 400 µl wash buffer 1 and resuspend the pellet by pipetting/vortexing.

Transfer suspension to a 1.5 ml screw-cap tube. Wash for 30 sec using the automated wash steps of the miniMAG/easyMAG extraction systems or by vortexing. After washing allow silica to settle using magnet of the miniMAG/easyMAG extraction system. Discard supernatant by e.g. aspiration.

Separate tubes from magnet, then add 400 µl wash buffer 1. Resuspend pellet, wash for 30 sec, allow silica to settle using magnet then discard supernatant.

Separate tubes from magnet, then add 500 µl wash buffer 2. Resuspend pellet, wash for 30 sec, allow silica to settle using magnet then discard supernatant. Repeat.

Separate tubes from magnet, then add 500 µl wash buffer 3. Wash for 15 sec, allow silica to settle using magnet then discard supernatant.

Note: samples should not be left in wash buffer 3 for longer than strictly necessary

Add 100 µl elution buffer. Cap tubes and transfer to thermoshaker or equivalent.

Incubate for 5 min at 60 °C with shaking at 1400 rpm.

Place tubes in magnetic rack and allow silica to settle, then transfer eluate to a clean tube and retain at 4 °C for a maximum of 24 hrs or -20°C for longer periods (up to 6 months).

7.3 Inhibitor removal kit (not included in ISO 15216)

For samples suspected to be unclean and inhibitory, for instance raspberries being freeze thawed several times, an inhibitor removal kit can diminish inhibition. The EURL has experience of OneStep™ PCR Inhibitor Removal Kit (Zymo Research).

Follow the manufacturers' instructions.

7.4 TaqMan® analysis – general requirements

TaqMan® analysis for all targets need not be carried out on the same plate – however the following restrictions must be observed;

Full sets of target assay control reactions (EC RNA and water only) should be used for every plate where sample RNA is assayed for that target.

Full sets of mengo virus assay control reactions (RNA dilution series from all relevant batches of mengo virus process control material and water only) must be included on every plate where sample RNA is assayed for mengo virus.

Prepare TaqMan® mastermixes immediately before starting procedure.

7.5 TaqMan® plate set-up - analysis of target viruses

Note: this section describes plate set-up for a single target virus.

Before starting 96 well real-time PCR plate preparation, prepare 10⁻¹ dilutions of each sample RNA in nuclease free water.

For each sample and each target assay add 5 µl of undiluted and 10⁻¹ sample RNA to two wells of the plate each.

For each negative extraction control and each target assay add 5 µl of undiluted RNA to one well.

For each target assay, add 5 µl of nuclease-free water to two wells.

For each target assay add 1 µl of EC RNA to one well for each undiluted sample RNA, one well for each 10⁻¹ sample RNA and one well containing water only.

Add 20 µl of the relevant TaqMan® mastermix to each well.

7.6 TaqMan® plate set-up - analysis of mengo virus

For each batch of mengo virus process control material extracted (7.2) prepare 10^{-1} , 10^{-2} and 10^{-3} dilutions of mengo virus RNA in a suitable buffer (e.g. TE buffer).

Add 5 μ l of undiluted and 10^{-1} sample RNA to one well of the plate each.

For each negative extraction control add 5 μ l of undiluted RNA to one well.

For each batch of mengo virus process control add 5 μ l of undiluted, 10^{-1} , 10^{-2} and 10^{-3} mengo virus RNA to one well each.

Add 5 μ l of nuclease-free water to one well.

Add 20 μ l of the mengo virus TaqMan® mastermix to each well.

See layout on following page for example TaqMan® plate testing one sample for all three targets. The plate-set-up follows the ISO 5126 set up, but it is recommended to use at least double wells for each RNA eluate. Especially is this true for samples with suspected low level of target virus.

Example plate layout (single sample – all assays on one plate)

Test sample (undiluted)	Test sample (-1)	Test sample (undiluted) + GI EC RNA	Test sample (-1) + GI EC RNA	H2O + GI EC RNA	NPC or NEC	H2O					
Test sample (undiluted)	Test sample (-1)	Test sample (undiluted) + GII EC RNA	Test sample (-1) + GII EC RNA	H2O + GII EC RNA	NPC or NEC	H2O					
Test sample (undiluted)	Test sample (-1)	Test sample (undiluted) + HAV EC RNA	Test sample (-1) + HAV EC RNA	H2O + HAV EC RNA	NPC or NEC	H2O					
Test sample (undiluted)	Test sample (-1)	Process control virus RNA (undiluted)	Process control virus RNA (-1)	Process control virus RNA (-2)	Process control virus RNA (-3)	NPC or NEC)	H2O				

Norovirus GI assay
Norovirus GII assay
HAV assay
Mengo virus assay

5 µl RNA (+/- 1 µl EC RNA) & 20 µl mastermix per well

7.7 TaqMan® assay run parameters

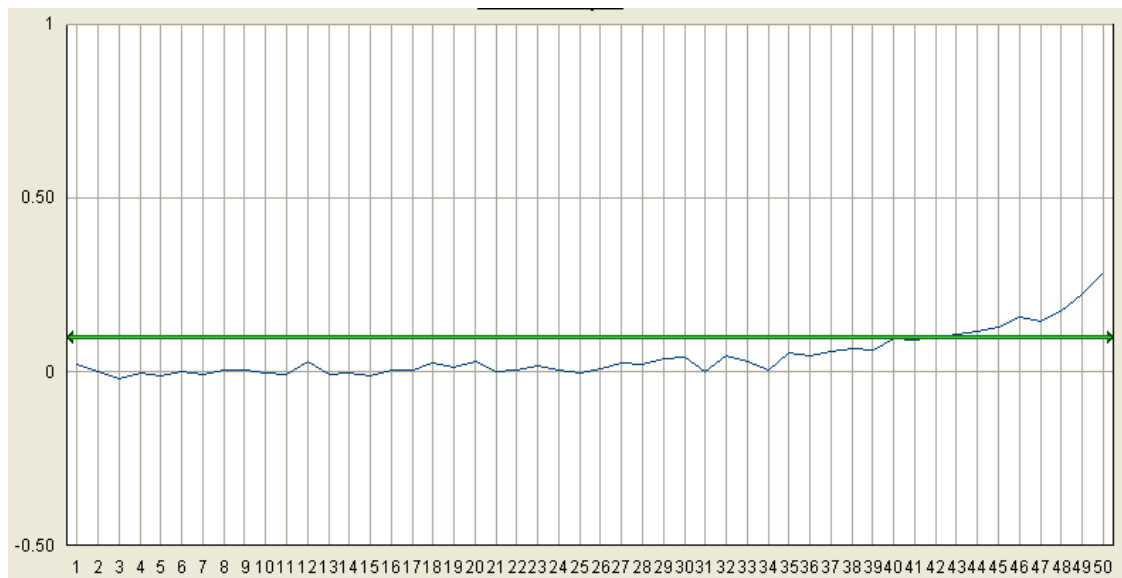
Run the TaqMan® assay with the following parameters:-

Step description	Temperature and time	Number of cycles
RT	55 °C for 1 h	1
Preheating	95 °C for 5 min	1
Amplification	Denaturation	95 °C for 15 s
	Annealing-	60 °C for 1 min
	extension	65 °C for 1 min

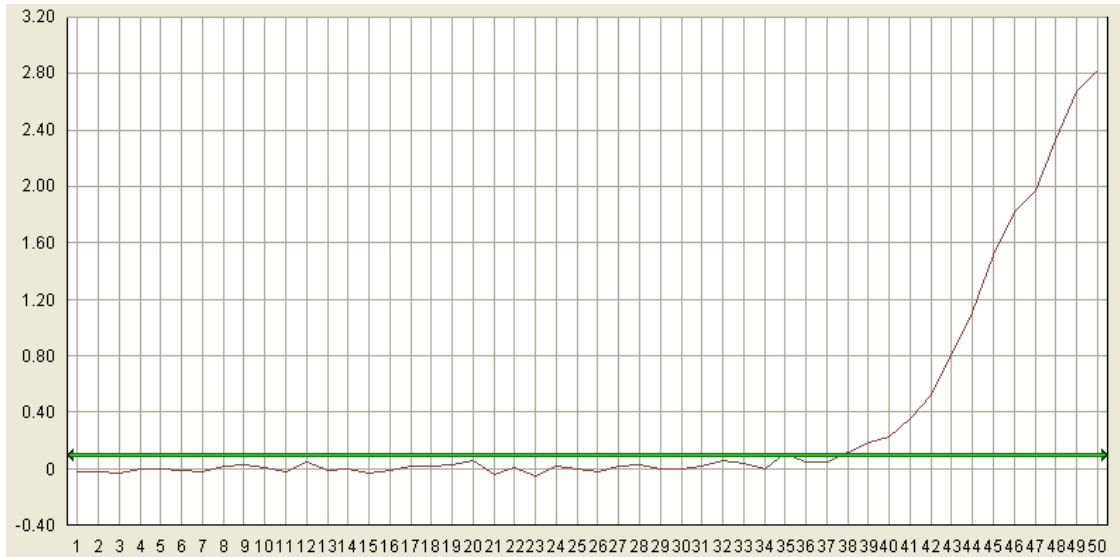
7.8 Analysis of results

Analyse the amplification plots using the approach recommended by the manufacturer of the real-time PCR machine. The threshold should ideally be set so that it crosses the area where the amplification plots (logarithmic view) are parallel (the exponential phase). Alternatively, thresholds are set automatically by the software. Some platforms do not have logarithmic view, still threshold should be set early in the exponential phase.

Check all amplification plots to identify false positive results caused by high or uneven background signal. Results for any wells affected in this way should be regarded as negative e.g.



Check all amplification plots to identify true positive plots where the recorded Cq value is significantly distorted by high or uneven background signal. Approximate correct Cq values should be noted (in addition to the recorded value) for any wells affected in this way. Corrected Cq values should be used for all quantity calculations.



e.g. in this case the recorded Ct value was 34.92, however it should be noted by the participating laboratory that the correct figure should be e.g. 38.

Check Cq values of the process control virus RNA standard curve dilution series for any points that do not fall close to the line of best fit. These Cq values should not be incorporated into standard curve calculations. For each dilution series points from a minimum of 3 dilutions must be retained.

Use the remaining Cq values of each dilution series to create a standard curve by plotting the Cq values obtained against \log_{10} concentration to determine r^2 , slope and intercept parameters.

Curves with r^2 values of <0.980 , or where the slope is not between -3.10 and -3.60 (corresponding to amplification efficiencies of $\sim 90-110\%$), should not be used for calculations.

To determine the RT-PCR inhibition for each sample and each target refer to the Cq values for the wells containing EC RNA. If the Cq value of the undiluted sample RNA + EC RNA well is $< 2,00$ greater than the Cq value of the water + EC RNA well, results for the undiluted RNA should be used for that sample. If the Cq value of the undiluted sample RNA + EC RNA well is $> 2,00$ greater than the Cq value of the water + EC RNA well, repeat the comparison with the 10^{-1} sample RNA + EC RNA well.

If the Cq value of the 10^{-1} sample RNA + EC RNA well is $< 2,00$ greater than the Cq value of the water + EC RNA well, results for the 10^{-1} RNA should be used for that sample. If the Cq value of the 10^{-1} sample RNA + EC RNA well is $> 2,00$ greater than the Cq value of the water + EC RNA well, results may not be valid and the sample may need to be retested.

Use the Cq value for the mengo virus assay from the test sample RNA well (undiluted or 10^{-1} dependent on the RT-PCR inhibition results; see above) to estimate extraction efficiency by reference to the mengo virus RNA standard curve as follows (if 10^{-1} sample RNA results are used multiply by 10 to correct for the dilution factor):-

$$\text{Mengo virus recovery} = 10^{(\Delta C_q / \text{slope})} \times 100\%$$

where $\Delta C_q = C_q$ value [sample RNA] – C_q value [undiluted process control virus RNA]

A sample producing the same Cq value as undiluted mengo virus RNA will have an extraction efficiency of 100%. Where the extraction efficiency is < 1 % sample results are not valid and the sample may need to be retested.

For each sample with acceptable RT-PCR inhibition level and extraction efficiency, results for each target can be determined by looking at results for the appropriate sample RNA only well. Where a Cq is determined the test result for the sample is positive and should be expressed as **“virus genome detected in 25 g”**. Where no Cq is determined the test result for the sample is not detected and should be expressed as **“virus genome not detected in 25 g”**.

If a valid result is not obtained results should normally be expressed as **“no result”**. If however, an otherwise valid positive result is obtained from a sample showing an unacceptable RT-PCR inhibition level or extraction efficiency, results may be expressed as detailed above. Details should be included in the test report.

Sampling is not considered in this protocol. It should be noted that absence of virus in the sample under test may not guarantee absence of virus in an entire consignment.

8.0 Uncertainty of test results

Uncertainty inherent in any test method, i.e. instruments, media, analyst performance etc. can be assessed by the repeatability and reproducibility of test results. These should be monitored through control tests analysed alongside sample tests, in-house comparability testing between analysts and external intercomparison exercises, which would highlight any uncertainties within the test methods.

9.0 References

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10.0 Appendix 1: Primer and probe sequences

Norovirus GI

QNIF4 (FW): CGC TGG ATG CGN TTC CAT [da Silva et al., 2007]

NV1LCR (REV): CCT TAG ACG CCA TCA TCA TTT AC [Svraka et al., 2007]

During the development of ISO 15216, two different probes for norovirus GI were used. Either can be used with the FW and REV primers detailed here.

NVGG1p (PROBE): TGG ACA GGA GAY CGC RAT CT [Svraka et al., 2007]

Probe labelled 5' 6-carboxyfluorescein (FAM), 3' 6-carboxy-tetramethylrhodamine (TAMRA)

TM9 (PROBE): TGG ACA GGA GAT CGC [Hoehne & Schreier, 2006]

Probe labelled 5' FAM, 3' MGBNFQ (minor groove binder/non-fluorescent quencher)

Norovirus GII

QNIF2 (FW): ATG TTC AGR TGG ATG AGR TTC TCW GA [Loisy et al., 2005]

COG2R (REV): TCG ACG CCA TCT TCA TTC ACA [Kageyama et al., 2003]

QNIFS (PROBE): AGC ACG TGG GAG GGC GAT CG [Loisy et al., 2005]

Probe labelled 5' FAM, 3' TAMRA

HAV

HAV68 (FW): TCA CCG CCG TTT GCC TAG [Costafreda et al., 2006]

HAV240 (REV): GGA GAG CCC TGG AAG AAA G [Costafreda et al., 2006]

HAV150(-) (PROBE): CCT GAA CCT GCA GGA ATT AA [Costafreda et al., 2006]

Probe labelled 5' FAM, 3' MGBNFQ

Mengo virus

Mengo 110 (FW): GCG GGT CCT GCC GAA AGT [Pinto et al., 2009]

Mengo 209 (REV): GAA GTA ACA TAT AGA CAG ACG CAC AC [Pinto et al., 2009]

Mengo 147 (PROBE): ATC ACA TTA CTG GCC GAA GC [Pinto et al., 2009]

Probe labelled 5' FAM, 3' MGBNFQ