

In-vitro digestibility assays for ruminants and monogastric animals made easier

Gas Endeavour



In-vitro digestibility assessment of feeds for ruminants and monogastric animals

For the purpose of feed evaluation, *in-vitro* digestion and fermentation methods are ethically superior, faster and less expensive than *in-vivo* techniques. A good example of an *in-vitro* fermentation method is the *in-vitro* gas production technique, in which the gas evolved as a result of fermentation is used as the primary measurement. The method relies on the relationship between degradation and fermentative gas production to evaluate the nutritional parameters of a feed. Although the gas production technique is well-established in the area of ruminant feed evaluation, reports can also be found for nutritive evaluation of feed for monogastric animals and even for the food evaluation for human. The benefits of *in-vitro* gas production techniques for digestibility evaluation include the possibility to run large batches simultaneously at a low cost, the ability to measure fermentation kinetics of soluble and insoluble fractions of feed or food, and to easily make relative comparisons among different samples.

The Gas Endeavour® is our premier automatic instrument for continuous monitoring of fermentation gas (i.e., hydrogen, methane, carbon dioxide) released in *in-vitro* ruminant digestive models and *in-vitro* monogastric hindgut digestive model for monogastric animals and humans. In comparison with the other *in-vitro* methods measuring the transformation of fermentable substrate, the Gas Endeavour® allows highly accurate analysis of a large number of samples in a short time. In addition, the automated *in-vitro* protocol based on the Gas Endeavour® significantly reduces the workload compared with manual analyses.

15
test lines

2
measuring
resolutions



Standard system configuration for total fermentation gas monitoring



Incubation unit with mechanical agitation



Flow meter array and DAQ unit

Modular design for
easy replacement
and maintenance

Continuous monitoring of
fermentation gases
released in *in-vitro*
ruminant & monogastric
hindgut digestive models

Highly precise and accurate data

The Gas Endeavour® gives you a better understanding of the digestion kinetics of fermentable substrates. The precision of measurement and data calculations have been validated with the highest quality and standards by scientists in international interlaboratory studies.

Standardised measurement procedures, data interpretations and reports

Real-time temperature and pressure compensations minimise the impact of possible variation in measurement conditions and standardise data presentation satisfying the highest demands for data accuracy and precision. A nonlinear mathematical model is also implemented in the latest released Gas Endeavour® to achieve an outstanding high linearity for *in-vitro* gas production analysis in all measurement ranges.

The instrument provides advantages in the standardisation of measurement procedures, data interpretation and reporting. This allows for data from different laboratories around the world to be easily compared.

Significantly reduce labour demands

The instrument allows fully automated analytical procedures, extendable testing capacity and full control of experiments with remote access. The Gas Endeavour® reduces the time and labour requirement for *in-vitro* digestibility analysis and make the test being less skill dependent for precise and accurate data.

Compact and modular design

The modular approach enables flexible system set-up, easy upgrading options and simple maintenance. The Gas Endeavour® can easily be further expanded by connecting multiple instruments with a network switch.

User-friendly operations with remote access

The instrument is simple to use and easy to learn. The web-based software application makes setting up and monitoring experiments very easy. The Gas Endeavour® allows easy access from a remote location using any computer, smartphone or tablet.

Software for Gas Endeavour

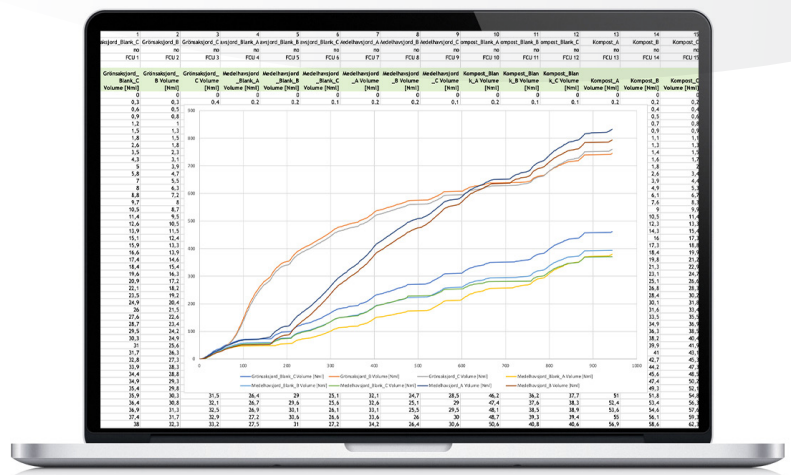
A simple and intuitive software application

The Gas Endeavour® software application has been specifically designed to be applicable for a wide range of batch tests where gas volume or gas flow needs to be measured with high demand on accuracy and precision. This application, which is easy to understand and navigate, allows users to set up an experiment, monitor its progress, and download results with little effort. Moreover, all data is in a standard format that allows for easy analysis. The software application is simply a natural extension of a universal hardware platform that has been designed for carrying out various batch tests where gas flow, volume, and composition measurements are important.

Total control throughout an experiment

The control feature of the Gas Endeavour® software application allows users to control the status of each batch test in real-time during an experiment. For the system with our multifunctional agitation system, users can control the interval, speed, rotation directions, and on/off time of the mixing of reactors, to ensure each reactor is operated under optimum mass transfer conditions. Users can also easily start, pause, and stop data acquisition of an ongoing experiment at any time by means of a simple to use control feature, which also indicates the status of each test line at all times.

Overall, this allows users to have optimal control of all test vessels and batch experiments at all times with the simple click of a virtual button from the software user interface.



The graph feature of the Gas Endeavour® software application and embedded web server allows users to see their experiment in real-time and from any location. Users can easily monitor the accumulated gas volume and flow rate of each reactor in real-time by selecting and viewing only the one they wish to see.

Moreover, all values displayed are already adjusted for gas volumes normalised to 1 atmospheric pressure, 0 °C, and zero moisture content.

If a flush gas with a different gas composition from the produced gas is used to establish initial headspace gas conditions, the impact of the flush gas is also taken care of by the Gas Endeavour® software application.

This flexibility and precision allows Gas Endeavour® users to always know the status of an experiment, as well as keep an eye on the data being produced.

Always have total control over your experiment at any time and any place

An evolution tool for *in-vitro* digestibility analysis

Application areas

***In-vitro* digestibility assay for ruminants**

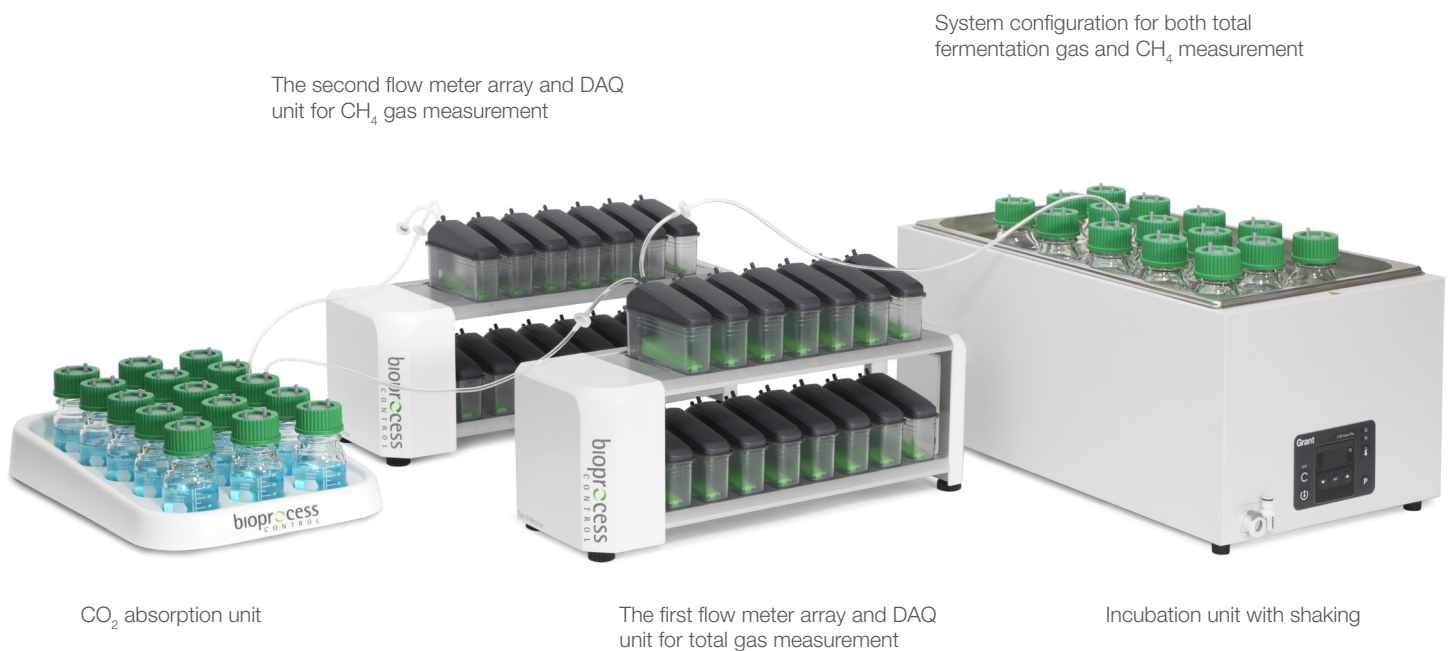
Gas Endeavour® is a powerful analytical tool to predict the rumen feed degradation potential through provision of kinetic information. Examples of application include estimating the energy content of feedstuffs for diet formulation, optimising efficiency of feed utilization, ruminant output, assessing bioactive components with antimethanogenic properties as well as antinutritive factors.

***In-vitro* hindgut digestion/fermentation for monogastric animals**

Like the rumen, the large intestine of simple-stomached animals is essentially a fermentation chamber where material is degraded by gut bacteria. The cumulative gas production technique can also be applied here and Gas Endeavour® can be an ideal batch test platform of *in-vitro* hindgut digestion to investigate differences among feedstuffs, unweaned and adult animals and also the effect of enzymatic pre-treatment on fermentation kinetics.

***In-vitro* hindgut digestion/fermentation for humans**

The fermentation of dietary fibers by gut microbiota results in the generation of gas and production of short-chain fatty acids (SCFA), and can also provide selective substrates for growth of specific groups of bacteria that may enhance the intestinal health of the host. Gas Endeavour® is an automated batch test platform of *in-vitro* lower gastrointestinal digestion and human fecal fermentation for studying microbiota population in lower gastrointestinal tract and fermentation properties of various dietary fibers.



Technical specifications

Sample incubation unit with mechanical agitation (option 1)

Maximum number of reactors per system: 15

Reactor material: glass

Reactor volume: 500 ml (standard), 1000 ml (optional)

Dimension: 57 x 34 x 27 cm

Temperature control: up to 95 °C (203 °F) (precision of 0.2 °C)

Mixing in the reactor: mechanical agitation (adjustable interval, speed and rotation directions), 10 to 200 rpm



Sample incubation unit with shaking (option 2)

Maximum number of reactors per system: 15

Reactor material: glass

Standard reactor volume: 250 ml

Dimension: 57 x 34 x 27 cm

Dimension tray insert: 44 x 26 x 7 cm

Temperature control: up to 95 °C (203 °F) (precision of 0.2 °C)

Mixing in the reactor: shaking water bath, linear shaking motion, 20 to 200 rpm (depending on load)



Ex-situ gas absorption unit

Gas trap bottles: 15

Bottle material: glass

Bottle volume: 100 ml

Dimension of unit: 44 x 30 x 6 cm

Absorption liquid: depending on gas to be removed.

For CO₂ removal: 3 M NaOH with pH indicator, 80 ml per bottle (not included)

Absorption efficiency: for CO₂ removal with NaOH: >98%



Flow meter array and DAQ unit

Working principle: Liquid displacement and buoyancy. Up to 15 independent gas flow measurement units and built-in sensors for real-time temperature and pressure compensation.

Single gas measurement: measurement for 15 test vessels in parallel

Double gas measurement (i.e. total gas and one specific gas component, such as methane): measurement for 7 test vessels in parallel

Measuring resolution: 2 ml or 9 ml

Detection capacity: up to 200 l cumulative gas for each batch test for 2 ml flow cell and up to 900 l cumulative gas for each batch test for 9 ml flow cell

Measuring range: 0.2 to 1500 ml/h* for 2 ml flow cell and 1 to 6000 ml/h* for 9 ml flow cell

Dimension of unit: 51 x 26 x 17 cm

Housing: aluminium and plastic

Measuring precision: $CV \leq 1\%$

* Lower range limit refers to measurement of gases with low solubility in water (e.g. N_2 , CH_4 , O_2 , CH_4 , H_2)



Software and System

- User friendly web-based software running on an embedded server, with no need of pre-installation on pc, tablet, or smartphone
- Online real-time gas flow and volume display
- Automatic real-time pressure and temperature compensation
- Extended measurement linearity for high gas flow analysis
- Real-time gas flow and volume normalisation
- Algorithm to avoid over- or underestimation of gas flow and volume that may be introduced by flush gas during experiment setup
- Possibility of multiplexing, allowing for simultaneous batch analysis at different start-up times
- Online system logger for operational diagnosis
- Power supply: 12 V DC / 5 A (Flow cell array and DAQ unit), 24 V DC / 2.7 A (mechanical agitation)
- Usage: indoor



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