BRS

BQC REDOX SYSTEM

New analytical device to assess the redox state of **agri-food samples**

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BRS DEVICE

BRS (BQC Redox System) is the first **multiparametric portable** device **based on electrochemistry** designed to assess the redox state of agri-food samples. With one single device, it is possible to determine different markers of the redox state in a simple, fast and precise way.

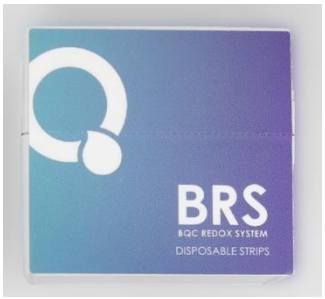
The device is now available and ready for the measurement of **Total Antioxidant Capacity** (TAC) in a wide variety of agri-food samples.

The device has been designed for a continuous upgrading and improvement through the incorporation of new redox measurements.

BRS performance has been validated in **fruits and beverages.**

The technology behind the BRS for TAC determination is protected by a granted utility model.

BRS TEST STRIPS



BRS device works **exclusively** with **BRS disposable strips**.

TAC Strips are plastic support test strips covered with a carbon material, specially designed for TAC measurement.

BRS is a new electrochemical, multiparametric and portable device designed to assess the global redox state of different agri-food samples

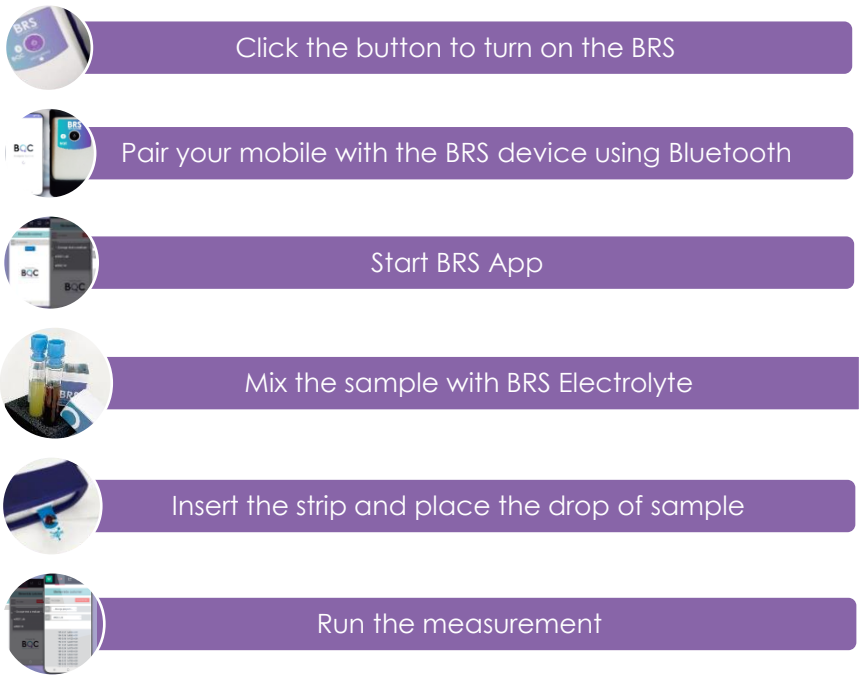
WHY TO USE BRS?

- ✓ **Simple and fast analysis**
- ✓ **Easy operation**
- ✓ **No need of lab equipment**
- ✓ **No modification of sample native conditions**
- ✓ **Suitable for color and turbid samples**
- ✓ **Suitable for on-site analysis**

HOW TO USE BRS DEVICE

The **use** of the BRS device is very **simple**. Just insert the test strip into the device, mix the sample with the BRS Electrolyte, place a drop of sample onto the test strip, and start the measurement.

The device is controlled by a specially designed App to use on your mobile device. **BRS App** functions include running the measurements and storing and sharing the data. In approximatly 1 min results are displayed on your mobile device.



Some Technical data

Weight

±250 g

Power supply battery

>6 hours continuous measurements

Communication

Bluetooth

Temperature range

0 °C to +40 °C

Measuring range

0-35000 BRS Value

ANTIOXIDANTS IN AGRI-FOOD PRODUCTS

Diet plays an important role in preventing several diseases and improving people´s health and wellbeing. Antioxidants are nowadays one of the most important health promoting food components. These compounds are naturally present in most agri-food products, especially in plant-based foods, such as blueberries, green leafy vegetables, cocoa, and beans. The health benefit of antioxidants resides in their ability to fight against damaging oxidizing agents (reactive oxygen and nitrogen species, ROS/RNS) in living organisms. The balance between oxidizing species and antioxidant compounds is critical in maintaining healthy biological systems. Oxidative stress is a state of imbalance between the production of reactive oxidizing species and their removal by protective antioxidants.

In humans and animals, oxidative stress is responsible for ageing and has been related to different pathologies. Oxidative stress is also involved in **biotic and abiotic stresses** in plants affecting negatively to plant growth, development and crop productivity.

Diet as a source of exogenous antioxidants, plays a relevant role in modulating the redox state of living organisms. In this scenario, agri-food industries are required to ensure the quality of their products, maintaining the availability of natural antioxidants and other nutrients, during the production, processing and storage processes.

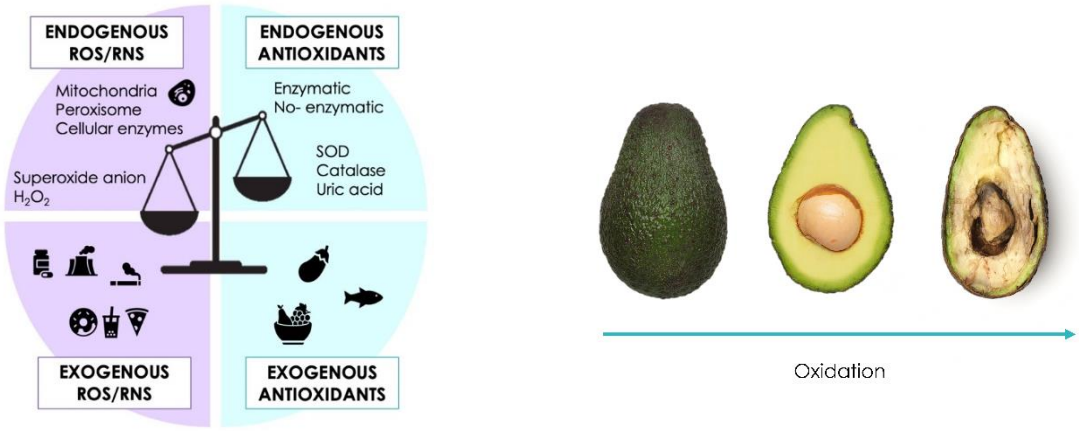


Figure 1. *Schematic representation of Oxidative Stress.*

Additionally, oxidative damage is the second most important cause of **food degradation**. Food oxidation has adverse effect not only on food quality but also on human health. Synthetic antioxidants owing to their ability to prevent or slow oxidation of molecules have been extensively used in agri-food industries as an additive to limit the oxidative degradation of food products. In recent years and due to the health problems associated with the long-term intake of synthetic antioxidants a considerable research has been focused on the study of new substances as **natural antioxidant additives** for agri-food products.

Control the total antioxidant capacity of agri-food products is therefore fundamental to ensure their **quality and safety**. Due to the transient nature of ROS/RNS, their measurement in agri-food samples is very difficult and the antioxidant capacity is also usually measured as an indirect marker of the redox state of agri-food products.

TOTAL ANTIOXIDANT CAPACITY (TAC)

WHAT IS TOTAL ANTIOXIDANT CAPACITY?

Total antioxidant capacity (TAC) is a global measure of the non-enzymatic antioxidant activity that integrates the individual effect of all antioxidants in a given matrix, and their additive, synergistic or antagonistic interactions. **TAC is considered as an important parameter to establish the redox state of agri-food samples**.

WHY TO ASSAY THE TOTAL ANTIOXIDANT CAPACITY OF AGRI-FOOD PRODUCTS?

The quality and safety of agri-food products is strongly influenced by their redox state. Total antioxidant capacity is an important parameter to assess for the redox characterization of these products.

Determining the redox state of agri-food products is of **great interest** to study:

- The antioxidant capacity of new products/additives.
- The impact of processing methods, packaging and storage conditions on antioxidant properties.
- Shelf-life, remaining useful life of the products.
- Quality and safety of the products.

TRADITIONAL METHODS FOR TAC DETERMINATION OF AGRI-FOOD SAMPLES

Due to the lack of standard quantification methods for TAC determination a wide variety of assays have been used to assess the antioxidant capacity of agri-food samples. Most popular TAC assays are based on the spectrophotometric monitoring of reactions between antioxidants and specific oxidants or radicals generated in situ. TAC assays may be broadly classified as the electron transfer (ET)- and hydrogen atom transfer (HAT)-based assays. Briefly, HAT-based assays measure the capability of an antioxidant to quench free radicals by H-atom donation while ET-based assays measure the capacity of an antioxidant in the reduction of an oxidant. The most popular HAT-based TAC assays is the fluorometric oxygen radical absorbance capacity (ORAC). Ferric reducing antioxidant capacity (FRAP), cupric reducing antioxidant capacity (CUPRAC), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid radical scavenging assay (ABTS) and 2,2-diphenyl-1-picryl-hydrazyl-hydrate radical scavenging assay (DPPH) are the most frequently used ET-based TAC assays (ABTS and DPPH are considered as mixed-mode HAT/ET by some authors). The results obtained from the different TAC assays are **hardly comparable because of the different mechanisms, pHs and solvents required for each assay.**

Independently of the mechanism, **spectrophotometric TAC assays are usually quite complex, time consuming and require expensive instrumentation.**

ORAC is the most used assay for evaluating the total antioxidant capacity of agri-food products. The main advantage of this assay is the use of a natural radical to measure the antioxidant capacity. Main limitations of the ORAC include long analysis time, complexity of the assay (very careful control of temperature, reagent concentrations, etc.) and the need of sophisticated instrumentation. Although more simple than ORAC assay, DPPH and ABTS use non-natural radicals for evaluating the total antioxidant capacity. Regarding the non-radical based TAC assays, the redox reaction producing coloured species in CUPRAC is carried out at nearly physiological pH as opposed to the unrealistic acidic conditions of FRAP. The main limitations of CUPRAC are the need of organic solvents and sample pretreatment.

ELECTROCHEMISTRY TO MEASURE TAC OF AGRI-FOOD PRODUCTS, WHY?

Redox reactions are involved in the origin and consequences of oxidative stress. Electrochemistry is recognized as the best tool to study this type of reactions. Another important aspect in favor of the electrochemical methods to study oxidative stress, is the electroactivity of most of the oxidants and antioxidants present in agri-food samples.

Electrochemistry is therefore a powerful tool to study the redox state of agri-food samples, with features that include **rapid response, high sensitivity, inherent miniaturization, low cost and low-power requirements.** Moreover, electrochemical techniques are **non-destructive** and can be used in **turbid or colored samples.**

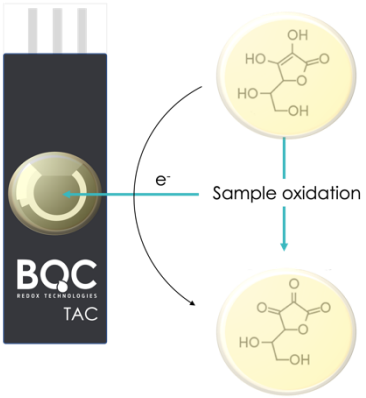
BRS is the first electrochemical based device designed to study the redox state of agri-food samples.

BRS allows a simple and fast measurement of the redox state by measuring total antioxidant capacity.

BRS DEVICE FOR TAC ANALYSIS

BRS electrochemical device provides a rapid, simple and sensitive alternative to spectrophotometric assays for TAC determination.

BRS uses a voltammetric technique to measure TAC. The sample is electrochemically oxidized by applying a potential scan and TAC value is calculated from the voltammetric charge.



Similar to ET spectrophotometric TAC assays the BRS measurement is based on an electron transfer process from the antioxidants to the electrode.

Different from ET spectrophotometric TAC assays that require sample modification, **BRS analyses can be considered as a direct evaluation of the antioxidant activity of the sample in its native environment**.

BRS TAC results for agri-food analysis are expressed in terms of BRS Value. This value is calculated from the **electric charge transferred during the sample oxidation.**

TAC measurements obtained with **BRS** device in BRS Value can be easily converted into Trolox Equivalents (**TEAC**, Trolox Equivalents Antioxidant Capacity), Vitamin C Equivalents (**CEAC**, Vitamin C Equivalents Antioxidant Capacity) or Gallic Acid Equivalents (**GAE**) by simply performing calibration curves with the device using Trolox, Ascorbic Acid or Gallic Acid as standard.

Samples must only be mixed with a BRS electrolyte before the assay. BRS Electrolyte has been formulated to guarantee the conductivity required for the electrochemical measurement without altering sample characteristics.

BRS overcomes main limitations of spectrophotometric TAC methods

The technology behind the BRS for TAC determination is protected by a granted utility model

Table 1. *Comparison of methods for TAC determination.*

TAC Spectrophotometric Method		BRS
Method	**Main Limitations**	**Advantages**
ORAC	Complexity	Simple
DPPH	Non-natural radical	No radical/oxidant
ABTS	Non-natural radical	No radical/oxidant
FRAP	Acid pH	No modification of sample native conditions
CUPRAC	Organic solvents	No organic solvents
All methods	Interferences from colored/ turbid samples	Suitable for colored/turbid samples
	Time consuming	Fast (~ 1 min)
	Lab equipment	No lab equipment

BRS ANALYTICAL CHARACTERISTICS FOR TAC ANALYSIS

LINEAR RANGE

BRS exhibits a **wide linear range** for the most used standards of TAC. All the standards were prepared in BRS Electrolyte. Thanks to this wide linear range **no sample dilution** is required for the analysis of most of the samples.

The wide linear range of BRS Device minimizes sample dilution.

Table 2. *BRS linear range for TAC standards.*

TAC Standard	BRS Linear range (µM)
Ascorbic Acid	50-10000
Trolox*	50-10000
Gallic Acid	25-10000

***Linear range for TROLOX spectrophotometric detection (BQC Assay Kits):**

ORAC, 10-175 µM

ABTS, 50-600 µM

DPPH, 100-500 µM

CUPRAC, 250-2000 µM

PRECISION

Intra-assay precision was evaluated by replicate analysis (n=10) of an apple juice using a new strip for each measurement. Inter-assay precision was calculated by measuring a standard solution (100 µM Trolox) on ten different days using a new strip for each measurement.

BRS analysis shows good precision with intra and inter-assay coefficients of variation (CV) **< 10 %.**

Table 3. *BRS intra and inter-assay precision.*

Precision (n=10)	BRS Value/Mean ± SD	CV (%)
Intra-assay (Apple Juice)	2079 ± 79	4
Inter-assay (Trolox 100 µM)	205 ± 15	7

BRS TAC SAMPLE ANALYSIS

Table 4 shows the TAC values obtained for several fruits and beverages. Samples were 1:1 mixed with BRS Electrolyte.

Table 4. *TAC values on several samples*

Sample	BRS Value (n=3)
Red wine	7085 ± 550
Coffe	4187 ± 390
Green Tea	4143 ± 250
Kombucha	2522 ± 190
Orange Juice	2447 ± 120
Pineapple juice	2388 ± 98
Apple juice	2064 ± 79
Blueberry extract	1253 ± 60
Chamomile	690 ± 40

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