ROTRONIC APPLICATION NOTE

Application note: N°F054

November 2014

Importance of Measuring Water Activity in Coffee

Coffee

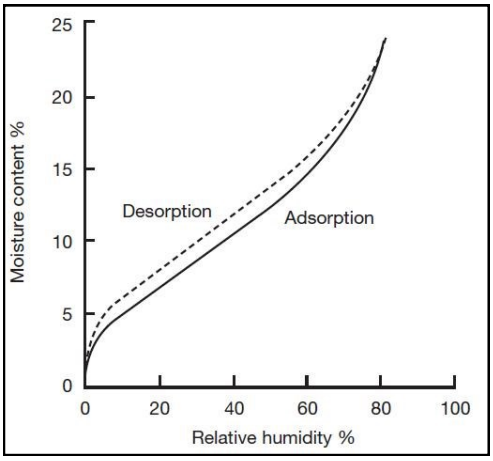
Facts & figures:

A change in a_w of a product can change the shelf life from a couple of days to a couple of weeks!

Pure distilled water has a water activity of exactly 1.

Salmonella bacteria can survive several weeks in a dry environment.

An example of a sorption isotherm:



Discussed in this edition:

Water activity in general

Water activity:

Water activity (a_w) or equilibrium relative humidity (ERH) measures the water vapour pressure generated by the water present in a hygroscopic product.

Water activity is based on a scale from 0 to 1.

The formulas:

$a_w = p / ps$

(p is the water vapour pressure above the product surface and ps the water vapour pressure above the surface of pure water at the product temperature)

$ERH = 100 \times a_w$.

Moisture content:

Water activity is often confused with moisture content. The moisture content of a product is usually defined as the percent weight of water content in relation to the dry weight of the sample.

Sorption isotherm:

At equilibrium, the relation between the percentage of water and the water activity of a hygroscopic material can be graphically represented by a curve: the sorption isotherm. For each a_w value, the sorption isotherm shows the corresponding moisture content at a given constant temperature. Each product has its own sorption isotherm.

Water migration:

The a_w of a product will always try to reach equilibrium with the surrounding atmosphere. Water will migrate from regions with a high a_w to the regions of low a_w. Water will migrate until equilibrium is reached!

The effect of water in foodstuffs:

Water is also recognised in the food industry as being critical for the stability of most products. a_w exerts a decisive influence on such phenomena as change in colour, taste and aroma, food poisoning and spoilage (shelf life), loss of vitamins…

Controlling the water activity of a product:

The a_w in foods can be controlled by using various additives (humectants), by using satisfactory packaging materials, by maintaining favourable maturation and storage conditions...

Water activity and micro-organisms:

Water activity also indicates the amount of water which is available to micro organisms. Each species of micro organism (bacteria, yeast, mould) has a minimum a_w value below which, growth is no longer possible.

Salmonella

Chemical stability:

Water activity control is also an important factor for the chemical stability of foods. Most foodstuffs contain carbohydrates and proteins and are therefore subject to non-enzymatic browning reactions (Maillard reaction). The Maillard reaction gets stronger at increasing a_w values and reaches its peak at a_w = 0.6...0.7 with further increase of a_w this reaction gets rapidly weaker.

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rotronic MEASUREMENT SOLUTIONS

Why the need to measure water activity?

Water activity and micro-organisms

As mentioned previously, a_w indicates the amount of water in the total water content which is available to micro-organisms.

Each micro-organism has its own minimum a_w value below which, growth is no longer possible (growth is no longer possible but this doesn't mean that the micro-organisms are not present).

By measuring the a_w of food stuffs it is possible to determine which micro-organisms will be able to develop.

The US Food and Drug Administration (FDA) has adopted the concept of a_w for establishing moisture limits beyond which certain types of food are considered susceptible to invasion by mould and bacteria. (Please see tables on page 4 for more information).

Often, a_w is described as the amount of "free" water in a product and the moisture content, the amount of "bound" water in a product. Even though this is not a scientific description of a_w, it is easy to understand that chemically bound water is not accessible to micro-organisms, whereas free water is.

a_w	Micro organisms generally **inhibited** by a_w at this point	Examples of foods within this range of water activity.
0.950	Pseudomonas, Escherichia, Proteus, Shigella, Klebsiella, Bacillus, Clostridium perfringens, some yeast.	Highly perishable foods (fresh and canned fruits, vegetables, meat, fish) and milk; cooked sausages and breads; foods containing up to 4oz (w/w) sucrose or 7%NaCl…
0.910	Salmonella, Vibrio parahaemolyticus, C. botulinum, Serratia, Lactobacillus, Pediococcus, some molds, Rhodotorula, Pichia.	Some cheese (Cheddar, Swiss, Muenster, Provolone); cured meat (ham); some fruit juice concentrates; foods containing 55%(w/w) sucrose or 12%NaCl…
0.870	Many yeasts (Candida, Torulopsis, Hansenula), Micrococcus.	Fermented sausage (salami); sponge cakes; dry cheese; margarine; foods containing 65% (w/w) sucrose (saturated) or 15%NaCl…
0.800	Most molds (mycotoxigenic penicillia), Staphylococcus aureus, most Saccharomyces (baillii) spp., Debaryomyces.	Most fruit juice concentrates; sweetened condensed milk; chocolate syrup; maple and fruit syrups; flour; rice; pulses containing 15-17% moisture; fruit cake; country style ham; fondants; high-sugar cakes…
0.750	Most halophilic bacteria, mycotoxigenic aspergilla.	Jam, marmalade; marzipan; glazed fruits; some marshmallows…
0.650	Xerophilic molds (aspergillus chevalieri, A. Candidus, Wallemia sebi), Saccharomyces bisporus	Rolled oats containing ~10% moisture; grained nougats; fudge marshmallows; jelly; molasses; raw cane sugar; some dried fruits; nuts
0.600	Osmophilic yeasts (Saccharomyces rouxii), few molds (Aspergillus echinulatus, Monascus bisporus)	Dried fruits containing 15-20% moisture; some toffees and caramels; honey…
0.500	No microbial proliferation	Noodles, spaghetti, etc. containing ~12% moisture; spices containing ~10% moisture…
0.300		Cookies, crackers, bread crusts, etc. containing 3-5% moisture…
0.030		Whole milk powder containing 2-3% moisture; dried vegetables containing ~5% moisture; corn flakes containing ~5% moisture; dehydrated soups; some cookies and crackers…

Why the need to measure Water Activity in Coffee?

Coffee quality is evaluated by factors such as climatic conditions during growth, processing method and storage conditions. During the Sun drying method of fermentation, coffee fruits are spread on the ground. The natural microbial fermentation that occurs can influence the final quality of the product.

Microbial contamination can occur in the cherries and during harvesting, fermentation, drying and storage of coffee beans. Bacteria, yeasts and filamentous fungi have been found in the pulp and beans of coffee that was being processed in some countries.

Filamentous fungi predominate at the end of the processing and during storage, and may affect the quality and safety of the final product due to production of mycotoxins (toxins generated by fungi).

Ochratoxins are a small group of chemically related toxic fungal metabolites (mycotoxins) produced by certain moulds of the genera Aspergillus and Penicillium growing on a wide range of raw food commodities. The most important and most toxic ochratoxin found naturally in food is ochratoxin A (OTA).

Detection and removal of OTA-contaminated material from the food supply chain is important. The most important and effective control measure in post-harvest handling and storage is the control of the water activity.

Ensuring that susceptible crops are dried to a safe level immediately after harvest is vital to prevent mould growth and OTA production during storage. In tropical and sub-tropical climates stored grains must be dried rapidly to an Aw value of below 0.8 to prevent mould growth.

At high water activity (aw > 0.95) OTA- producing fungi will not likely grow, as fast-growing hydrophilic fungi and yeasts grow first. At lower water activity (aw <0.80) the OTA-producing fungi can be present but not produce the toxin, and at aw below 0.78–0.76 they cannot grow.

Therefore the most important point is to control the period of time in which coffee remains in the drying yard, in the range of water activity where OTA-producing fungi can grow (aw 0.8– 0.95). According to results, 5 days or less in the drying yard is enough and effective to prevent OTA accumulation.

In general, a maximum aw of 0.67 to 0.70 and moisture content < 12.5% (wet basis) is sufficient for protecting parchment coffee from damage by fungi.

What solutions can Rotronic offer?

Water activity or equilibrium relative humidity is usually defined as the percent relative humidity generated in equilibrium with the product sample in a closed system at constant temperature.

ERH = 100 x a_w

Therefore, a_w can be measured with a relative humidity sensor provided that the conditions specified in the above definition are fulfilled.

Practical conditions for measuring water activity:

Leak proof measurement chamber: closed system.

Volume ratio: air/product. The volume of air must be kept to a minimum: a small air volume reaches equilibrium with the sample faster than a large air volume

Temperature homogeneity: any temperature difference between the sensor, the chamber and the sample will result in significant errors. The higher the a_w value the greater the error will be (a $0.8a_w$ at 25°C with a 1°C temperature difference can result in an error of $0.05a_w$).

Constant temperature needs to be kept.

Equilibrium time: in order to read the correct water activity value, equilibrium needs to be reached! The higher the a_w the longer it takes!

Calibration of the sensor: using traceable humidity standards.

Rotronic offers a complete a_w meas-

HP23-AW-A with the HC2-AW and HC2-P05

HygroLab C1

Rotronic products:

Humidity and temperature probes:

- ***HC2-AW***
  5...50°C,
  0…1a_w,
  Large thermal mass,
  ±0.008a_w and ±0.1K…
- ***HC2-AW-USB***
  Same as HC2-AW but with direct connection to PC.
- ***HC2-P05***
  Insertion probe,
  -40...85°C,
  0…1a_w,
  Ø5mm x 200mm,
  ±0.015a_w and ±0.3K…
- ***HC2-HP28***
- ***HC2-HP50***
  Insertion probe,
  40...85°C,
  0…1a_w,
  Ø10mm x 280 or 500mm,
  ±0.008a_w and ±0.1K…

Laboratory display units:

- ***HygroLab C1***
  4 probe connections,
  Data logging,
  Display,
  Ethernet & USB connection,
  AwE and AwQuick,
  Buzzer...
- ***HP23-AW-A***
  Hand held device,
  2 probe connections,
  Data logging,
  Display,
  AwE & AwQuick
  Buzzer…

Accessories:

- ***Sample holders***
  WP-14-S, 14mm depth,
  WP-40, 40mm depth.
- ***Disposable sample containers***
  PS-14, containers for WP-14-S,
  PS-40, containers for WP-40
- ***Clamp sealing mechanism:***
  AW-KHS, sealing clamp
- ***SCS humidity standards***
  EAxx-SCS, unsaturated salt solutions,
  Different humidity values available: 0, 5, 10, 11, 20, 35, 50, 60, 65, 75, 80 and 95%...

Water activity sets:

Various sets are available, please

WP-14-S

AW1-SET-40

AW-KHS sealing clamp

HC2-P05

HC2-HP28 or HC2-HP50

WP-14-S

Customer benefits:

How Rotronic measures water activity:

With the Rotronic product range, there are two different ways to measure water activity: ***AwE*** and ***AwQuick***.

AwE mode: the natural equilibration of the product is measured and the measurement process is automatically stopped once equilibrium is reached. With most products, natural equilibrium requires from 45 to 90 minutes.

AwQuick mode: this mode reduces the time required to measure water activity to a few minutes, usually with almost the same accuracy as the ***AwE mode***.

Water activity measurement reports:

Combined with the Rotronic HW4 software, it is possible to automatically generate a report as soon as the measurement is finished.

Rotronic water activity sets:

Rotronic offers different sets, offering a complete solution for everyone needing to measure water activity. The sets often contain, a display units, a a_w measurement device, a sample holder and disposable containers as well as Rotronic humidity standards for the calibration of the measurement device.

Accuracy and long term stability:

Choosing Rotronic gives you the best accuracy on the market.

This helps carry out fast and effective water activity measurements on all foodstuffs.

With a long term stability of under $0.001a_w$, the measurement devices will not need much taking care of! This being said, we would recommend frequent spot checks in-between calibrations.

Calibration and adjustment:

Calibration and adjustment is very easy with the Rotronic product range. As all of the communication is digital, the whole calibration procedure can be done via a PC, or directly from the display unit (HP23-AW-A or the HygroLab C1) with the help of the Rotronic humidity standards. Rotronic can also offer a factory calibration (certified or not).

Table A. Interaction of pH and A_W for control of spores in FOOD heat-treated to destroy vegetative cells and subsequently PACKAGED

A_W values	pH values		
	4.6 or less	> 4.6 - 5.6	> 5.6
≤0.92	non-PHF*/non-TCS FOOD**	non-PHF/non-TCS FOOD	non-PHF/non-TCS FOOD
> 0.92 - .95	non-PHF/non-TCS FOOD	non-PHF/non-TCS FOOD	PA***
> 0.95	non-PHF/non-TCS FOOD	PA	PA

* PHF means POTENTIALLY HAZARDOUS FOOD
** TCS FOOD means TIME/TEMPERATURE CONTROL FOR SAFETY FOOD
*** PA means Product Assessment required

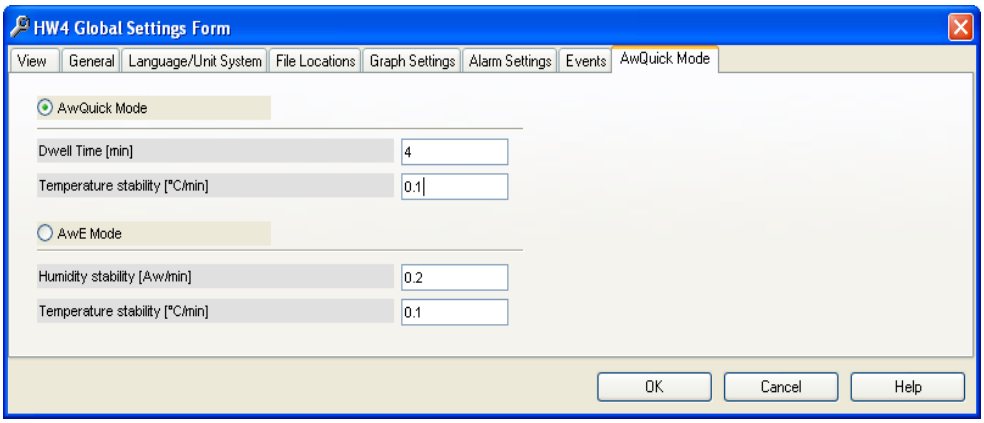
Table B. Interaction of pH and A_W for control of vegetative cells and spores in FOOD not heat-treated or heat-treated but not PACKAGED

A_W values	pH values			
	< 4.2	4.2 - 4.6	> 4.6 - 5.0	> 5.0
< 0.88	non-PHF*/ non-TCS food**	non-PHF/ non-TCS food	non-PHF/ non-TCS food	non-PHF/ non-TCS food
0.88 – 0.90	non-PHF/ non-TCS food	non-PHF/ non-TCS food	non-PHF/ non-TCS food	PA***
> 0.90 – 0.92	non-PHF/ non-TCS food	non-PHF/ non-TCS food	PA	PA
> 0.92	non-PHF/ non-TCS food	PA	PA	PA

* PHF means POTENTIALLY HAZARDOUS FOOD
** TCS FOOD means TIME/TEMPERATURE CONTROL FOR SAFETY FOOD
*** PA means Product Assessment required

FDA Food code 2005: Potentially hazardous food

Rotronic HW4 Software



Contact us:

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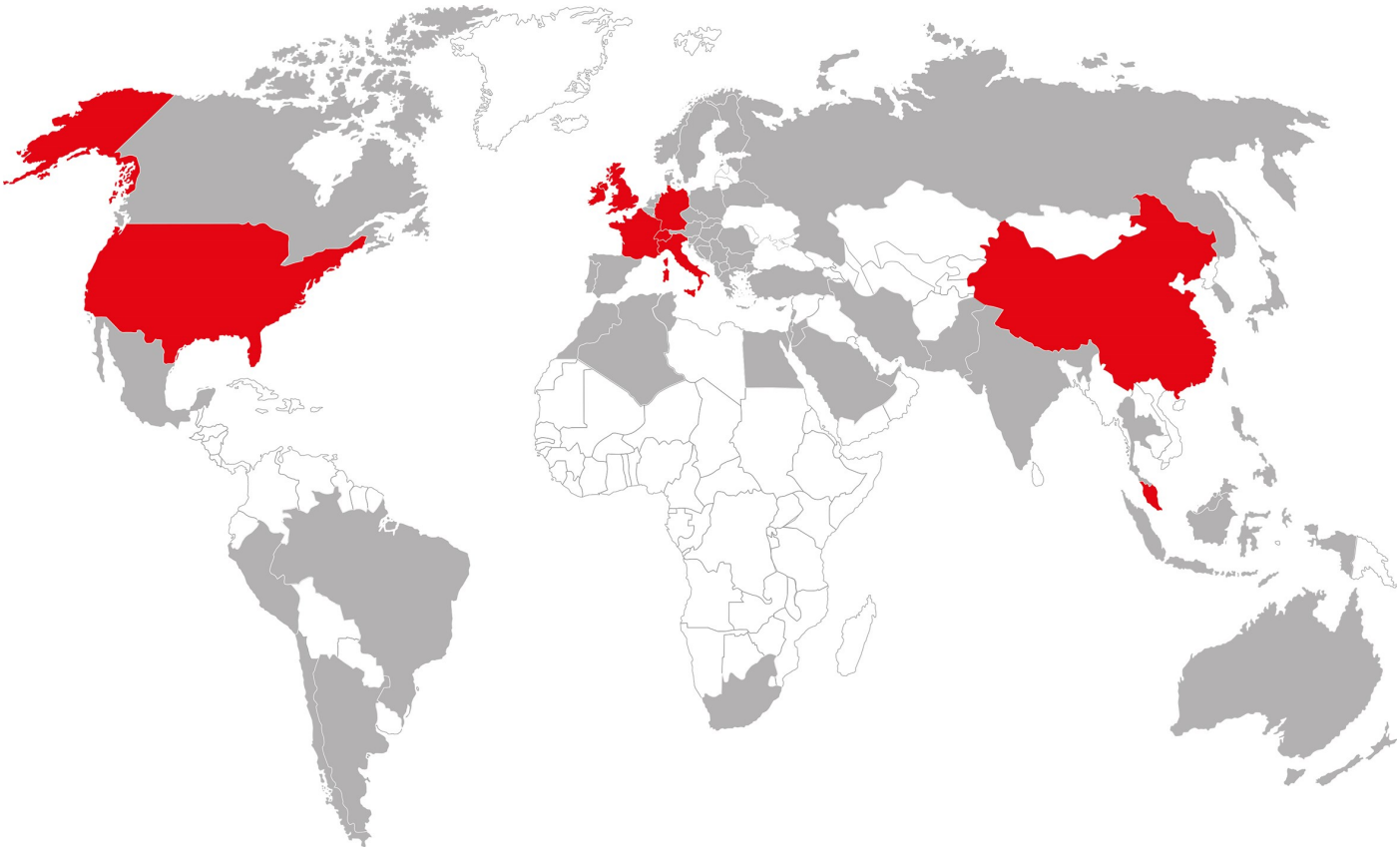

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