Water Activity in Coffee

Clockwise from above: Dried coffee beans . . . Coffee beans being dried . . . Coffee cherries.

Water activity in general

Water activity:

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

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

The formula: $a_w = p / ps$

(p is the water vapor pressure above the product surface and ps the water vapor 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 food products:

Water is also recognized in the food industry as being critical for the stability of most products. Variations in a_w can significantly affect color, taste, aroma, food poisoning, and spoilage.

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 or by maintaining favorable maturation and storage conditions.

continued

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.

Water activity and micro-organisms:

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

Chemical stability:

Water activity control is an important factor for the chemical stability of foods. Most food products 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 weaker.

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 products 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 mold and bacteria. Water activity is described as the amount of "free" water in a product. Moisture content is described as 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 available to micro-organisms.

Coffee plantation

Water Activity in Coffee

Coffee quality is determined by factors such as climatic conditions during growth, processing method and storage conditions. During sun drying fermentation, coffee fruits are spread on the ground and the natural microbial fermentation that occurs influences the final quality of the coffee.

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 molds 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 mold growth and OTA production during storage. In tropical and subtropical climates, stored grains must be dried rapidly to a water activity value of below 0.8 to prevent mold growth.

At high water activity (a_w > 0.95) OTA-producing fungi will not likely grow, as fast-growing hydrophilic fungi and yeasts grow first. At lower water activity (a_w <0.80) the OTA-producing fungi can be present but not produce the toxin, and at a_w 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 (a_w 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 a_w of 0.67 to 0.70 and moisture content <12.5% (wet basis) is sufficient for protecting coffee from damage by fungi.