Spotlight

Food & Beverage Analysis

The Influence of Water Activity (aw) in Bakery Products

Markus Bernasconi, Sales Engineer & Product Manager, Novasina AG, markus.bernasconi@novasina.ch

Water activity - a widely unknown or underestimated quality parameter offers many more benefits than just normal moisture content determination. It is the key parameter of gathering information about product shelf life, texture and taste or microbiological and chemical stability. Nowadays, where foodstuffs are shipped around the globe, a tough control of a product's water activity helps to reach the shelf-life goals and provides support for safe and uncontaminated foods to the consumer.

Especially bakery products are very difficult to handle because in most of the cases, they contain different types of ingredients such as sugar, fats/oils, milk proteins etc. This paper sets out to discuss the influence of those kind of ingredients on water activity measurement and how the determination of aw helps to reach the required quality goals for bakery products.

What is Water Activity (aw)?

Water activity is defined as the current volume and availability of 'free' water in a sample and should not be directly compared with the water content (g water/ g substance). The water activity is given as the aw – value and ranges between 0 (absolute dryness) and 1 (100% relative humidity).

Only this component takes an active part in the exchange of moisture with the ambient air and can possibly form the ideal medium for microbiological growth on the surface, which influences the microbiological stability. The water activity also has an important effect on the chemical reactions in food.

To determine the aw-value the relative humidity over a sample is measured after reaching the equilibrium humidity (partial water vapour pressure). This relates proportionally to the aw-value. An accurate and significant aw-measurement is only possible, if the sample shows a constant temperature during the measurement, thus a temperature controlled measuring chamber in the range of 0°C to 50°C is absolutely mandatory.

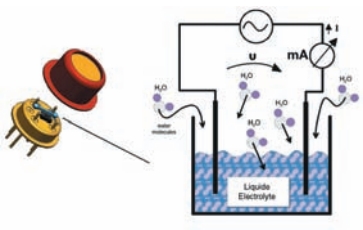
The time for establishing the equilibrium between the free water in and water vapour over the sample is the key for an accurate, reliable and reproducible aw measurement.

A temperature pre-conditioning of the sample reduces the measurement time.

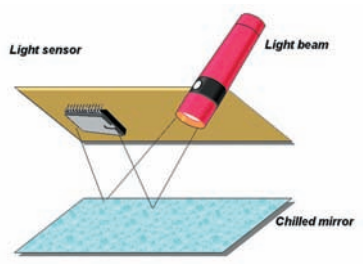
Water activity measurement methods

Different measurement methods can be found in currently available instruments:

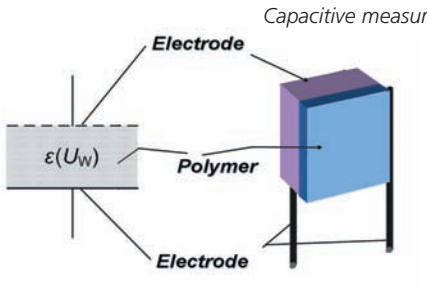
Resistive electrolyte cell



Dew point mirror



Capacitive measurement



Some measuring sensors have in-built calibration data memory at a number of points across the range or aw. The accuracy of available instruments in the market is +/- 0.003 aw.

The Influence of Water Activity in Foods

The equilibrium relative humidity value of a product, which is ascertained through its partial pressure of water vapour on the surface depends on the chemical compound, temperature, water content, storage environment (T/rh), absolute pressure and packing.

'Free' water in products is jointly responsible for the growth of unwanted micro organisms such as bacteria or fungi, which produce "toxins" or other harmful substances. But also chemical/biochemical reactions (for example, the Maillard reaction) increasingly take place and can change the following factors of a product:

- Microbiological stability (growth)
- Chemical stability
- Content of proteins and vitamins
- Colour, taste and nutritional value
- Stability of the compound and durability
- Storage and packing
- Solubility and texture

The optimisation and stabilisation of the product properties require a partially narrow aw value margin. The aw – value of a product can be changed by the adding of so called 'Humectants' such as sugar or polymeric polyols, lactic acid or natural extracts which normally bound water and thereby reduce the amount of free water and finally the water activity. Nowadays the measurement of water activity in the food industry is established in research, development, quality control and production.

Bakery Products

The expression bakery products also covers the product categories of long-life bakery products such as biscuits, crackers, cake, waffles, gingerbread etc., which are durable without cooling or freezing over a longer period (6 to 12 months) at ambient temperature (18°C – 25°C). In long-life bakery products the water content but is reduced severely.

The main criteria for the quality of a durable product, is the hygiene during processing and handling as well as the optimal sensory properties.

Both factors, such as quality and durability of a product, are affected by the raw materials, quality, formulation and storage conditions. The durability of bakery products of middle and high moisture content is limited by the growth of molds. Some species grow at a water activity around 0.8 aw , while xerophilous species still can grow down to an aw-value of 0.6.

Bakery products can be filled with various ingredients such as cream, nuts, nougat, fruit and jam. These ingredients change different factors of the product, which again change the microbial and sensory properties of the bakery product. Combined food that consists of one or several layers differs in its composition. In such food there is the possibility for moisture to migrate from one component to another. This migration happens from regions of high water activity to regions of lower water activity. The water activity is a physical parameter that indicates the 'energy status' of the moisture in a material. Thus it is better to qualify the moisture migration tendencies of the combined food product, using aw, than simply to control the absolute water content of the components.

Waffles

The most important quality characteristics of waffles for ice cream are the texture (crispness) and the mechanical stability. For example, for waffles filled with ice cream there is quickly reached a water content where the texture passes from crispy to stringy and then to leathery and finally supple.

Thus water activity is better qualified to determine this water migration between the different layers as opposed to simply determining the water content.

Bakery products and fruit

The use of fruit in bakery and confectionery has increased in popularity during the last few years. The question of how the fruit is used is mainly answered by the type and the manufacturing technology of the bakery product. The possibilities are fresh fruit and processed range of products such as jam, jellies and gel, which are mainly used for long-life bakery products.

The advantages of the processed fruit compared to the fresh fruit are:

- All season availability
- Simple storage conditions
- Long time shelf life
- Simple handling

The main reason for a shortened shelf life of fruit is primarily caused by the microbial spoilage. Thus the environmental conditions of the micro-organisms have been made unfavourable.

The following procedures for the preservation of fruit are:

- Lowering of the water activity (aw-value) with:
  - dehydration
  - adding sugar (osmotic effect)
  - freezing (transformation from water to ice)
- Temperature
  - heating
- pH lowering
- Oxygen concentration

Durability of sponge cake

Long-life bakery products such as sponge cake are good examples of food where the water activity is one of the main preservation factors. These bakery products have a shelf – life of approximately 6 months regardless of a water content of between 15 to 27%. The filling of these products consists of a variety of different sugars, jams or chocolate.

The main preservation factor is the aw-value that is set in a range between 0.7 and 0.8 aw. This may be achieved by the help of different sugars (glucose, sucrose) or polyol (sorbitol). But also to spray the surface of a product with ethanol helps to control the growth of xerophilous moulds. These steps, together with a packaging under controlled atmosphere build a hurdle to microbiological spoilage

Example of a sponge cake with chocolate filling:

	Water activity (aw)	Water content (%)
Dough	0.755	23.2
Milk caramel mousse	0.785	15.4

The migration and equilibrium properties of water in combined food are an important point for the shelf life stability of the product. High baking temperatures support the level of the aw-equilibrium between the different components.

The adjustment of the equilibrium between the different layers or components of the food is not only influenced by the baking process but also by the storage time between production and packaging.

The level of the water migration during the shelf life time of a combined food, hence the adjustment of the relative equilibrium humidity, if high enough, is what leads to rather homogenous aw-values in the different components. This simplifies the use of the water activity as an indicator for the microbial stability of combined bakery products.

To produce a stable product, yet one that still appeals to the senses of taste & texture, then monitoring during the production according to the HACCP regulations should be performed, where the aw-value measurement forms part of this control.

Conclusion

Even if the measurement of water activity is not a familiar one, it must have its place in every reasonable quality assurance plan (integration into the SOP). For bakery products, the water activity is of paramount importance to avoid bad influence as changes in taste or texture, growing of moulds or microbes, which finally make the product uneatable and reduces the shelf life dramatically. Bakery products are a very good example to demonstrate, how important it is to be focussed on water activity instead of water content. The water content is very low which would assume that the water activity is the same; but this is not the case, the water activity is mostly bigger than 0.700, which allows different moulds and microbes to grow. Additionally, the water activity provides useful information regarding packaging technology due to the fact that most of the bakery products are multi-phase with liquid and solid zone and as well different water activity. Water activity is as well of relevance in other food samples, drugs and life-science products.

The Author

Markus Bernasconi (B.S, Chemistry, post-graduate course in integrated micro-systems, University of Applied Sciences, Burgdorf, Switzerland) worked at his first place of employment for about 4 years, leading research projects in the field of thin film physical and chemical vapour deposition and wet chemical wafer processing. He then changed to Mettler-Toledo Thornton, working as a project leader in R&D. In 2006, Markus Bernasconi joined Swan Analytical Instruments, working first as a product manager and afterwards as a sales and support manager. Since the beginning of Feb 2011 he is a sales engineer/key account manager and responsible for Novasina's water activity instrument portfolio.