Microbial update
dry foods

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Dry foods are a diverse group of materials, in which the microbial stability (the prevention of microbial growth) is aided by use of a low water activity. Water activity is a concept that requires some description before moving onto microbiological aspects of dry foods.

What is water activity?

Water activity or Aw, is defined as the ratio of the vapour pressure of water in a material (p) to the vapour pressure of pure water (po) at the same temperature.

The water activity of pure distilled water is 1.00 and as sugars, salts or other solutes are added to water, the water activity reduces.

Micro-organisms need water in order to be able to grow, in the absence of water growth will not occur, however it is important to realise that although growth may be impossible, the organism may well survive over long periods, and may 'reactivate' and begin to grow once more if the water activity is raised for example if a dehydrated product is rehydrated)

Many preservation processes attempt to eliminate spoilage and risks of pathogen growth, by lowering the availability of water to micro-organisms.

Reducing the amount of free, or unbound, water also minimises other undesirable chemical changes that occur during storage by affecting enzyme activity.

The processes used to reduce the amount of free water in foods include concentration,

dehydration, freeze drying, addition of salt, sugar or even freezing, as water in frozen foods is in the form of ice crystals and therefore unavailable for use by micro-organisms.

Water activity in foods

With food products the control of water activity is very important, as low water activity can help prevent microbial growth (thus increasing shelf life, and reducing or preventing the possible growth of pathogens increasing safety margins).

It can also cause large changes in textural characteristics such as crispness and crunchiness and additionally changes the rate of chemical reactions.

Growth of most bacteria is inhibited below about Aw 0.91 (equivalent to about 57% w/w sucrose); similarly most yeasts cease growing below Aw 0.87 (equivalent to about 65% w/w sucrose) and most moulds cease growing below Aw >0.80 (equivalent to about 73% w/w sucrose).

However, particularly for yeasts and moulds, it must be remembered that there are some specific osmophilic or xerophilic types that can grow at much lower water activities and can become specialised specific spoilage organisms of low water activity foods. The absolute limit of microbial growth is about Aw 0.5-0.6.

Table 1 gives some indication of the water activity values of a range of food products.

Effects on micro-organisms

All micro-organisms have a limiting water activity value below which they cannot grow. This value is dependent on the type of micro-organism and on other factors acting on that organism such as temperature, pH or presence of preservative.

Table 2 shows examples of the minimum water activity for growth of a range of micro-organisms if all other factors are optimal for that organism. It can be seen that water activity has a very specific effect on different types of organism. Bacteria stop growing at higher Aw values than yeasts and moulds. Specific osmophilic and xerophilic yeasts and moulds can grow at very low Aw values and these can become specific spoilage organisms of particular low Aw foods, such as preserves and dried fruits.

Bacterial pathogens tend to stop growing at Aw values of 0.92. An exception is Staphylococcus aureus which can grow down to values of 0.86, however reports would suggest that the toxins from this organism which are responsible for the pathogenic effects are not produced at Aws below approximately 0.90-0.92.

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Table 1. Approximate water activity of some common materials and foods. The values given are only approximate and may vary with food type/composition. Manufacturers wishing to use water activity as a control should always measure the water activity of their own products to get specific values.

Material	Water activity
Distilled water	1
Tap water	0.99
Raw meats	0.99
Cooked pasta	0.98
Milk	0.98
Preserves	0.88
Salami	0.87
Cooked bacon	< 0.85
Saturated NaCl solution	0.75
Dried fruits	0.60
Typical indoor air	0.5-0.7
Honey	0.5-0.7
Dried fruit	0.5-0.6
Dry pasta	0.5
Milk powder	0.2

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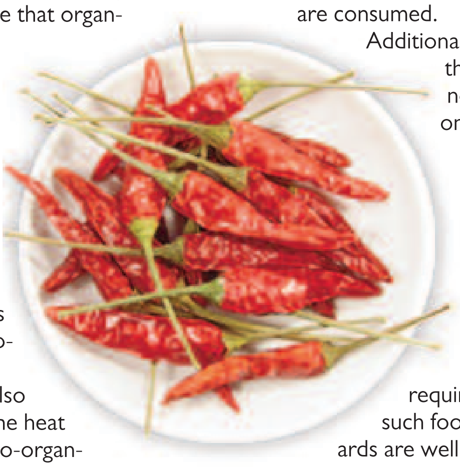
It should be noted that other factors will affect the ability of organisms to withstand the stress of water activity. As an example, lowering pH away from an organism's optimal pH will reduce that organism's ability to withstand Aw stress and the minimum water activity for growth will rise. This is often known as the hurdles concept, where multiple sub-lethal stresses can prevent microbial growth.



Water activity also has an effect on the heat resistance of micro-organisms. An organism within a lower water activity environment will have a higher heat resistance than the same organism in a higher water activity environment.

This is particularly important to consider when assessing heat processes required to inactivate organisms in low water activity foods, as the process required may be considerably higher than that needed in a similar higher water activity product. Food producers often require specialist advice when setting processing parameters for low water activity food products.

Safety of low Aw foods

As noted previously, whilst low Aw foods can prevent microbial growth, organisms can survive within them for some considerable time. This means that such foods can be a food safety risk, unless suitable actions have been taken to remove or destroy pathogens from such produces before they are consumed.

Additionally, it must be remembered that whilst organisms may not grow in a low Aw food, once that food is rehydrated, then the organisms once more attain the ability to grow. Foods such as herbs, spices, milk powder, chocolate, dried meats (salami, jerky, biltong) have all been implicated in outbreaks of food poisoning. Great care is required in the production of such foods to ensure microbial hazards are well controlled.

Dry food production environments are an ideal harbourage for micro-organisms and need careful consideration when considering microbial contamination of the product.

A number of major food poisoning outbreaks have been traced to contaminated food production environments. Cleaning dry production areas is difficult, water use has to be minimised, but cleaning must still be done. It is often good for producers to obtain specific specialised advice on cleaning such areas to minimise the risk of pathogen harbourage.

Table 2. Minimum water activities allowing growth of specific micro-organisms. Note the values given are indicative, specific strains of organisms may vary in their limiting water activity value. The values below should not be used to set stability of foods to the named organisms without taking specialist microbiological advice.

Micro-organism inhibited	Aw
C. botulinum (proteolytic)	0.94
C. botulinum(non-proteolytic)	0.97
Pseudomonas fluorescens	0.97
Clostridium perfringens	0.93-0.95
Escherichia coli	0.93-0.94
Salmonella	0.92-0.95
Vibrio cholerae	0.95
Bacillus cereus	0.93-0.95
Listeria monocytogenes	0.92
Bacillus subtilis	0.91
Saccaromyces cerevisiae	0.90
Staphylococcus aureus	0.83
Zygosaccharomyces bailii	0.80
Most moulds	0.80
Zygosaccahromyces rouxii	0.62
No microbial proliferation	0.50

Measuring water activity

Two method are commonly used:

- **Dew point methods**

The major advantage of this method is speed. Some readings can be taken in as little as five minutes compared to 30-90 minutes for the capacitive sensors. Some manufacturers produce instruments that come pre-calibrated. Others require calibration using a variety of saturated salt solutions. Some reports suggest that the chilled/mirror sensors can determine water activity over a wider range than the capacitive sensors.

- **Capacitive sensors**

Capacitance instruments use a sensor made from a hygroscopic polymer and associated circuitry that gives a signal relative to the Equilibrium Relative Humidity (ERH). The sensor measures the ERH of the air immediately around it. This ERH is equal to sample water activity only as long as the temperatures of the sample and the sensor are the same.

Since these instruments relate an electrical signal to relative humidity, the sensor must be calibrated with known salt standards. Some capacitive sensors need between 30 and 90 minutes to come to temperature and vapour equilibrium. Accurate measurements with this type of system require good temperature control, and can take some time to perform.

Conclusions

Dried or low water activity foods have excellent stability and can be considered very stable and safe as long as manufacturers understand the importance of maintaining the Aw of the product relative to the organisms of concern, and that low Aw only prevents growth and does not necessarily kill micro-organisms.

This knowledge and the use of good manufacturing techniques in a well designed and cleaned production facility will considerably reduce microbial risk and allow production of very stable food products. ■

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