AQUALAB
by Addium

EDUCATION GUIDE

How water activity controls microbial growth

MICRO ORGANISMS RELY ON WATER FOR GROWTH – WITHOUT IT, THEY'RE FORCED TO GO DORMANT.

But how do you know how much water is available and which microbes will grow? In 1953, William James Scott showed that microbial growth in food is governed not by water content, as most people thought, but by water activity. Four years later, he established the concept of a minimum water activity for microbial growth. Water activity is now routinely used by food manufacturers to determine whether or not a product is susceptible to microbial proliferation.

Control water activity, prevent microbial growth

Like all organisms, microorganisms rely on available water in food for growth. They take up water by moving it across the cell membrane. This water movement mechanism depends on a water activity gradient—on water moving from a high water activity environment outside the cell to a lower water activity environment within the cell. When water activity outside the cell becomes low enough, it causes osmotic stress: the cell cannot take up water and becomes dormant. The microorganisms are not eliminated, they just become unable to grow enough to cause infection. Different organisms cope with osmotic stress in different ways. That's why there are different growth limits for each organism. Some types of molds and yeasts have adapted to withstand very low water activity levels. Table 1 shows water activity growth limits for many common microorganisms.

a_w	Bacteria	Mold	Yeast	Typical Products
0.97	*Clostridium botulinum E* *Pseudomonas fluorescens*			fresh meat, fruits, vegetables, canned fruit, canned vegetables
0.95	*Escherichia coli* *Clostridium perfringens* *Salmonella spp.* *Vibrio cholerae*			low-salt bacon, cooked sausages, nasal spray, eye drops
0.94	*Clostridium botulinum A, B* *Vibrio parahaemolyticus*	*Stachybotrys atra*		
0.93	*Bacillus cereus*	*Rhizopus nigricans*		some cheeses, cured meat (ham) bakery goods, evaporated milk, ral liquid suspensions, topical lotions
0.92	*Listeria monocytogenes*			
0.91	*Bacillus subtilis*			
0.90	*Staphylococcus aureus (anaerobic)*	*Trichothecium roseum*	*Saccharomyces cerevisiae*	
0.88			*Candida*	

0.87	*Staphylococcus aureus (aerobic)*			
0.85		*Aspergillus clavatus*		sweetened condensed milk, aged cheeses (cheddar), fermented sausage (salami), dried meats (jerky), bacon, most fruit juice concentrates, chocolate syrup, fruit cake, fondants, cough syrup, oral analgesic suspensions
0.84		*Byssochlamys nivea*		
0.83		*Penicillium expansum* *Penicillium islandicum* *Penicillium viridicatum*	*Deharymoces hansenii*	
0.82		*Aspergillus fumigatus* *Aspergillus parasiticus*		
0.81		*Penicillium Penicillium cyclopium* *Penicillium patulum*		
0.80			*Saccharomyces bailii*	
0.79		*Penicillium martensii*		
0.78		*Aspergillus flavus*		jam, marmalade, marzipan, glace fruits, molasses, dried figs, heavily salted fish
0.77		*Aspergillus niger* *Aspergillus ochraceous*		
0.75		*Aspergillus restrictus* *Aspergillus candidus*		
0.71		*Eurotium chevalieri*		
0.70		*Eurotium amstelodami*		
0.62			*Saccharomyces rouxii*	dried fruits, corn syrup, licorice, marshmallows, chewing gums, dried pet foods
0.61		*Monascus bisporus*		
0.60	No microbial proliferation			
0.50	No microbial proliferation			caramels, toffees, honey, noodles, topical ointments
0.40	No microbial proliferation			whole egg powder, cocoa, liquid center cough drop

0.30	No microbial proliferation	crackers, starch-based snack foods, cake mixes, vitamin tablets, suppositories
0.20	No microbial proliferation	boiled sweets, milk powder, infant formula

Table 1. Water activity growth limits for many common microorganisms

Water activity and FDA, FSIS, FSMA

If you measure the water activity of any material, you will know which bacteria, molds, or fungi can grow on and in it. By reducing water activity, you can rule out the growth of certain classes of microbes. At low water activities you can preclude the growth of anything at all. Water activity is not a kill step. It's a control step, and an integral part of many HACCP plans. These well-established microbial growth limits have been incorporated into FDA, FSIS, and other regulations. Water activity is part of the 2013 Food Code's definition of potentially hazardous foods, which is referenced by the Food Safety Modernization Act (FSMA).

While temperature, pH, and several other factors can influence whether an organism will grow in a food product and the rate at which it will grow, water activity may be the most important factor. Most bacteria, for example, do not grow at a water activity range below 0.91, and most molds cease to grow at water activities below 0.70. Water activity in combination with other hurdles, such as pH, temperature, or modified atmosphere packaging, will limit microbial growth even at water activities higher than 0.91.

Learn more—Watch Water Activity 102

Everyone knows water activity is related to microbial growth. But how can you use that knowledge to your advantage in formulation, specification, production, and packaging? In this 30-minute webinar, learn:

- what you need to know about how water activity predicts microbial growth
- how to use specific organism aw limits relevant to your industry in setting your specs
- how to use different formulation techniques (including humectants, films, coatings) to hit the water activity you need
- why you should consider hurdle technology to address certain challenges

Watch Now →

Drive your company's total moisture performance.

LEARN HOW

