

Available Moisture in Foods: What Is It Anyway?

Food preservation methods such as drying, freezing and adding salt or sugar work by lowering the available moisture in foods. Moisture in foods occurs in two forms: (1) water bound to ingredients in the food (proteins, salt, sugars), and (2) free or unbound water that is available for microbial growth. Water activity (A_w) describes water available for microbial growth and ranges from 0 (bone dry) to 1.0 (pure water). Water activity is controlled by removing water (drying or freezing), by adding salt (curing) or by adding sugar (jams, jellies). Water activity is a good predictor of food safety and of how long a food product will last on the shelf.

The relationship between total moisture and water activity is complex, is related to the relative humidity of the food and its water content and must be determined for each specific food. Foods with higher moisture content might be expected to have higher water activity than dry foods but the expectation is not necessarily correct. Products with the same water content may have very different water activities. For example, salami and cooked beef have similar total moisture (approximately 60%). However, the water activity of salami is 0.82 and that of cooked beef is about 0.98.

Total Moisture and Available Moisture of Common Food Products

Food	Total Moisture (%)	Available Moisture (A_w)
Peppers	92	
Broccoli	91	
Oranges	87	
Apples	84	
Chicken, raw	69	
Beef, raw	73	
Beef, cooked	60	
Chicken, cooked	62	
Bread, commercial	36	
Beef jerky	23	
Jams/preserves	30	

Cocoa	7 to 10
Peanut butter	2
Whole milk powder	7
Whole milk powder	2 to 3
Dried fruits	31

Source: <http://www.gov.mb.ca/agriculture/food-safety/at-the-food-processor/water-content-water-activity.html#relationship>

The majority of microorganisms that cause spoilage or foodborne disease grow well in foods with a water activity (A_w) of 0.91 to 0.99. Assuming other conditions are favorable, the organism that causes botulism, *Clostridium botulinum*, will grow and produce toxin in foods with a water activity (A_w) above 0.93. *Staphylococcus aureus* grows in foods containing high levels of salt at a water activity (A_w) above 0.85 but produces staphylococcal toxin in foods with an A_w of 0.93 or higher. The following table lists sample foods, their range of water activities and the microorganisms that can grow in them.

A_w	Microorganisms That Grow at or above This A_w	Typical Foods Containing This A_w or Higher
>0.95	Spoilage bacteria, some yeasts, <i>Bacillus</i> , <i>Clostridium perfringens</i>	Fresh and canned fruits, vegetables, meat, fish, milk, containing up to 7% salt, breads
0.91	<i>Salmonella</i> , <i>Vibrios</i> , <i>Clostridium botulinum</i> , some molds	Cheddar cheese, Swiss cheese, cured meat, fruit jellies, table sugar, foods with 12% salt
0.85	Most yeasts, <i>Staphylococcus aureus</i>	Fermented sausage, sponge cakes, dry cheese, foods with 10% or 15% salt, margarine,
0.80	Most molds, bread yeasts	Jams, marmalades, fruit preserves, condensed milk, molasses, syrup, flour, high-sugar cakes
0.75	Most salt-loving bacteria, molds that produce aflatoxins	Glace fruits, marzipan, marshmallows, ground black pepper
0.70	Dry-tolerant molds	Peanut butter containing 15% total moisture; dry cereals
0.60	Some sugar-loving yeasts, a few dry-tolerant molds	Dried fruits containing 15 to 20% total moisture, dry cereals
0.50		Noodles with 12% moisture, spices with 10% total moisture

0.40	Whole egg powder with 5% total moisture
0.03	Whole milk powder with 2 to 3% total moisture,

Table modified from <https://extension.psu.edu/food-safety-and-quality/home-food-safety>

Water activity cannot be measured at home so it is important to following science-based directions for drying foods. Following science-based procedures reduces the available moisture (A_w) in foods to less than 0.60 so that microorganisms cannot grow. Storing properly dried foods in glass jars, metal cans or boxes with tightly fitted lids or moisture-vapor resistant freezer containers prevents them from re-absorbing water from the atmosphere.

Sources:

- [HGIC 3080. Drying Foods](#). (06/99.) P.H. Schmutz, E.H. Hoyle.
- Shelly J. Schmidt and Anthony J. Fontana, Jr. 2008. Appendix E. Water Activity Values of Select Food Ingredients and Products. In *Water Activity in Foods: Fundamentals and Applications*. Wiley On-line. <http://onlinelibrary.wiley.com/doi/10.1002/9780470376454.app5/pdf>
- Water Activity (A_w) in Foods. US Food & Drug Administration Inspection Technical Guides. Number 39 (4/16/84) <http://www.fda.gov/ICECI/Inspections/InspectionGuides/InspectionTechnicalGuides/cm072916.htm>
- Water Activity of Foods Table. Pennsylvania State University Cooperative Extension. <https://extension.psu.edu/food-safety-and-quality/home-food-safety>
- Water Content and Water Activity: Two Factors That Affect Food Safety. Manitoba Agriculture, Food and Rural Development. <http://www.gov.mb.ca/agriculture/food-safety/at-the-food-processor/water-content-water-activity.html#relationship>