

Water Activity vs. Water Content



Water is present in all food. It usually takes two forms:

- free or available water
- water that is bound to different molecules such as proteins and carbohydrates

Available water in food can support the growth of bacteria, yeast and mold, which can affect the safety and quality of food. Knowing the available water value of a food product or ingredient is necessary when conducting a hazard analysis.

Water Activity (a_w)

- measurement of the availability of water for biological reactions
- expression: $a_w = P/P_0$
P: vapor pressure in a food
P₀: vapor pressure of pure water

- expression:

$$M_w \text{ (wet basis)} = (w-d)/w \times 100$$

M_w: moisture content on a wet percent basis

w: wet weight

d: dry weight

Water Activity of Common Food Products

Foods	a_w
fresh meat, fish and vegetables	0.99
raw fruits	0.98
cooked meat, bread	0.91-0.98
moist cakes	0.90-0.95
sausages, syrups	0.87-0.91
flours, rice, beans, peas	0.80-0.87
salami	0.82
jams, marmalades, jellies	0.75-0.80
dried fruits	0.60-0.65
dried spices, milk powder	0.20-0.60
biscuits, chocolate	<0.60

Water Content (Moisture Content)

- measurement of the total water contained in a food including available water and bound water

Water Content of Common Food Products

Foods	% Water
apple	84
orange	87
broccoli	91
beef, raw	73
chicken, raw	69
beef, cooked	62
chicken, cooked	62
salami, beef	60
bread	36
jams/preserves	30
beef jerky	23
wheat flour	11
cookies/biscuits	6

Relationship between Water Content and Water Activity

The relationship between water content and water activity is complex and related to the relative humidity of the food and its water

content. This relationship must be determined for each specific food item. Water content on its own is not enough information to determine food safety or predict product shelf life.

Factors that Influence Water Activity

- Drying**
 Water activity is decreased by physically removing water, e.g., beef jerky.
- Solutes**
 Water activity is decreased by adding solutes such as salt or sugar, e.g., jams.
- Freezing**
 Water activity is decreased by freezing, e.g., water is removed in the form of ice.
- Combination**
 One or more factors can be combined for a greater influence on water activity, e.g., salting and drying fish.

When and How to Test

There is a variety of tests for determining water content and water activity:

	Useful When	Method
Water Activity	<ul style="list-style-type: none"> determining the safety or shelf stability of a product 	1) Health Canada - Compendium of Analytical Methods 2) Water Activity Meters
Water Content	<ul style="list-style-type: none"> confirming the end point of a drying process knowing the dry weight of a food 	1) Official Methods of Analysis of AOAC International 2) Moisture analyzers

Typical Water Activity Limits for Organisms

Group of Micro-Organisms	Minimum a_w required for growth
most gram-negative bacteria	0.97
most gram-positive bacteria	0.90
most yeasts	0.88
<i>Staphylococcus aureus</i>	0.86 (produce toxin at 0.93)
Halophilic bacteria (grow best at high salt concentrations)	0.75
Xerophilic molds (grow on dry foods)	0.62-0.60
Osmophilic yeasts (grow in high concentrations of organic compounds, e.g., sugars)	0.62-0.60
<i>Penicillium cyclopium</i> (produce Ochratoxin)	0.82-0.85 (produce toxin at 0.87- 0.90)
<i>Aspergillus flavus</i> <i>Aspergillus parasiticus</i> (produce Aflatoxins)	0.82 (produce toxin at 0.83-0.87)
<i>Penicillium expansum</i> (produce Patulin)	0.81 (produce toxin at 0.99)
<i>Penicillium patulum</i> (produce Patulin)	0.81 (produce toxin at 0.95)
<i>Aspergillus ochraceus</i> (produce Ochratoxin)	0.77 (produce toxin at 0.85)
most molds	0.80

For more information on food safety please contact the Food Safety and Inspection Branch at foodsafety@gov.mb.ca.