http://www.gov.mb.ca/agriculture/food-safety/at-the-food-processor/water-content-water-activity.html

Water activity

Water activity is a measurement of the availability of water for biological reactions. It determines the ability of micro-organisms to grow. If water activity decreases, micro-organisms with the ability to grow will also decrease.

Water activity (aw) is expressed as the ratio of the vapor pressure in a food (P) to the vapor pressure of pure water (P0). It predicts whether water is likely to move from the food product into the cells of micro-organisms that may be present.

aw= P/P0

For example, a water activity of 0.90 means the vapor pressure is 90 per cent of that of pure water. Water activity increases with temperature due to changes in the properties of water such as, the solubility of solutes such as salt and sugar, or the state of the food.

Relationship between Water Content and Water Activity

Water content on its own is not enough information to determine food safety or predict product shelf life. 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.

It is easy to assume that foods with higher water content will have a higher water activity than dry foods. This is not always correct. It is possible to have products with the same water content but very different water activities. For example, salami and cooked beef have similar water content of approximately 60 per cent. However, the water activity of salami is 0.82 and cooked beef is approximately 0.98.

Water Activity of Common Food Products

Most food has a water activity greater than 0.95 which supports the growth of bacteria, yeast and mold. Knowing the water activity of a food is important when preparing a Hazard Analysis Critical Control (HACCP) plan. The water activity of a product or ingredient is necessary when conducting a hazard analysis and completing Form 1 for many products.

|  |  |
| --- | --- |
| Foods | aw |
| fresh meat and fish | 0.99 |
| raw vegetables (ex: carrots, cauliflower, peppers) | 0.99 |
| raw fruits (ex: apples, oranges, grapes) | 0.98 |
| cooked meat, bread | 0.91-0.98 |
| Liverwurst | 0.96 |
| Caviar | 0.92 |
| moist cakes (ex: carrot cake) | 0.90-0.95 |
| sausages, syrups | 0.87-0.91 |
| flours, rice, beans, peas | 0.80-0.87 |
| Salami | 0.82 |
| soy sauce | 0.80 |
| beef jerky | <0.80 |
| jams, marmalades, jellies | 0.75-0.80 |
| peanut butter | 0.70 |
| dried fruits | 0.60-0.65 |
| dried spices, milk powder | 0.20-0.60 |
| biscuits, chocolate | <0.60 |

Water Content of Common Food Products

Water content measurement may be useful in some situations such as determining yield. Water activity, however, is a more suitable measurement for predicting food safety and quality. The approximate water content of some typical food is listed below:

|  |  |
| --- | --- |
| Foods | % Water |
| Apple | 84 |
| Orange | 87 |
| Grapes | 81 |
| Strawberry | 92 |
| Broccoli | 91 |
| Cucumber | 96 |
| Peppers | 92 |
| Potato | 79 |
| beef, raw | 73 |
| chicken, raw | 69 |
| beef, cooked | 62 |
| chicken, cooked | 62 |
| salami, beef | 60 |
| bread, commercially prepared | 36 |
| dried fruit | 31 |
| jams/preserves | 30 |
| beef jerky | 23 |
| wheat flour | 11 |
| cookies/biscuits | 6 |
| peanut butter | 2 |

Typical Water Activity Limits for Organisms

By lowering water activity, food can be made safe to store. The table below shows water activity levels that can support the growth of particular groups of organisms.

|  |  |
| --- | --- |
| Group of Micro-Organisms | Minimum aw required for growth |
| most gram-negative bacteria | 0.97 |
| Staphylococcal toxin production (by Staphylococcus aureus) | 0.93 |
| most gram-positive bacteria | 0.90 |
| most yeasts | 0.88 |
| Staphylococcus aureus | 0.86 |
| most molds | 0.80 |
| Halophile bacteria (grow best at high salt concentrations) | 0.75 |
| Xerophillic molds (can grow on dry foods) and Osmophillic yeasts (can grow in the presence of high concentrations of organic compounds, ex: sugars) | 0.62-0.60 |

Molds have minimum water activities for growth and toxin production. Most molds require a higher water activity than the minimum requirement for growth to produce mycotoxins. The table below shows a few common mycotoxins and minimum water activities for mold growth and toxin production.

|  |  |  |  |
| --- | --- | --- | --- |
| Mycotoxin | Mold |  | Minimum aw requirement |
|  |  |  | Toxin Production | Growth |
| Aflatoxins | Aspergillus flavus |  |  |  |
|  |  Aspergillus parasiticus |  | 0.83-0.87 | 0.82 |
| Ochratoxin | Aspergillus ochreceus  |  | 0.85 | 0.77 |
|  |  Penicillium cyclopium |  | 0.87-0.90 | 0.82-0.85 |
| Patulin | Penicillium expansum  |  | 0.99 | 0.81 |
|  | Penicillium patulum |  | 0.95 |  |

The grain industry often tests for water content when receiving and storing grain. The Canadian Grain Commission developed the document: Good operating practices for: Grains, oilseeds and pulses grain handling and processing facilities, which has useful information:

Safe Storage Timeframes for Wet Grain

Finished product moisture (FPM) levels will minimize the risk of mycotoxin development due to high-moisture grain. FPM leves are:

wheat <14.6%

soybeans <14%

beans <16.1%

lentils <13.1%

peas <16.1%

mustard seed <9.6%

When moisture level of incoming grain exceeds FPM levels, safe storage timeframes are:

* if moisture is > FPM and <=18% dry to below FPM within 40 days
* if moisture is > 18% and <=20% dry to below FPM within 20 days
* if moisture is > 20% and <= 22% dry to below FPM within 10 days
* if moisture is >22% and <= 24% dry to below FPM within five days
* if moisture is >24% dry to below FPM within three days

Factors that Influence Water Activity

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

When to Test for Water Activity or Water Content

Water activity values are useful when:

* determining the safety or shelf stability of a product

Water content values are useful when:

* establishing the dry weight of a food or ingredient
* determining yield
* confirming the end point of a drying process

How to Test for Water Content (Moisture) and Water Activity

There are a variety of test methods and equipment available for determining water content (moisture) and water activity in food and other commodities, including:

Water content:

* Official Methods of Analysis of AOAC International
* Moisture Analyzers
* Water Activity (aw):
* Health Canada - The Compendium of Analytical Methods (Volume 3)
* Water Activity Meters

There are a number of companies that manufacture and supply equipment for water activity testing. Also, many laboratories can conduct water content (moisture) and water activity testing on a fee-for-service basis. This is a good option for processors without access to testing equipment in their own facility.