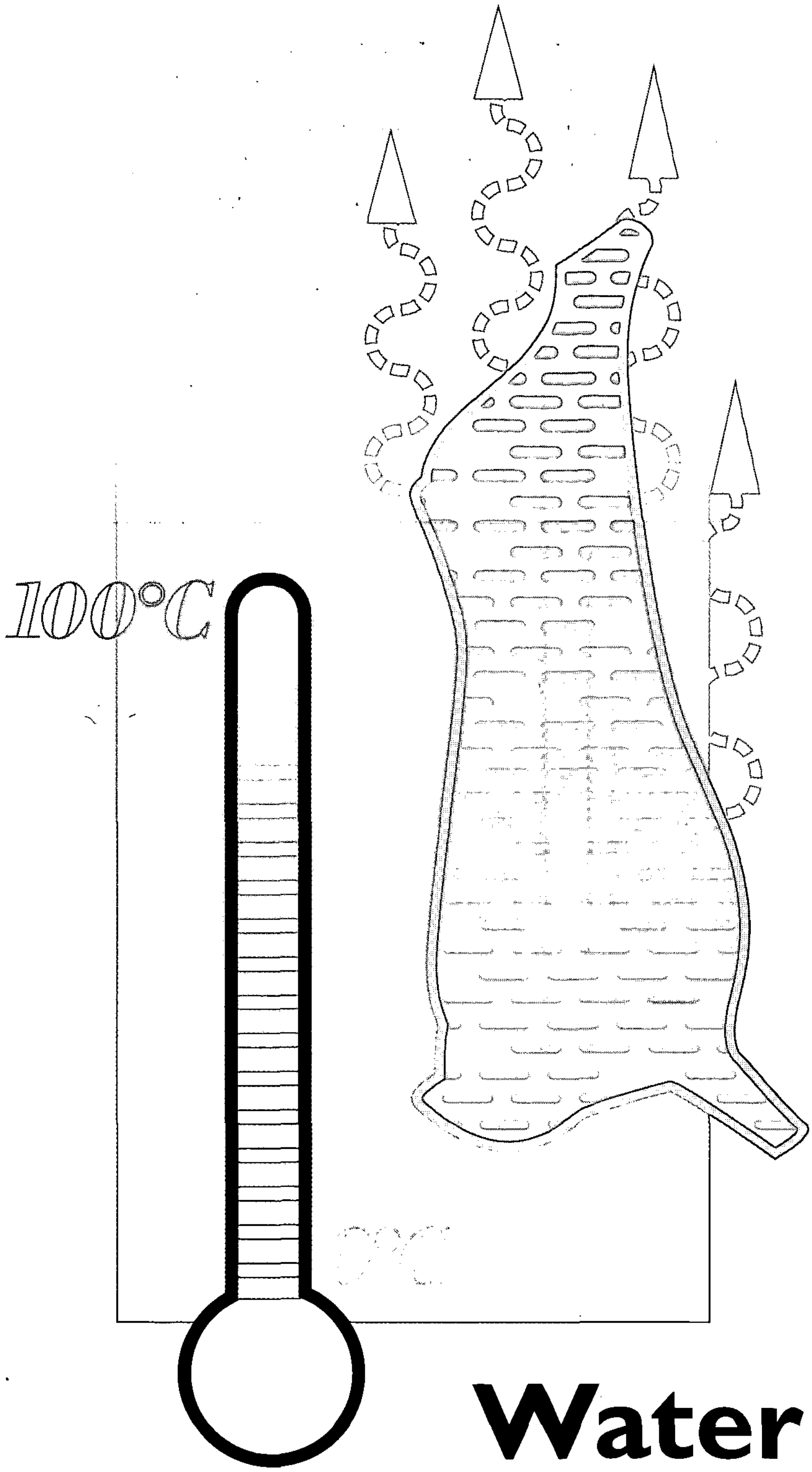

Water Activity (a_w)

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Meat Research Corporation

AMT
AUSTRALIAN MEAT TECHNOLOGY

The regulation of water as an ingredient in foods was the earliest form of food preservation. The availability of water for microbiological growth and biochemical reactions can be controlled by dehydration, freezing or the addition of solutes such as salt and sugar. Water activity (a_w) is a measure of the availability of water and is defined as the ratio of the water vapour pressure of the sample to the vapour pressure of pure water at the same temperature. It can have values ranging from 0 (bone dry) to 1 (pure water). Water activity, a measure of unbound water in foods available for use by microbes and for biochemical reactions, is not the same thing as moisture content which is a measure of the total moisture content of the food. A variety of foods may have exactly the same moisture content yet have quite a different a_w. Table 1 gives examples of the water activity of some common meat products.

TABLE 1 **Water activity of meat products**

Product	Typical a_w
fresh meat	0.99
bacon	0.92 - 0.95
continental frankfurter	0.92
cabanossi	0.9 - 0.92
non-fermented salami (eg. polish)	0.09 - 0.94
fermented salami (eg. Danish, mettwurst)	0.85 - 0.9
prosciutto ham	0.85
biltong	0.75 - 0.85
jerky	0.75 - 0.85

Water activity can be determined by measurement of freezing point depression or by measurement of equilibrium relative humidity (ERH), with the latter being the more common method.

Application

The most useful application of water activity is in predicting the growth of bacteria, yeast and moulds. There are specific a_ws below which certain micro-organisms cannot grow. For example most spoilage and pathogenic organisms cannot grow below a_w 0.91 and no microbiological growth is possible below a_w 0.6. Meat products with an a_w below 0.9 are protected against most bacterial growth. Products with a_w between 0.75 and 0.85 are very well protected against the growth of bacteria but can support slow mould growth. Below 0.75 mould growth is possible but is very slow.

In addition to influencing microbial spoilage, a_w can play a significant role in determining the activity of enzymes and vitamins in foods and can have a major impact on food colour, taste and aroma. Examples of reactions directly influenced by a_w are Maillard reactions (non enzymic browning reaction), and the breakdown of triglycerides to produce free fatty acids.

If the reduction of available water is used as a preservation method for meat products it will be necessary to test for a_w, especially if adjustment of a_w is a critical control point in a HACCP plan. Meeting the required a_w will ensure the required preservative effect is achieved. Common meat products which rely on water activity for a preservative effect include: bacon, continental smallgoods (eg. cabanossi), fermented salamis, prosciutto ham, biltong and jerky.

Some products such as dried meats (including jerky and biltong) and semi-dried heat treated manufactured meats are defined by their a_w according to the Food Standards Code. For example, dried meats must have a_w less than 0.85 to take advantage using the ingredients that are permitted in these products.

The Australian smallgoods industry is currently adopting food safety guidelines. In these guidelines, model HACCP plans for some products use adjustment of a_w as a critical control point.

Outline of Method

The most common method for the determination of water activity is by measurement of equilibrium relative humidity (ERH). The ERH refers to the relative humidity of the atmosphere surrounding the food and is equal to 100 times the a_w. Several procedures are available for the determination of the ERH and consequently a_w. Some common procedures are:

CSIRO Water Activity kit

In practice the method involves placing a small amount of the detector liquid in a small Petri dish which is rested on a sample placed in a hermitically sealed container, such as a glass jar. The atmosphere comes into equilibrium with the food sample and the detector liquid absorbs or desorbs water until it is equilibrium with relative humidity of the atmosphere in the container. After the detector liquid has equilibrated, its refractive index is measured by refractometer. Above a_w 0.76, a hand held refractometer is sufficient for determining the refractive index. The a_w of the liquid is then read off from a calibration chart which converts the refractive index to a_w. The a_w of the detector liquid after equilibration is equal to the a_w of the food. The initial concentration of the water in the detector liquid can be adjusted so that its a_w is close to that of the sample, thus minimising the equilibration time. A feature of the procedure is that the readings are insensitive to temperatures between 15 and 25°C. A drawback of the procedure is that overnight equilibration of the detector liquid is recommended to achieve accurate results.

Luft a_w Value Analyser

The Luft a_w analyser measures ERH with a hair hygrometer. The hair hygrometer is a water-sorbing fibre that changes in length depending on relative humidity. The Luft meter kit includes two sensor heads with sample jars. One sensor can be used for measuring a sample a_w while the other sensor is calibrated in preparation for measuring a sample. The sensors are calibrated with saturated barium chloride solution.

Advantages of the Luft analyser are that it is a complete kit including an insulated container to help stabilise the temperature during measurement, two measuring sensors and calibration solution. Also, it is small and easily transportable. Disadvantages are that lengthy calibration is required (approximately 1½ hours) at constant temperatures and the time to achieve an a_w result after calibration is approximately 3 hours. It is also critical that the sample jars are not inverted as the sample could contaminate and damage the sensor. The analyser can measure a_w in the range 0.4 to 1.0.

AquaLab CX-2 Water activity meter

The AquaLab meter is an instrumental method which uses chilled mirror or dew point technology to determine the a_w. It involves the use of a sensor which determines the dew point temperature of air equilibrated with a food sample. In addition, infra red thermometry pin-points the sample temperature. The dew point and temperature measurements are converted to vapour pressure and the a_w of the sample is determined from the head space vapour pressure.

The major advantage of this procedure is speed. The water activity of a sample can be determined in approximately 5 minutes. It is claimed that the AquaLab does not require calibration as it comes pre-calibrated, however, salt solutions are used for verification where contamination of the sensory head has occurred. Disadvantages of this system are that it can be susceptible to dust contamination and may require periodic maintenance and cleaning. Secondly, the instrument cannot be used on samples which contain propylene glycol because this chemical will condense on the sensor and interfere with the reading.

AquaLab operating conditions are 5 to 43°C and 20 to 85% relative humidity. It has an accuracy of 0.003 a_w, with a range of 0.03 to 1.00 a_w. Weight is 4.5 kilograms and dimensions are 25.4 x 22.8 x 11.4 cm. The procedure used for determination of a_w by AquaLab is approved by the AOAC

Precautions

When measuring a_w by estimating equilibrium relative humidity, it is essential to allow sufficient time for the head space in the measuring chamber to come into equilibrium with the sample and for the sensor to equilibrate with the head space. Equilibrium can be reached more quickly if samples are comminuted, minced or cut into small pieces.

Alternative procedures

Other procedures for the determination of ERH include the non-equilibration sorption rate method in which samples of the food are placed in atmospheres of known ERH. These atmospheres are created in sealed cabinets containing saturated salt solutions of known ERH. The food sample will either absorb or lose moisture depending on its a_w and from a plot of the weight change over a fixed period of time against relative humidity, the interpolated ERH at which no weight change occurs gives the figure for a_w. This procedure is lengthy, complex and requires considerable operator input.

Several other instrumental methods are available. Most use electrical sensors which measure humidity-induced changes in resistance or capacitance. The sensors have to equilibrate with the head space relative humidity above a sample and this takes at least 30 - 90 minutes. The sensors must be calibrated regularly by using them to measure the ERH above salt solutions of known a_w.

Equipment Suppliers

CSIRO Water Activity Kit

The CSIRO water activity kit can be obtained form the CSIRO Division of Food Science and Technology at a cost of $450.00. This cost does not include a refractometer. For further information contact:

Dr Bob Steele
CSIRO Division of Food Science
and Technology,
PO Box 52 NORTH RYDE NSW 2133
Phone (02) 9490 8333

Luft a_w Value Analyser

The Luft Analyser costs approximately $1900 and can be purchased from.

Banksia Scientific Company Pty Ltd
PO Box 76 NEWSTEAD QLD 4006
Phone (07) 3252 9944

AquaLab CX-2 Water activity meter

The price of the meter is approximately $11 000 and can be purchased by the following suppliers:

Graintech
PO Box 336 TOOWOOMBA QLD 4350
Phone (07) 6387 677 Fax (07) 6381 761
Contact – Ron Leamon

or

Arrow Scientific Pty Ltd
Unit 2/87 More Street
LEICHHARDT NSW 2040
Phone (02) 9564 1065 Fax (02) 9564 1813
Contact – Louis Petrin

Method

Equipment

- □ CSIRO Water Activity Kit.
  The kit includes sample jars, detector liquids that can be supplied at water activities to suit the products that will be measured, and calibration charts (in refractive index or °brix). If needed, a refractometer can be supplied at extra cost.
- □ Luft a_w Value Analyser.
  The kit comes complete with all materials required to perform a_w. Included are materials for calibration, two sample jars and two sensor heads.
- □ AquaLab CX-2 Water activity meter.
  Included in the purchase price is the AquaLab meter, performance verification standards and 100 sample dishes which are reusable.

Procedure

The methods of measuring water activity use proprietary kits or instruments and the procedures should follow the manufacturers instructions.

Additional Information

CSIRO Meat Research News Letter No 90/3, "Water Activity"

Additional information

Additional help and advice are available from Food Science Australia, Meat Industry Services Section:

	Phone	Fax
Ian Eustace	(07) 3214 2117	(07) 3214 2103
Neil McPhail	(07) 3214 2119	(07) 3214 2103
Bill Spooncer	(02) 4567 7952	(02) 4567 8952
Chris Sentence	(08) 8370 7466	(08) 8370 7566

Processing and Product Innovation
Meat & Livestock Australia

Tel: (02) 9463 9166
Fax: (02) 9463 9182

Email: ppi@mla.com.au