

Humectants and Water Activity

by Sarah Koerber

WATER IN FOOD PRODUCTS functions as a reaction medium, reactant, oxidizer, and structural component. Water activity (a_w) affects food chemistry and can be controlled by removal (dehydration or drying) or by chemically binding the water, reducing its activity. Water activity in foods ranges from 0.95 to 1.00 in fresh meats and vegetables to 0.20 in dried milk. (see table 1 for expanded list)

Humectants as Food Additives

Humectants are additives that bind water and control a_w . Although humectants have applications in many industries - pharmaceutical, cosmetic, veterinary - the focus here is on humectants in foods. Water activity reduction achieved by adding humectants to food enhances stability, maintains texture, and reduces microbial activity.

Humectant use in foods is widespread and has a long

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New NSF Certification Program



■ How are your product's water activity numbers measuring up?

The NSF (National Sanitation Foundation) is an independent not-for profit organization known for the development of standards, product testing and

certification services for public health safety and protection of the environment. The NSF Mark is placed on millions of consumer, commercial and industrial products annually and is trusted by users, regulators and manufacturers alike.

NSF INTERNATIONAL has announced a new certification program, Draft Standard 75, for non-potentially hazardous bakery products.

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→→→ Inside:

■ Q&A on New Series 3TE ■ Food Recalls & Water Activity ■ Moisture Sorption Book Review and more.



■ AquaLab Pawkit- Decagon's new portable water activity device.

DECAGON TRADESHOWS

● **International Food Ingredients Asia**

May 16-18
Japan

● **Food Safety Farm to Table Conference**
May 16-17

Moscow, ID

● **Institute of Food Technologists**

June 11-14
Dallas, TX

● **American Society of Agricultural Engineers**

July 9-12
Milwaukee, WI

● **International Association for Food Protection**

August 6-9
Atlanta, GA

● **International Symposium on the Properties of Water**

September 16-21
Zichron Yaakov, Israel

● **NSF International Conference on Food Safety**

October 11-13
Savannah, GA

● **Food Quality**

October 3-5
Philadelphia, PA

● **American Association of Pharmaceutical Scientists**

October 29-November 2
Indianapolis, IN

● **American Association of Cereal Chemists**

November 5-9
Kansas City, MO

CUSTOMER VISITS

ILLINOIS
MAY 8-12

WISCONSIN
JULY 6-14

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SEPT 26-OCT 6

MINNESOTA
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Q&A on New AquaLab Series 3TE

Q: What does the “TE” stand for in the new model name AquaLab Series 3TE?

A: TE stands for thermoelectric (TE) device (Peltier cooler).

Q: What are the benefits of internal temperature control?

A: Though the a_w of most products varies by less than ± 0.002 per $^{\circ}\text{C}$, some regulations are set requiring measurement at a specific temperature. The most common specification is 25°C , though 20°C is sometimes indicated. The internal temperature control of AquaLab Series 3 model TE makes it the logical choice for compliance with these regulations.

Temperature dependence can be a factor in some manufacturing processes. The ability to make water activity measurements at a constant temperature on a production floor allows for better process control.



■ *Protect the vision of your product's future by monitoring water activity.*

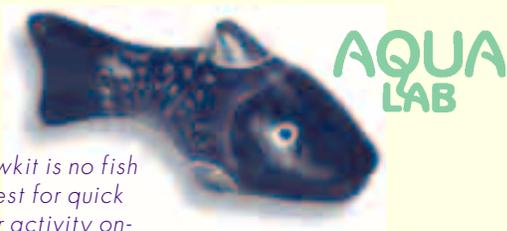
Reasons for sample temperature control include: 1. Research purposes, 2. Government or company regulations, 3. Extreme ambient temperature fluctuations.

Q: What effect does temperature have on the water activity of my product?

A: Typically water activity of a product changes by less than $0.002 a_w$ per degree temperature change. This topic is discussed in detail in our free 1996 and 1999 newsletters.

Q: Can I put a sample straight out of the oven into AquaLab Series 3TE?

A: No. The operating range of AquaLab Series 3TE is



■ *AquaLab Pawkit is no fish story. It's the best for quick checking water activity on-the-go.*

15°C to 40°C . You will need to cool the sample to about the set temperature of AquaLab Series 3TE before measurement.

Q: What if I want to measure a sample that is colder than 15°C ?

A: In this situation we recommend turning off the temperature control feature of the 3TE and putting the entire instrument in a refrigerator.

Q: You have been offering a trade-in program—\$1000 value for old AquaLab CX1 or CX2 if I want to get a new AquaLab Series 3. Does this same program apply to the purchase of a Series 3TE?

A: Yes! We will even give you a \$500 credit if you wish to trade in another company's old model gathering dust in your laboratory. ■

New NSF Certification Program (continued)

Draft Standard 75 was developed based on the current FDA Food Code definition of potentially hazardous foods (see sidebar at right) and outlines test methods and evaluation criteria to determine that a product will not support the rapid and progressive growth of pathogenic microorganisms when inoculated and stored at ambient temperatures for a time specified by the manufacturer.

NSF has teamed with Silliker Laboratories to test and certify products to NSF Draft Standard 75. Silliker Laboratories measures a product's pH and water activity level, and then, if necessary, will challenge test the product to determine the product's inability to support growth of specific bacteria.

The NSF Draft Standard 75 includes a variety of bakery products formulated to no longer be considered potentially hazardous. The standard applies to foods such as breads or pastries containing vegetables or soft cheeses added prior to baking (e.g., danish), baked products filled or topped with cream, creme, custard, or cheese after baking (e.g., creme pies), some products

continued on next page

Water activity—four inches sleek and four ounces slim.



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Ultracompact water activity kit.

- Low-maintenance sensor and readout in a single unit.
- Perform quick checks, measure a_w in 5 minutes or less.
- Easy-to-read display shows water activity and sample temperature together.
- Long 3-year battery life. No adapter or external power supply required.
- Remarkably portable, and lightweight.
- One year warranty—parts and labor. *Extended warranty available.*
- Easy calibration saves time.
- Included: protective case, cups, solutions, quick-start guide, and manual.

Pawkit

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▼
filled prior to baking (e.g., pumpkin pie), and components such as toppings or fillings stored without temperature control prior to use in other products.

Products excluded from the scope of Standard 75 include bakery products containing dehydrated vegetables or fruit fillings; individually pre-portioned wrapped and fruit-filled, creme-filled, and/or frosted products; traditional breads and pastries; and food products rendered non-potentially hazardous by special packaging.

The key elements of the Standard 75 certification include: 1) worldwide recognition and trust among public health officials, 2) assurance to manufacturers, retailers, regulators, and consumers that the products have been tested and are safe to store at room temperature, 3) ability to store or display NSF certified products at room temperature, and 4) reduction in the need for multiple testing for different states. ■

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Potentially Hazardous Foods:

■ Potentially hazardous foods are those that require temperature control because they support the rapid and progressive growth of infectious or toxigenic microorganisms.

■ Potentially hazardous foods include foods of animal origin that are raw or heat-treated, foods of plant origin that are heat treated or consist of raw seed sprouts; cut melons; and garlic and oil mixtures that are not acidified or otherwise modified to prohibit microorganism growth.

■ Potentially hazardous food does not include items with water activity (a_w) values of 0.85 or less, food with a pH level of 4.6 or less, food in unopened hermetically sealed containers, those that maintain commercial sterility under non-refrigerated storage and distribution, or those in which rapid and progressive growth of infectious or toxigenic microorganisms cannot occur.

4 Food Product Recalls & Water Activity

ACCORDING TO THE CENTERS for Disease Control (CDC), foodborne disease is responsible for approximately 76 million illnesses, 325,000 hospitalizations and 5,000 deaths annually in the United States. Known pathogens, such as *Salmonella*, *Escherichia coli* O157:H7, *Campylobacter* and *Listeria monocytogenes*, account for an estimated 14 million illnesses, 60,000 hospitalizations and 1,800 deaths.

The Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA) are responsible for ensuring that products are safe, wholesome, and accurately labeled. Facility inspections and follow-up enforcement actions, both civil and criminal, complement the agency's pre-market approval procedures for keeping potentially unsafe products from reaching American consumers.

Product Recalls, Alerts, and Warnings

Recalls are actions taken by a company to remove a product from the market. They can cost millions of dollars in product losses and operational delays, along with losses to consumer confidence and company reputation. However, protecting the consumer is the number one priority in a product recall. Recalls may be conducted on a firm's own initiative, by FDA request, or by FDA order under statutory authority. There are three classes of recall.

A Class I recall involves a health hazard situation where there is a reasonable probability that eating the food will cause health problems or death. Meat contaminated with pathogenic bacteria, such as *Listeria monocytogenes* in a ready-to-eat product, *Escherichia coli* O157:H7 in raw ground beef, or food found to contain botulinum toxin fall into this category.

Class II recalls involve a potential health hazard situation when products might cause a temporary or medically reversible health problem or pose only a remote chance of serious health consequences. For example, the presence of unlisted milk proteins, a Class II allergen, might prompt a recall.

Class III recalls occur when eating the food will not

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■ Are you toasting your product just to get better shelf-life? Start doing quick easy checks with AquaLab Pawkit.

cause adverse health consequences. An improperly labeled product that actually contains fewer items than those listed on the label could trigger a Class III recall.

Recognizing the need to commit more resources to food safety, President Clinton announced the "Food Safety from Farm to Table" program in 1997, a multi-agency effort to improve the safety of the US food supply. The most flexible approach to meet the particular needs of a company is HACCP (Hazard Analysis and Critical Control Point). Many companies already use HACCP voluntarily. Both programs include steps requiring an early warning system, risk assessment, improved detection/control methods, and improved inspections and compliance.

Water activity affects the ability of microorganisms to proliferate in foods. Therefore, monitoring water activity is a critical control point for many manufacturers. Incorporating water activity testing and other science-based analyses into a food safety program helps ensure the highest quality and safest food supply. Prevention of food-borne diseases will continue to be central to food safety from both the processor and government perspective. ■

**80% of the Top 100
Food Companies use
AquaLab water activity
meter in their labs and
on the production floor.**

Book Review

Moisture Sorption: Practical Aspects of Isotherm Measurement and Use. Second Edition. by Leonard N. Bell and Theodore P. Labuza.

This new edition was published by Eagan Press in April 2000. The authors do an excellent job of describing moisture sorption isotherms, water activity, and humectants. They explain these difficult concepts with well illustrated equations and practical real world examples. This book is a prime addition to the application of water activity and moisture sorption isotherm concepts in product design and development. This book is available from the American Association of Cereal Chemists.

HERE IS A REVIEW OF THE BOOK BY AACC:

This manual explains water activity in foods and shows why commonly held ideas about free and bound water are often inaccurate. It demonstrates how moisture sorption isotherms are created and how they are used to solve real-world problems such as the change in rate of moisture gain for individual packaged products over time, or the amount of sugar needed to lower the water activity of a product to make it shelf stable.

The authors emphasize the physical chemistry of water in biological systems. For every equation provided they furnish examples from practical experience. These examples will help food scientists understand thermodynamics (equilibrium processes and water activity), dynamics (rate processes such as mass

Trade-in your old CX2 or CX1 and receive a credit on the purchase of a new AquaLab Series 3 or Series 3TE.

transfer of moisture between ingredients), and structure (weeping, swelling, droplets, and edible barriers). Using this manual will help solve product development problems and improve the quality of the foods brought to the market. ■

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Appendix B Description of Computer Programs; Water Analyzer Series; Macintosh Water Activity Software; ERH CALC; Aw CALC

From the International Desk:

Brazil Sadia S.A. is a national leader in the Brazilian food industry and one of Brazil's largest exporters of meat products. They produce and package swine, chicken and turkey, along with fowl and meat derivative products. They have more than 30 central processing plants and commercial affiliates in Brazil, in addition to plants in Italy, Japan and Dubai. Sadia S.A. distributes nearly 400 products to 90,000 retail outlets in Brazil and exports approximately 100 items to 50 countries. Keeping pace with the industries of frozen and chilled foods, they bring out 30 to 40 new products annually.

Currently, Brazil lacks legislation for water activity analysis in food products. But Sadia S.A. took the initiative by adopting water activity measurement to ensure high quality products. Sadia S.A. uses AquaLab instruments to help them achieve their high standards. Braseq Brasileira of Equipamentos, in Sao Paulo, Brazil, supplies Sadia with their AquaLab instruments. Braseq, together with Decagon technical assistance, supports Sadia's program of water activity measurement and control implemented throughout Brazil. ■

■ *New AquaLab Pawkit is light and portable.*



Humectants and Water Activity (continued)

history. Salt and sugar are the oldest, most widely used humectants. Other commonly used humectants include sorbitol, glycerol, and propylene glycol. Humectants are widely available from domestic suppliers with prices around \$0.30/lb for sugar, \$1.00/lb for sorbitol, and \$0.10/lb for salt.

As food additives, humectants must meet several criteria for acceptance: safety, lack of adverse odors and flavors, nutritional value, economy, and ease of use. A primary benefit is the reduction of microbial activity in foods, achieved through reduction of a_w to less than 0.90.

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■ Are product failures getting too hot for your lab? Time to measure water activity.

Water Activity and Food Degradation

Rates of degradation due to microbial action increase with higher water activities. Many common bacteria proliferate at $a_w > 0.9$. Some yeasts can develop at a_w as low as 0.6 to 0.7, requiring either additional lowering of a_w

or addition of antimicrobial agents. Microbial activity can be reduced by drying foods, thereby lowering the moisture content and a_w , but the addition of humectants reduces a_w , while retaining moisture.

Food Treatment

Blending, moist infusion, and dry infusion methods are commonly used to treat foods with humectants. Blending involves mixing the product with a humectant solution and requires that the food product be mixed or homogenized. With moist infusion, the food product is soaked in the humectant solution. Dry infusion involves first drying or dehydrating the product and then soaking it in the humectant solution.

Effects of humectants on water activity

Sloan et.al (1977) used propylene glycol, sucrose, and sodium chloride to achieve water activities of 0.78 or 0.79 in semi-moist dog food. Linko et. al (1985) predicted a_w of 0.85 in cereal-based products using a combination of sugar (7%), glycerol (2%), propylene glycol (1%), and salt (15%) under certain extrusion conditions. Ledward (1985) discussed development of intermediate moisture meats and concluded that a water activity less than 0.85 could be achieved using glycerol as 15 to 45% of the food product.

Humectant Research

Research indicates some of the difficulty in achieving low a_w in foods through the addition of humectants. The humectant propylene glycol has intrinsic antimicrobial properties; however, its use in food is limited. Kapsalis et. al (1985) studied the potential of polyglycerols and polyglycerol esters as humectants in food and generally found them to be objectionable due to taste and odor characteristics.

Measuring and Predicting a_w

Effective measurements of a_w becomes an important aspect of quality control in the food industry, since shelf life and food quality depend on a_w . In turn, the ability to predict the effects of humectants on a_w is important for the purpose of calculating use and effectiveness of humectants. Sloan and Labuza (1976) accurately predicted a_w resulting from the addition humectants to semi-moist dog food and achieved a range of water activities from 0.81 to 0.98.

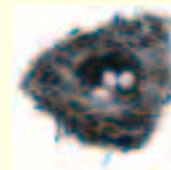
Intermediate Moisture Foods

Intermediate moisture foods (IMFs) are sufficiently moist to eat "as is" and have a_w low enough to prevent bacterial growth. Typical water contents range from 10 to 40%, with water activities ranging from 0.6 to 0.9. Jams, some cheeses, dried fruits are traditional IMFs. IMFs manufactured with humectants for human consumption have become a target of increasing interest, but development has been slow due to problems related to consistency, texture, and flavor changes caused by humectants. Public perception of potential toxicological properties of food additives has also limited widespread development of IMFs for human consumption.

Recent applications have focused on developing IMFs for use in space programs and the military. The addition of humectants to fresh meats can reduce the water activity into ranges that allow for storage without refrigeration. Cubed meat products produced with glycerol, gelatin, and sorbitol have a_w of 0.61 to 0.79.

Conclusion

Water content and water activity remain areas of high importance in the food industry. The ability to influence a_w through the addition of humectants to food products continues to be an area of active research in the development of wholesome, flavorful foods for human consumption. ■



■ Before you spend your nest egg, better take a look at New AquaLab Pawkit. It's an ultracompact water activity kit for QC professionals on-the-go.

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Table 1

Foods	Water Activity
fresh meats, vegetables, canned fruits	0.95-1.00
processed cheese, orange juice concentrate	0.90-0.95
aged cheddar, condensed milk, Hungarian salami	0.80-0.90
molasses, heavily salted fish, soft dried figs	0.70-0.80
parmesan cheese, dried fruit	0.60-0.70
chocolate, honey, noodles	0.50-0.60
dried egg, cocoa	0.40
potato flakes, cake mixes	0.30
dried milk, dried vegetables	0.20

▲ Adapted from Trailer & Christian (1978)

Some common humectants added to food product to depress the water activity.

aminobutyric acid
alanine
citric acid
DE 42
fructose
fibers
galactose
glucose
glycine

glycerol
gums
high fructose corn syrup
lactic acid
lactose
lactulose
malic acid
maltose
mannitol
mannose

PEG 400
PEG 600
propylene glycol
sodium chloride
sorbitol
starch
sucrose
tartaric acid
xylose

AquaLab's NEW internal temperature control conquers even the harshest conditions.



AquaLab Series 3 TE: Our most accurate water activity meter measures a_w in under **5** minutes guaranteed.

■ Precise temperature control, to $\pm 0.2^\circ\text{C}$, with the push of a button. Check out our specs at our website:

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Dear Customer,

I can't wait for you to meet our new baby, Pawkit, in person. Check out our schedule of tradeshow and exhibits to see when we can arrange a personal introduction.

As you can see we have been busy this year working to bring you new instrumentation for water activity measurement. This year alone we have added internal temperature control and ultra-portability to our line. If there is anything we can do better to serve you, call (800)755-2751 and ask to speak with me. We listen to your suggestions and use them to improve our products.

Sincerely,

Tamsin Campbell

Tamsin Campbell
AquaLab Product Manager

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AquaLab Water Activity Instrument Comparison

Pawkit—NEW

Series 3TE—NEW

Series 3

	Pawkit—NEW	Series 3TE—NEW	Series 3
Accuracy	±0.02	±0.003	±0.003
Measurement time	5 min	<5 min	<5 min
Range	0.00 to 1.00 _{a_w}	0.100* to 1.000 _{a_w}	0.100* to 1.000 _{a_w}
Internal Temp. Control	No	Yes, 15–40° ±0.2°C	No
Footprint	6.5 x 10.3 cm	24.1 x 22.9 cm	24.1 x 22.9 cm
Weight	115 grams	2.8 kilograms	2.7 kilograms
Power	2 Li Coin cells (3V)	110V to 220V AC	110V to 220V AC
Warranty	1 year	3 years	3 years
Price	<\$2000	\$6K+	\$5K+

*Low block option available at no extra charge allows measurement to 0.03 _{a_w}

Water Activity Definition Water activity determination Humectants Effect of water activity on thiamin breakdown Assay of Thiamin. 5 5 7 8
8 15 21 23. 23 25 27 27 28 31 32 34. Besides these factors, the type and concentration of the reducing sugar (Doyon and Smyrl, 1983) and water activity (Kamman et al., 1981; Fox et al., 1982) are known to affect thiamin breakdown. Many investigators (Fox et al., 1982; Mulley et al., 1975b) have studied the effect of pH on thiamin retention and found that as pH increased, thiamin retention decreased. If the water activity is further reduced by desiccation, this could lead to dryness or discolouration in the product. Therefore, modifying water activity by using certain humectants could be considered as a mean (hurdle) to preserve these products. Consecutively, to avoid undergoing laborious manufacturing processes and to minimize product variations, while selection of humectant, use of model khoa system was proposed. In this study, water activity and other physical properties including moisture content and instrumental colour parameters, as well as sensory parameters were analyzed to investi