Moisture Sorption Isotherm Method

The relationship between water activity (a_w) and moisture content at a given temperature is called the moisture sorption isotherm. This relationship is complex and unique for each product due to different interactions (colligative, capillary, and surface effects) between the water and the solid components at different moisture contents. An increase in a_w is almost always accompanied by an increase in the water content, but in a nonlinear fashion. Moisture sorption isotherms are sigmoidal in shape for most foods, although foods that contain large amounts of sugar or small soluble molecules have a J-type isotherm curve shape.

The moisture sorption isotherm of a food is obtained from the equilibrium moisture contents determined at several water activity levels at constant temperature. There are three types of isotherm curves; adsorption (starting from the dry state), desorption (starting from the wet state), or working (native state). An isotherm prepared by adsorption will not necessarily be the same as an isotherm prepared by desorption. This phenomenon of different moisture contents for the same a_w is called moisture sorption hysteresis, and is exhibited by many foods. Some reasons for hysteresis are: differences in the filling and emptying of pores and capillaries, swelling of polymeric materials, transition between glassy and rubbery state, and supersaturation of some solutes during desorption. Many disciplines use water content calculations to regulate product quality, however, water content measurement can be inaccurate, time-consuming and require a precision balance.

One way to obtain a moisture sorption isotherm is by placing a food, either dried (absorption), hydrated (desorption) or native (working), into controlled humidity chambers at constant temperature and measuring the weight until equilibrium as measured by constant weight is established. Isotherms, by definition are done at constant temperature (±1°C), with room temperature not advised because of changes during evenings and weekends. One needs six to nine different water activity levels and must wait for vapor equilibration, which may take one to three weeks. Saturated salt solutions are typically used to create the controlled water activity levels. Several types of containers (desiccators, glass jars, or fish tanks) can be used for holding the samples at constant

a_w. Triplicate samples weighed to ±0.0001g should be used if enough space is available.

Another method to create a moisture sorption isotherm involves measuring water activity. See Application Note 13461-00, *Measurement and Plotting of Moisture Sorption Isotherm Using the AquaLab* for more information. In this method a set of samples of varying moisture content are prepared. Dry samples are place in a desiccator over water or moistened with water while, wet samples are equilibrated over desiccant or dried down. The water activity and moisture content are then measured by some appropriate method. Moisture content can be determined from the change in weight if the original moisture content is known. This is acceptable as long as the a_w device is properly calibrated and is sensitive enough for the a_w whole range (Bell and Labuza 2000). The concern with this method is the time of equilibration of the samples before a_w measurement. This method readily lends itself to doing both the absorption and desorption isotherms and allows a_w at different temperatures for constant moisture to determine isotherms as a function of temperature.

The moisture sorption isotherm is presented in either graphical form, by plotting moisture content on the Y-axis as a function of a_w on the X-axis, or as an equation. The GAB (Guggenheim-Anderson-de Boer) model is one of the most widely accepted models for foods over a wide range of water activity from 0.10 to 0.90a_w. This equation has the form:

$$m = \frac{C_1 k m_o a_w}{(1 - k a_w)(1 - k a_w + C_1 k a_w)} \qquad [5]$$

where C_1 and k are constants and m_o is the monolayer moisture content. This equation can be solved using computerized nonlinear regression or by rearranging into a polynomial form.

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