

Water Activity of Dry and Dehydrated Products

Water activity is an important factor affecting the stability of dry and dehydrated products during storage. Dry and dehydrated products have a high level of popularity with today's consumers. Dry mixes are economical and convenient with increased shelf life, reduced packaging, decreased cost (via weight and/or volume reduction) and improved handling properties. Controlling water activity in a dry product maintains proper product structure, texture, stability, density, and rehydration properties.

Physical and structural changes occur during a dehydration process. Drying techniques include freeze-drying, spray drying, solar drying, drum drying, vacuum drying, and osmotic dehydration. Shrinkage of cells, loss of rehydration ability, wettability, migration of solids, case hardening, and loss of volatile aroma components are important factors (Bruin *et al.*, 1980). Freeze drying typically results in products with minimal shrinkage and superior rehydration properties. Hot air drying results in a dense product with a hard outer crust and slower water adsorption properties. Functionality and final use determines the appropriate drying or dehydration method and conditions.

Water activity affects the textural properties of dry cereal based foods and starch-based snack products. Crackers, potato chips, puffed corn curls, and popcorn each lose their sensory crispness with increasing water activity. The crispness intensity and overall hedonic texture of dry snack food products are a function of a_w (Katz and Labuza, 1981). Critical water activities are found where the product becomes unacceptable from a sensory standpoint. These fall into the a_w range where amorphous to crystalline transformations occur in simple sugar food systems and mobilization of soluble food constituents begins. Excessive and rapid drying or moisture re-absorption by a glassy

material can cause the undesirable consequence of product loss by cracking and excessive breakage.

To preserve the initial quality as much as possible during dehydration and storage the chemical and biochemical reactivity and stability must be considered. Water activity influences non-enzymatic browning, lipid oxidation, degradation of vitamins, enzymatic reactions, and protein denaturation. The likelihood of non-enzymatic browning increases with increasing a_w , reaching a maximum at a a_w range 0.6 to 0.7. Generally, further decreases in water activity will hinder browning reactions. Lipid oxidation has a minimum in the intermediate a_w range and increases at both high and low a_w values, although due to different mechanisms. This type of degradation results in the formation of highly objectionable flavors and odors, and the loss of fat-soluble vitamins.

Water-soluble vitamin degradation in food systems increases with increasing a_w values (Kirk, 1981). Enzyme and protein stability is influenced significantly by water activity due to their relatively fragile nature. Most enzymes and proteins must maintain conformation to remain active. Therefore, maintaining critical a_w levels to prevent or entice conformational changes is important to food quality. Most enzymatic reactions are slowed down at water activities below 0.8, but some reactions occur even at very low a_w values. Knowledge of the water activity of powders as a function of moisture content and temperature is essential for the control of water content during processing, handling, packaging and storage to prevent the deleterious phenomenon of caking, clumping, collapse and stickiness. Caking is a deleterious phenomenon by which a low-moisture, free-flowing powder is transformed into lumps and eventually into an agglomerated solid, resulting in loss of functionality and lowered quality (Tsourouflis *et al.*, 1976; Saltmarch and Labuza, 1980). This problem is

ubiquitous in the food and pharmaceutical industries.

Caking is water activity, time, and temperature dependent and is related to the collapse phenomena of the powder under gravitational force (Chuy and Labuza, 1994). Stages in caking involve bridging, agglomeration, compaction, and liquefaction. Factors known to affect caking kinetics may be divided into those related to the powder itself (particle size distribution, hygroscopicity and charge of particles, state of the material, presence of impurities) and external factors such as temperature, relative humidity and mechanical stress applied to the substance (Aguilera and del Valle, 1995; Peleg and Mannheim, 1977).

To maintain the proper flow properties of powders and prevent caking of powders, the following methods are available; (a) drying to low moisture content, (b) treatment of the powders at low humidity atmospheres and packaging in high barrier packages, (c) storage at low temperatures, (d) in package desiccation, (e) agglomeration, and (f) addition of anti-caking agents. Anti-caking agents are food ingredients added to hygroscopic powders to improve their flow ability and inhibit caking. Main food-grade anti-caking agents are silicon dioxide, silicates and sterates, phosphates and polysaccharides (Peleg and Hollenbach, 1984).

An important class of anti-caking agents are those which can compete with the host powder for the available humidity due to their large water adsorptive capacity, thus reducing their hygroscopicity and the tendency to cake. Many of these ingredients are of porous nature and exert their protective action in foods first by preferentially adsorbing large amounts of water vapor onto specific sites with high binding energy, thus depressing a_w dramatically for relatively large moisture contents (Labuza, 1984; Aguilera and Del Valle, 1995)). When all binding sites are occupied

pores start to fill and a_w corresponds to that of capillary water.

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