Water Activity and its Importance in Making Candy

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Water is one of the most important ingredients in candymaking. We usually take water for granted and do not completely understand its function in confectionery products. We commonly know the quantity of water in a product, but we need to better understand its form and location to really grasp its function.

To better understand the function of water in confections we can use water activity as an analytical tool. This tool can help us control texture, appearance, flavor and keeping quality in our finished products. As the title indicates, this paper will focus on the importance of water activity in candymaking.

We have known for years that water content is important in candymaking. We measure the total water in a product or ingredient by driving off the water in an oven. However, this measurement does not always explain why materials are not compatible, why some products have a short shelf life or why some confections spoil. Measuring a confection’s level of water activity can give us an understanding of these observations.

Water activity of a confection can be determined by measuring the equilibrium humidity in the air in a sealed container that holds a sample of the confection. This equilibrium develops after a period of time.

When a liquid is placed in a closed container, the rate at which the molecules escape from the liquid phase is constant. Evaporation is temperature dependent. The rate at which molecules condense is proportional to the number of molecules in the vapor. Equilibrium is reached when evaporation rate equals condensation rate (Figure 1).

Water activity (A_w) is related to equilibrium relative humidity (ERH) through the formula: (ERH) = (100) (A_w). Water activity of a confection is also defined as the vapor pressure exerted by that confection divided by the vapor pressure of pure water at the same temperature: A_w = V_Pcandy / V_Pwater.

The concept of water activity (and ERH) is not new. But it was an awkward analytical tool. In the past, the fundamental way we had to measure water activity

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was by using dessicators holding various saturated salt solutions of known water activity. Into these we placed samples, which would come to equilibrium within a few days. The samples would gain weight by taking in water, or lose weight by giving up water to the atmosphere in the dessicators. We could then estimate the water activity of a sample by measuring how much weight the sample gained or lost. This technique was very time consuming and not so accurate.

Today, we have laboratory instruments that can provide an accurate water activity measurement within minutes. Analysis times of 2.5–5.0 minutes are routine. Operation of the water activity meter requires only the filling of a sample cup (usually disposable), putting it in a chamber and pushing the button.

Why is it important to know the water activity of a confection or of an ingredient?

The water activity in a confection can be divided into two categories, inactive water and free water. Water activity is a measure of how tightly the water in a confection is bound or how much of the water in a confection is free to support microbial activity or migrate into adjoining components.

The portion of the water that is bound in a confection is attached to hydroxyl groups in polysaccharides, the carbonyl and amino groups in proteins and other polar sites.

**CHOCOLATE COATING**

Consider, for example, chocolate-coated raisins. Raisins have a moisture content of about 15 percent. Chocolate has moisture of less than 0.5 percent. Yet despite this large difference in moisture, chocolate-coated raisins are very stable. Water does not move quickly from the raisins into the chocolate.

On the other hand, pecans, which are much lower in moisture than raisins, must be sealed before they can be successfully coated with chocolate. If uncoated, moisture moves quickly from the pecans into the chocolate. This can cause an unacceptable change in the chocolate emulsion and a change in the chocolate’s appearance.

Moisture movement between materials is predetermined by water activity. Moisture moves from materials of higher water activity to materials of lower water activity, so before multicomponent confections are developed, the components’ water activity levels should be known.

Although chocolate has a low water content, it has a rather high water activity of 0.5. What water it has is not bound tightly. Raisins have a water activity comparable to chocolate. This is why raisins coated with chocolate are stable. There is not a tendency for water to migrate from the raisins into the chocolate coating. Pecans, however, have a lower water content than raisins, but have a water activity of about 0.65. Therefore, pecans should be sealed with a water barrier before being coated with chocolate.

**FONDANT**

Let us consider the importance of water activity in making fondant. Fondant can be both a finished product and an ingredient.

Fondant is a two-phase system. Fondant has a syrup phase which consists of corn syrup solids and sucrose dissolved
in water; further, fondant has a solid phase of crystallized sugar. Hopefully, the sugar crystals are of sufficiently small size so as to be unnoticed by the palate. But since these crystals are no longer dissolved, and no matter how small they are, they take no part in determining the water activity and thus the stability of the fondant.

The shelf life and resistance to microbial spoilage depends on the concentration of the syrup phase. Sucrose that has crystallized does not contribute to microbiological stability. Sucrose that has crystallized in a fondant lowers the concentration of the syrup phase. Measuring the total solids in a fondant does not adequately describe the keeping properties of a fondant. One needs to know the water activity too.

Upon aging, sucrose dissolved in the liquid phase of the fondant can come out of solution. This lowers the concentration of the liquid phase and leaves the fondant more susceptible to microbial spoilage. Therefore the water activity of a fondant can change over time, especially if the fondant is permitted to stand in a warm area. Warmth lowers the viscosity of the syrup phase and hastens crystallization.

Spoilage organisms are everywhere in our environment. When the water activity of a fondant rises to the spoilage organism’s tolerance range, activity is soon to follow. The spoilage organisms break down the fondant into energy, water, carbon dioxide, alcohol and more noxious materials. The initial microbial activity also raises water activity, which invites other microorganisms to join the banquet.

If the water activity of a fondant is measured, then one knows if it is going to be stable. For example, fondants that are produced quickly with small crystals, like in fondant machines, show lower water activities than fondants made with dry mixes or on beating tables. Fondants made with various concentrations of corn syrup will have different water activity levels. With the help of a water activity meter, one can match his formula with the needed water activity for best stability.

It is easier to stop a potential problem in the beginning than to correct a problem. That is the basis for the saying, “An ounce of prevention is worth a pound of cure.” The cost of preventing a problem is less than reworking or destroying poor finished product. Using a water activity meter is like having an insurance policy against microbial spoilage.

**HARD CANDY AND CARAMELS**

Candies that contain proteins and simple carbohydrates are prone to non-enzymatic browning reactions during cooking. This is known as the Maillard browning reaction and in making caramels this is a desired reaction.

The formation of Maillard browning products increases as the water activity increases. When the water activity of the candy mass is in the 0.6–0.7 range, the desired browning will result most quickly.

Usually, the browning is accomplished by controlled heating during the manufacturing process. It is at this point in the process where control of water activity is important too. Later, solids are increased to 92–95 percent and this yields a finished water activity of 0.4–0.5.

Many of us have used the method of estimating the amount of reducing sugar in candy to decide if our formula is correct. I suggest that we can use water activity for more reliable results. When adding rework to candy we can tell if too much reducing sugar has been added with the rework if we test the rework and finished candy for water activity. This will avoid making low water activity candy, which can have a short shelf life.

One of the questions I have been asked
over the years is, “How much corn syrup should I use?” The other most common question is, “What kind of corn syrup should I use?” These are important economic questions in many parts of the world since corn syrup costs more than sucrose in many places. The answer to each is quite simple. One needs to add the amount of corn syrup that will give the preferred texture (viscosity) and the needed water activity. The same answer applies to the type of corn syrup employed. If the water activity of your finished hard candy is too low, making it susceptible to rapid moisture uptake from the environment, more corn syrup can be added. Limiting the amount of invert in your candy through improved cooking will also raise the water activity of the finished hard candy and yield a longer shelf life.

JELLY CANDY

Adequate free water is necessary to gelatinize starch when making starch jelly candies. When inadequate starch gelatinization results during cooking, poor-setting jellies result. I have seen candymakers change a formula by employing more reducing sugars to make a softer jelly candy. The total solids of the formula were unchanged, but the sugar, corn syrup and starch solution did not cook out as in the original formula. The starch was undercooked even though the final temperature was unchanged.

The water in the formula was the same, but all of the water was not available for starch gelatinization. The water activity of the starting solution was reduced by the formula change and therefore starved the starch of available water.

When changing formulation in jelly candies, consideration of available water is important in making a consistently high quality candy. The water activity meter can be a useful tool in making sure sufficient water is available.

We have looked at water activity in just five candymaking applications: chocolate coating, caramels, hard candy, jelly candy and fondant. In each case, water activity is noted as an important parameter in formulation and process (Figure 2). Water activity is important and today, water activity meters are user-friendly and reliable. We need to consider water activity as we develop new products and as we produce established products. It will improve our craft.

Presented at the National AACT Technical Seminar.