Water Activity Before and After Freezing

Water activity is a useful tool for monitoring product quality and safety for foods in the unfrozen state. However, in the frozen state where water has transitioned into ice, water activity is completely determined by the temperature and no longer needs to be measured with an instrument. In addition, the correlation between water activity and critical safety and quality factors that exists in the unfrozen state does not exist in the frozen state. Luckily, the frozen state drastically slows down most degradative reactions and hence provides similar controls to water activity in the unfrozen state.

While water activity doesn't need to be measured in the frozen state, there are many products that are frozen during transport or storage and then thawed before being consumed. A common question posed to us here at Decagon Devices is whether the water activity of a material prior to being frozen will be the same when the material is thawed. Considering the complexities of the freezing process, the presence of unfrozen water, and freeze concentration of solids, it seems possible that a freeze/thaw cycle could change the water activity of a product when measured at room temperature.

So to answer this question, Decagon conducted an experiment looking at several food products before and after freezing. The products analyzed included a yellow crème filled snack cake, a chocolate covered and crème filled snack cake, and raisins at several different moisture levels. The cake, crème filling, and icing of the snack cakes were measured individually. For the yellow snack cake, the moisture contents of the cake and crème components were 22.75% and 21.18% respectively. For the chocolate snack cake, the moisture contents of the cake, crème, and icing components were 17.78%, 12.17%, and 5.47% respectively. Raisins with 11%, 18%, and 23% moisture were used. The products were analyzed for water activity in duplicate prior to being frozen using an AquaLab Series 4TE at 25 °C. Then subsamples of each product were frozen for 2 days, 1 week, and 30 days and analyzed for water activity again using an AquaLab Series 4TE at 25 °C. The temperature of the freezer was -15 °C, but the temperature of each product was not monitored. The results are presented in the following table.

The results indicate that the impact of a freeze thaw cycle is minimal and doesn't appear to be of great concern. Freezing the products for longer periods of time did not translate to bigger changes in water activity. Instead, the results are fairly randomly distributed likely due to experimental error and not to changes in water activity due to the freeze/thaw cycle. The largest difference in water activity, 0.03 aw, was between the cake from the yellow snack cake prior to freezing and after being frozen for 1 week. All of the water activity values for the snack cake components were higher after being frozen, but again not by more than 0.03 aw. The water activity values for raisins decreased for the low and high moisture samples, but increased for the intermediate moisture samples, with none varying by more than 0.01 aw.

In conclusion, it does not appear that a freeze/thaw cycle has a huge impact on water activity even in products with very different moisture contents.

Printed in USA

13991 06-22-15

Time Frozen	Yellow Snack Cake		Chocolate Snack Cake			Raisins		
	Cake (27.8%)	Crème (21.2%)	Cake (17.8%)	Crème (12.2%)	Icing (5.5%)	11%	18%	23%
Unfrozen	0.7891	0.7873	0.7311	0.7216	0.7137	0.4337	0.6154	0.7113
2 days	0.7902	0.7894	0.7385	0.7359	0.7375	0.4326	0.6179	0.7034
1 Week	0.8191	0.8039	0.7356	0.7248	0.7277	0.4348	0.619	0.7073
1 month	0.7916	0.7895	0.7468	0.7367	0.7415	0.4228	0.6164	0.7087