The Critical Water Activity from Dynamic Dew Point Isotherms as an Indicator of Crispness in Cookies

Brady Carter, Mary Galloway, and Gaylon Campbell

Decagon Devices, Inc. Pullman, WA

OBJECTIVES

- Determine if the DDI curves for low water activity snack cookies identify a critical water activity.
- Is this RHc related to the loss of crispness?

INTRODUCTION

Food texture is an important physical stability factor and gives an identity to a product. When the texture of a product is correct, it receives little notice, but when it is not, the product is rejected immediately. The most common texture attribute associated with low water activity products, such as cookies and crackers, is crispness. When a force is applied to a crisp product, it should fail abruptly with a distinct high pitched sound. The most important factors influencing the crispness of low moisture cookies are moisture and temperature. The pioneering work investigating the relationship between water sorption and textural changes was by Katz and Labuza (1981). They showed that there exists a critical water activity where desirable crispness will be lost. Typically, this critical water activity has been obtained through an extensive texture study. However, high resolution dynamic isotherm curves have recently been shown to identify critical water activities (RHc) by sharp inflections in the adsorption curve. Since previous studies investigating water and crispness identified a critical water activity range, there is the possibility that an RHc identified from a DDI curve for a crisp product could be an alternative option for finding the critical water activity for texture without an extensive texture study.

MATERIALS AND METHODS

- Graham crackers (GC) and shortbread cookies (SC) were obtained from a local grocery store.
- The ‘as is’ water activity was determined using an AquaLab Series 4TE (Decagon Devices, Inc. Pullman, WA).
- Triplicate dynamic adsorption isotherms using the Dynamic Dewpoint Isotherm (DDI) method were conducted on out of package samples of GC and SC at 25 °C, 35 °C, and 40 °C.
- The AquaLab VSA (Decagon Devices, Inc. Pullman, WA) was utilized to generate DDI curves.
- The RHc for each triplicate DDI curve at each temperature was identified as the water activity associated with a sharp inflection in the DDI curve.
- Four replicates of each cookie type were controlled to water activity levels higher and lower than the RHc.
- Four replicate samples of each cookie were subjected to 3-point bend testing using a TATX2i Texture Analyzer (Stable Microsystems Ltd., Godalming, UK).
- Crispness was determined as the maximum force (N) applied at failure of the sample.

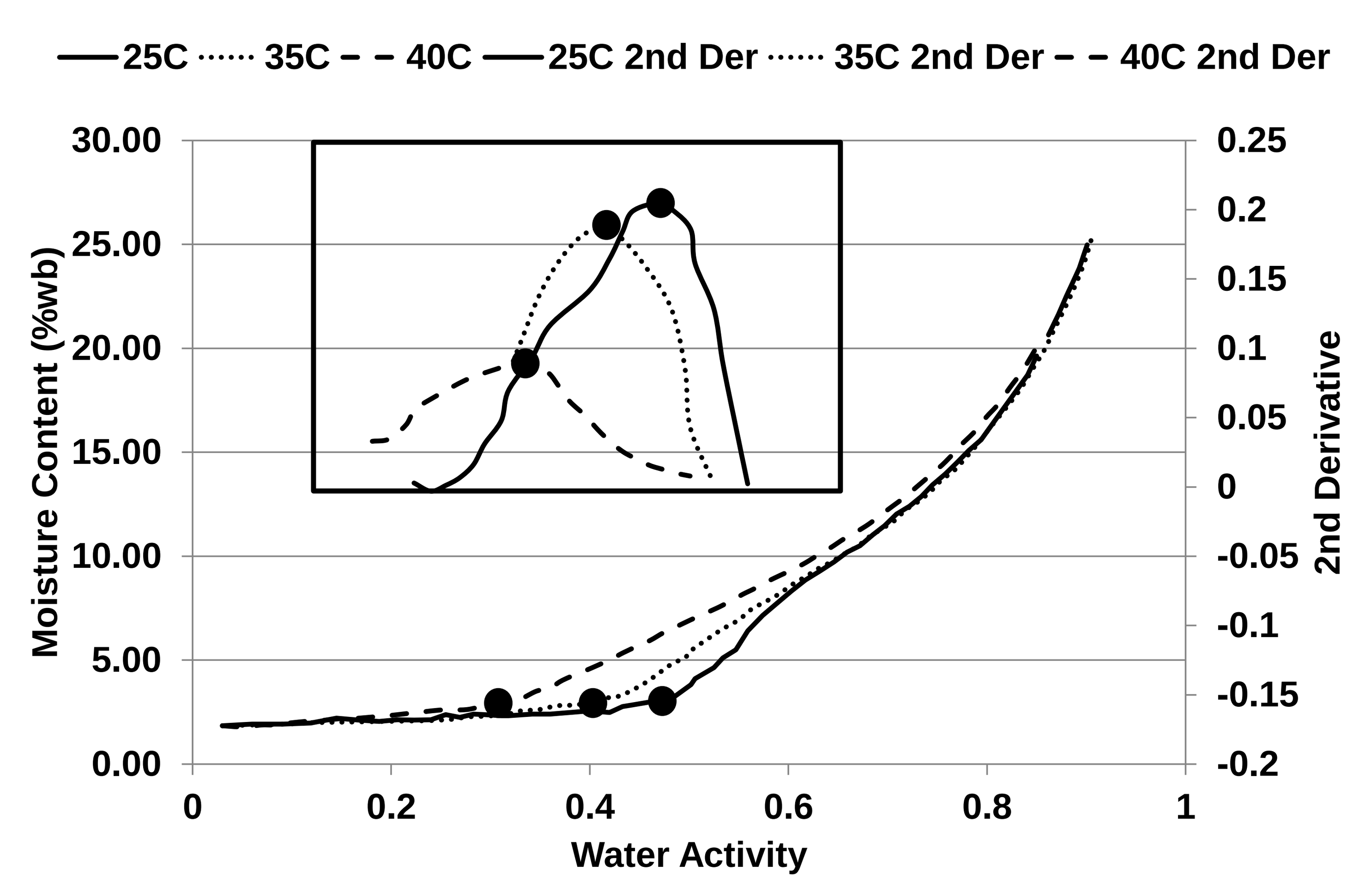

Figure 1. Dynamic dewpoint adsorption isotherm for graham cracker at 25 °C, 35 °C, and 40 °C. Within the superimposed solid box, the Savistky-Golay 2nd derivative plots are also shown on the secondary axis and the maximum in the curve identifies the inflection point in the original curve. The critical water activities associated with an inflection in the adsorption curve are identified as black circles.

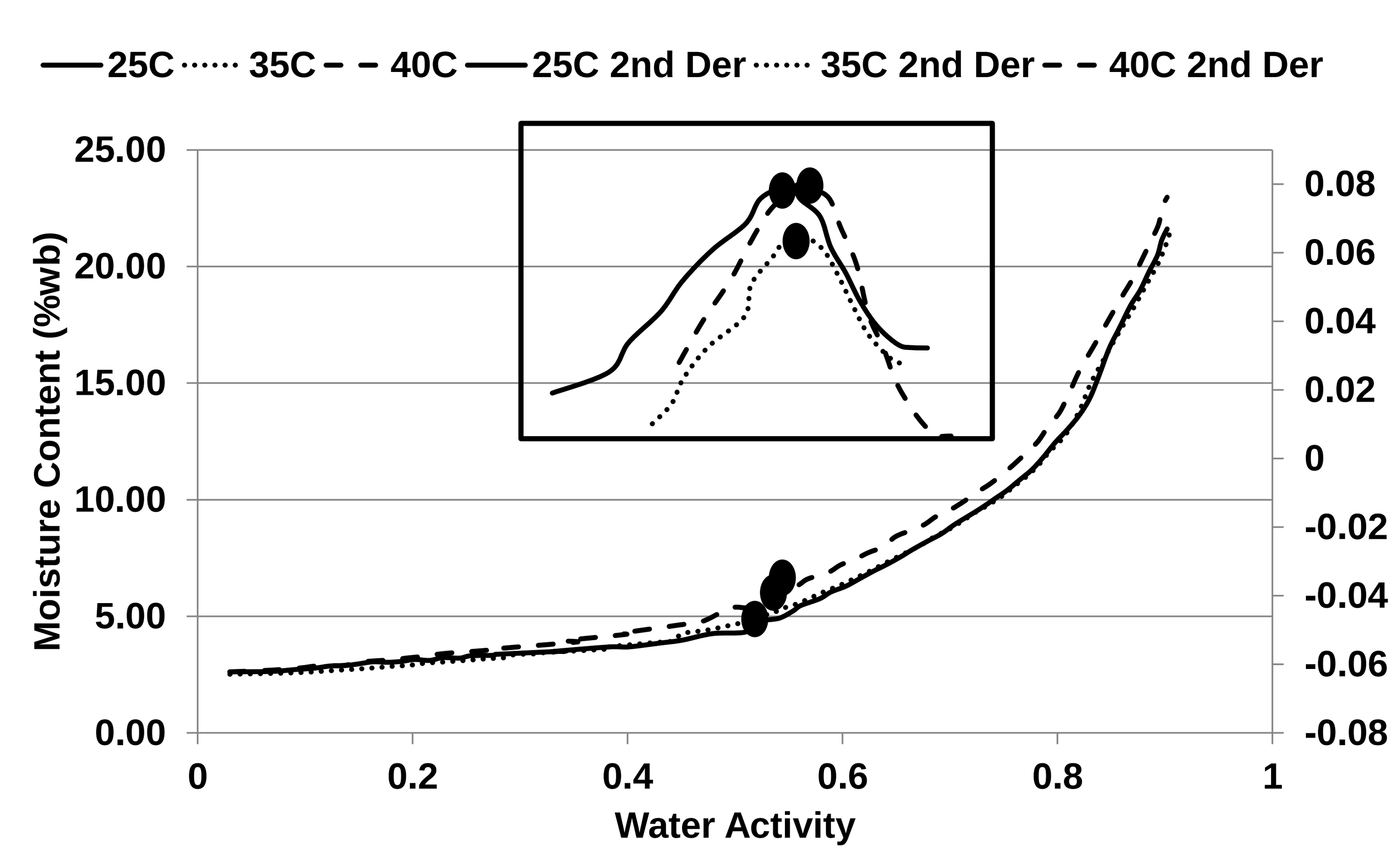

Figure 2. Dynamic dewpoint adsorption isotherm for shortbread cookies at 25 °C, 35 °C, and 40 °C. Within the superimposed solid box, the Savistky-Golay 2nd derivative plots are also shown on the secondary axis and the maximum in the curve identifies the inflection point in the original curve. The critical water activities associated with an inflection in the adsorption curve are identified as black circles.

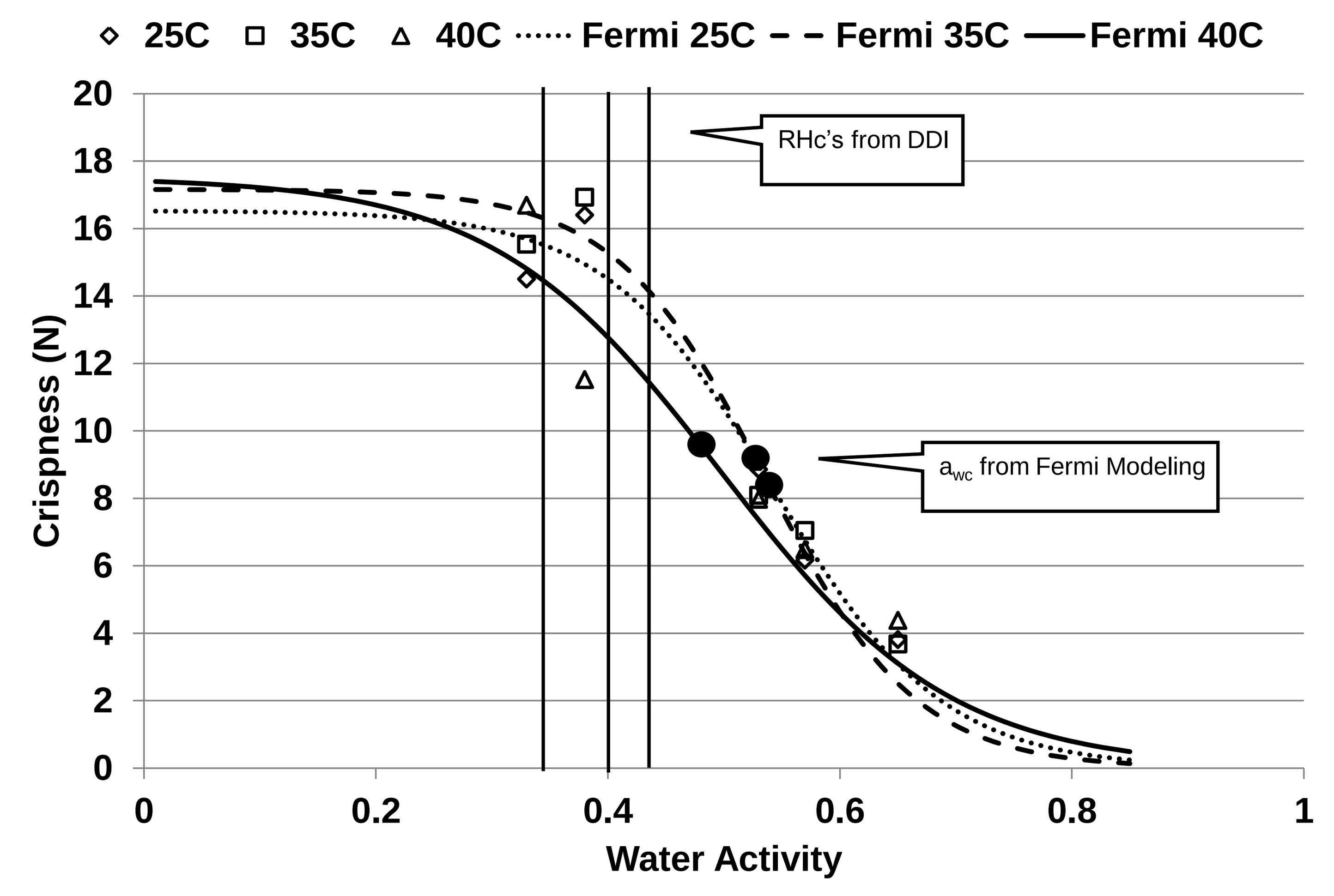

Figure 3. Average crispness of graham crackers as water activity increases at 25 °C, 35 °C, and 40 °C. Smooth curves representing Fermi models at each temperature are included and solid circles represent a_{wc} values from Fermi modeling. Solid vertical black lines represent average RHc values obtained from DDI analysis for each temperature.

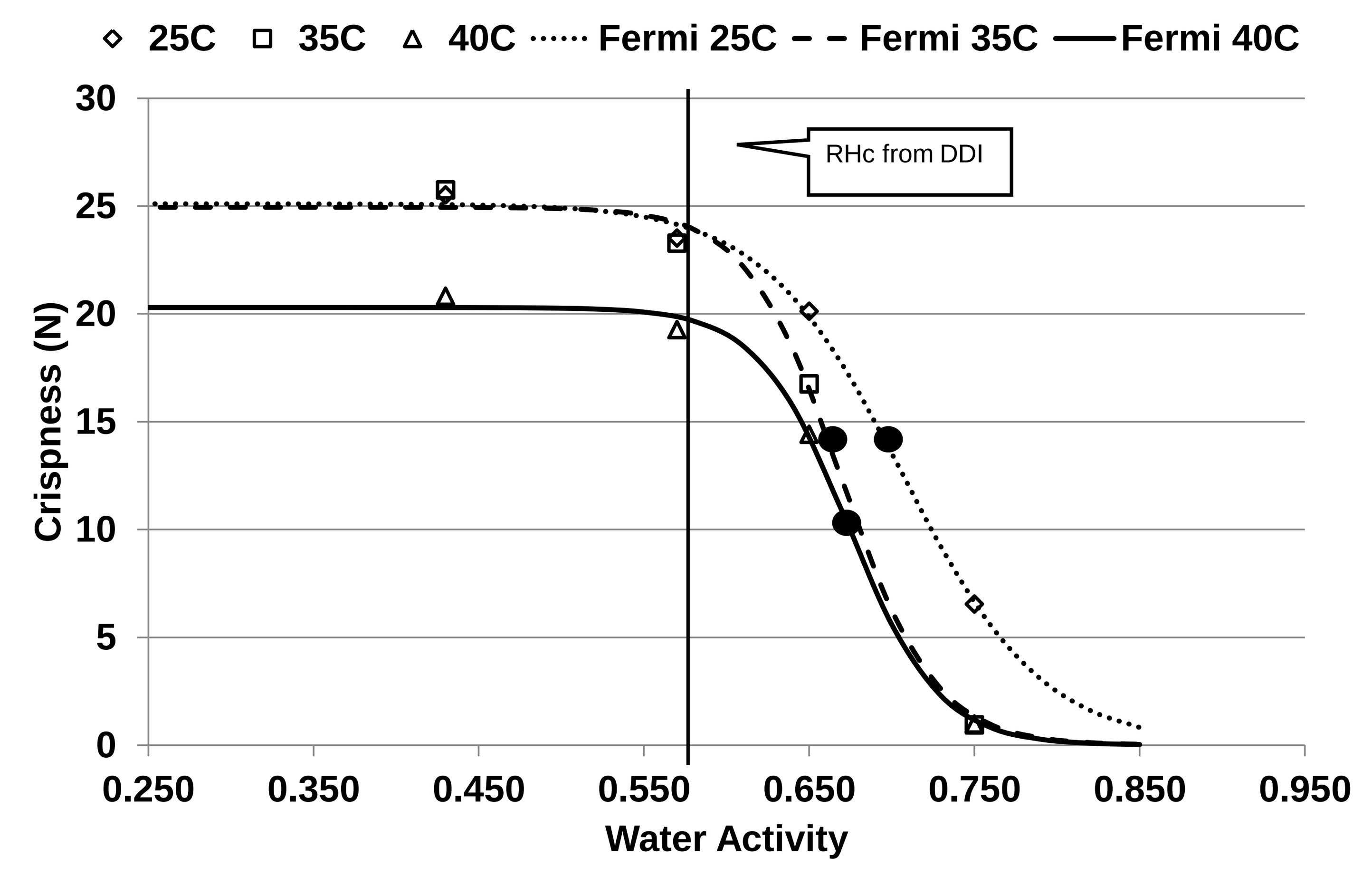

Figure 4. Average crispness of shortbread cookies as water activity increases at 25 °C, 35 °C, and 40 °C. Smooth curves representing Fermi models at each temperature are included and solid circles represent a_{wc} values from Fermi modeling. Solid vertical black lines represent average RHc values obtained from DDI analysis for each temperature.

RESULTS

- The high data resolution offered by the DDI method provided the opportunity to visualize inflection points in the DDI curves of both GC and SC (Figures 1 and 2).
- The RHc values for GC were significantly lower than those for SC indicating that the RHc for each product is unique to the matrix (Figures 1 and 2).
- The RHc value decreased significantly with temperature for GC, but not for SC (Figures 1 and 2.
- Changes in crispness were more pronounced at a given temperature as water activity changed than at a given water activity as temperature changed for both GC and SC (Figures 3 and 4).
- Analysis of variance with temperature, water activity and their interaction as factors indicated that all 3 factors were significant for GC whereas just water activity and temperature and not their interaction were significant for SC.
- Variance components indicated that water activity was a much larger source of variation than temperature for both GC and SC.
- The GC and SC samples equilibrated to different water activities and temperatures experienced losses in crispness as water activity increased at all temperatures SC (Figures 3 and 4).
- The crispness values were similar at water activities lower than the RHc, but were significantly reduced at water activities higher than the RHc (Figures 3 and 4).
- This sigmoidal response of texture to water activity changes was similar to other studies (Hough et al., 2001, Arimi et al., 2010).
- Rhc values from DDI were higher, but similar to a_{wc} values from the Fermi model (Figures 3 and 4).

CONCLUSIONS

- Adsorption of moisture by both GC and SC caused changes in texture as expected.
- DDI curves make it possible to observe inflections in the curve corresponding with distinct changes in sorption properties associated with irreversible changes in the product matrix.
- The RHc obtained from DDI curves matched with the initiation of a loss in crispness in GC and SC.
- Obtaining the RHc from DDI curves replaces the need for extensive texture studies to obtain the critical water activity for desirable texture.

Bibliography

- Hough G, Pilar-Buera Md, Chirife J, and Moro O. 2001. Sensory texture of commercial biscuits as a function of water activity. Journal of Texture Studies 32(1):57-74.
- Arimi JM, Duggan E, Sullivan M, Lyng JG, and Riordan ED. 2010. Effect of water activity on the crispiness of a biscuit (Crackerbread): Mechanical and acoustic evaluation. Food Res Intl 43(6):1650-5.
- Katz EE, Labuza TP. 1981. Effect of water activity on the sensory crispness and mechanical deformation of snack food products. Journal of Food Science 46:403-9.