Accelerated Shelf-life Testing of Natural Colours in Model Food Systems

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Abstract

A significant part of the UK food industry is moving from artificial colours towards natural alternatives. However, natural colours are less stable and more expensive. The lack of stability can be a problem when natural colours are added to food products with a long ambient shelf-life.[3] Normal shelf-life tests are time-consuming.[2] To investigate and identify accelerated tests for predicting the stability of natural colors (anthocyanin, lycopene, chlorophyll and Cu-chlorophyllin) used singly as an ingredient in three different food matrices (high-boiled sweets, gelatine jellies, juice-based drinks). Samples were stored in a constant climate chamber at 20°C, 30°C and 40°C and exposed to high-intensity light at 4.000 Lux with UV at 1.4 W/m^2 and in dark. Loss of color was monitored in terms of change in Hue (ΔH) over time (7 months at 20°C and 8 weeks at 30°C and 40°C.[1]

Results showed that the rate of acceleration of colour degradation was affected by the food matrix and the type of colour being used. In addition the results show that the use of elevated temperatures in combination with light allows samples to be screened for colour changes within shorter time scales.[1]

Introduction

The shelf-life of a product is determined by storing the product under typical storage conditions that the product will experience, and measuring the changes occurring (chemical, microbiological and physical) over a specified time interval until the product becomes unacceptable to consumers. Food manufacturers are under constant pressure to launch new products in shorter time scales and often do not have sufficient time for real time shelf-life testing. Accelerated shelf-life testing (ASLT) is an indirect method of measuring and estimating the stability of a product by storing the product under controlled conditions that increase the rate of degradation occurring in the product under normal storage conditions. In addition to the prediction of product stability including colour, ASLT are useful for a number of other purposes, e.g. to determine product safety under abuse conditions, for troubleshooting in the initial stages of product development and for assessing packaging performance of a product.[3]

Figure 1: Constant climate chamber (Binder KBF 720) with door mounted lights used at Leatherhead Food Research for colour stability testing.[3]

Stability Test Conditions	Real Time Storage	Accelerated Storage Conditions	
Temperature	20°C	30°C	40°C
Test with light	daylight bulbs	VIS 4.000 Lux UV 1,7 W/m^2	VIS 4.000 Lux
Test without light	dark	dark	dark
Test period	up to 7 months	8 weeks	8 weeks
Intervall of color measurement	monthly	weekly	weekly

Table 1: Stability test conditions maintained by a KBF 720.[3]

Material and Methods

Binder KBF 720 with door-mounted lights[2]
Anthocyanin (E163)
Chlorophyll (E140)
Cu-Chlorophyllin (E141)
Lycopene (E160d)
High-boiled sweets[1]
Gelatine jellies[1]
Juice-based drinks[1]
HunterLab ColourQuest XE[1]

Results

In this paper only the results of the anthocyanins colour stability tests for juice-based drinks are presented. For further information please refer to the literature listed below.

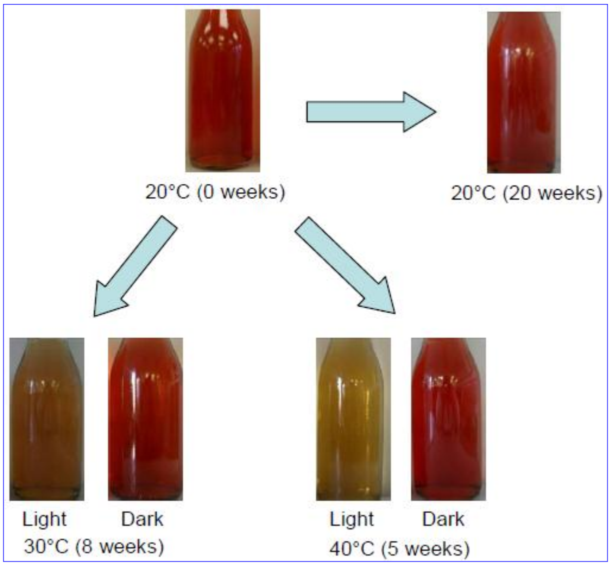

Figure 2: Appearance of juice-based drinks containing anthocyanin after storage.[1]

Figure 2 shows the appearance of juice-based drinks after exposure at 30°C and 40°C. The fading of the redness from the anthocyanin was more obvious in the samples that were stored in the light compared to samples that were stored in the dark.[1]

The redness in samples stored at 40°C for five weeks, and in the light, faded quicker than samples that were stored at 30°C for 8 weeks and in the light. The change in Hue between samples stored at the elevated temperatures (30°C and 40°C) and between light and dark storage is shown in Figure 3.[1]

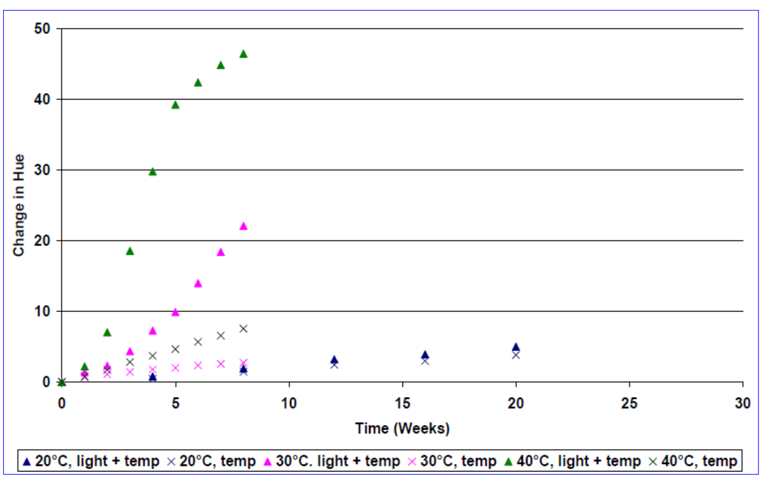

Figure 3: Effect of temperature and light on juice-based drinks containing anthocyanin.[1]

Figure 3 also shows that the change in Hue (ΔH) increases with increase in storage temperature. The ΔH in the juice-based drinks was higher than that observed in the high-boiled sweets and gelatine jellies especially those that were exposed to light. As expected, samples stored in the dark had a lower value of ΔH compared to samples stored in the light at 30°C and 40°C except for samples at 20°C which changed very little.[1]

The relative rates of colour change for juice-based drinks containing anthocyanin are given in Table 2. Samples stored in the dark at 30°C and 40°C were 1 and 4 times faster compared to samples that were stored at 20°C and in the light. The rate of acceleration was much greater for samples that were stored in the light at 30°C and 40°C with rates of acceleration of 11 and 26 times faster, respectively. This indicates that light had a more detrimental effect for juice-based drinks containing anthocyanin than temperature.[1]

Rate of Acceleration				
	30°C Dark	40°C Dark	30°C Light	40°C Light
Juice-based drinks with anthocyanin	1	4	11	26

Table 2: Relative rates of colour change (juice-based drinks with anthocyanin) compared to 20°C in the light.[1]

Summary and Conclusions

For juice-based beverage the systems with anthocyanins colour stability tests could be conducted at temperature of 30°C combined with light as colour change was 11 times faster than under real time 20°C storage.[1]

The change in colour (demonstrated as ΔH) showed that solid model systems (high-boiled sweets and gelatine jellies tend to change more slowly than the liquid model system (juice-based drinks). The anthocyanin molecules in the solid systems are thought to be bound more tightly than molecules in a liquid system and because of this the molecules are thought not to be able to move freely, resulting in a smaller change of colour.[1]

Anthocyanin appeared to be most stable in the high-boiled sweets followed by gelatine jellies and juice-based drinks as the values of ΔH were <10, <20 and <30 respectively after samples were exposed at 30°C and 40°C and high-intensity light.[1]

Generally, a good correlation was found between actual and predicted results for high-boiled sweets, gelatine jellies and juice-based drinks containing anthocyanin and chlorophyll and a better correlation between actual and predictive results was seen for products stored in light compared to those stored in the dark.[1]

The study showed that accelerated tests with a KBF 720 can be used to predict natural colour stability.[2] Please find detailed information on the KBF series at: www.binder-world.com.

References

1) Teoh A., Subramaniam P.: “Forum Project Report No. 952, Stability of Natural Colours in Model Food Systems”, October 2011, Leatherhead Food Research.
2) http://www.binder-world.com.
3) Teoh A.: “Predicting the stability of natural colours in food products, A review”, AgroFOOD Industry hi-tech, September/October 2010, Vol. 21 (5), 20-23.