Immersion stability of chocolatiferous artifacts within the museum

David Saunders and John Cupitt

Introduction

A variety of objects passing through the hands of conservators are not thought worthy of their professional attention. However, the past record of ephemera becoming first collectibles and later museum objects should alert us to the need to conserve what might, at first, seem to be transient items. This present study was prompted by a report from a colleague that certain chocolatiferous artifacts were subject to deterioration or disintegration when subjected to extreme damp environmental conditions [1].

The conservation literature contains little information on the care and treatment of such artifacts. One recent study dealt only with objects composed of chocolate throughout their depth [2], with no mention of binary or tertiary (chocolate-filled) systems, such as those present in most chocolate biscuits. This study aims to shed light on the moisture-sensitivity of bakery products possessing a protective chocolate layer, or exoskeleton.

Experimental

Four sample types were chosen for study. Each has a chocolatiferous exoskeleton, with a semi-porous, bi-layered, or multi-layered interior structure [3]. One of the samples chosen for study was the type in which this structural weakness was originally observed, the antipodean species *cooqui Australiensis* or 'tim-tam'. The remaining three were indigenous samples, one of which (*pingus cocoapithicus*, the chocolate penguin) closely resembles the tim-tam. The third sample type (*digitus cocoarylis*, the chocolate finger) is characterized by a circular cross-section and a denser core structure. Finally, for comparison purposes, and for assonance reasons, we tested individual filaments of the quadripartite kit-kat (*waferium tetrasnachus*).

In developing a standard procedure for testing we investigated a number of methods. Immersion was discounted, as many of the samples have an intact integument, which precludes the absorption of polar liquids at 298K. In most cases, immersion in non-polar fluids led to dissolution rather than absorption. At elevated temperatures we experienced problems with the coherence of the exoskeletal chocolate, as it was heated above its glass transition temperature Tg. Injection was also ruled out as it introduced fluid into a small, possibly unrepresentative, part of the interior matrix. Finally, mercury porosimetry was excluded, as it would introduce a poison into the biscuit that would prevent post-experimental consumption.

The method adopted, at the recommendation of colleagues from the Art Gallery of New South Wales, was to section the specimen at its extremities and draw liquid into the sample under reduced pressure; see Figure 1.

Figure 1. A sample sectioned prior to testing

Initial attempts to use a vacuum pump to draw fluids through the sample failed as the pressure differential was too high and because no satisfactory seal could be established between the rigid ends of the vacuum apparatus and the irregular exoskeleton. Gentle suction, applied with the experimenter's mouth, was used to draw liquid into the cavity through the lacuna at the opposite end, Figure 2.

Figure 2. One of the authors testing a sample purporting to be *pingus cocoapithicus*. [This specimen proved to be an inferior product.]

Both tea and coffee were tested, as both have inundation indices of the order of 3.71 to 4.06 $ml.g^{-1}K^{-1}$ in the range of temperatures for drinkable beverages [4]. As little structural difference was noted between samples treated with the two fluids, all the experiments were conducted using coffee (Colombian dark roast, mixed with 5% v/v semi-skimmed milk), as the resulting inundated matrix tasted nicer, Figure 3..

Figure 3. Test vessel and inundation fluid

Results and Discussion

The results are summarised in Table 1, which records not only the subjective measurements made on each sample, but some of the observations made by the experimenters.

As not all samples were identical, there were certain variations in behaviour, particularly as some experimenters were less skilled in achieving inundation without bringing on structural collapse.

The wafer structure of the kit-kat made it difficult to draw liquid through the biscuit, but channels of penetration were created, due to its laminar nature. Both the inter-wafer chocolate filling and the exoskeleton showed signs of melting but, disappointingly, the biscuit showed little sogginess or loss of form.

The dense interior of the chocolate finger again reduced the rate of liquid absorption. The result was that melting of the exterior coating preceded any change in volume or tensile strength in the biscuit. If inexpertly handled, the exoskeletal chocolate, by now well above its glass transition temperature, transferred to the experimenter's fingers. As normal health and safety precautions were observed, this soiling could not be dealt with by the usual method, i.e. licking.

Sample	'Tim-tam'	'Penguin'	Chocolate finger	Kit-kat
Coating	a. Plain b. Milk	Milk	Plain	Milk
Matrix type	Porous open-cell	Porous open-cell	Dense close-cell	Dense laminar
Surface	Irregular	Irregular	Smooth	Smooth
Cross-section Area mm^2	*Rectangular* 162	Rectangular 158	Circular 80	Square 92
Fluid uptake rate, $ml\ mm^{-2}\ s^{-1}$	1.32	1.42	0.34	0.23
Failure mode	Collapse of internal structure, often catastrophic	Disintegration around areas of liquid penetration	Coating melts resulting in shearing from biscuit surface	Coating melts Limited delamination at wafer/filling interface
Taste/mess ratio	high	High	medium	low

Table. Properties of chocolatiferous artifacts

The behaviour of the tim-tams and penguins was broadly similar. Liquid ingress was mainly through the biscuit matrix, causing rapid loss of structural integrity. There was a little superficial melting of the coating and filling, but these were not closely observed as the sample was consumed rapidly lest it collapse.

One sample that was subjected to close observation during the advanced stage of inundation, metamorphosed into a sticky mass around both the inside and outside edges of the teacup containing the experimental fluid.

It might have been expected that changing the coating would alter the saturation volume or rate of liquid transfer, particularly with hot fluids, where it has been suggested that the dark chocolate coatings might cause the object to behave like a black body and demonstrate a relationship between the saturation volume and the fourth power of the fluid temperature:

$$S = k.T^4 \qquad (1)$$

No such relationship was found, suggesting that this is a fatuous argument, in common with other such opinions expressed over the tea table.

Conclusions

Great variation was found in the ability of the four biscuit types tested to withstand inundation with hot fluids, from superficial melting to complete disintegration. Some relationship between the type of bakery product within the chocolate exoskeleton and the propensity to collapse can be hypothesized, but who cares?

The analogous behaviour of the penguin and tim-tam suggests that similar species evolve, or are developed, in geographically isolated habitats.

It is recommended that untrained conservators, or those trained in other unrelated disciplines, should not attempt to consolidate chocolatiferous items by immersion in hot fluids. Further research, perhaps concentrating on the behaviour of North American or South East Asian biscuits, is required before Class I museum standards for the care of such exhibits are formulated.

Acknowledgements

The authors acknowledge the suppliers of the various samples, particularly S. Laidler for the provision of antipodean natives, and the help of their colleagues at the National Gallery in conducting these messy yet pleasurable experiments.

References

1. Laidler, S., personal communication.

2. Cox, H., 'The deterioration and conservation of chocolate from museum collections', *Studies in Conservation* **38** (1993) 217- 223.

3. McVitie, M.R., and Freen, P.K., 'Structural properties of commonly-occurring biscuits in the British Isles', *Journal of Bakery Science* **23** (1983) 234 –250.

4. Horlicks, C.O, and Milo, A.,' Critical temperature studies for beverage scalding', *Proceedings of the 22nd International Symposium on Hot Bibendous Fluids,* Darjeeling, India (1995) 122 – 127.