What can we do? A case study in the conservation of canned wet food in museum collections

Emily J Fryer[a], Sarah F Murray[b]*, Lisa M Yeats[c]

[a]*Emily Fryer Conservation, Mulberry House, 2/378 Gilmours Road, Tai Tapu, Christchurch;* [b]*Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand;* [c]*Otago Museum, 419 Great King Street, Dunedin 9016, New Zealand*

*Email: smurray@canterburymuseum.com

This research report considers the process of conserving canned wet food in museum collections. It details, as a case study, the methods of content removal, sampling procedure and scientific analysis performed in 2014 on part of a collection of canned wet food from Cape Hallett Station, Antarctica, held in the collections of Canterbury Museum. Offering recommendations on storage, analysis and the display of canned wet food collections, the intent of the report is to encourage future, and more detailed, research into the conservation of wet food collections.

Keywords: Conservation, food, collections, cans, tins, Antarctic

Introduction

Canterbury Museum in Christchurch, New Zealand, cares for an estimated 2.3 million collection items including approximately 6,500 objects that represent Antarctic exploration and research activities from the late 1800s to the present day. In 2005, Canterbury Museum acquired a collection of more than 1,000 objects relating to Cape Hallett Station, Antarctica. Among the building components, fuel drums and tools was a collection of 42 cans of wet food from the 1950s – 1960s. Preserved in fluid, these canned foods ranged from fruit in juice or syrup (Fig. 1) and vegetables in water to meat and fish in brine. Although canning foods in fluid is generally a stable, long-term method of preservation, it is not an indefinite one; canned wet food is subject to physical, chemical and biological deterioration as it ages and, if the can is penetrated, oxygen can further affect the contents (Potter & Hotchkiss 1998).

The Cape Hallett Station collection of canned wet food had been stored in the Mammal Attic at Canterbury Museum for more than eight years. Over this time, the cans had been subject to an uncontrolled environment. In 2014, temperatures ranged from 14°C to 26.5°C and humidity fluctuated between 29.3% and 75.4%. When the collection was looked over as part of a routine check in 2014, some of the cans were found to be deteriorating rapidly. The condition of the cans varied greatly; some were in near perfect condition with undisturbed contents, whereas others were severely deteriorated with liquid leaking from the vessels onto surrounding objects. The individual cans had been wrapped in tissue paper and leaking fluid had soaked the tissue, causing it to stick to the metal cans and paper labels. The affected objects were immediately bagged and removed.

An initial examination was carried out by an objects and paper conservator. The cans were then placed inside a fume cabinet on top of cups or polyethylene foam so they could drain. The tissue paper used to wrap the cans for storage (where still wet) was removed and the cans were left for a short period to determine which were leaking and which were just contaminated with fluid. It was clear that conservation treatment

Figure 1. A can of Apricot Jam (2005.151.400) from the Hallett Station collection upon its acquisition in 2005.

would be required to ensure that the cans were, at minimum, cleaned and preserved for the future. As the cans are museum collection items, it was also important that they were treated in such a way that they would be available for future display and interpretation. A treatment plan was devised that included cleaning and removing rust from cans, treating and reattaching labels where possible and, where the cans were leaking, removing the contents. The latter decision ensured that the physical body of the can remained accessible for future exhibition. The actual conservation treatment of the metal cans, while of interest, is not the main subject of this article. Rather, we are interested in exploring the validity of retaining decanted and subsequently frozen contents from leaking cans. In this situation, analysis of the contents of frozen food collections will assist museums who face similar situations to decide on the value of retaining frozen samples in the long term. If chemical analysis of food, which helps us to understand food quality control, research and development, shows significant changes in the frozen samples, the benefit of retaining such samples may be questioned.

Literature review

The care and conservation of wet food in museum collections is challenging and can be problematic; to date, there is no generally accepted methodology for the conservation of wet food collections. Internationally, however, this area is gaining increasing attention. In Switzerland, the Haute Ecole de Conservation-Restauration Arc is examining the conservation of cans containing food in museum collections. The objective of their 'Conservation of cAns in collectioNS' project is to 'develop conservation methodologies respectful of the material authenticity and cultural values of these composite objects' and is due for completion in 2017 (CANS 2014). While it is hoped the CANS project will provide comprehensive information about the conservation of wet food collections in museums, there is still considerable information that can be drawn from a wider existing literature, particularly with regards to the construction of such items, the conservation of other food products and existing examples of decanting and freezing can contents.

Most cans in museum collections are likely three-piece cans constructed out of tinplated steel in order to slow corrosion and sealed with a tin-lead alloy solder (Potter & Hotchkiss 1998). The cans would have been hermetically sealed, meaning they were at one point completely sealed against ingress of micro-organisms, namely bacteria, yeasts, moulds, gases, water vapour, dirt and dust (Potter & Hotchkiss 1998). There are many scholarly food science resources that describe in detail the current and former food canning processes and techniques. These resources are targeted to the food industry and are concerned with the relatively short-term preservation of food through the use of cans (Robertson 1993; Potter & Hotchkiss 1998; Blunden & Wallace 2003). Similarly, there are general guidelines published by food authorities regarding the storage and shelf life of canned goods for consumption (Food Standards Australia New Zealand 2008). The Commonwealth Scientific and Industrial Research Organisation (CSIRO) suggest that canned foods have a shelf life of up to four years. They also advise that, as a general rule, the lower the temperature, the longer the life of the

canned goods (CSIRO 2011). To date, no testing has been completed to conclusively suggest that canned collections should be stored frozen. There are, however, resources that warn of the consequences of having improperly sealed, or defective metal cans, and the subsequent likelihood of contamination of contents with pathogenic bacteria such as *Clostridium botulinum* that can lead to the food-borne disease botulism, which can be fatal (Potter & Hotchkiss 1998).

Research into the storage and conservation of food in museum collections has traditionally focused on the challenges that dry food artefacts pose (Cox 1993; Daniels & Lohneis 1997; Wharton et al. 2011) and the preservation of food in contemporary art (Temkin 1999; Gilman et al. 2011). The relevance of these to collections of wet canned food in museum collections is limited due to the composite nature of cans containing wet food, specifically, the interaction between the metal can and food contents. In contrast, significant conservation work has been completed on cans containing wet food encountered in Antarctica (Bickersteth et al. 2008; Natural History Museum 2006, 2007, 2013). The Antarctic Heritage Trust, which cares for buildings and their contents on the Antarctic continent, has over the last 10 years undertaken conservation on canned wet food in various conditions. In order to perform metal stabilisation treatments, and to preserve the collection on open display, these cans are defrosted and, if leaking, opened using a rotary tool cutting wheel, and emptied. Following a sampling methodology developed with assistance from the University of Otago (Department of Food Science), representative samples of the contents are stored either in a small plastic container or a large plastic bag then refrozen (Meek, Fryer pers. comm. 2014). To date, no scientific testing has been undertaken to examine the chemical impact, and therefore consequent value of, freezing contents and questions exist as to whether the amounts currently being saved would be enough for standard food analysis tests.

Foods spoil over a period of time due to chemical and physical changes and microbial growth. The literature on food freezing processes is generally concerned with preventing food poisoning and maintaining optimum food taste and texture (Grout et al. 1991). Freezing does not stop degradation of food entirely but slows physical and chemical changes and microbial growth considerably. As such it is the only reliable method for storing wet food long-term (Zaritzky 2008). The standard temperature for most food being stored and transported is around -18°C as yeasts and moulds cannot multiply below -12°C and -18°C respectively (Zaritzky 2008). As a general rule, the lower the temperature at which a food is stored above freezing, the slower the deterioration (Ranken et al. 1997).

The rate of freezing, storage temperature and temperature fluctuations during storage play a major role in preventing degradation of frozen foods (Brown 1991). It can be difficult to maintain food products in a consistent, optimum frozen state. The Collaborative Crystallisation Centre, part of the CSIRO, deals with frozen food samples for analysis and recommends ensuring that each sample only goes through one freeze/thaw cycle if necessary. They also recommend that the freezing process is as rapid as possible, to reduce the chance of crystalline ice forming and that the crystals formed are as tiny as possible (slow freezing produces large crystals). They advise that freezing and thawing samples that contain protein almost certainly results in some level of degradation in the sample, however accept that there are very few other long-term, feasible options for storage of food samples (CSIRO 2013). Changes in the temperature, as minimal as those from opening the freezer door, can cause thawing. This thaw/freeze cycling can adversely affect the food through changes brought about by the formation and reformation of ice crystals. Other effects of freeze/thaw cycles are protein denaturation and microbial growth (Ranken et al. 1997). There is a need for a constant and systematic control and careful monitoring to ensure the ideal temperature is maintained.

Figure 2. A selection of cans after opening with a rotary tool (L Yeats, 2014).

Some museums have collected wet food items solely for the packaging. Durham Museum in Omaha, Nebraska, for instance drains and disposes of the content of soda and beer cans. This approach was developed from experience that an unopened can ultimately leaked after a few years, causing potential damage to other collection items. By puncturing the bottom end of the can, the objects can still be displayed with no visible damage (Stober 2011). Decanting can contents provides an opportunity to establish a baseline of the chemical composition of the contents. By undertaking scientific analysis of a sample of these decanted contents, a reference point can be established against which future tests of retained samples can be measured in order to understand the impact freezing contents has on these types of materials. That said, sampling protocol needs to be given significant consideration in order to obtain useful samples and meaningful data. No literature could be located that addresses the sampling techniques of aged canned food samples in preparation for laboratory analysis specifically. There are references that explain the sampling procedure used by food scientists and archaeologists prior to carrying out analytical tests (Peters 1996; Curren & King 2002; Ihnat 2003; Lourdes 2012). The general consensus is that samples should be collected in a sterile environment, stored for the shortest time possible and remain unaltered during transportation and storage until the moment of analysis. All stress the importance of taking representative and replicable samples for testing purposes. A sample must also be large enough to be able to measure the materials of interest. The leaking canned wet food collections from Cape Hallett Station provided an ideal opportunity to undertake baseline analysis in order to measure any deterioration that occurs in freezing samples over a period of years.

Methods

Once it had been confirmed that multiple individual cans were leaking the curator and

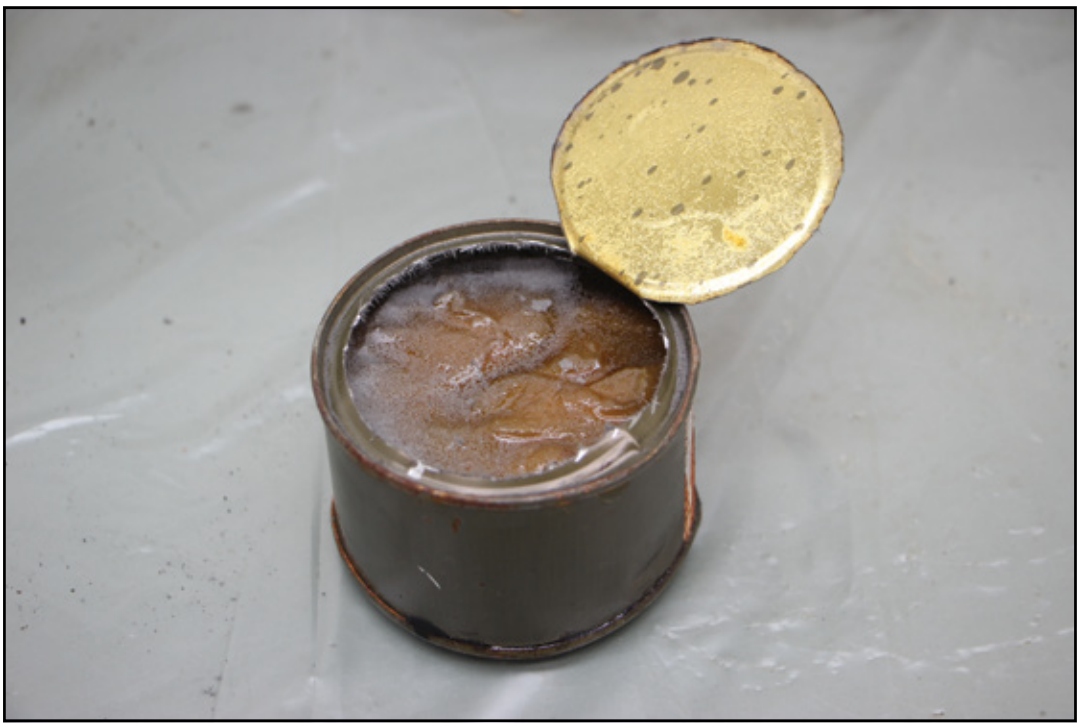


Figure 3. Open can showing fine metal filings (L Yeats, 2014).

conservator recommended that the contents of the leaking cans be removed to prevent further contamination. In order to leave the can displayable, a rotary tool was used to open the can around the rim of the base leaving a hinge of around 20mm (Fig. 2). While different methods of opening were considered, including commercial can openers, punches and drilling, the rotary tool method used by the Antarctic Heritage Trust was chosen for the minimal physical impact on the can itself and the ability to allow effective cleaning (Meek, Fryer pers. comm. 2014). This method of opening caused fine metal filings to deposit on the surface of the food contents (Fig. 3). The metal filings were scraped and syringed off the food as much as possible while it was still in the can, using sterile instruments, in order to reduce potential contamination. The contents were then transferred to sterile glass and plastic containers using a clean stainless steel instrument.

Samples were collected as soon as possible after the cans had been opened to deter further oxidation and contamination from microbes. The sterile containers were clearly marked with the can's accession number using a permanent marker (Fig. 4). The bulk of the samples were placed inside clearly marked plastic zipped lock

Figure 4. Samples of decanted can contents including apricot jam, kidney beans, apricots, apple sauce and white turkey.

bags and put into the freezer for permanent storage at Canterbury Museum. Five samples were not frozen, but instead placed in a plastic zipped lock bag and sent via post to Eurofins Laboratory in Auckland, New Zealand, for further analysis. The samples, while in transit and at Eurofins Laboratory, were in an uncontrolled environment for a maximum of two weeks. Future research may wish to consider ways of controlling the environment for such samples.

As the cans had been accessioned prior to the labels deteriorating, cross-referencing with the museum database allowed identification of the cans and their contents. Analytical tests were then carried out on the selected samples to provide an idea of any deterioration that had already occurred and to establish a baseline against which any further deterioration of the samples over time could be measured. The most worthwhile tests to carry out on the samples were determined by discussion with Eurofins Laboratory. As the metal filings could be present in the sample due to the opening method, and metal corrosion product could bind the vitamins in a sample, vitamin analysis was not carried out due to concern over unreliable results (Szparagowska, Fryer pers. comm. 2014). A series of tests to measure levels of nutrients, peroxide and anisidine values and tests that picked up the presence of mould and sulphite-reducing bacteria were completed.

Due to the relatively small size of the cans and consequently the small amount of sample (150 g) that could be provided, the samples were ultimately destroyed and results were based on one test (multiple tests are standard to ensure samples are not compromised; it is possible, despite measures undertaken to prevent this, that contaminants entered the samples and affected results). The amount of sample retained for future testing varied depending on the size of the tin and the amount that had already leaked out. In all cases, all that remained of the food, once the 150g sample had been removed, was retained and frozen. The samples chosen to submit for testing were selected to provide a representative range of fruits, vegetables and meats least contaminated by metal fillings and allow sufficient remaining contents for future testing. The analysis that was carried out was under the guidance and advice of food scientists who had not encountered aged samples such as this before. There was no published precedent for the testing of aged food samples to gauge degradation.

Tests and results

Upon the advice of Eurofins Laboratory a range of nutritional, chemical and microbiological tests were carried out. Nutritional panel tests recorded levels of specific nutrients. If the same tests were carried out in the future, any change in the levels of nutrients would be apparent, letting researchers know the sample has degraded. Similarly, oxidation which progresses at different rates depending on factors such as temperature, light, availability of oxygen and the presence of moisture and metals, can indicate a product has spoilt. High peroxide (primary breakdown product) and high anisidine (secondary breakdown product) values are an indication of oxidation (Szparagowska, Fryer pers. comm. 2014). Some samples were also tested for mould and sulphite reducing bacteria. If colonies of sulphite reducing bacteria are present, Eurofins sends the sample to North Shore Hospital, Auckland for further identification. The results are shown in Table 1.

Despite an expectation, drawn from the understanding that botulism frequently occurs in opened canned food, scientific testing revealed no significant amounts of botulism on any of the samples, even though they had been open for some time in room temperature conditions. Mould levels on the beans were high which was unsurprising as mould was visible prior to sending the sample for testing. The other samples had fairly low levels of mould. The mould on the beans increased in amount very quickly once emptied from the can. Original nutritional information was only available on the label of the can of white turkey (Fig. 5). Comparison of this against measured amounts

Table 1. Results of scientific testing undertaken on samples of wet canned food contents from Cape Hallett Station collection.

Test	**Reporting Units**	**White Turkey** (2005.151.454)	**Apricot Jam** (2005.151.400)	**Kidney Beans** (2005.151.450)	**Apple Sauce** (2005.151.451)	**Apricots** (2005.151.550)
Ash Leo TGA701	**%m/m**	1.00	0.15	1.41		
Carbohydrate 1.2.8	**g/100g**	0.9	71.6	17.0		
Energy 1.2.8	**kJ/100g**	510	1230	413		
Moisture AOAC 920.151 AOAC 945.43	**g/100g**		27.7			
Moisture Leco TGA701	**%m/m**	72.9		74.7		
Protein AOAR 981.10	**g/100g**	21.8	0.25	6.53		
Fat AOAC 922.06	**g/100g**		0.30	0.34		
Fat AOAC 960.39	**g/100g**	3.31				
Saturated Fat AOAC 991.39/ 1969.33/1963.22	**g/100g**	1.14				
Unsaturated Fat AOAC 991.39/ 1969.33/1963.22	**g/100g**	2.17				
Monounsaturated Fat AOAC 991.39/ 1969.33/1963.22	**g/100g**	1.28				
Polyunsaturated Fat AOAC 991.39/ 1969.33/1963.22	**g/100g**	0.89				
Trans Fat AOAC 991.39/ 1969.33/1963.22	**g/100g**	<0.10				
Sodium AOAC 984.27	**mg/100g**	217	10.9	166		
Total Fat	**g/100g**					
Total Sugars AOAC 980.13/JAOAC 75:1992	**%m/m**	<0.05	64.3	0.32		
Peroxide Value AOCS Cd8.53	**Meq/kg**	34.31				
Anisidine Value AOCS Cd 18-90	**Meq/kg**	12				
Yeasts and/or Moulds APHA	**Cfu/g**	<10		600	<10	<10
Sulphite Reducing Bacteria ISO 15213:2003 (E)	**Cfu/g**	<1		<1	<1	<1

Measuring units g/100 = grams per 100 grams, meq/kg = milliequivalents per kilogram, cfu/g = colony forming units per gram, %m/m = percentage by mass. Abbreviations: AOAC (Association of Analytical Communities); TGA701 (Thermogravimetric Analyser); AOCS (American Oil Chemists' Society); APHA (American Public Health Association); ISO (a horizontal method for the enumeration of sulphite-reducing bacteria growing under anaerobic conditions)

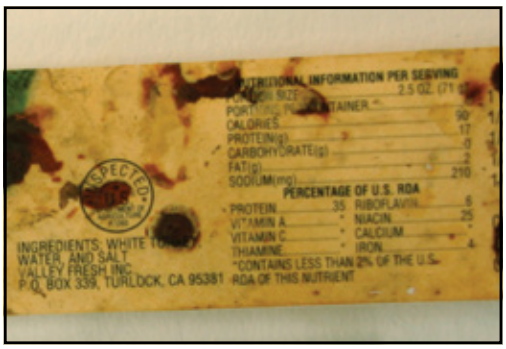


Figure 5. White turkey can label showing nutritional information (note there is a margin of error on this)

from the can in Table 2 show, as expected, that these figures are a guide only and the tin label cannot be taken to be exact. The results of this analysis will be linked to the database record of each object for comparison with future tests. These results suggest that museum staff can follow a clear staged approach in relation to the storage, display and conservation of canned wet food (Figs 6–8).

Conclusions

As this was the first project of its kind that the researchers and scientists involved had undertaken, few expectations were placed on the results; rather this information is intended to act as a base point for further sampling or analysis and to provide ideas for consideration in the storage, display and conservation of canned wet food. It is hoped that the results can act as a reference point for future analysis of canned wet food contents in Canterbury Museum's collection and, potentially, provide useful information for the care, storage and conservation of wet food collections held elsewhere.

This case study has highlighted a number of areas that require further thought in future research and practice. A different can opening method is required in order to obtain uncontaminated food samples specifically to prevent metal filings from contaminating the samples. This may have implications for museums in making the can less displayable. It should be noted that botulism was not detected in the samples although this was thought to be a high risk in this type of food collection. Care still needs to be taken in dealing with such samples, although this may be a lower risk than previously thought. Going forward the contribution of food scientists to interpret these results further and discuss different testing options will be invaluable. Key indicators of deterioration that can be easily analysed and work for a number of food groups require identification. Similarly, we need to be very clear about the ethical considerations of discarding contents as well as separating them from their can. As discussed, there are a number of costs, and logistical challenges in decanting cans, analysing the contents and retaining their frozen contents. Although the comparison of information on can labels versus scientific test results is interesting, due to the margin of error on the former and the (possible) unrepresentative sampling on the latter they may not be statistically significant. Of greater significance will be the analysis taken of the samples from the same can in several years' time which will provide comparison with the

Table 2. Nutritional information on the label of White Turkey compared to nutritional information from scientific testing. Units changed to be as on label (per serving of 71g rather than per 100g)

Nutritional Information	On label	By scientific testing (in units the same as on the Turkey label)
Calories	90	87
Protein	17	15.48
Carbohydrates	0	0.64
Fat	2	2.35
Sodium	210	154.07

baseline testing undertaken here to consider the value of retaining frozen food samples in museum collections.

It is important for staff to consider both the reality and feasibility of freezing removed contents long-term before making a decision regarding keeping or discarding contents. Until the results of the CANS project are published in 2017, the authors recommend no decision is taken on emptying non-leaking cans. Should cans be leaking, current research recommends that wet food contents be removed from metal cans in museum collections as this is currently the only way to responsibly conserve all the

Figure 6. Flowchart of steps for storage of canned wet food collections

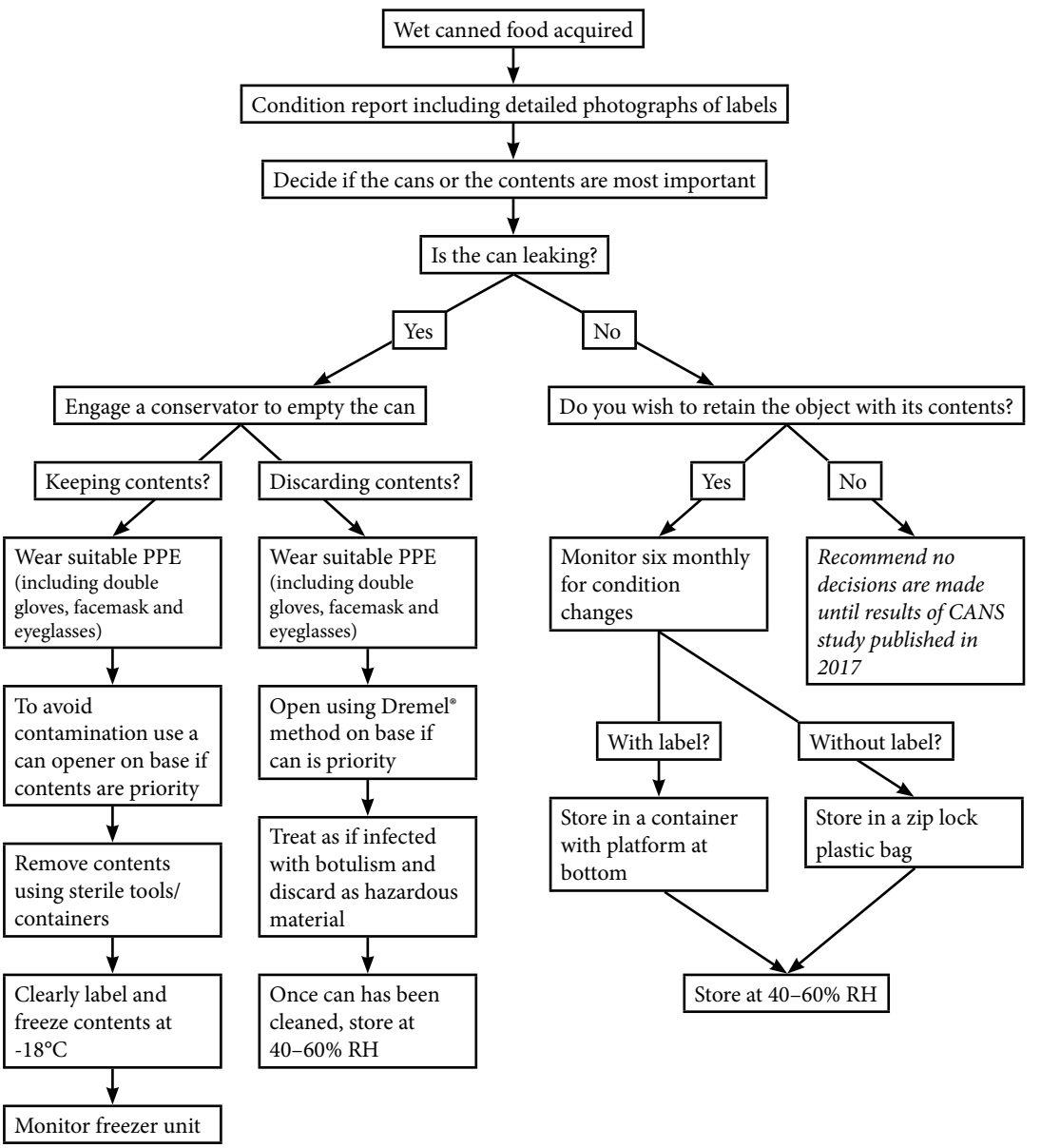


Figure 7. Flowchart of steps for analysis of canned wet food collections

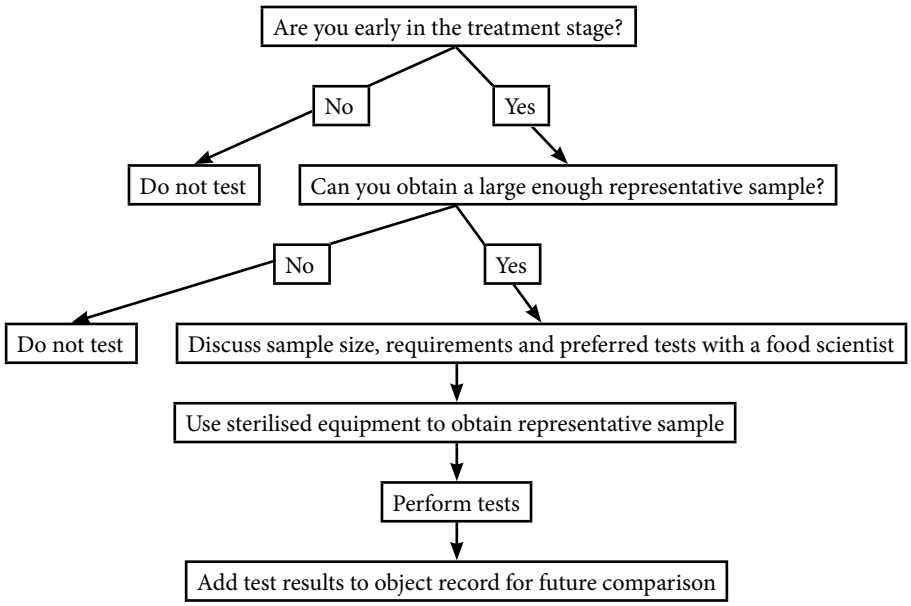
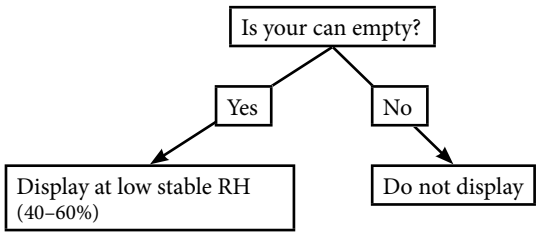


Figure 8. Flowchart of steps for display of canned wet food collections



components - cans, labels and contents - long term. While museums may consider freezing the leaking tin until such a time as a better treatment option is presented, this does not allow for access or display and requires suitable monitored freezer space which may be prohibitively expensive or impractical. There are also implications to be considered should the cans thaw at any point in future as condensation can affect any paper based labels. In Christchurch, the recent series of seismic events demonstrated just how unreliable freezer storage can be for long periods of disrupted power supply (even with generator back up).

How to successfully conserve cans containing food in museum collections is a difficult task and one that requires special consideration. On the one hand, wet canned food items are inherently unstable over a long period of time and pose a potential hazard to other collections. On the other hand, it is evident that once removed from the cans (even compromised ones) that degradation of the food element occurs at a greatly increased rate. This project reveals a lack of knowledge regarding the conservation of cans containing food in collections and the subsequent treatment of the removed contents. The project also emphasises the research potential in this area and the applicability of nutritional, chemical and microbiological analysis to the contents of canned food in museum collections. The results obtained through analytical testing

provide a useful baseline to gauge degradation (for the tested cans only) and from which to continue with research into the best methods of emptying, storing and testing canned wet food collections.

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