

Report on the Mummification of Plant and Animal Tissue Samples - Gwenllian Anthony 1404702

Abstract:

This experiment investigated the effectiveness of using salt to desiccate and mummify two different samples: satsuma as an organic plant material and a hot dog as processed meat. The process consisted of using 100g of table salt to cover each sample, and the results were recorded over three weeks. The results show that salt successfully decelerates the decomposition of organic and processed material by drawing water out, which inhibits microbial activity (Aufderheide, 2003). The salt is shown to shrink, colour change and alter the weight of samples significantly, with the biggest change seen in the satsuma sample. Due to the high water content of the satsuma, it shows the greatest physical transformation, including structural collapse. In contrast, the hot dog shows relatively minor changes in size but moderate changes in colour. Overall, this experiment successfully displays the process of ancient Egyptian mummification and provides insight into the mechanisms behind these preservation practises.

Keywords: Mummification, Salt, Dehydration, Preservation, Experimental Archaeology

Introduction:

Artificial mummification is a preservation technique that is commonly associated with ancient Egyptians, but evidence of similar treatment can be found across the world, including within Andean cultures, the Guanche culture of the Canary Islands, and across Southeast Asia (Cockburn, A. et al. 1998). In these societies, the preservation of the body held cultural, spiritual, and religious significance.

In ancient Egypt, the body was essential for the continuation of life after death. It was believed that the 'soul' was comprised of multiple elements, such as the Ka, the Ba, and the Akh. The Ka was to remain close to the body to receive sustenance, while the Ba and Akh could leave the body. Therefore, it was vital to keep the body preserved so it could survive for all eternity (Loynes, R. 2015). The soul would not be able to function properly if decomposition were allowed to happen, and the individual's existence in the afterlife would be compromised.

A crucial part of preservation in ancient Egypt was the use of natron, a naturally occurring compound of sodium bicarbonate and sodium carbonate, to remove moisture and desiccate the corpse. Natron - and specifically sodium carbonate - is highly hygroscopic and significantly enhances the dehydration of all biological material (Nerlich, A.G. Et al. 2005). The removal of water is crucial to obstruct bacteria and enzymes from decomposing the body. By removing the moisture, the process of decay is significantly slowed or completely halted, which makes desiccation a highly effective way of preserving (Brier, B. and Wade, R.S. 1996).

This experiment focuses on replicating ancient Egyptian mummification processes by using table salt to desiccate two different samples. Evidence shows that table salt was used by ancient Egyptians to mummify, with traces of table salt being found on the surface of Tutankhamen's mummy alongside a combination of other, different salts (Szleszkowski, L. 2022).

The experiment uses two different materials: a hot dog, which represents protein and fat-rich processed animal tissue, and a satsuma, which represents high-water organic plant material. The difference in composition of plant and animal tissue is vital to understand preservation. Organic plant tissues are mostly composed of water-filled vacuoles, which make them highly vulnerable to collapse during dehydration. Animal tissues, however, contain structural proteins such as collagen, which provide greater resilience (Aufderheide, 2003). Comparing the decay and preservation of both samples will show how composition affects the process of mummification.

Aims:

The aim of this experiment is to investigate the effectiveness of using salt to desiccate and mummify organic materials by comparing two different types of samples: plant-based and processed animal tissue.

Hypothesis:

It is hypothesised that the salt will ease or stop the decay of both organic materials by removing moisture and inhibiting microbial activity. However, the satsuma is expected to undergo the biggest change, including shrinking and structural collapse, due to its high water content. The salt-treated samples are expected to show greater signs of dehydration, such as a reduction in size and weight, compared to the control samples.

Method:

Design:

The experiment used a comparative design, with two different organic materials subjected to identical preservation conditions. The independent variable was the type of organic samples, whilst the dependent variables were the changes in size, change of colour and change of weight. The controlled variables were the amount of salt used, the duration of the experiment and environmental conditions such as temperature and sunlight. The Munsell chart was used to note colour changes as it is a standardised system to compare colour and reduces subjectivity within the archaeological practise.

Materials:

- One hot dog cut in half (processed animal tissue)
- One satsuma cut in half (organic plant material)
- Table salt (100g for each sample - standardisation)
- Ziplock bags (controlled environment)
- Weighing scales
- Ruler
- Munsell colour chart (Online reference)
- Observation Log

Procedure:

An initial observation of both samples was recorded, including weight, size, and colour. Each sample was then placed into a ziplock bag. One-half of the hot dog and one-half of the satsuma were designated as experimental samples, while the remaining halves served as controls.

Both experimental samples were covered in 100g of table salt, ensuring full contact with the surface. Both the control samples were placed into ziplock bags without salt. All bags were sealed tightly after expelling air to minimise external environmental influence.

All the samples were stored in a consistent, dry, room-temperature environment for all three weeks. Observations were recorded once per week over a three-week period, focusing on changes in weight, size, and colour.

Results:

WEEK 1 (Pre-experiment)	Satsuma (Control)	Satsuma (Experiment)	Hot Dog (Control)	Hot Dog (Experiment)
Weight	29g	30g	11g	12g
Width	5.5cm	5.5cm	1.8cm	1.8cm
Height	3.7cm	3.7cm	4.9cm	4.8cm
Colour	5YR 4/8	5YR 4/8	2.5YR 3/4	2.5YR 3/4
WEEK 2				
Weight	27g	30g	11g	12g
Width	5.5cm	5.5cm	1.8cm	1.8cm
Height	3.7cm	3.1cm	4.9cm	4.5cm
Colour	2.5YR 5/10	5YR 5/10	5YR 5/6	5YR 4/4
WEEK 3				
Weight	27g	33g	10g	15g
Width	5.4cm	5.7cm	1.8cm	1.5cm
Height	3.6cm	2.9cm	5.4cm	4.5cm
Colour	2.5YR 4/6	2.5YR 6/10	2.5YR 4/6	2.5YR 4/4

Discussion:

The results of this experiment show a clear difference between the control and experimental samples over the three-week period.

The satsuma experimental sample shows the biggest change, with its height decreasing 21.6% from 3.7cm to 2.9cm, which clearly indicates substantial shrinkage. The width of the satsuma showed a slight increase by the end of the three-week period, and its weight increased 10% from 30g to 33g. The satsuma's colour also became darker over time.

The satsuma control sample showed minimal change compared to the experimental sample. Its size stayed relatively stable whilst its weight decreased 6.9% from 29g to 27g. Its colour also darkened, but not to the extent of the experimental sample.

The hot dog experimental sample showed some changes overall, but not as dramatic as the satsuma. Its height decreased 6.25% from 4.8cm to 4.5cm, and its width reduced 16.6% from 1.8cm to 1.5cm. Although its dimensions shrank, its weight increased 25% from 12g to 15g, likely due to the absorption of salt into the tissue.

The hot dog control sample showed minimal changes overall. Its weight decreased 9% from 11g to 10g, and its dimensions remained quite consistent. Its colour also stayed relatively consistent.

The results show that salt has a significant effect on the preservation of organic materials through desiccation. The most obvious changes were the satsuma, especially its height. As the satsuma has a high-water content, it supports the hypothesis that salt is effective in removing moisture, which results in the structural collapse of the sample. This process is called osmotic dehydration, and it occurs when water molecules migrate from areas of lower solute concentration to areas of higher solute concentration. The cell wall of the samples acts as a semipermeable membrane in which moisture is extracted to maintain an equilibrium (Mari, A. Et al. 2024).

In contrast, the hot dog showed less dramatic shrinkage, which is likely due to its composition, which includes proteins, fats, preservatives and less water. The preservatives within the hot dog inhibit microbial activity, which could be reducing visible decomposition. Sodium nitrite is a pre-existing antimicrobial agent that is present in processed meats, which differs from the satsuma, which has no preservatives at all. One of the properties of nitrite is its ability to effectively delay the development of oxidative rancidity, even in the presence of salt, which is a strong oxidant (Sindelar, J.J. and Milkowski, A.L. 2011). This means that the microbial inhibition of the hot dog sample cannot be attributed solely to the salt desiccation, and it would be beneficial to test fresh, unprocessed meat to isolate the effect of salt from the effect of preservatives.

A surprising result within the experiment was the increase in weight observed in both experimental samples. This is likely due to the salt absorption into the tissues. This highlights an issue when using weight to indicate dehydration, as it does not distinguish between loss of water and salt gain. It is clear that weight alone is an unreliable dependent variable within a salt-based desiccation experiment, and the experiment would benefit from measuring water activity or moisture content as a more reliable variable.

Colour changes observed in the experimental samples suggest chemical changes during the preservation process. Both of the experimental samples were found to become darker over the three-week period, consistent with oxidation and the concentration of pigments as water is removed. Forensic studies of mummified remains have found that darker colouration in desiccated tissue corresponds directly with greater water loss, with yellow-orange discolouration at earlier stages of desiccation and reddish-brown and black at more advanced stages (Ceciliason, A.S. et al. 2023). The progressive darkening observed in this experiment's Munsell chart data therefore, provides independent corroboration of desiccation occurring in the experimental samples.

The minimal changes observed in the control samples confirm that the effects seen in the experimental samples were due to the presence of salt rather than natural processes. This strengthens the credibility of the experiment and supports the conclusion that salt is an effective preservative.

The findings closely parallel archaeological observations of mummified remains in arid environments, where rapid desiccation prevents bacterial proliferation. In ancient Egyptian contexts, natron functioned similarly to the salt used in this experiment, creating a hypertonic environment that extracted moisture from tissues (David, R. 2008).

Conclusions:

This experiment shows that desiccation through salt is an effective way of preserving and mummifying organic and processed material, and there are a few key conclusions to this experiment.

One of these conclusions is that salt causes structural collapse and shrinkage through dehydration. This is evident in both samples, but particularly the satsuma sample. The evidence shows the process of osmotic dehydration through the cell walls of the samples, which results in the structural collapse of the samples. Alongside this, another conclusion is that samples with

higher water content are affected more, which is evident when comparing the satsuma, which has a high water content, to the hot dog, which does not.

Another key conclusion is that the absorption of salt can cause samples to increase in weight. This is seen with both experimental samples and highlights a limitation within the experiment. Although weight was recorded as a dependent variable on the assumption that mass reduction would indicate water loss, by week three, it is clear that both samples gained weight, which ultimately contradicts this assumption.

Colour changes reported in both experimental samples show chemical alteration, which is similar to what is seen with ancient Egyptian mummies. Forensic case studies on mummified people report that skin becomes hard with a brown to black appearance, often leathery (Byard, R.W. 2024). Similar changes can be seen with this experiment's experimental samples.

The little-reported change with regards to the size and weight of the control samples further shows that table salt is an effective tool to desiccate and mummify biological materials. The salt is seen to significantly alter weight, size, and colour while, the control samples are seen to remain quite stable.

The experiment successfully reflects ancient Egyptian mummification processes and gives insight into how the decomposition of material can be affected by salt.

Recommendations:

To improve the reliability of this experiment, several modifications could be made. Firstly, increasing the sample size would provide more reliable data and allow for deeper statistical analysis. Including additional materials, such as fresh, unprocessed meat would help to determine the impact of preservatives of the mummification process.

Secondly, changes in the environment could be explored further. An example of this is storing samples under contrasting environmental conditions, such as high or low temperatures, direct sunlight, or darkness. This would help gather an understanding of how different environmental conditions can influence the mummification process. This would also allow comparisons with real-world mummification contexts, such as the hot, arid conditions of ancient Egypt or the cold, high-altitude environments of the Andes.

Additionally, more precise measurements could be taken. Recording daily changes rather than weekly observations would provide a more detailed understanding of the rate of desiccation. Also, measuring moisture content directly, rather than relying on weight, which has been found to be unreliable, would also improve accuracy.

Finally, extending the duration of the experiment beyond three weeks would allow for the observation of long-term preservation effects and provide a closer comparison to archaeological mummification processes.

References:

Aufderheide, A.C. (2003) *The Scientific Study of Mummies*.

Brier, B. And Wade, R.S. (1996) *The Use of Natron in Human Mummification: A Modern Experiment*

Byard, R.W. (2024) *Mummification - a forensic case series*.

Ceceliason, A.S. et al. (2023) *Mummification in a forensic context: an observational study of taphonomic changes and the post-mortem interval in an indoor setting.*

Cockburn, A. Et al. (1998) *Mummies, Disease and Ancient Cultures.*

David, R. (2008) *Egyptian Mummies and Modern Science.*

Loynes, R. (2015) *Prepared for Eternity: A study of human embalming techniques in ancient Egypt using computerised tomography scans of mummies.*

Mari, A. Et al. (2024) *Exploring Osmotic Dehydration for Food Preservation: Methods, Modelling and Modern Applications.*

Nerlich, A.G. et al. (2005) *Why did the Egyptians use natron for artificial embalming? An experimental study on organ mummification.*

Sindelar, J.J and Milkowski, A.L. (2011) *Sodium nitrite in processed meat and poultry meats: A review of curing and examining the risk/benefit of its use.*

Szleszkowski, L. Et al. (2022) *“Self Mummification”: a typical method of embalming a corpse.*

Bibliography

Byard, R.W. (2025) *Mummification - An historical and cultural overview.*

Ikram, S. (2015) *Death and Burial in Ancient Egypt.*

Price, C. et al. (2016) *Mummies, Magic and Medicine in Ancient Egypt: Multidisciplinary Essays for Rosalie David.*

Taylor, J. (1995) *Unwrapping a Mummy.*

Vandenbeusch, M. (2019) *Observations on mummification practices between the 22nd and the 26th Dynasties.*

Zesch, S. et al. (2024) *The multifaceted nature of Egyptian mummification: Paleoradiological insights into child mummies.*