

Simulating Ancient Egyptian mummification: an investigation into salt-induced desiccation of tomatoes

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Abstract

This study investigated the effect of a natron-like salt mixture on the desiccation of organic tissue, using tomato as a model. One half of a tomato was embedded in a salt mixture composed of sodium chloride and sodium bicarbonate, while the other half served as an untreated control. Changes in mass, dimensions, and physical characteristics were recorded over a three-week period. The experimental sample exhibited a significant reduction in mass (55.7%) and notable structural changes, including shrinkage and increased firmness, whereas the control sample showed minimal mass loss and greater microbial growth. These results demonstrate the effectiveness of salt-induced desiccation in preserving organic tissue and support historical accounts of natron use in Ancient Egyptian mummification.

1 Introduction

This study aimed to examine the effect of a natron-like salt mixture on the desiccation of organic tissue, using tomato as a model, and to compare changes in mass, dimensions, and physical characteristics with those of an untreated control sample over time.

This study investigated the mechanisms underlying desiccation observed in Ancient Egyptian mummification practices, in which natron salt was used to preserve organic remains. By replicating aspects of this process under controlled conditions, the study aims to better understand how salt-based mixtures affect the preservation of biological tissue.

It is well established that natron, a naturally occurring alkali mixture of sodium carbonate, sodium bicarbonate, sodium chloride, and sodium sulphate, was used extensively in Egyptian mummification.¹ Historical accounts, such as those of Herodotus (c. 450 BC),² describe the use of natron to dry the body. The desiccating effect of such salts is attributed to the creation of a hypertonic environment, which draws water out of biological tissues via osmosis.³ This loss of moisture inhibits microbial activity and slows decomposition. However, the precise composition and proportions of natron used historically remain uncertain,⁴ and there is limited experimental replication of its effects on organic tissue.

¹ Edwards, H. G. M. *et al.* (2007) 'Raman spectroscopy of natron: shedding light on ancient Egyptian mummification', *Analytical and Bioanalytical Chemistry*, 388, pp. 683–689 (p. 683).

² Herodotus (c. 440 BCE) *Histories*, 2.87. Available at: <https://www.livius.org/sources/content/herodotus/mummification/> (Accessed: 26 March 2026).

³ David, R. (2008) *Egyptian mummies and modern science*. Cambridge: Cambridge University Press, p. 63.

⁴ Taylor, J. H. (2001) *Death and the afterlife in ancient Egypt*. London: British Museum Press, p. 49.

Tomato tissue provides a suitable model for this investigation due to its high water content and soft cellular structure.⁵ The cells within the tissue are surrounded by semipermeable membranes that allow water to move via osmosis. When exposed to a hypertonic environment, such as a concentrated salt mixture, water is expected to move out of the cells, resulting in loss of mass, shrinkage of tissue, and changes in texture. This makes tomato an effective model for observing desiccation processes similar to those involved in mummification.

It was expected that the experimental sample exposed to the salt mixture would exhibit significant desiccation, resulting in reduced mass and shrinkage, as well as reduced microbial growth, including less mould formation, compared to the control sample.

2 Materials and Methods

2.1 Study objects

The experiment was performed using supermarket-bought tomato, cut in half through the longitudinal axis. One-half served as the experimental subject, the other as the control subject.

2.2 Experiment protocol

The experiment was conducted over a three-week period, with initial measurements recorded at Week 0 and subsequent measurements taken weekly. The samples were stored in a lecture room, airconditioned during working hours at 21 degrees. centigrade for the first two weeks. It was relocated to a non-air-conditioned room for the final week.

A compound of 50% table salt and 50% bicarbonate of soda was used. Table salt is a minimum 97% NaCl, and may contain minor traces of other additives, including calcium, potassium, magnesium and sodium sulphates, carbonates, bromides and of calcium, potassium, magnesium chlorides.⁶ The table salt used in this experiment also contained sodium ferrocyanide as an anti-caking agent. Bicarbonate of soda is NaHCO³. A total mixture mass of 400 grams was used (see Table 1).

Table 1: Composition of salt mixture used for the desiccation experiment

Chemical compound	NaCl	NaHCO ³	Na ₄ [Fe(CN) ₆]
Fraction in %	≥48.5%	50%	≤1.5%
Amount in grams	≥194g	200g	≤6g

After cutting the tomato longitudinally, both samples were left otherwise unmodified, with seeds and internal structures intact. The experimental sample was embedded in the salt mixture within a low-density polyethene (LDPE) bag with a double-track press-seal closure. The bag was rolled to

⁵ Hou, X. *et al.* (2020) ‘Responses of water accumulation and solute metabolism in tomato fruit to water scarcity and implications for main fruit quality variables’, *Journal of Experimental Botany*, 71(4), pp. 1249–1264. Available at: <https://pmc.ncbi.nlm.nih.gov/articles/PMC7242001/> (Accessed: 26 March 2026).

⁶ Codex Alimentarius Commission (1985) *Standard for food-grade salt (CXS 150-1985)*. Rome: FAO/WHO, p. 1. Available at: https://www.fao.org/fao-who-codexalimentarius/sh-proxy/zh/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXS%2B150-1985%252FCXS_150e.pdf (Accessed: 26 March 2026).

minimise entrapped air, sealed via the closure, and reinforced with adhesive tape. The control sample was placed in an identical LDPE bag, rolled to minimise air, and sealed.

At weekly intervals, at the same time on each occasion, both samples were removed from their bags and measured. Mass, dimensions, photographic evidence, and qualitative observations on colour, texture and smell were recorded.

3 Results

3.1 Overview

Desiccation of the experimental sample was successfully achieved, resulting in significant mass loss. Marked differences were observed between the control and experimental samples. Both samples exhibited decreases in height, width, and depth during the initial observation period, followed by increases in these dimensions in the final week.

3.2 Quantitative results

Overall, the experimental sample lost 28.42 g over three weeks, representing a 55.7% decrease (Table 2; Figure 1), whereas the control sample showed only a slight decrease in mass. While both samples exhibited fluctuations in height and width, these changes were more pronounced in the experimental sample (Table 2; Figures 2 and 3). The control sample showed a fractional increase in dimensions over time, particularly in height and width (Table 2; Figures 2 and 3). In contrast, the experimental sample exhibited an overall decrease in width and depth, with depth showing a substantial reduction of 8.91 mm (31.65%) (Table 2; Figure 4). Height in the experimental sample showed only a slight net increase despite initial decreases.

Table 2: Mass and dimensions measurements for control and experimental tomato samples

WEEK	SAMPLE	MASS (g)	HEIGHT (mm)	WIDTH (mm)	DEPTH (mm)
0	Control	45.10	55.06	54.78	26.64
0	Experimental	51.00	54.30	55.98	28.15
1	Control	44.77	56.73	55.48	26.99
1	Experimental	29.20	52.18	52.15	19.12
2	Control	44.12	58.28	56.33	27.59
2	Experimental	25.24	51.21	49.71	15.38
3	Control	43.87	64.22	60.42	28.22
3	Experimental	22.58	54.71	55.67	19.24

Figure 1: change in mass of control and experimental tomato samples over time

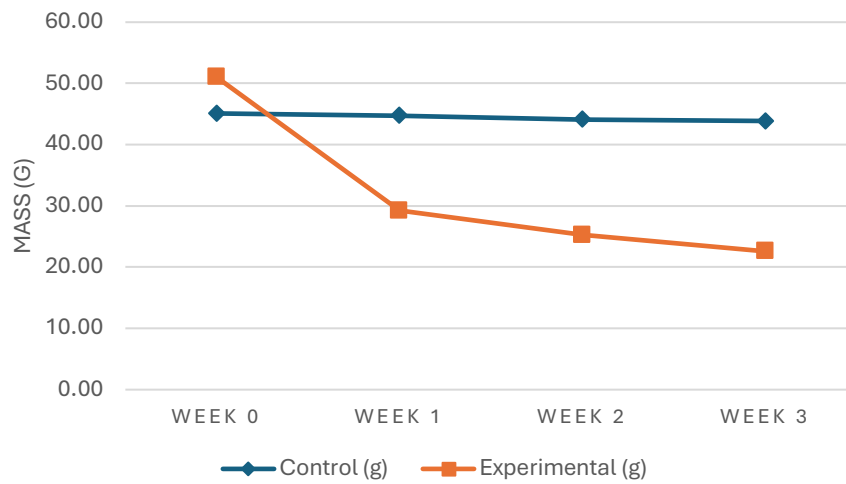


Figure 2: change in height of control and experimental tomato samples over time

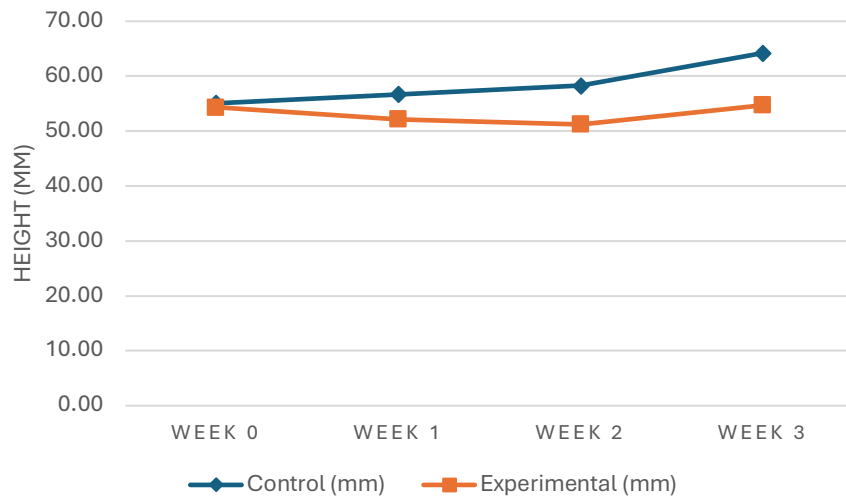
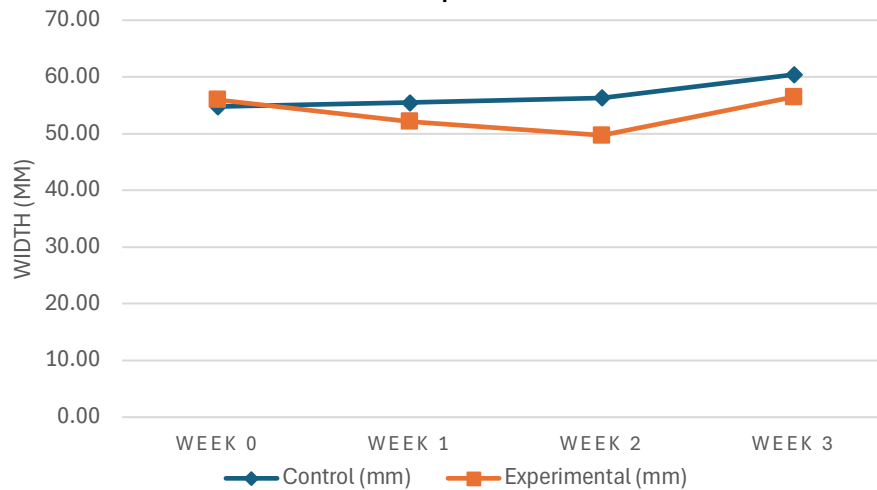
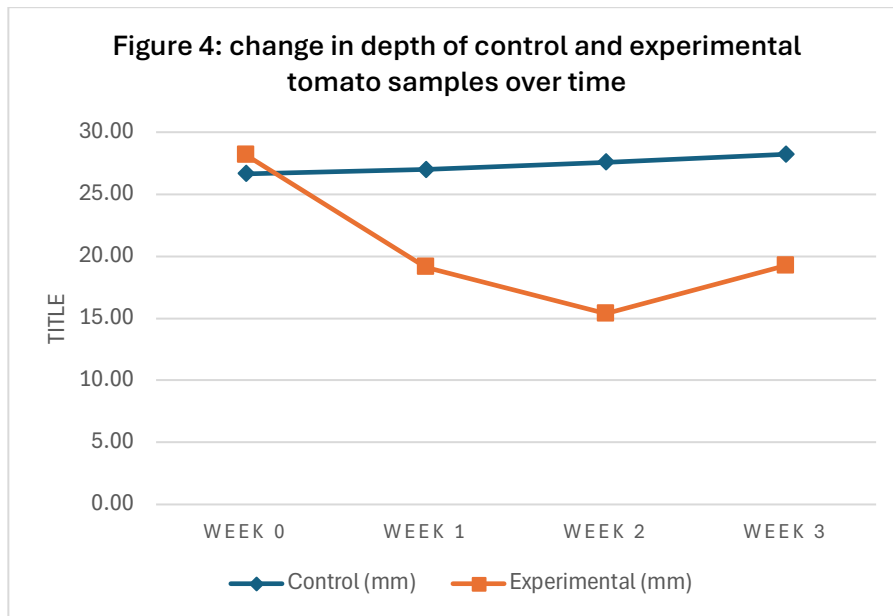


Figure 3: change in width of control and experimental tomato samples over time





3.3 Qualitative results

Qualitative observations were recorded at weekly intervals as follows:

Week 0 (Initial)

Control and experimental samples:

- Colour consistent with Munsell 7.5R 5/16
- Exocarp smooth, glossy, and firm to the touch
- No visible signs of microbial growth or tissue degradation

Week 1

Control sample:

- Cut surface appeared slightly desiccated, with areas of white crystalline residue
- Seeds exhibited darkening and early signs of microbial colonisation
- Odour remained characteristic of fresh tomato, with slight deterioration

Experimental sample:

- Cut surface concave, with noticeable inward collapse of tissue
- Early signs of mould growth observed on exposed surfaces
- Seeds remained largely intact but appeared sunken
- Sepal showed initial signs of microbial growth
- Exocarp markedly wrinkled and leathery
- Odour similar to control

Week 2

Control sample:

- Extensive darkening and decomposition of seeds
- Presence of both white crystalline deposits and areas of black mould
- Exocarp exhibited discolouration (red, black, and white mottling)

- Tissue remained moist
- No strong odour of advanced decay

Experimental sample:

- Slightly sour odour detected
- Seeds and surrounding membrane remained structurally intact but had collapsed inward
- Significant reduction in internal moisture; flesh appeared shrunken and lighter in colour
- Minor mould growth observed at surface edges
- Exocarp highly wrinkled, curled at cut edges, and firm with a leathery texture
- Sample appeared misshapen and structurally fragile under pressure

Week 3 (Final)

Control sample:

- Extensive mould growth across cut surface
- Increased surface moisture with tissue softening and partial liquefaction
- Evidence of germination observed (small white sprouts)
- Exocarp exhibited splitting, likely due to expansion of internal tissues
- Overall structure appeared softened but expanded

Experimental sample:

- Further reduction in size with pronounced desiccation
- Exocarp extremely wrinkled and leathery
- Tissue remained firm and structurally intact despite shrinkage

See figures 6 – 9 and Appendix 1 for photographic evidence.



Figure 6: Control (left) and experimental sample (right) (Week 0) cut surface (longitudinal section).



Figure 7: Control sample and experimental sample (Week 0), external surface (exocarp)

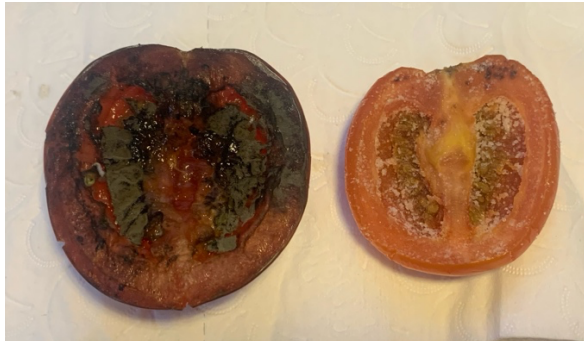


Figure 8: Control (left) and experimental sample (right) (Week 3) cut surface (longitudinal section).



Figure 9: Control sample and experimental sample (Week 3), external surface (exocarp)

4 Discussion

The results support the hypothesis that exposure to a salt mixture promotes desiccation of organic tissue. The experimental sample showed a substantial decrease in mass (55.7%), whereas the control sample exhibited only minor changes, indicating that the salt mixture was responsible for the observed effects.

The mass reduction observed in the experimental sample can be attributed to osmosis. The salt mixture created a hypertonic environment, causing water to move out of the tomato cells across semipermeable membranes. This loss of water decreased overall mass and contributed to the observed tissue shrinkage.

In contrast, the control sample was not exposed to a hypertonic environment and, therefore, retained most of its internal moisture. As a result, only minor decreases in mass were observed, likely due to natural evaporation rather than osmotic processes.

The reduction in dimensions of the experimental sample is consistent with water loss from the cells, leading to tissue collapse and structural contraction. The leathery texture and wrinkling of the exocarp, together with the inward collapse of the central tissue and overall deformation of the sample, further support this.

The experimental sample exhibited reduced microbial growth compared to the control. This is likely due to the removal of moisture, which is essential for microbial activity. In contrast, the control sample retained moisture, creating conditions conducive to mould growth and decomposition. The germination of sprouts supports this.

The increase in dimensions observed in the final week for both samples may be attributed to environmental variation, as the samples were relocated to a non-air-conditioned environment. Changes in humidity and temperature may have led to slight rehydration or expansion of the tissue, particularly in the control sample.

Several limitations may have affected the reliability of the results. The experiment was not conducted under controlled laboratory conditions, but in a classroom environment, and although air conditioning was present, temperature and humidity were not strictly regulated. This lack of

environmental control may have influenced the rates of desiccation and microbial growth, particularly after the samples were relocated in the final week.

In addition, the salt mixture used was not a true synthesis of natron but a household approximation composed of commercially available ingredients. The table salt used may have contained trace amounts of other minerals and additives, and it did contain sodium ferrocyanide, which could have influenced the desiccation process.

The samples were stored in low-density polyethylene food bags, which are not airtight and may have allowed some moisture exchange with the external environment, potentially affecting the rate of water loss.

Measurement accuracy was also limited. Although digital callipers were used, the irregular and changing shape of the tomato samples, including concavity and surface deformation over time, reduced the reliability of dimensional measurements. While direct volume measurement would have provided a more accurate representation of size change, this was not feasible as submerging the samples in water would have altered their moisture content and compromised the results.

Photographic documentation was captured using a mobile device (iPhone X) rather than laboratory imaging equipment. As a result, variations in lighting, angle, and image quality may have affected the consistency and accuracy of visual observations.

Despite these limitations, the results clearly demonstrate the effectiveness of salt-based desiccation in preserving organic tissue, supporting historical accounts of natron use in mummification.

5 Conclusion

In conclusion, the results demonstrate that a natron-like salt mixture effectively promotes the desiccation of organic tissue, as evidenced by the significant mass reduction and structural changes observed in the experimental sample. In contrast, the control sample retained moisture and exhibited greater microbial activity. These findings support the role of salt-induced desiccation in preservation processes such as mummification.

Appendix A: Photographic record of samples

Week 0



Figure A1: Control sample (Week 0), external surface (exocarp).



Figure A2: Control sample (Week 0), cut surface (longitudinal section)



Figure A3: Experimental sample (Week 0), cut surface (longitudinal section)

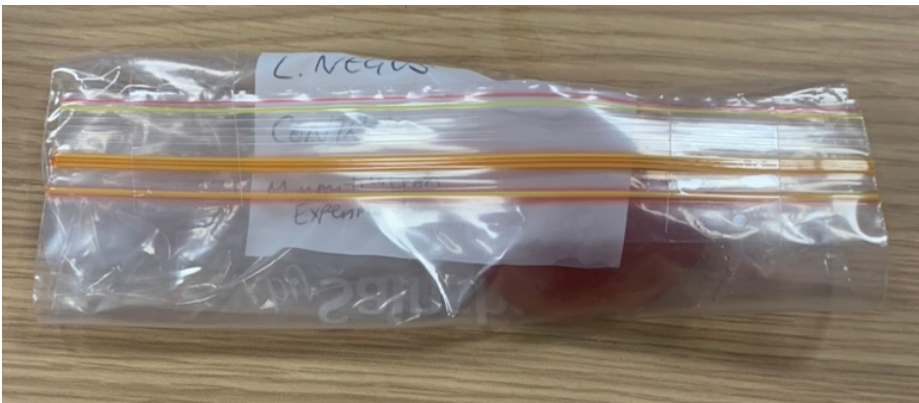


Figure A4: Control sample (Week 0), within sealed LDPE bag

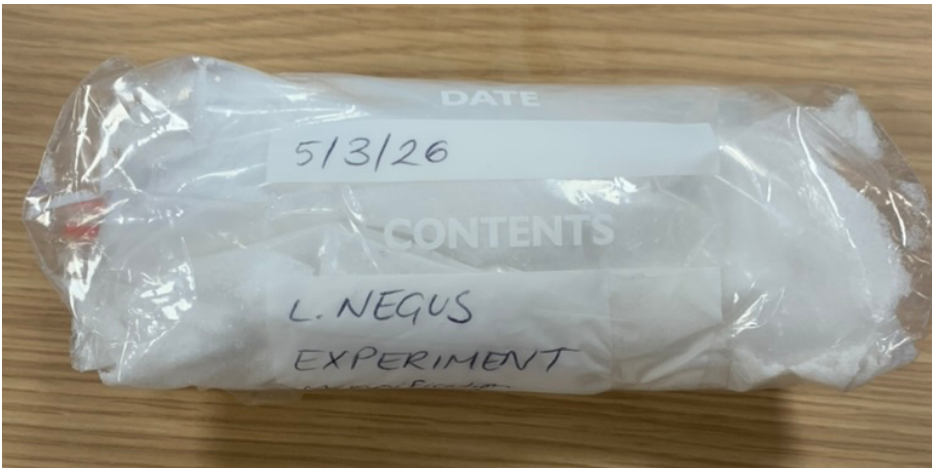


Figure A5: Experimental sample (Week 0), within sealed LDPE bag

Week 1
Control Sample



Figure A6: Control sample (view 1)



Figure A7: Control sample (view 2)



Figure A8: Control sample (view 3)

Week 1
Experimental Sample



Figure A9: Experimental sample (view 1).



Figure A10: Experimental sample (view 2)

Week 1

Experimental Sample (continued)



Figure A11: *Experimental sample (view 3)*



Figure A12: *Experimental sample (view 4)*

Week 1

Side-by-side comparison



Figure A13: *Control (left) and experimental (right) samples*



Figure A14: *Control (left) and experimental (right) samples*

Week 2
Control Sample



Figure A15: Control sample (view 1).



Figure A16: Control sample (view 2)



Figure A17: Control sample (view 3)

Week 2
Experimental Sample



Figure A18: Experimental sample (view 1)



Figure A19: Experimental sample (view 2)



Figure A20: Experimental sample (view 3)



Figure A21: Experimental sample (view 4)



Figure A22: Experimental sample (view 5)

Week 3 (Final Week)
Control Sample



Figure A23: Control sample (view 1)



Figure A24: Control sample (view 2)

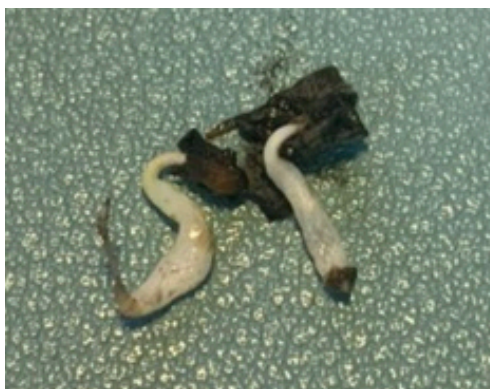


Figure A25: Germinated seeds (sprouts) from control sample



Figure A26: Control sample (view 4).



Figure A27: Control sample (view 5)

Week 3 (Final Week)
Experimental Sample



Figure A28: Experimental sample (view 1)



Figure A29: Experimental sample (view 2)



Figure A30: Experimental sample (view 3)



Figure A31: Experimental sample (view 4))



Figure A32: Experimental sample (view 5)



Figure A33: Experimental sample (view 6)

