

The Effects of Different Chemical Salts on the Mummification of a Tomato

Abstract and Key Words

The use of salt in the desiccation of organic material can be incredibly useful in artificial mummification. In ancient Egypt, natron salt was used to aid in their creation of mummified people. To test the effectiveness of different kinds of salts at mummification, three different chemical salts (sodium chloride, magnesium sulfate, and sodium bicarbonate) were used to cover a piece of tomato. The tomato was weighed and measured to document the changes that occurred to it over a three week period. The experiment revealed that of the salts used, sodium chloride was the most effective.

Desiccation
Mummification
Tomato
Salt

Introduction

Desiccation is an incredibly important part of the mummification process. Proper mummification required a body to be dehydrated, which was something the ancient Egyptians understood very well. Though this could be done naturally thanks to the very hot and dry Egyptian climate, the Egyptians also performed artificial desiccation using natron, a naturally occurring combination of sodium carbonate, sodium bicarbonate, sodium chloride, and sodium sulfate (Kaup et al., 2003, p. 214-215; Abdel-Maksoud et al., 2011, p. 291-292; Öhrström et al., 2020, p. 860-862). Artificial mummification using natron salt has been successfully replicated multiple times in the present day. One experiment involving submerging porcine internal organs in artificial natron for seven weeks saw all organs successfully mummify (Öhrström et al., 2020, p. 862-864). Another involving the mummification of a human lower leg showed that natron was able to remove all of the water present in the leg, without damaging it or allowing the leg to

decompose (Panzer et al., 2013, p. 1532). These natron experiments can be used to create a standard for salt mummification; successful mummification should include both a loss of mass and volume (Öhrström et al., 2020, p. 864) and a lack of signs of decomposition (Panzer et al., 2013, p. 1532). Using this baseline, the effectiveness of pure sodium chloride, magnesium sulfate, and sodium chloride as mummification agents can be observed. Because of their presence in natron (Öhrström et al., 2020, p. 862), sodium chloride and sodium bicarbonate are likely to be the most effective at mummification. While the magnesium sulfate being used in the experiment and sodium sulfate found in natron both contain sulfate, it is unknown if that will effect the mummification.

Method

The tomato was first weighed using an electronic scale before being cut into four approximately equal-sized pieces. After quartering, each of the tomato pieces was reweighed and measured using electronic callipers. The maximum length (mL) was taken from the distance between the superior and inferior ends, the maximum width (mW) from the longest distance between either edges, and the maximum breadth (mB) was taken from the longest distance between the interior and exterior of the tomato. The tomatoes were placed into separate plastic bags labeled Control, Experiment A, Experiment B, and Experiment C. 100g of sodium chloride was added to Experiment A's bag, while 150g of magnesium sulfate and sodium bicarbonate were added to Experiment B and Experiment C, respectively. The control bag did not have any salt added. The additional 50g of salt was added to Experiments B and C so that the tomato in each would be completely submerged. After each tomato was completely submerged in its respective salt, the air was removed from the bag and rolled up so that the tomato would stay submerged. The air removal and rolling were done to the control bag as well. The bags were then

taped so they would not unroll. All four bags were then put aside, covered, and left for one week. After one week, the tomatoes were removed from their bags and had the salt removed from them. This was done using a combination of a toothbrush and a dental pick, with the brush brushing off most of the salt on the skin as well as large clumps on the interior, and the pick scraping off the smaller clumps present on the interior. When the salt was removed, the tomatoes were each weighed and measured in the same manner as the first week. The tomatoes were then placed back in their bags, resubmerged, rewrapped, and set aside for another week. The process was then repeated the following week.

Results and Discussion

The tomatoes exposed to salt all experienced a degree of mummification. This resulted in a general loss of both size and mass, as can be seen in Table 1.

Table 1: Dimensions and Mass of Tomato Slices by Week

	Week 1	Week 2	Week 3
Control	mL-52.01mm mW-40.94mm mB-32.96mm mass-29.15g	mL-54.16mm mW-40.83mm mB-32.96mm mass-26.40g	mL-55.20mm mW-35.57mm mB-26.74mm mass-21.90g
Experiment A (sodium chloride)	mL-52.01mm mW-38.07mm mB-28.88mm mass-23.36g	mL-42.59mm mW-24.39mm mB-24.26mm mass-9.50g	mL-42.59mm mW-24.35mm mB-24.26mm mass-10.05g
Experiment B (magnesium sulfate)	mL-52.46mm mW-41.33mm mB-27.45mm mass-23.71g	mL-42.53mm mW-30.26mm mB-22.90mm mass-12.70g	mL-45.26mm mW-26.04mm mB-18.32mm mass-9.17g
Experiment C (sodium bicarbonate)	mL-50.35mm mW-37.47mm mB-24.20mm mass-23.00g	mL-50.53mm mW-31.39mm mB-21.22mm mass-10.60g	mL-40.81mm mW-33.37mm mB-26.47mm mass-10.50g

Overall, the largest changes in the experimental tomatoes occurred between Week 1 and Week 2. Experiment A saw an 18.11% decrease in length and a 59.33% decrease in mass from Week 1 to Week 2. As can be seen in Figure 1, Experiment A became wrinkled and had lost most of the moisture found on the inside of the tomato. The tomato became firmer than it was during Week 1.

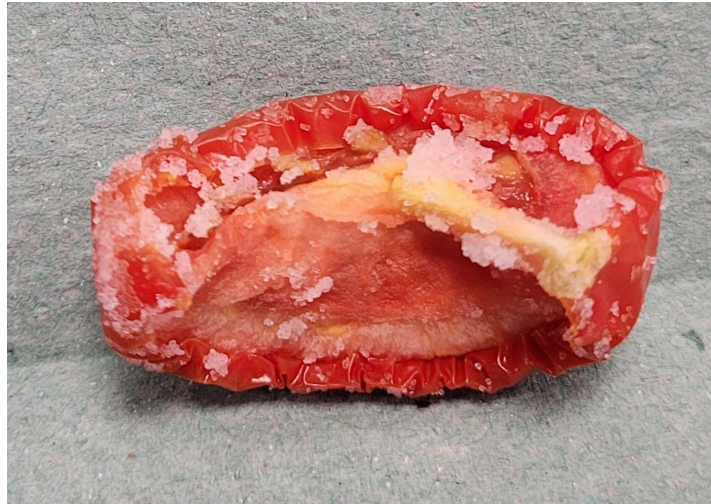


Figure 1: Experiment A, Week 2

Experiment B had an 18.93% decrease in length and a 46.44% decrease in mass. No photographs were taken of Experiment B in Week 2, but the tomato saw similar changes as Experiment A, wrinkled skin and loss of moisture on the interior, though white mold had also begun growing on the interior of the tomato. The tomato was firmer than it was during Week 1.

Experiment C saw a 0.36% increase in length between Weeks 1 and 2, but a 53.91% decrease in mass. A possible explanation for why Experiment C saw an increase in length can be found in other possible sources of error. Experiment C experienced the same changes as Experiment B: wrinkled skin, moisture loss, and mold growth on the interior. As can be seen in Figure 2, this mold appeared as small black spots. The tomato was firmer than it was during Week 1.



Figure 2: Experiment C, Week 2

The control tomato saw relatively little change, with a 1.85% increase in length and a 3.43% decrease in mass. The tomato skin did not wrinkle, and moisture was present on the interior of the tomato. While the tomato interior was wet, there was still a loss of liquid, as evidenced by the liquid that was present in the bag after the tomato was removed. A small amount of white mold was also present on the interior, seen in Figure 3. The increase in length may have been a result of the tomato swelling during decomposition, thus increasing its size, or due to measurement error. Unlike the experimental tomatoes, the control tomato had become softer and more delicate than it was during Week 1.



Figure 3: Control, Week 2

There were fewer significant changes from Week 2 to Week 3. Experiment A saw no change in length, and a 9.95% increase in mass from Week 2. The tomato was more wrinkled

than in Week 2, was the same level of firmness, and the interior was dry. It also appeared that sodium chloride crystals were being absorbed by the tomato, which may explain why the mass increased after Week 2. This can be seen in Figure 4.



Figure 4: Experiment A, Week 3

Experiment B saw a 5.32% increase in length and a 27.80% decrease in mass from Week 2. A possible explanation for the increase in length can be found with the explanation of other sources of error. The tomato may have been reabsorbing liquid that had been removed from it, as the interior appeared wet, though the exterior was the same level of firmness as the previous week. As can be seen in Figure 5, the entire interior of the tomato was covered in a white and brown mold. This mold appeared spongy, and may have been absorbing magnesium sulfate crystals the same way Experiment A had with the sodium chloride.



Figure 5: Experiment B, Week 3

Experiment C saw the largest change, with a 19.24% decrease in length and a 0.94% decrease in mass. The tomato had very little change in length between Week 1 and 2, so the

length decreasing in Week 3 was unexpected. The tomato appeared slightly more wrinkled than it had been in Week 2, was the same level of firmness as the previous week, and the interior remained dry. The mold that was present in Week 2 spread significantly, covering most of the interior of the tomato. This can be seen in Figure 6. Though not pictured, mold has also begun growing in the sodium bicarbonate that the tomato was submerged in.

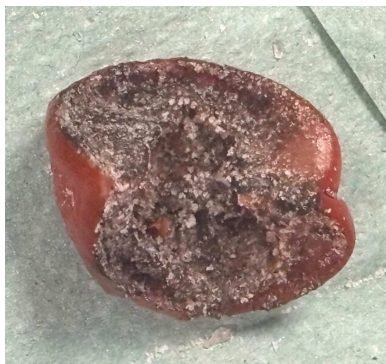


Figure 6: Experiment C, Week 3

The control had a 1.90% increase in length and a 17.05% decrease in mass. The tomato remained unwrinkled, and the amount of liquid present in the bag was greater than in Week 2, though the tomato interior remained wet. The tomato was very delicate, and the structure appeared to have broken down partially. The length increasing again in Week 3 suggests that the increase is not a result of error. Instead, the likely explanation is that the loss of structure in the tomato was allowing it to lay flatter than it had in the previous week while being measured, meaning the tomato appeared longer. More evidence for the loss of structure can be seen in Figure 7, where the interior of the tomato appears to have collapsed. This is more apparent when compared with Figure 3. The mold found in Week 2 was no longer present. Possible explanations for this are that the mold was removed during the handling while the tomato was being resealed, wrapped, or unwrapped, or that the mold was dissolved or washed off naturally by the liquid present in the control bag.



Figure 7: Control, Week 3

The main explanation for the increases in length and mass that some of the tomatoes saw is human error. The increase in length seen in Experiment C at Week 2 and Experiment B at Week 3 was likely due to how the tomato was being measured changing slightly from the previous week. If the lengths were being measured from different points than they should have, this would result in measurements being either too large or too small. The increase in mass for Experiment A in Week 3 may have been due to a failure to completely remove the salt left on the tomato when it was removed from its bag. This would have resulted in a greater mass, as more than the tomato was being weighed.

According to the standards for mummification (Öhrström et al., 2020, p. 864; Panzer et al., 2013, p. 1532), the sodium chloride used in Experiment A proved to be the most effective at mummifying a tomato. The tomato saw a large decrease in both size and mass, without also showing signs of mold or other kinds of decomposition. Both Experiments B and C had comparable losses of size and mass to Experiment A, but had significant mold growth. While all three tomatoes saw similar losses, the sodium bicarbonate did not result in a major size loss until Week 3, compared to the sodium chloride and magnesium sulfate which had their primary loss of size in Week 2. This mold growth shows that while capable of desiccation, both pure magnesium sulfate and sodium bicarbonate are ineffective at mummification overall. The effectiveness of sodium chloride in mummification is unsurprising given its presence in natron (Öhrström et al.,

2020, p. 862) and use as a preserving agent in food (Bidlas and Lambert, 2008, p. 98). A possible explanation for why Experiments B and C saw mold growth is that while they are salts, like sodium chloride, both magnesium sulfate and sodium bicarbonate lack the antimicrobial properties of sodium chloride that allowed it to stop mold from growing on the Experiment A tomato.

The results from this experiment open two possible inquiries for further study. The first is the smallest ratio of sodium chloride to either magnesium sulfate or sodium bicarbonate needed to prevent mold growth. Research into this topic may reveal new information on both natron, and sodium chloride as an antimicrobial. The other inquiry would be into why the sodium bicarbonate saw similar levels of mass loss compared to the other salts, but the loss of size occurred a week later. This research would help further knowledge on sodium bicarbonate as a desiccant.

Conclusion

Overall, sodium chloride showed the most effectiveness at mummifying a tomato. All three salts were effective at desiccating their tomato, but the preserving qualities of sodium chloride were likely what made it work best, as it showed no signs of mold while the other tomatoes were covered. That there was mold growing in the sodium bicarbonate as well as on the tomato indicates that sodium bicarbonate is likely the least effective mummifying agent of the three, as the decomposition was able to spread onto the substance meant to prevent decomposition.

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