Title: Using Historical Idiomatic Expression to Solve Modern Maple Syrup Bacteria Contamination

Name: Elizabeth Frantz
Grade: 10
School: Wooster High School
County: Wayne County

ABSTRACT

This study investigates whether placement of a silver coin in maple sap can reduce bacterial growth. The Silver Coin Theory, attributed to this author, suggests silver possesses antibacterial properties, rooted in ancient practices. This research tests whether this theory holds up. When the number of bacteria in sap increases, pH goes down, with 7 being neutral, 1 being acidic and 14 being basic. Maple sap samples were placed in clear containers with either a penny, nickel, or dime (pre-1965) and monitored for pH and temperature every 15 minutes over three hours. A digital pH meter was used to measure pH levels, with the hypothesis the silver dime would show the least bacterial growth. The results showed no significant difference in bacterial growth or pH levels between containers with coins and those without coins. All containers, including those with silver dimes, experienced a gradual decrease in pH, indicating bacterial activity, but no coin outperformed others in preserving sap quality. The reason milk and apple cider were tested was because milk spoils and apple cider turns to vinegar during bacteria growth, reducing pH. The penny and nickel were also tested as other variables to show different possible reactions of the liquids. The hypothesis a silver dime would prevent the most bacterial growth was not supported. The findings suggest the Silver Coin Theory may not be

effective in preserving sap. Future studies could focus on testing different antimicrobial agents or exploring other preservation methods to ensure sap quality.

INTRODUCTION

The research question is “Does the presence of a silver coin in maple sap containers reduce bacterial growth and preserve the quality of maple sap, compared to containers without silver coins?”

The research hypothesis is if a penny, nickel, and dime (copper, nickel, or silver) are placed into a sap container, the dime will prevent the most bacterial growth because pre-1965 dimes are 90% silver and 10% copper, while pennies minted before 1982 are 95% copper and 5% zinc, and nickels are 75% copper and 25% nickel except during WWII in which nickel was not used.

The purpose of this experiment is to evaluate the effectiveness of the Silver Coin Theory when applied to used maple sap collection buckets. The Silver Coin Theory suggests that placing a silver coin in a sap collection bucket helps to prevent bacterial growth and preserve the quality of the sap, or in general, prevents any container from collecting bacteria. In maple syrup production, sap quality is crucial, as any bacterial contamination can lead to spoilage, ropey sap, or poor-quality tasting syrup. Given that many sap collectors hope to reuse plastic buckets year after year, it is important to understand if the Silver Coin Theory is effective when applied to containers that have already been used, as they may have residual sap or bacteria from previous seasons.

The Silver Coin Theory has its roots in ancient practices where silver was highly valued, not only for its beauty and rarity but also for its purported medicinal and preservative properties. In many ancient cultures, silver was believed to possess antibacterial and antimicrobial qualities. The Greeks, Romans, and Egyptians used silver vessels to store food and liquids, believing it could prevent spoilage and contamination. For example, silver was often used in drinking cups, water cups, and storage containers to protect against harmful bacteria and maintain freshness. This ancient use of silver laid the foundation for modern interpretations of its potential benefits, such as the Silver Coin Theory in maple sap collection. While these historical applications were based on tradition rather than scientific evidence, the belief in silver's protective qualities persisted, leading to its continued use in various preservation methods today (Madurai et al 2017).

The Silver Coin Theory has been popular among some maple syrup producers, who claim that silver has natural antibacterial properties that can help maintain sap quality. According to the theory, the silver coin acts as a barrier, keeping harmful bacteria from growing in the sap. However, there is little scientific research specifically focused on testing the validity of this theory, especially when applied to used plastic buckets and containers, which may have accumulated dirt, bacteria, or other contaminants over time. Therefore, it is important to test whether the theory still holds in such conditions, where used buckets might introduce additional variables.

In this experiment, maple sap buckets will be tested with and without silver coins to see if the presence of the silver coin affects bacterial growth or sap preservation. The coins used

are pennies, nickels, and dimes. Samples of last year's sap have been collected and placed into a container being tested for pH. By comparing the sap from the containers with the coins to that from the containers without, the experiment aims to determine if the Silver Coin Theory has any measurable effect on sap preservation when using previously used equipment.

This experiment seeks to provide maple syrup producers with a clearer understanding of whether the Silver Coin Theory is a viable method for preserving sap quality in used collection buckets. If the theory is proven to be ineffective, it could lead to the recommendation of alternative methods for preventing contamination and preserving sap during collection. If the Silver Coin Theory proves successful, it could become a more widely adopted practice among maple syrup producers, improving the quality and yield of their products. During the 2024 Ohio Maple Day Conference, one of the presenters, Mr. Gortner, mentioned that after forty-five minutes, sap having gone through reverse osmosis, which basically doubles the sugar content by removing water, will have a pH of 5 or below, which makes the sap unusable (Gortner et al 2024). By doubling the sugar content of the sap increases the rate at which bacteria multiply. Fresh sap tends to have a pH of 6.5-7.0. The hypothesis is if a penny, nickel, or dime are placed into separate containers of sap, bacteria growth will cease or be slowed down, because pennies minted before 1982 are 95% copper and 5% zinc, nickels used 75% copper and 25% nickel and pre-1965 dimes are 90% silver and 10% copper.

METHODS AND MATERIALS

METHODS:

To begin the experiment, obtain three clear, short containers and fill each with room-temperature sap. Place a penny in each container, ensuring that it is fully submerged. Next, fill another container with room-temperature water for rinsing purposes. Over three hours, test the pH and temperature of each container every 15 minutes, making sure to rinse the pH tester in distilled water between each test to prevent cross-contamination. Record both the pH and temperature of the sap in each container after each measurement. Once the tests are completed with pennies, repeat the process using nickels and dimes in separate containers, following the same steps for data collection and rinsing. When using milk and apple cider, repeat the steps above.

MATERIALS:

PmoYoKo Digital pH Meter (EZ-9901) – used to measure air temperature (°C) and the percent of hydrogen ions (pH).

Distilled Water – used to clean the pH Meter and as a neutral pH

3 pennies, 3 nickels, and 3 dimes – placed into sap to see which will prevent the most bacterial growth

Maple Sap (gone through reverse osmosis) – The control and where the coins will be placed

12 clear short containers – where the maple sap will be held, clear to see if cloudiness will occur (sign of bacterial growth)

Incubator – What speeds along the process of bacterial growth

PROCEDURE:

The Use of PmoYoKo Digital pH Meter:

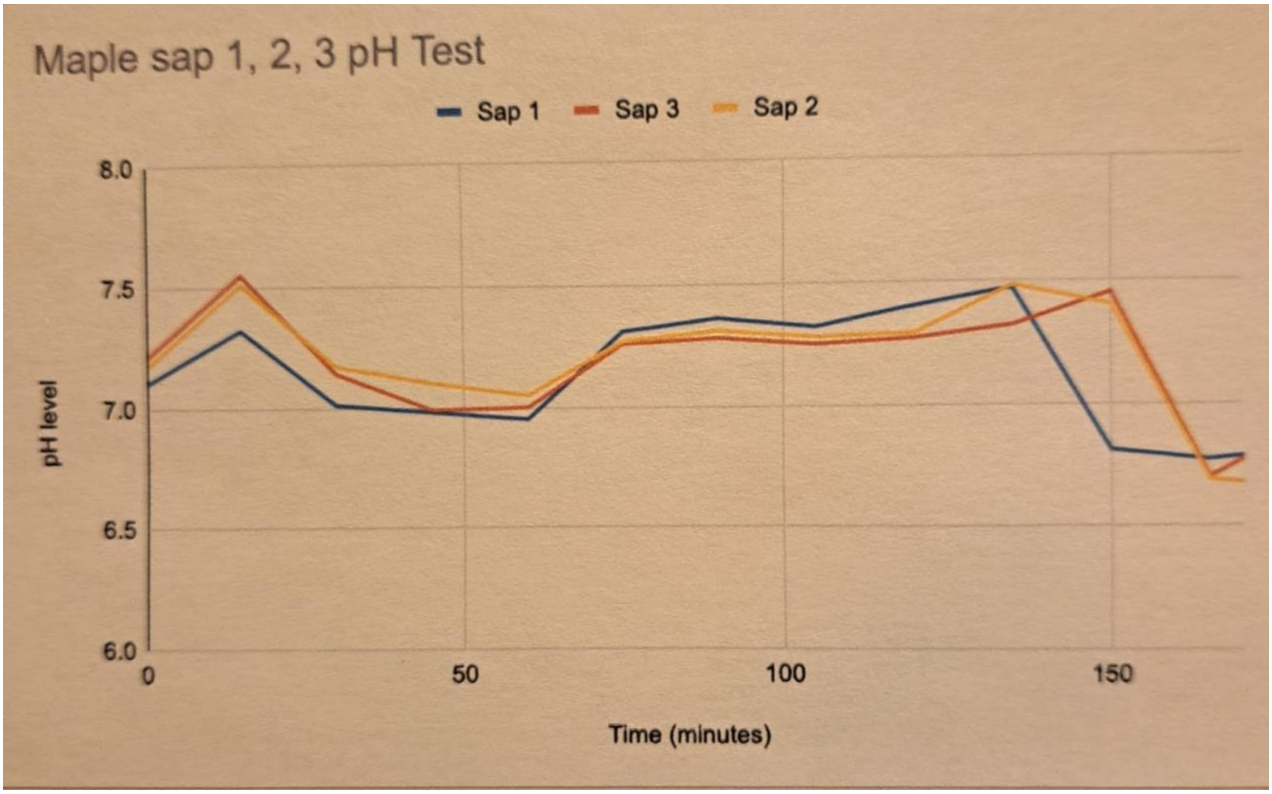
Data collection and analysis were done by using the PmoYoKo Digital pH Meter. The meter was turned on and the "MODE" key to switch the measurement style to pH. The cap was removed and the tip of the tester was soaked in water for about five minutes to prepare for use. Next, the tester was placed in the fresh maple sap for 30 to 60 seconds. Once the reading stabilizes, press the "HOLD" key to lock the measurement. Finally, the tester was removed from the fresh maple sap. pH goes from 1-14, with 7 being neutral, like water. 1 is the most acidic and 14 being the most basic. Fresh maple sap has a pH of 6.5-7.0, and when it reaches a pH of less than 5, it is unable to be used to make syrup because of bacteria growth resulting in an unpalatable flavor.

Testing Maple Sap:

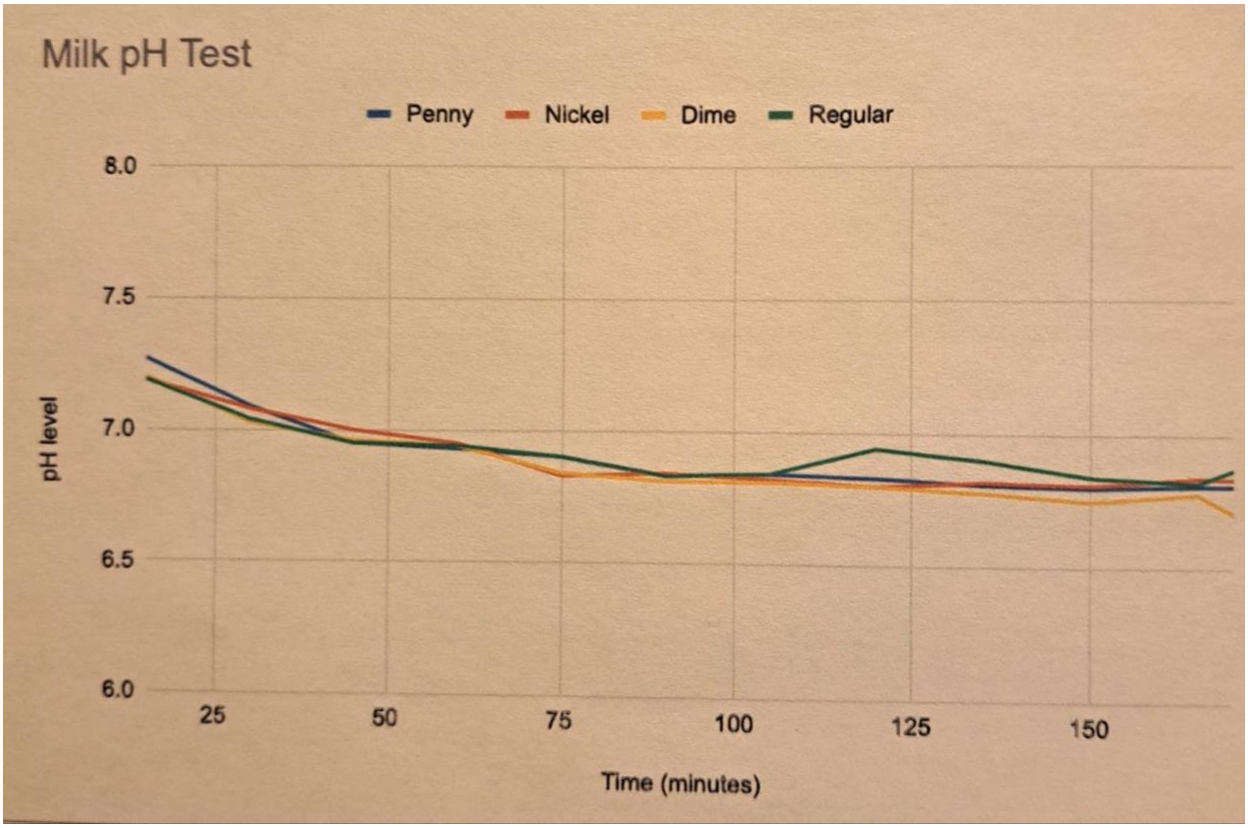
The experiment began by preparing three clear, short containers and each was filled with room-temperature (20^{o}C) sap. A penny was placed in each container, ensuring that it was fully submerged. Next, another container was filled with distilled water for rinsing purposes. Over three hours, the pH and temperature of each container were tested every 15 minutes. The pH tester was rinsed in the distilled water between each test to prevent cross-contamination. The results of both the pH and temperature of the sap in each container were recorded after each measurement. Once the tests were completed with pennies, the process was repeated using nickels and dimes in separate containers, following the same steps for data collection and rinsing. The results needed to support the hypothesis were for the dime to result in the least amount of bacterial growth in the container with maple sap.

PRESENTATION OF DATA AND RESULTS

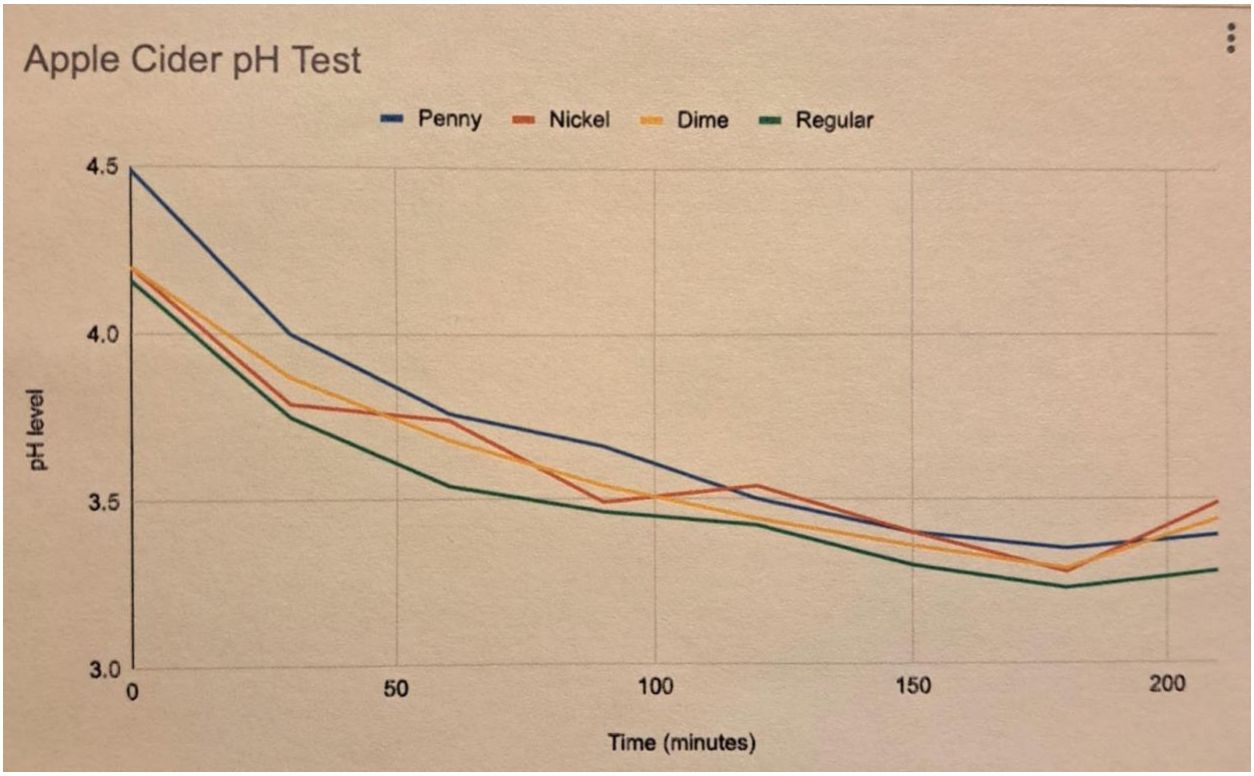
Graph 1



Graph 2


Milk pH Test
Penny
Nickel
Dime
Regular
8.0
7.5
7.0
6.5
6.0
pH level
25
50
75
100
125
150
Time (minutes)

Graph 3



The results from the experiment, as represented in the graphs above, show no significant differences in bacterial growth or pH changes between containers with coins and those without. In all tested containers, the pH gradually decreased over time, indicating bacterial activity, but the presence of a copper penny, nickel, or silver dime did not appear to slow this decline. Specifically, the pH in the containers with coins, including those with pre-1965 silver dimes, dropped at similar rates as those without coins. There was no noticeable trend that suggested a coin had any distinct effect on preserving the sap's pH or preventing bacterial growth.

The pH reduction followed a general downward trend in all containers, regardless of the metal used. This suggested that bacterial contamination occurred in all conditions, but no coin

seemed to impact the rate of pH change significantly. The lack of variation between the different types of coins (penny, nickel, or dime) suggests that the Silver Coin Theory, which posits that silver has antibacterial properties, may not hold up when applied to used maple sap collection buckets. There were no obvious outliers in the data, as all containers followed similar patterns, further indicating that the coins did not alter the bacterial growth or sap quality.

Overall, the results indicate the hypothesis— the silver dime would show the least bacterial growth—was not supported by the data. This highlights that, contrary to the expectation based on historical beliefs about silver's antibacterial properties, the use of silver coins in maple sap containers does not have a measurable effect on preserving sap quality or preventing bacterial contamination.

INTERPRETATION OF RESULTS AND DISCUSSION

The research hypothesis is if a penny, nickel, or dime (copper, nickel, or silver) are placed into a container of sap, then the dime will prevent the most bacterial growth because pre-1965 dimes are 90% silver and 10% copper, while pennies minted before 1982 95% copper and 5% zinc, and nickels are 75% copper and 25% nickel. The results did not support the hypothesis, there were no major changes between the nickel, penny, dime, and liquid without metals tested. The first maple sap test showed slight changes in pH, generally decreasing over time. The milk pH decreased over time but at different rates. Milk has a slightly acidic pH to begin with, which is around 6.5-6.7, and when exposed to metals, might undergo changes because of oxidation or acidification. Pennies might have accelerated the spoilage in the milk since copper can catalyze reactions. The different decreasing pH rates could be a result of the

varying reactivity of metals. The apple cider pH decreased more significantly compared to the milk and sap, with the decline being in all the coins tested. Apple cider is acidic by nature because of its organic acids, like acetic acid and has a relatively high sugar content. The coins could have reacted more strongly with the acidic liquid, which could release ions that further acidify the liquid. Acetic acid in apple cider is known to be reactive with metals, like copper and zinc. Metals like copper could have promoted further acidification through oxidation reactions.

Inconsistent calibration and maintenance of the pH meter may lead to inconsistent results. This can be prevented by regularly calibrating the pH meter for precise measurements and consistency. Temperature variations could influence the rate of chemical reactions. Using the incubator helped to keep the temperature controlled.

CONCLUSION

Based on the results of this experiment, the hypothesis that a silver dime would prevent the most bacterial growth in maple sap was rejected. Despite using pre-1965 dimes, along with pennies and nickels, no significant differences were observed in bacterial growth seen through pH changes between the containers with coins and those without. The pH in all containers, including those with coins, showed a gradual decline, indicating bacterial activity through pH testing, but no coin was found to outperform the others in preserving sap quality.

Several factors may explain this outcome. The expected antibacterial effect of the silver coin may not have been strong enough to noticeably influence the pH in the containers, especially given the residual bacteria that could have been present in the used buckets. The same might have occurred with the milk and apple cider tests, but with the milk souring and

hardening and the apple cider turning to apple cider vinegar with the bacterial growth. Furthermore, the chemical reactivity of the metals (such as copper's potential to accelerate spoilage) may have had an unintended effect on the sap's pH, which could have overshadowed any potential antibacterial properties of the silver coin.

If this project were to be continued, it would be beneficial to focus on improving experimental controls, particularly in cleaning procedures of coins to prevent the contamination of the liquid containers, which can lead to inaccurate results. Additionally, using freshly collected sap instead of sap from the previous season could yield more accurate results, as it would likely contain fewer variables. Analyzing the metals' interactions with sap in greater detail, or testing with higher concentrations of metal ions, might also yield more conclusive data.

Future investigations could explore alternative methods of sap preservation, such as testing different antimicrobial agents or innovative storage techniques such as temperature-controlled storage containers, as mentioned by Mr. Gortner. Understanding the impact of environmental factors, such as temperature fluctuations, on bacterial growth and sap quality could also provide valuable insights.

This research is significant because it challenges the longstanding belief in the antibacterial properties of silver in the context of maple sap preservation. By providing a scientific evaluation of the Silver Coin Theory, this study offers clarity on its potential as a viable preservation method and encourages further exploration into alternative solutions to prevent bacterial contamination in maple syrup production. These findings may help maple syrup

producers make more informed decisions about equipment care and sap collection practices, ultimately improving the quality and safety of their products.

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