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Analyzing Bacteria Growth Differences Among Home Produced and Industrially Manufactured Samples of Maple Syrup from a County in Northeast Ohio

Caden Coleman[1] and Patricia Talarczyk[#]

[1] Mentor High School OH, USA
[#]Advisor

ABSTRACT

Maple syrup has been identified as one of the healthiest natural sweeteners by many scholarly sources. Previous research has examined the bacteria growth in syrup samples to assess its antibacterial properties. The goal of this research study was to examine the bacteria presence on locally versus commercially produced maple syrup in Geauga County, where home produced maple syrup options are prevalent. To assess the differences in terms of bacteria growth and sugar content of syrup samples in Northeast Ohio, a quantitative method was conducted where five samples from roadside stands and five samples from mass produced locations sold in stores were purchased. The colonies were counted over a period of six days and the sugar content was measured using a refractometer. It was concluded from this research that home produced samples contained less bacteria than store bought samples, which indicates potential health benefits for consumers to choose the best source of maple syrup production for their health. There was also a slight correlation discovered between the sugar content of the syrup and the number of colonies grown by the end of the data collection period.

Introduction

In recent years, maple syrup has become widely recognized for its health benefits and has even been touted as the healthiest type of natural sweetener. Maple syrup is increasingly being thought of as the most beneficial sweetener because of its natural and healing (antibacterial) properties (Li and Seeram, 2011). The investigation conducted in Li and Seeram (2011) confirms that the antioxidant biological properties of maple syrup composition imparts health benefits. These advantages are largely due to maple syrup's phenolic properties. Ho (1992) defines phenolics as substances found largely in plants that possess antioxidant properties. His study concludes that the use of substances containing phenolics inhibit the unwanted editing of DNA and growth of cancer cells. As studies have been published touting the health benefits of plant-based sweeteners such as maple syrup, there has also been an increase in consumer consumption of these products. A study by Perry et al in the *Maple Syrup Digest* (2018) shows that there has been a marked increase in maple syrup intake in the United States and discusses a rise in consumer interest in locally produced options. The Agricultural Marketing Resource Center (n.d.) similarly confirms that in 2019, the U.S. production of maple syrup rose 1% to 4.24 million gallons. Noting both the health benefits discussed in studies and the widespread availability of healthy sweeteners, The Cleveland Clinic (2021) has even started to encourage individuals to replace current sugars in their diets with maple syrup because of the plentiful antibacterial and humoral benefits. In conjunction with the information provided by the Cleveland Clinic, a study from McGill University asserts that using maple syrup combined with low doses of antibiotics could potentially help cut or limit the use of such drugs because the syrup increases

the microbes' susceptibility by working synergistically to destroy resistant bacterial colonies known as biofilms (McGill, 2015). The same article posits that overuse of antibiotics resulting in resistant strains of bacteria have become a worldwide health concern. Maisuria et al (2015) found that the phenolic compounds found in maple syrup were especially effective in combating bacterial activity in four strains of antibiotic resistant bacteria, including *E. coli*. As such, maple syrup's phenolic-rich properties have promising potential in fighting infection-causing bacteria, in addition to other overall health benefits including acting as an anti-inflammatory and containing lower glycemic levels than other sweeteners.

The health benefits of maple syrup are corroborated in ways that are both global and individual to consumers. Neacsu & Madar (2014) conclude that the optimal path to an overall healthier lifestyle is through the use of natural rather than artificial sweeteners. According to the journal *Environmental Nutrition* (2011), researchers have found that maple syrup contains phytochemicals that act as antioxidants and offer anti-inflammatory benefits. This, along with the aforementioned antibacterial properties, have led to widespread promotion of maple syrup as a natural and healthier alternative to refined sugar, with Johns Hopkins University (n.d.) echoing the Cleveland Clinic's endorsement of antioxidant and mineral-rich maple syrup as a more beneficial sweetener. Abou-Zaid, et al (2008) describe how a high level of interest has developed in the phenolic properties in maple syrup and also conclude that the high levels of sugar present in some syrups should be mitigated to maximize health benefits without resulting in an excessive level of sugar intake. Similarly to Abou-Zaid, a peer reviewed source from the University of Sydney showed that maple syrup has a lower glycemic index than other sugars. In other words, maple syrup does not increase the risk of developing high blood sugar. Moreover, Stanhope (2015) describes how sugar intake leads to metabolic disease and obesity. The low glycemic profile of maple syrup could mitigate such risks.

Literature Review

There are multiple studies that have informed the understanding of the scholarly conversation surrounding the topic of evaluating the potential health benefits of maple syrup. One study that informs the conversation and information surrounding the topic was done by Perry et al (2018) and appeared in the journal *Maple Syrup Digest*. In this study, maple syrup was tested for shelf life by being left in a closed environment for a period of time (21 days). The study looked specifically at bacterial growth in refrigerated and unrefrigerated beverages containing maple sap. The conclusions drawn relate to maple sap beverages rather than maple syrup specifically. This study inspired some of the method development used in this research; many of the tools were utilized in this research method with the hopes of replicating the study as closely as possible but also allowing for unique variables such as the source from which maple syrup was purchased, while still yielding the most reliable results.

Another source that has informed the body of knowledge of this study and that was used to provide context for scholarly conversations already surrounding the topic of inquiry is information from The Ohio State University. In this test, lab students tested the ideal conditions for bacteria growth. Researchers in this study discovered that temperatures from 40-140 F produced the most growths of bacteria colonies. Also in this study, the author outlined one of the methods used to collect bacteria as counting growths of colonies. A similar counting method was implemented in this research project to replicate this data in an "as close to home" environment while using an incubator to achieve the ideal temperatures.

In another source, "Chemical Compositional, Biological, and Safety Studies of a Novel Maple Syrup Derived Extract for Nutraceutical Applications," the sugar content and other nutritional values of maple syrup were measured from two samples. Sucrose and glucose samples were measured and, as the source states, there were levels that were about 66% or ⅔ sucrose. A peer reviewed source from Mizzi et al. (2020), concluded that the higher levels of sugar present in a solution, the less bacteria would grow. This is due to the fact that bacteria are aqueous and must have water to survive. When the environment, or in this study, the syrup samples have

too much sugar, less bacteria will be able to grow over a period of time. These scholarly articles provide evidence of a gap in research as well as context and a possible path to a new understanding of the ways that sugar levels influence the growth of bacteria in a range of samples.

Northeast Ohio, specifically Geauga County and the city of Chardon, is renowned as a maple syrup-producing region. According to a Dr. Gary Graham of The Ohio State University, Ohio typically ranks as the 4th or 5th highest producers of maple syrup in the United States, with Chardon falling within the "maple belt," a region in the state with the highest concentration of syrup output. Home to the largest annual maple festival in the United States, Chardon offers a variety of maple syrup including that made industrially through large scale businesses, as well as syrup produced in the home setting that is sold at small shops, markets, and roadside stands. The prevalence of maple syrup in the local community of Northeast Ohio combined with the potential for health benefits for area citizens leads to the necessity of a study to determine which syrup production strategy yields the highest health benefits. Specifically, this study examines whether home produced or industrially manufactured maple syrup results in the least number of bacteria and damaging sugars to the purchaser. This will allow local consumers to maximize the health benefits of maple syrup by understanding the bacteria content of home versus industrially produced maple syrup.

Gap

The research conducted in this study addresses the gap in the pertinent literature of bacterial growth in maple syrup in a home environment. As indicated previously, there is a substantial amount of scholarly research and literature showing that maple syrup is increasingly being thought of as the healthiest sweetener both because of natural and healing (antibacterial) properties. While studies have been done related to maple sap and maple sap beverages, prior research focused on nationally/commercially produced products, whereas this study intentionally focuses on contrasting syrup from Chardon, OH with commercial products.

Other studies have not specified production regions of maple syrup and there are no studies done specifically involving Northeast Ohio. It is common to find both homemade and small business producers of this product in the local area and a study was needed to determine which source is deemed as more safe for consumers based on bacteria content of the samples. According to "Ohio Maple Producers Association," 100,000 gallons of syrup are produced annually in Northeast Ohio. This makes Ohio one of the top five states in the nation in terms of syrup production. With widespread availability of maple syrup made in Northeast Ohio homes and small businesses, it is important for consumers to consider the safety of the product they purchase. According to the source "Maple Producers of Northeast Ohio," there are 16 *recognized* maple syrup producers in Geauga County alone who source the syrup for the county. This provides numerous sources for roadside stands and small business products in just one county of Northeast Ohio.

A final area not addressed by previous research is in where the maple syrup is produced. Because there is availability of maple syrup in homes and at small businesses in Northeast Ohio, researching the bacteria and sugar content of maple syrup purchased in the two different settings will be important in maximizing the potential health benefits associated with maple syrup. The source, *Ohio Maple History*, concludes that despite the wide range of availability to consumers, many homemade syrup stands are overlooked because of safety concerns. The combined relevance of maple syrup in the local community and the many health benefits for consumers leads to the research question: How do the bacteria colonies and sugar content differ among industrial versus home-produced maple syrup samples?

Method

The method used for this project was an experiment due to the fact that a designed method gave me the ability to manipulate variables and examine the relationship between the inputs and outcome. The majority of the experiment was conducted at school, as the goal was to create a similar environment to the one by which bacteria would grow in a normal home setting.

According to a test conducted by Perry et al (2018), maple syrup was treated with heat at 212°F and then measured for bacterial colonies to test shelf life. Bacteria colonies were then measured both before and after being treated and left sitting for a period of 21 days (three weeks). Researchers found through the data that there was a significant growth in the bacterial colonies present. Approximately 1.1 bacterial colonies were found to have grown in this period (1,000,000 cells/ml). My research was used to identify the gap, as stated, of maple syrup in a home environment with temperatures in the incubator (24-37℃ or 75-100°F). It was hypothesized that in the findings, more bacterial colonies would have grown after a period of time than this study conducted by Perry. Bacteria grow best at temperatures between 40-140°F, meaning that 212°F, as used in the experiment, may not be the most suitable environment for the maximum amount of bacteria growth. Instead of counting the cells per mL of fluid however, a counting method similar to that stated in the Ohio State University Research Journal of counting the colonies was used, where colonies of bacterial growth were enumerated by the naked eye and through the use of a microscope.

In the method implemented in this study, five of each sample bottles of home and store purchased maple syrup samples were purchased, accounting for 10 total samples. In mid-January, the samples were collected; five industrially produced samples were purchased from a variety of stores and five homemade samples were bought from local roadside stands. Ten petri dishes were also purchased with pre-poured nutrient agar to provide the best growing environment for bacteria colonies. The expert adviser for this project was the school's AP Biology teacher who provided insight as to preparation for and conduction of elements of the experiment, such as which agar to buy for the best results. The petri dishes also came with sterilized cotton swabs that were used to spread syrup samples across a larger surface area of a petri dish. A pack of 10 sealed dropper pipettes was purchased for transferring drops of syrup to the surface of the dish. Each syrup sample was assigned a label (ex. Home 1) with the corresponding label on each respective dish. 1 mL of syrup was measured using the plastic pipette droppers and placed in the center of the dish, forming a nickel coin-sized droplet. The small amount of syrup in the dish was then spread across the agar using the cotton swab, covering nearly the entire surface area of the compound. The original droplet was swabbed vertically across one face, then the dish was rotated 45 degrees and spread again until the entirety of the dish was covered. The 10 petri dishes were covered and kept overnight in a sealed bag and placed in the refrigerator to avoid contamination from contact and brought to the school science lab the following day. They were then placed and kept in an incubator that was set to 98°F, as recommended by the expert adviser, for a period of two days. After running for two days, the incubator was turned off to conserve the nature of the agar and prevent it from drying out, which was also insight provided by my adviser. The temperature was still measured and, although it decreased daily, the lowest recorded temperature was 75°F. Although conditions changed, the bacteria still experienced growth. Furthermore, the USDA (2017) states that "bacteria grow most rapidly in the range of temperatures between 40°F and 140°F," making 70-80°F almost ideal in addition to keeping the nutrient agar from becoming dry and cracked. Each day, the bacteria colonies were counted for each dish and the collected data was input into a data table. For five days, the colonies were measured at approximately the same time each day, leaving six data points including the control before the syrup was put in the incubator. Throughout the collection process, the expert adviser also gave permission for the use of a microscope to examine bacterial colony structures and identify many of the types of bacteria present. A series of photos were taken through the viewing lens of the microscope for use in the final presentation.

At the end of the bacteria collecting process, a great difference among the bacteria content in each syrup sample was observed, leading to a hypothesis for the source of the colony growth. According to Mizzi et

al, "Highly concentrated sugar solutions are known to be effective antimicrobial agents." In other words, solutions with more sugar should be effective in reducing the number of bacteria present in the sample. This is because food bacteria are aqueous and need a moist environment to survive, but highly concentrated sugar solutions limit the growth of bacteria because they cause them to dry out and lose nutrients. In order to test the hypothesis that the syrup samples with higher sugar content would have produced less bacteria, a refractometer or sugar content measuring device, often used in brewing and cooking, was purchased. The device originally purchased measured the sugar content of solutions from 0-30% brix. The brix percentage means the weight of sucrose as it compares to every part of water. For example, a reading of 75% on a refractometer would mean that the solution measured contained 75% sucrose. According to Graham et al (2006), the sugar content of maple syrup is typically between 66-68% brix. After reviewing this source, a new refractometer that measured samples up to 90% brix was acquired. Each maple syrup sample was then tested for its sugar content and the results were recorded. Similar to the method used to measure bacterial growth, a pipette dropper was used to place a small amount of maple syrup, approximately the size of a pencil eraser, onto the viewing stage of the refractometer. After measuring each sample, the glass face of the refractometer was thoroughly cleaned and dried. A control test, using a droplet of tap water to ensure that the tool was completely clean and no remnants of the previous syrup sample remained on the stage, was conducted after each sample was measured. The sugar content, after being measured in Brix, was then inputted into a table and represented in a line graph to show the wide range of results among the 10 samples.

Results, Trends, Analysis

Results

Table 1 below shows the number of bacteria colonies in each container as the days progressed. Days one through six are measured and present in the table for both Store-Bought samples and their Homemade counterparts.

Table 1. Comparison of Store versus Home Purchased Syrup Samples

	Store Bought Samples					Homemade Samples				
Days	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1	0	0	0	0	0	0	0	0	0	0
2	4	41	1	1	16	0	0	4	0	0
3	5	43	2	6	18	1	7	7	0	0
4	5	44	3	6	18	1	8	7	0	0
5	7	45	3	6	22	2	10	8	0	0
6	11	46	3	7	24	3	12	11	0	0

Note. Bacteria measurement values represent the number of bacteria colonies present by visual inspection for each day of incubation.

Figure 1 below represents the data for the Store Sample colonies over a period of 6 days. Each color represents its own sample, as displayed in the key.

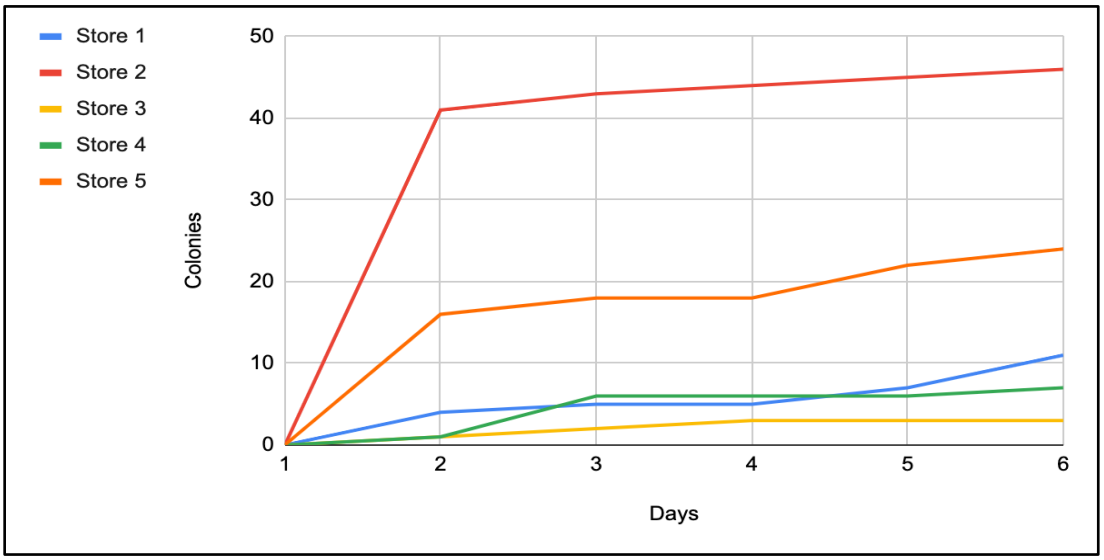

Figure 1. Store Samples Over a 6-Day Period

Figure 2 below represents the data for the Homemade Sample colonies over a period of 6 days. Each color represents its own sample, as displayed in the key.

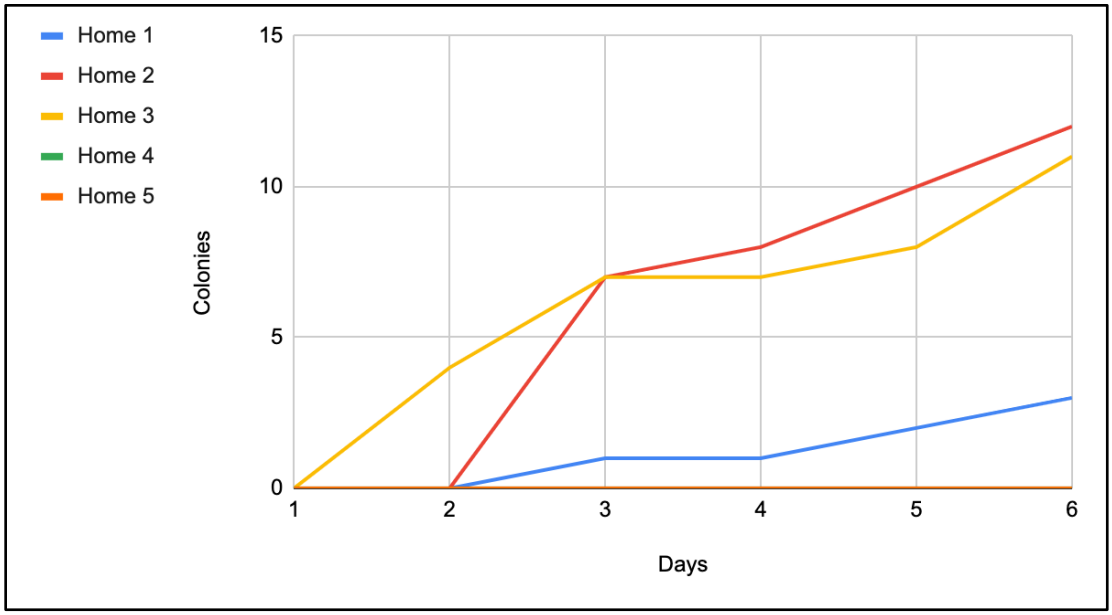

Figure 2. Home Samples Over a 6-Day Period

Figure 3 combines figures 1 and 2 into one graph to visualize the relationship between the bacteria grown in Store versus Home samples. As shown by the key, each sample corresponds to its own color.

Figure 3. A Comparison of Store and Home Samples Over a 6-Day Period

Note. The lines on this graph show the number of colonies over a period of days; Figure 3 is a combined chart of Figure 1 and Figure 2.

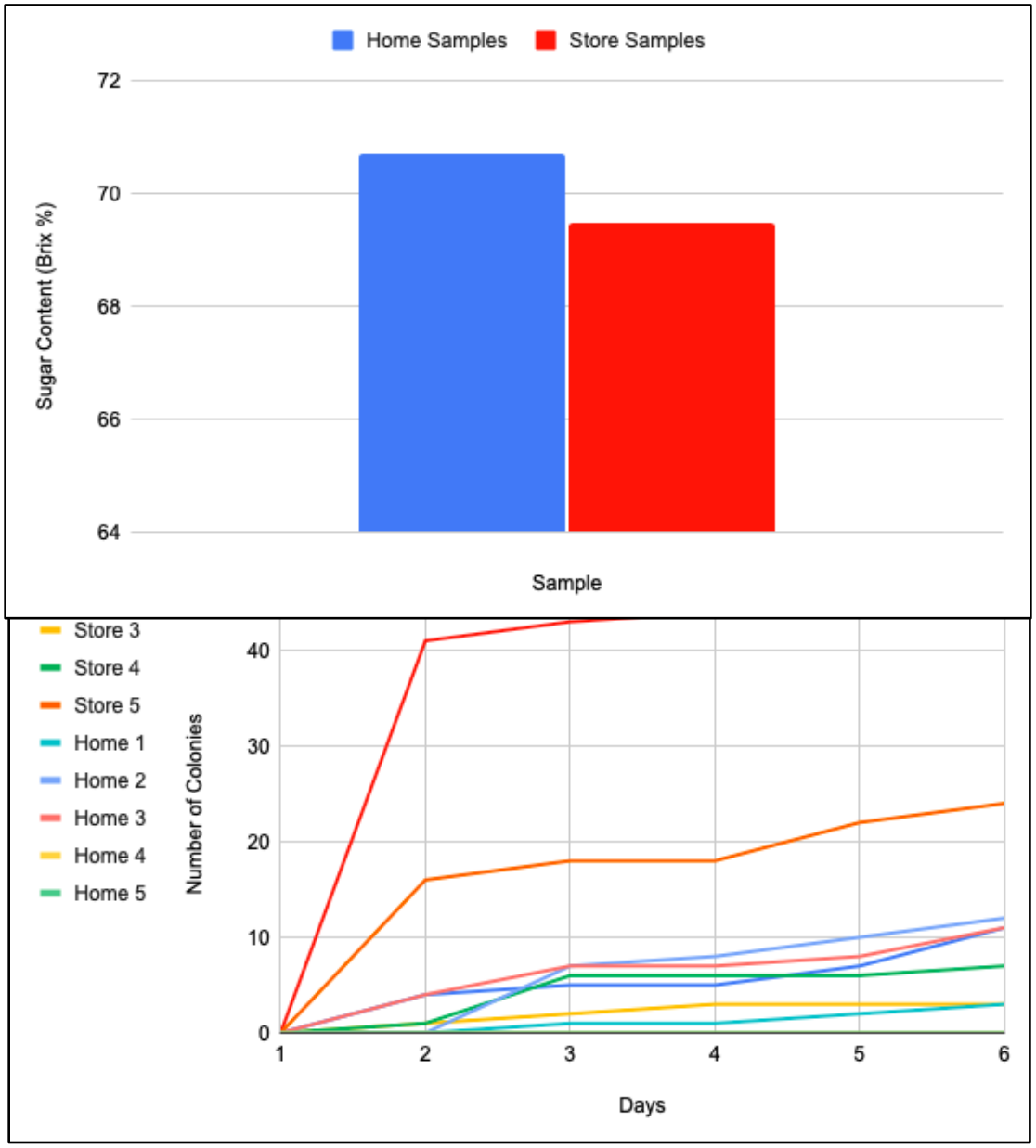

Figure 4 demonstrates the average sugar content in Brix of Home and Store samples.

Figure 4. A Comparison of the Sugar Content of Store and Home Samples

Note. This graph shows the relationship between the sugar content of the averages of 5 home samples, blue, and 5 store samples, red.

Trends

After the period of incubation and counting in daily increments, the bacterial colonies showed a great difference in the averages and overall bacteria growth in the samples. These results are visualized in the tables above, where the left column is days one through six and the top row is the sample location one through five samples. The results from the tables were also translated into graphs. There was one graph for home samples, labeled Figure 2 above and a separate graph, Figure 1 created for the store samples. The graphs are shown above, where the x-axis is time in days one through six. On the home samples in Figure 2, the colony counts are on the y-axis of the graph 0-15 in increments of five whereas the y-axis on the store-bought graph in Figure 1 shows the same colony count in increments of 10, 0-50. Different graphs and units were used for the store graph because of the one outlier of 46 growths in the store sample, which would not have fit on the previously sized graph and the remaining data sets would have been too close together to make a distinction. Each sample is represented by a different colored line and a respective key is set for each graph on the left-hand side. Figure 3 represents a comparison of the two sources. Similarly to Figures 1 and 2, this chart has an x-axis labeled days one through six and a y-axis labeled with colonial growths.

The sugar content is shown above in Figure 4, with the y-axis being the content measurement in Brix, a viscosity measurement where the higher the percent, the more sugar is present in the solution. The x-axis shows the averages of each of the five samples from the store and home purchased sources. The sugar contents for the five home samples (shown by the blue bar) read 72, 65.5, 75, 71, and 70 respectively with the average on the chart being 70.7. Store samples (depicted by the red bar) one through read 69.5, 69.5, 70.5, 69, and 69 with the average on the chart reading 69.5. Overall, the home samples contained more sucrose in the solution than did store samples.

Analysis

From the results, the main claim can be generated that store-bought, mass-produced samples were shown to contain more bacteria over a period of time than homemade samples. This is evidenced in Table 1 and Figures 1 through 3. This is contrary to the original hypothesis that home samples would contain more bacteria than store samples due to less standards being in place for homemade food items.

In each of the 10 samples, bacterial colonies ranged in number, size, shape, and color. Some colonies were observed to be small, lacked color, and had undefined edges whereas others were vibrant yellow and orange colored. Each colony was examined under a microscope to possibly identify the sample. One type of bacteria that was present was a yellow color and was organized in spherical clump colonies. This bacteria was identified as cocci because of its spherical nature and, more specifically, as *Staphylococcus Aureus* or Staph bacteria (Verrans, 2022). A peer reviewed study from the journal *Environmental and Applied Microbiology* concluded that staph is one commonly found microorganism in sap samples (Lagacé, 2004). This professionally conducted study, as it found similar results in terms of the bacteria grown in samples of maple syrup, underscores the credibility of the method and results of my study.

The vast difference between the bacteria colonies produced in store versus home samples may be attributed to the batch size and numerous variables present on a production line. In other words, homemade samples are usually made by one or two people and in much smaller quantities. One man who sold syrup produced at his home explained how he makes his syrup in one-gallon batches by himself. Additionally, the syrup is being produced and packaged by only a small group of people when made in smaller quantities in the home.

The syrup, once fully prepared to be sold, is most often kept in the same location and sold out of the same source it was made. On the other side of the spectrum, store bought samples are produced on a much larger scale. Many large-scale producers of maple syrup created batches in sizes of up to 3,000 gallons per batch (Mistler, 2022) and use tens of thousands of taps for the sap. This means that the production line contains many more people and workers which could lead to contamination, but also a plethora of equipment used to boil, stir, bottle, package, and widely distribute each batch made. Moreover, all of this equipment and the mass production of the syrup may mean that each tool is not properly cleaned or removed of contaminants before being used to make the next batch. In such a large production line, it would be extremely difficult to perfectly clean all of the pieces of equipment. All of these factors could potentially play a role in the bacteria content being so high for the majority of the mass-produced samples.

In terms of the relation between the sugar content and the number of bacteria grown, there is a weak correlation. The home samples did, in fact, contain more sucrose than the store samples by average. Relatively, the store samples contained more bacteria possibly due to less sucrose. However, the relationship is not as strong because, for example, home sample three contained the highest sugar content among all of the samples and produced more bacteria than the majority of home purchased samples. This is the reason for the weak correlation.

The results of this experiment lead to the new understanding that home syrup samples contain less bacteria over time than store samples and that there is, although weak, a correlation between the amount of sucrose in each sample and its relative bacteria growth.

Discussion

This study answers the research question and addresses the gap created in the scholarly surrounding literature and shows that homemade samples contained less bacterial colonies overall than samples purchased from stores. In the scholarly sources reviewed, many addressed bacterial contamination among store samples such as the source from Perry et al (2018). Because there are many homemade syrup sources locally, this research fits in with the surrounding literature to fill this hole in the gap and not only examine the bacterial colonies in home-made samples from Northeast Ohio producers but compare it to store bought syrup as well.

The results of this research allow consumers of maple syrup to maximize health benefits and choose what source of maple syrup is most beneficial to their health in terms of avoiding bacterial infection and consuming a healthy amount of sugar. This new understanding addresses the gap in the surrounding literature that compares home and store purchased samples. Moreover, in order to maximize the phenolic bacteria fighting properties of maple syrup, the number of bacteria contained in the syrup itself must be considered. The aforementioned conclusion by Maisuria et al (2015) that phenolics in maple syrup were especially effective in combating bacterial activity is one that may be hindered in syrup that inherently contain higher levels of bacteria.

The results, in addition to providing health information to local consumers of syrup, also provide guidance for future research in the field. For example, similar studies can be conducted on any food that can be made in the home as well as purchased from the store. Honey is another very prevalent natural sweetener that is industrially manufactured but is also home produced in Northeast Ohio and can be found and sold at many roadside stands across the area. An implication of his study is that it provides a framework for future researchers, who are interested in conducting their own experiments on home versus store produced honey samples, to examine the connection between sugar content of honey and the number of bacteria present.

One question that arose as a result of this research is regarding the generalizability of the findings. The geographical region in which the study was conducted may limit the scope by which the research extends to a smaller area. For example, different findings may have been discovered in a state like Vermont, where maple syrup production is also extremely high and where in-home food production standards are also different. This leads to another implication that future research must be conducted in different regions where maple syrup

production is prevalent in the community. Comparing home and store-bought samples in other counties across a variety of regions will provide consumers, not just in Geauga County but in much larger areas, with the proper information regarding the best possible source of maple syrup.

As well as providing insight to local consumers as to what the safest mode of production is and source of purchasing options are, my study also affirms methods developed by past studies and creates direction for future research. The study "Determining the Shelf Life of Maple Sap Beverages" informed the method used. From this scholarly study, a very similar design process was replicated by using an incubator and counting the dishes in increments of 24 hours. In order to properly obtain the most accurate results, future methods conducted for similar studies should include multiple batches of each sample. With the time constraint, the data process was only able to be run one time. This means that there was very little margin for error. One store sample, Store 2, contained 46 colonies of bacteria. The reason for this extremely high count may have been due to contamination. The reason cannot be determined because the study was conducted once. By running through the experiment multiple times with many batches from each source, a researcher would be able to calculate the average growth per study for each sample and calculate the averages as opposed to making a claim based off of one test.

The limitations of the method include a series of calamity days during the data collection process. Three days of the week were canceled because of weather conditions and, when combined with the weekend, five total days off of school were the result, which directly impacted my collection period. While the bacteria growth was still monitored each day and data was collected, the colonies were not able to be counted in exact 24-hour increments. On the first day of data collection, a count was conducted at approximately one in the afternoon. The next day, as it was a calamity day, a time had to be organized with the school administration where I could come in when the building was open and collect my data. The latest time the building was open was at 9:00 in the morning. This meant that data was not collected in the original 24-hour period planned, but instead only 20 hours after the first measurement. Although this may not have provided a significant change to the results, the accuracy and credibility of the data may have been affected.

Another limitation of this study is that the syrup samples were not collected during peak tapping season. The best time to tap syrup for the sweetest results is mid to late March, whereas the samples used in this study were collected in the middle of January. This would have meant the sugar content may not have been as exact or to typical standards which could have influenced the bacteria samples grown and the relationship discovered between the sugar content and bacteria growth.

In addition, the colonies on the petri dish were extremely close together. Some samples had to be placed under a microscope to count the colonies because they were hardly distinguishable. This may have resulted in incorrectly counted bacterial samples, providing too many or too few numbers for each dish. Moreover, the methods used may have resulted in contamination of the syrup samples, which would have yielded incorrect results in the number of microorganisms measured. This means that many contaminants, ranging from contaminated equipment to airborne bacteria may have polluted the dishes and introduced foreign bacteria to the samples. Gloves were also not worn during the experimental process and, although extreme care was taken to ensure that the procedures and equipment were as clean as possible, this may have resulted in some foreign bacteria being introduced into the samples.

A way to address possible limitations of this study is that further research conducted on bacterial growth in maple syrup could replicate this study but could involve a larger sample size and a more extensive timeframe to study continued bacterial growth. Future research regarding bacterial growth in maple syrup samples should also directly identify all colonies of bacteria. As stated in the analysis section, some bacteria present in the samples was identified as being *Staphylococcus* and *Streptococcus*, both harmful microorganisms. According to a publication from The Cleveland Clinic (2020), however, some of the bacteria present in food is actually beneficial for humans to consume and occurs naturally in the body as probiotics. These bacteria, which are considered *normal flora*, take up 70% of all of the cells in humans and can actually help the body fight off

infections through skin, ingestion, and air transmission. In other words, a future study to test the properties of each colony could determine how truly dangerous or beneficial a sample of maple syrup is for consumers.

There is still much to be learned about maximizing the health benefits of maple syrup while mitigating the risks related to bacteria and sugar content. This study is a step toward understanding the benefits of home produced versus mass manufactured products and offers several avenues for further research.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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