Jurnal Inovasi Teknologi Terapan

Vol. 02, No. 2, (2024) e-ISSN : 3026-0213

Pasteurization For Water: Unit Testing And Potential For Commercial Application

Hadi Apriliawan[1]
[1]University of Islam Malang, Malang
*E-mail : hadiapri@unisma.ac.id

Received : 9 Agustus 2024; Received in revised form : 12 Agustus 2024; Accepted : 15 Agustus 2024

Abstract

Waterborne diseases continue to pose a significant global health challenge. Traditional water treatment methods often fall short in ensuring complete microbial inactivation. This study investigates the efficacy of pasteurization as a potential solution for water disinfection. The research focuses on unit testing the pasteurization process to determine optimal temperature and exposure time for effective pH level. Water, being a fundamental component in numerous pasteurization processes, undergoes significant changes when subjected to heat. This study involves five steps to analyze pH changes in water during pasteurization. Starting at 50°C, a water sample is taken and its pH level measured. The temperature is then increased to 60°C, 70°C, 80°C, and 90°C, with pH measurements taken at each step. The recorded pH levels are compared to determine the effect of temperature on water pH, leading to a comprehensive conclusion based on the observed data. The result shows that increasing the temperature during pasteurization leads to an increase in the pH level of water. Consequently, for applications requiring a specific pH level, such as the ideal pH [1] a *pasteurization temperature of 90°C is recommended. The Environmental Protection Agency (EPA) of the united states recommends a pH level of 7 for daily consumption.*

Keywords: Water pasteurization, Water quality. Water pH, Pasteurization, Mineral water

Abstrak

Penyakit bawaan air terus menjadi tantangan kesehatan global yang signifikan. Metode pengolahan air tradisional seringkali gagal memastikan inaktivasi mikroba secara lengkap. Penelitian ini menyelidiki efektivitas pasteurisasi sebagai solusi potensial untuk desinfeksi air. Fokus penelitian ini adalah pengujian satuan proses pasteurisasi untuk menentukan suhu dan waktu paparan optimal bagi tingkat pH yang efektif. Air, sebagai komponen utama dalam banyak proses pasteurisasi, mengalami perubahan signifikan ketika terkena panas. Studi ini melibatkan lima langkah untuk menganalisis perubahan pH air selama pasteurisasi. Dimulai dari 50°C, sampel air diambil dan tingkat pH-nya diukur. Suhu kemudian dinaikkan menjadi 60°C, 70°C, 80°C, dan 90°C, dengan pengukuran pH dilakukan pada setiap tahap. Tingkat pH yang tercatat dibandingkan untuk menentukan efek suhu terhadap pH air, menghasilkan kesimpulan komprehensif berdasarkan data yang diamati. Hasil menunjukkan bahwa peningkatan suhu selama pasteurisasi menyebabkan peningkatan tingkat pH air. Akibatnya, untuk aplikasi yang membutuhkan tingkat pH tertentu, seperti pH ideal [1], *suhu pasteurisasi 90°C direkomendasikan. Standar pH yang direkomendasikan untuk dikonsumsi sehari-hari adalah 7, menurut Environmental Protection Agency (EPA) Amerika Serikat.*

Kata kunci: Pasteurisasi air, Kualitas air, pH air, Pasteurisasi, Air mineral

1. INTRODUCTION

Waterborne infections continue to be a major cause of morbidity and mortality worldwide, especially in underdeveloped nations, water desease cause five million deaths per year [2]. While physical contaminants can be effectively removed by traditional water treatment procedures, total microbiological inactivation is generally not achieved. This has made the creation of sophisticated disinfecting methods necessary.

Pasteurization is widely utilized in various industries, particularly in food and beverage production, to eliminate pathogenic microorganisms and extend shelf life [3]. Water, being a fundamental component in numerous pasteurization processes, undergoes significant changes when subjected to heat. The pH level of water, a various studies, the US Environmental Protection Agency (USEPA) suggests that drinkable water should ideally have a pH level ranging from 6.5 to 8.5 [1]. Additionally, the taste of alkaline electrolyzed water (AEW) made by electrolyzing mineral waters was found to be preferred in certain cases, suggesting that pH levels can influence sensory perceptions of water taste [4].

Measure of its acidity or alkalinity, can be influenced by various factors, including temperature. Previous research has established that temperature variations can alter the carbonic acid formed by CO2 leading to shifts in pH levels [5] .

Higher pH levels in mineral water can have varying effects depending on the specific context. Alkaline mineral water with elevated pH values often contains dissolved minerals such as calcium, magnesium, and potassium, which contribute to its alkaline properties. A pH of 10.0 has been found to improve acid-base balance and hydration status in healthy adults, indicating potential benefits when consumed regularly [6].

The recommended pH level for water varies depending on its use and the organisms it supports. while higher pH levels in mineral water can offer benefits like improved acid-base balance and taste preferences, it is essential to consider the source and composition of the water to determine its overall impact on health [7].

Furthermore, this study explores the implications of these pH changes for industrial processes and product quality. By examining the potential factors contributing to pH variations, such as the release of dissolved. Gasses and accelerated chemical reactions, the research aims to offer a comprehensive perspective on the thermal effects of pasteurization, because water with disinfection become useless in function [8]. The outcomes of this investigation will be valuable for industries that rely on precise pH control, ensuring that pasteurization processes are both effective and efficient in maintaining the integrity of the products.

The purpose of this study is to assess which temperature during pasteurization optimally and effectively achieves the recommended pH level of water. Specifically, this study aims to determine which temperature can produce the desired pH level based on the requirements for potable water [9].

2. MATERIAL AND METHOD

Tools And Material

The tools utilized in this study included a pasteurization machine, six sample cups, and a pH meter. The material used was tap water with an initial pH level of 7.25. The pasteurization process, particularly batch pasteurization, involves heating water to a specific temperature and maintaining it until it reaches another predetermined temperature. This method typically requires a considerable amount of time to achieve the desired temperature change.

Study Method

This study involves a series of five distinct steps to analyze the pH changes in water during pasteurization. Initially, the temperature is set to 50°C, and a water sample is taken to measure its pH level. The temperature is then incrementally increased to 60°C, 70°C, 80°C, and finally 90°C. At each temperature, a water sample is taken, and its pH level is measured. The pH levels recorded at each temperature are compared to understand the effect of temperature on the pH of water, leading to a comprehensive conclusion based on the observed data.

Table 1. Study Design

step	pH level
Before pasteurization	7.25
After pasteurisation each temperature	
50°	
60°	
70°	
80°	
90°	

Key Objective

- To evaluate the effectiveness of HTLT pasteurization at different temperatures in inactivating a broad spectrum of microorganisms commonly found in water.
- determine the optimal temperature for achieving maximum microbial reduction while minimizing adverse effects on water quality.
- To compare the efficiency of HTLT pasteurization with traditional water treatment methods.
- To measure the pH level.

Methodology

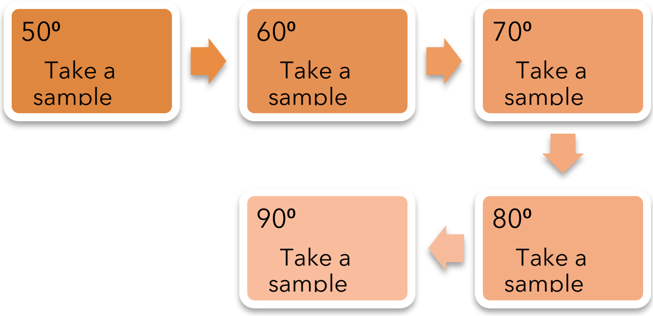
1. Water Sample Preparation**:** Water samples were collected from [source of water] and inoculated with a known concentration of target microorganisms.
2. HTLT Treatment**:** The inoculated water samples were subjected to HTLT treatment at each of the five temperatures for a predetermined holding time.
3. Microbial Analysis**:** Before and after HTLT treatment, microbial analysis was performed using standard microbiological techniques to quantify the reduction in microbial load.
4. Water Quality Analysis**:** Water quality parameters, such as pH, conductivity, and total dissolved solids, were measured to assess any changes caused by the HTLT process.
5. Water pH Analysis**:** A pH meter is the most common tool for measuring pH. It consists of a glass electrode that is sensitive to hydrogen ions and a reference electrode.

Expected Result

It is anticipated that increasing the temperature will result in a higher reduction in microbial load. However, excessively high temperatures may lead to undesirable changes in water quality or the formation of by-products. By comparing the microbial reduction at different temperatures, an optimal temperature range for effective water pasteurization can be determined. And change the pH level.

Significance

The findings of this study will contribute to the development of more effective and sustainable water treatment technologies. The optimized HTLT process can be applied in various settings, including households, communities, and industries, to ensure the safety and quality of drinking water.



Picture 1. Pasteurization With Different Heating

3. RESULT AND DISCUSSION

The study examined the effects of batch pasteurization on the pH levels of tap water, which initially had a pH of 7,25. The water was heated to specific temperatures of 50°C, 60°C, 70°C, 80°C, and 90°C, and the pH level was measured at each temperature. The results are as follows:

Table 2. pH of Water Before and After Pasteurization

Step	pH level
Before Pasteurization	7.25
After Pasteurization on each temperature:	-
50^0	7.45
60^0	7.49
70^0	7.70
80^0	7.95
90^0	8.45

The data reveals a trend in the pH levels corresponding to the different temperatures.

1. At 50°C: The pH level of 7.45 indicates a slight increase/decrease from the initial pH of 7.25. This change suggests that minimal pasteurization at this temperature does not significantly alter the water's pH.
2. At 60°C: The pH level of 7.49 shows a more noticeable shift, implying that as the temperature rises, the chemical properties of the water begin to change more markedly.
3. At 70°C: With a pH level of 7.70, the trend observed at 60°C continues, indicating a further alteration in water chemistry due to increased thermal input.
4. At 80°C: The pH level of 7.95 suggests a substantial change, which may be attributed to the accelerated reaction rates of substances in the water as the temperature increases.
5. At 90°C: The pH level of 8.45 indicates the most significant change, highlighting that high temperatures have a pronounced effect on the water's pH level.

These findings demonstrate that batch pasteurization affects the pH level of water, with higher temperatures leading to more significant changes. As the temperature increases, dissolved gasses like carbon dioxide (CO_2) can be released from the water. CO_2 in water forms carbonic acid, which lowers the pH [8]. When CO_2 is released, the pH can increase because the acid concentration decreases.

Understanding these effects is crucial for applications where maintaining specific pH levels is essential, such as in food processing or chemical manufacturing. The results also suggest that careful monitoring and control of temperature are necessary to achieve desired outcomes in the pasteurization process.

A bench-scale chulli system evaluated using highly contaminated pond water. Rapid heat transfer within the coil enabled the production of hot effluent (70-76 °C) within five minutes of rice cooking initiation, despite cold cooking water. With a hydraulic residence time of approximately 45 seconds at a flow rate of 500 mL/min, the system consistently produced over 30 liters of effluent per cooking cycle (1.5-2 hours). This equates to a potential daily output of 60-90 liters for households cooking two to three times daily. Microbiological analysis revealed complete inactivation of total and fecal coliforms in the effluent, demonstrating the system's effectiveness in treating highly polluted water [3].

The available data sets were descrbed in detail by a mathematical model called the log R-fat: the thermal inactivation of pseudomonas viscosa at 48° C Streptococcus faecalis at 60 C, and salmonella anatum at 55 C: the data from lambert sets Clostridium botulinum spores at varying temperatures in the range of 101-121C; the inactivation of salmonella Bedford over the temperature range of 50-58C, a water activity range of 0.94-0,99 and a pH range of 4-7, Bacillus stearothermophilus spores from 105 to 121 C, and the dry heat sterilization of an indigenous mesophilic soil population across the temperature range 120-160 C [10].

The system effectively inactivates bacteria through rapid heat transfer, offering a promising low-cost, sustainable solution for threating contaminated water for treating contaminated water in resource-limited settings. This aligns with current research emphasizing the importance of thermal inactivation for pathogen reduction in water treatment. While the chulli system demonstrates efficacy against coliforms, further studies are needed to assess its effectiveness against a broader spectrum of pathogens and to optimize its performance under varying water quality conditions. Additionally, exploring the potential for integrating this technology with other water treatment processes to enhance overall water quality is a promising avenue for future research.

4. CONCLUSION

The findings of this study indicate that the temperature during the pasteurization process can significantly alter the pH level of water, with varying temperatures resulting in different pH changes. Our objective was to identify the optimal and most effective temperature for pasteurization to achieve the desired pH level in the water. The data revealed that the highest temperature tested, 90°C, led to the highest pH level. And the good pH level at 7.

The optimal pH level for water is 6.5 to 8.5 [1]. Given that pasteurization at 90°C resulted in the highest pH level, it can be inferred that this temperature is recommended for pasteurization to attain the optimal pH. This finding underscores the importance of precise temperature control in pasteurization processes to achieve the desired chemical properties in water.

In conclusion, the study demonstrates that increasing the temperature during pasteurization leads to an increase in the pH level of water. Consequently, for applications requiring a specific pH level, such as the ideal pH [1], a pasteurization temperature of 90°C is recommended. This research provides valuable insights into the relationship between temperature and pH levels, contributing to the optimization of pasteurization processes in various industrial contexts.

APPRECIATION

We extend our sincerest gratitude to PT. Metro Mesin for their invaluable contributions to the successful completion of this research. Their generous provision of essential equipment has significantly enhanced our experimental capabilities, enabling us to conduct thorough and accurate investigations. Furthermore, the technical expertise offered by their team has been instrumental in overcoming challenges and ensuring the methodological rigor of our study.

The support provided by PT. Metro Mesin has been indispensable to the overall success of this project. Their commitment to advancing scientific research is commendable, and we are truly grateful for their partnership.

REFERENCES

[1] R. Bhardwaj and A. Bangia, "Improvement in Explicit Prediction of Water Quality Using Wavelet-Based LSSVR and M5pRT," Complexity, vol. 2021, no. 1, Jan. 2021, doi: 10.1155/2021/6643472.

[2] UNICEF, "The State of The World's Children," 1995.

[3] M. F. Islam and R. B. Johnston, "Household Pasteurization of Drinking-water: The Chulli Water-treatment System," J Health Popul Nutr, vol. 24, no. 3, 2006.

[4] M. Koseki, Y. Tanaka, H. Noguchi, and T. Nishikawa, "Effect of pH on the Taste of Alkaline Electrolyzed Water," J Food Sci, vol. 72, no. 5, Jun. 2007, doi: 10.1111/j.1750-3841.2007.00384.x.

[5] M. C. De Belen and F. R. G. Cruz, "Water quality parameter correlation in a controlled aquaculture environment," in 2017IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), IEEE, Dec. 2017, pp. 1–4. doi: 10.1109/HNICEM.2017.8269429.

[6] J. Schmidt and B. Huang, "The pH of bottled water commercially available in Australia and its implications for oral health," J Water Health, vol. 20, no. 5, pp. 871–876, May 2022, doi: 10.2166/wh.2022.070.

[7] WASH, "Lessons Learned in Water Sanitation and Health: Thirteen Years of Experience in Developing Countries," 1993.

[8] The World Bank Water Demand Research Team, "The demand for water in rural areas : determinants and policy implications (English)," vol. 1, 1993.

[9] H. Apriliawan, "Laban Electric Alat Pateurisasi Susu Kejut Listrik Tegangan Tinggi (Pulsed Electric Field) Menggunakan Flyback Transformer," 2011.

[10] R. J. W. Lambert, "A model for the thermal inactivation of micro-organisms," J Appl Microbiol, vol. 95, no. 3, pp. 500–507, Sep. 2003, doi: 10.1046/j.1365-2672.2003.02009.x.