



Temperature Monitoring and Fan Control System for Breast Milk Storage Coolbox Based on Arduino Uno

Tri Haryanti¹, Anugrah Pamungkas², Rahajeng Kurnianingtyas³, Icha Fatwasauri⁴.

Indramayu State Polytechnic, Indramayu 45252, Indonesia

Article Info

Keywords:

Arduino Uno,
Coolbox,
Temperature Sensor,
Automatic Control

ABSTRACT

Breast milk is the main source of nutrition for infants and is highly susceptible to spoilage if not stored at the right temperature. This system uses temperature sensors to monitor the thermal conditions in the storage cabin and automatically control the cooling fan to maintain the ideal temperature for breast milk storage. Test results show that the thermoelectric-based cooling system works optimally in conditions without products, with an initial temperature of 31.3°C that decreases to 2.3°C within 70 minutes. However, in conditions with breast milk products, the initial temperature of 35.3°C could only be reduced to 5.4°C within 120 minutes. This difference indicates that the presence of the product provides an additional thermal load that slows down the cooling process. Therefore, a responsive automatic temperature control system and better thermal insulation are needed to maintain the breast milk storage temperature stably around 4°C. This system is expected to maintain the quality of breast milk during storage and support users' needs in maintaining stable storage temperature efficiently.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

Tri Haryanti
Department of Engineering
Indramayu State Polytechnic
Email: tri.haryanti@polindra.ac.id

1. INTRODUCTION

Breast milk is the best source of nutrition for babies, containing complete nutrients and natural antibodies to support optimal growth and development[1]. In certain circumstances, such as when the mother is working or unable to breastfeed immediately, breast milk needs to be expressed and stored so that it is available for the baby. The process of storing breast milk requires attention to the temperature factor, as exposure to unstable temperatures can reduce the quality of breast milk, accelerate bacterial growth and reduce the content of essential nutrients. A cool box is one of the alternative media often used for storing breast milk because it is practical and can maintain low temperatures for a period of time. Optimum storage temperature Breast milk must be stored at the right temperature to keep it fresh and safe for the baby. The recommended temperature for storing breast milk is usually between 0-4 degrees Celsius[2].

The control and monitoring system in this cool box aims to ensure the right temperature and environmental conditions to maintain the quality of breast milk[3][4]. With the development of technology, the use of microcontrollers such as Arduino Uno allows the development of a more effective and efficient temperature monitoring and control system[5]. The DHT11 sensor, which is capable of measuring temperature and humidity, can be used to detect conditions inside the cool box in real time[6][7]. The temperature information received from the sensor is then processed by the Arduino to control the cooling fan, which is automatically activated when the temperature exceeds a predetermined limit[8].

The application of this system not only increases the stability of breast milk storage temperature, but also extends the shelf life of breast milk and provides a sense of security for mothers. Therefore, in this study, a temperature monitoring system and fan control on a breast milk storage cooler based on Arduino Uno was designed and built with the aim of creating a smarter, safer and more effective breast milk storage device.

2. RESEARCH METHOD

This study uses a quantitative approach to determine the effectiveness of the temperature monitoring system and fan control in a breast milk storage cooler based on numerical data obtained by direct measurement. The quantitative approach was chosen because this study involves regular collection of temperature data and systematic testing of the system using measuring instruments.

Data was collected by direct observation of the operating system. The temperature sensor built into the system reads the temperature inside the cabin and displays it on the LCD. Each change in temperature and fan response is recorded in the observation table over several test cycles. Data is collected at regular intervals (e.g. every 5 minutes) to ensure accurate and consistent results[9].

The data obtained were analysed in a descriptive and quantitative manner by presenting the data in the form of tables, temperature versus time graphs, and the percentage success of the system in maintaining temperatures between 4°C and 9°C. The aim of this analysis is to determine whether the system has performed as expected[10].

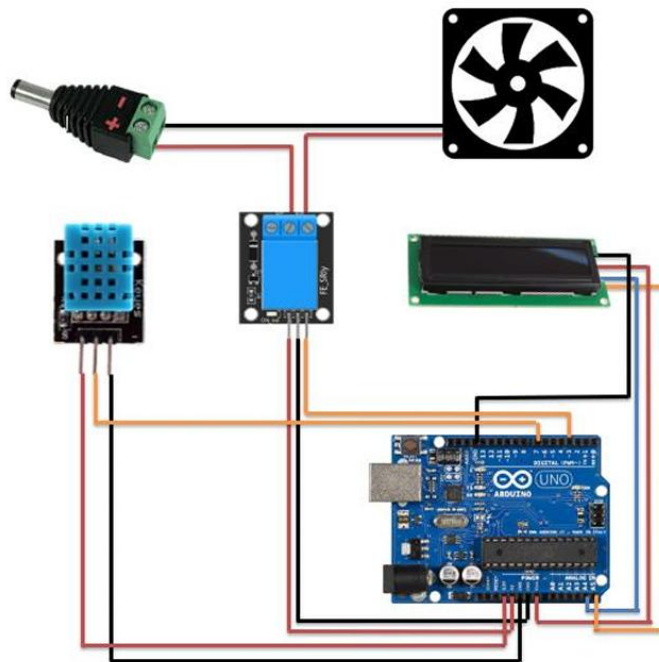


Figure 1. Design of Temperature Monitoring System and Fan Control on Arduino Uno-based Breast Milk Storage Coolbox

The temperature monitoring and fan control system inside the breast milk storage coolbox is designed to maintain a stable and safe breast milk storage temperature. The process starts with activating the 12V 50A DC power supply, which then switches on all the components of the control system. The temperature sensor installed in the cooling cabin detects the temperature in real time, and this information is displayed on the LCD screen for easy monitoring. When the temperature inside the cabin reaches 4°C, the system will automatically switch off the cooling fan to prevent the temperature from dropping further. Conversely, if the temperature

increases beyond 9°C, the system will reactivate the cooling fan to lower the temperature to the desired level. This process occurs automatically and repeatedly to ensure that the cabin temperature remains within the ideal range. The system will continue to operate and link the temperature until manually activated.

3. RESULTS AND DISCUSSION

This section presents the results of the implementation and testing of the temperature monitoring and fan control system on the breast milk storage coolbox. Testing was conducted to observe the system's performance in detecting cabin temperature in real-time and controlling the fan automatically based on a predetermined temperature threshold. Data is obtained from sensor readings displayed via LCD. The results obtained are then analyzed to transmit the effectiveness of the system in maintaining a stable breast milk storage temperature in the range of 4°C to 9°C, according to recommended storage standards.

3.1. Temperature Monitoring Result Data Without Product

Table 1. Temperature monitoring data of the coolbox without product

Time	Temperature Without Product (°C)
0	31.3
5	9.8
10	6.6
15	6.6
20	6.5
25	6
30	7.3
35	7.6
40	7.8
45	5.7
50	3.2
55	2.8
60	2.8
65	2.4
70	2.3
75	2.3
80	2.4
85	2.5
90	2.9
95	3
100	3.1
105	3.8
110	3
115	4.1
120	3.8

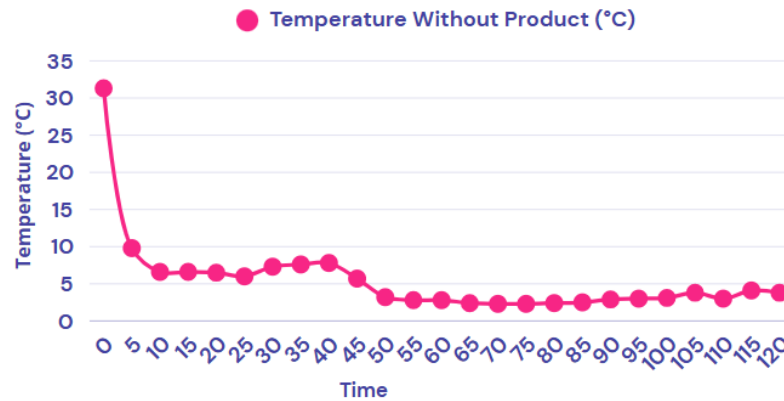


Figure 2. Temperature monitoring graph of coolbox without product

Based on the graph of the no-load test results, it is known that the initial temperature without the product in the coolbox is 31.3°C. The temperature then decreases gradually until it reaches the set point of 6°C at the 25th minute. After the sensor detects that the temperature has reached the set point, the blower fan automatically stops operating. Subsequently, the temperature increased again, and at 30 minutes the temperature was recorded to rise to 7.3°C. At this point, the blower fan switches back on automatically to lower the temperature back to the desired range.

3.2. Temperature Monitoring Result Data With Product

Table 2. Temperature monitoring data of the coolbox with product

Time	Temperature With Product (°C)
0	35.3
5	33.4
10	31.1
15	29.1
20	27.1
25	25
30	23.3
35	21.8
40	20
45	18.9
50	17.9
55	16.8
60	15.8
65	14.7
70	13.6
75	12.9
80	13.6
85	11.5
90	9.6
95	9.1
100	8.6
105	8
110	7.5
115	6.9
120	5.4

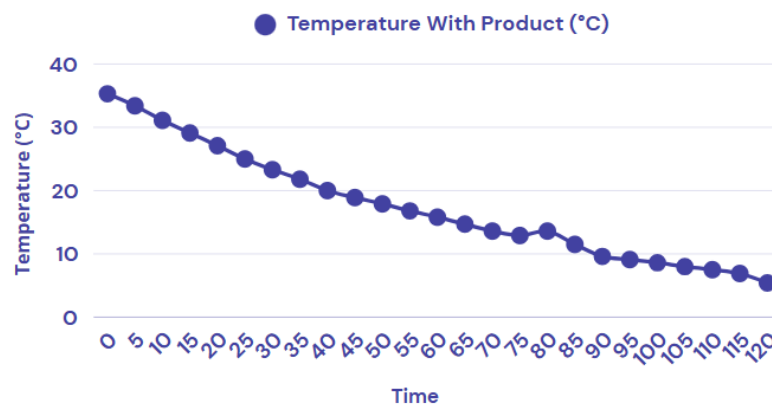


Figure 3. Temperature monitoring graph of coolbox with product

In the graph of the test with the product, there is no significant change in temperature. This is due to the basic characteristics of thermoelectric-based cooling systems, where the temperature drop is constant until it reaches a certain point, then tends to stabilise at a predetermined set point. When the temperature starts to approach the stable point, the system will experience a stagnant state (stuck) and not show a drastic decrease anymore. At this stage, the fan control function is utilised to channel cold air from the heatsink that has been cooled by the thermoelectric module. Based on the test results, the final temperature reached when the system was tested with the product was 4.6°C.

3.3 Temperature monitoring comparison data with and without product

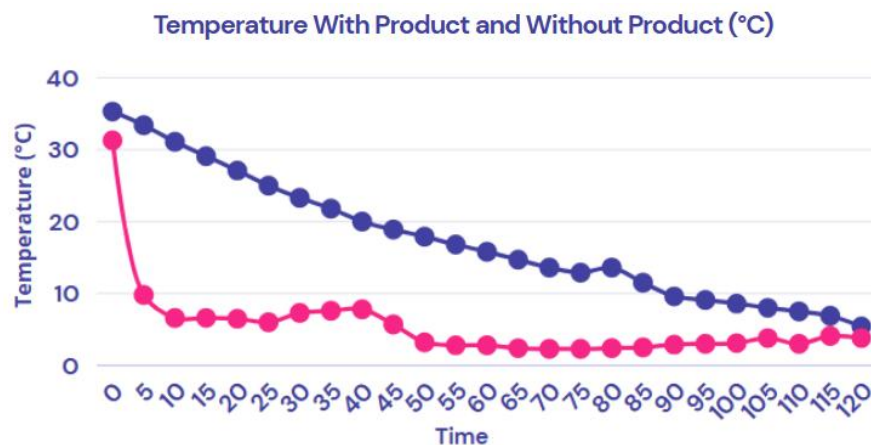


Figure 4. Comparison chart of temperature monitoring with and without product

The graph above is a graph comparing the cooling performance of the coolbox cabin in two conditions, namely without product and with breast milk product. Based on the results obtained, there is a significant difference in the rate of temperature decrease and the stability of the final temperature.

In the test without the product, the initial cabin temperature was recorded at 31.3°C. The temperature decreased dramatically in the first five minutes to 9.8°C, then continued to decrease until it reached the target temperature (set point) of 6°C in the 25th minute. After the temperature reached the set point, the fan blower automatically stopped according to the system control function. As a result, the temperature fluctuated up and down in a small range, and was recorded at 3.8°C at the 120th minute.

Different from the condition with the product, in the test with the product, the initial temperature of the cabin was recorded to be higher, 35.3°C. The temperature drop was slower and more constant as the cooling energy was also used to lower the product temperature. The temperature only reached below 10°C at the 90th minute and the final temperature was recorded at 5.4°C at the 120th minute. This condition shows that the presence of the product affects the performance of the cooling system, where the fan blower stays active longer to maintain the cabin temperature.

3.4 Temperature monitoring comparison data with control and without control

The following table shows the test results of the cooling system in the coolbox containing breast milk products, both without temperature control and with temperature control. This test was conducted to compare the effectiveness of the systems in maintaining the breast milk storage temperature within the standard range. The system without control shows an uncontrolled temperature drop to below the safe limit, while the system with control is able to maintain the temperature stably in accordance with the predetermined setpoint.

Table 3. Temperature monitoring comparison data with control and without control

Time	Temperature Without Control	Temperature With Control °C
0	30.8	30.9
5	7.8	12.1
10	6.6	10.2
15	4.5	9.5
20	4.8	8.8
25	5.4	8.3
30	6.5	7.8
35	6.9	7.3
40	7.3	7.1
45	0.9	6.5
50	-1.7	6.5
55	-1.7	6.8
60	-1.8	7
65	-2.2	5.8
70	-2.2	3.9
75	-2.2	3.6
80	-2	3.4
85	-1.7	3.4
90	-0.9	4
95	-1.1	2
100	0.5	1.5
105	0.6	1.5
110	0.7	1
115	1.2	0.5
120	1.4	0

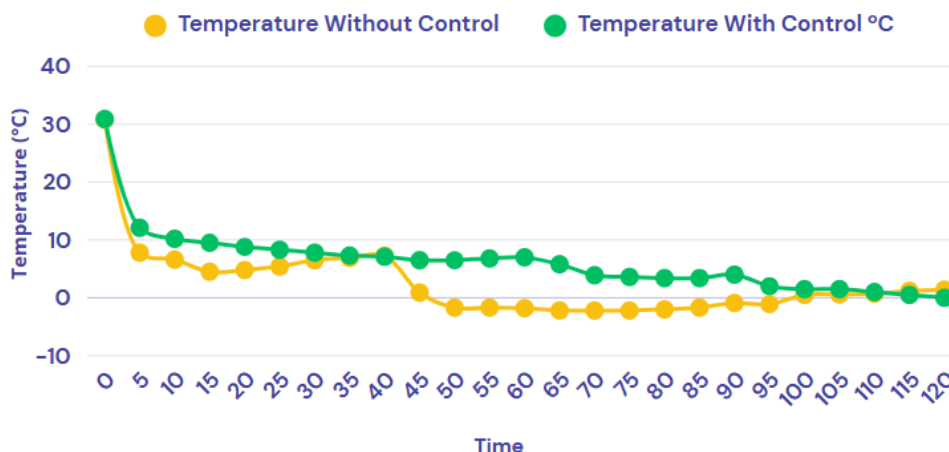


Figure 5. Temperature monitoring graph with control and without control

Based on the temperature monitoring graph on the coolbox with breast milk product load both using control and without control, it can be concluded that there is a significant difference in temperature stability during the cooling process. In the uncontrolled system, the initial temperature of 30.8°C decreased dramatically until it reached the lowest point of -2.2°C at the 70th minute. This sharp drop was followed by unstable temperature fluctuations until the end of the test, indicating the absence of a temperature control system that keeps the temperature within the desired range. This could cause the temperature to become too low and potentially damage the stored product, especially when it comes to sensitive materials such as breast milk.

In contrast, in the controlled system, the temperature drop was gradual and more stable, from an initial temperature of 30.9°C to 0°C at 120 minutes. This process shows that the control system is capable of keeping the coolbox temperature within a safe and appropriate range. The control function plays an important role in preventing the temperature from dropping excessively by automatically regulating the fan or cooler performance based on the temperature readings from the sensors. Thus, the use of the control system proved to be more effective in maintaining temperature stability and maintaining the quality of the products stored in the coolbox.

4. CONCLUSION

The cooling system in the coolbox using thermoelectricity shows optimal performance in conditions without products in the cooling cabin. The initial temperature of 31.3°C was significantly reduced to the lowest temperature of 2.3°C within 70 minutes. The temperature drop was relatively fast and stable because there was no thermal load that inhibited the cooling process. Testing with the product (breast milk) showed that the cooling process was slower. The initial temperature of 35.3°C can only be reduced to 5.4°C within 120 minutes. This is due to the thermal mass of the product that absorbs most of the cooling energy, making the system performance less efficient than when unloaded. Comparison of the two conditions shows that the presence of products in the cabin significantly affects the cooling effectiveness. Therefore, to maintain the ideal breast milk storage temperature (around 4°C), an automatic temperature control system and improved thermal insulation design are required so that the cooling process can run more efficiently and the target temperature can be maintained stably.

ACKNOWLEDGEMENTS

The authors would like to thank Indramayu State Polytechnic for the facilities, guidance and opportunities provided during this research process. Such support was very helpful in the smooth conduct of experiments and the preparation of this scientific report.

REFERENCES

- [1] C. R. Martin, P. R. Ling, and G. L. Blackburn, "Review of infant feeding: Key features of breast milk and infant formula," *Nutrients*, vol. 8, no. 5, pp. 1–11, 2016, doi: 10.3390/nu8050279.
- [2] P. W. Edemba, G. Irimu, and R. Musoke, "Knowledge attitudes and practice of breastmilk expression and storage among working mothers with infants under six months of age in Kenya," *Int. Breastfeed. J.*, vol. 17, no. 1, pp. 1–8, 2022, doi: 10.1186/s13006-022-00469-6.
- [3] G. Naufal, "RANCANG BANGUN COOLER BOX TERMOELEKTRIK DENGAN AIR STERILIZER SEBAGAI TEMPAT PENGIRIMAN AIR SUSU IBU (ASI)," *J. Rekayasa Mesin*, vol. 14, p. 87, Dec. 2019, doi: 10.32497/jrm.v14i3.1637.
- [4] A. W. Rika, "Pemanfaatan Smart Cool Box Untuk Meningkatkan Kesegaran Udara Windu Pada

- Petani Tambak,” *J. Cahaya Mandalika* | 377, pp. 373–379, 2023, [Online]. Available: <https://www.ojs.cahayamandalika.com/index.php/JCM/article/view/1576>
- [5] R. J. Setiawan, K. Ma’ruf, Darmono, I. D. Suryanto, and A. T. Hermawan, “Design system and performance analysis of fish storage box by utilizing solar energy,” *Int. J. Power Electron. Drive Syst.*, vol. 15, no. 4, pp. 2591–2602, 2024, doi: 10.11591/ijpeds.v15.i4.pp2591-2602.
- [6] I. Saraswati, A. Rahman, H. haryanto, Alimuddin, and U. Mardono, “Design of Temperature and Humidity Monitoring System for Drying and Storage of *Allium Ascalonicum* L . (Onion) ,” *Jt. Proc. 2nd 3rd International Conf. Food Secur. Innov. (ICFSI 2018-2019)*, vol. 9, pp. 1–7, 2021, doi: 10.2991/absr.k.210304.021.
- [7] ABDUL RAUF SURO, “PERANCANGAN PORTABLE COOLBOX BERBASIS IOT MENGGUNAKAN SISTEM KOMPRESI UAP DC,” Institut Teknologi Sepuluh Nopember, 2020. [Online]. Available: https://repository.its.ac.id/80408/1/04211640000048-Undergraduate_Thesis.pdf
- [8] “H. Widiarto, I. Koswara, D. Nasution, S. Wahyuni and I. Sulistianingsih, ‘Smart Food Box Design with IoT Based Android Monitoring System,’ 2023 Eighth International Conference on Informatics and Computing (ICIC), Manado, Indonesia, 2023, pp. 1-6, doi: 10.”.
- [9] I. Agustina and I. Noviasari, “Education on How to Express and Correct Breast Milk Storage Techniques for Working Mothers,” *J. Community Serv. Heal.*, vol. 2, no. 2, pp. 047–050, 2021, doi: 10.26699/jcsh.v2i2.art.p047-050.
- [10] W. Pambudi *et al.*, “Perceptions, practices, and associated factors towards expressed breastfeeding among mothers in Jakarta, Indonesia,” *Paediatr. Indones. Indones.*, vol. 64, no. 2, pp. 168–175, 2024, doi: 10.14238/pi64.2.2024.168-75.