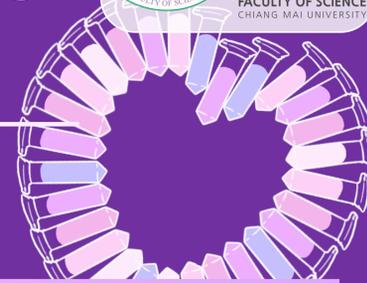# Use of Multi-spectrum Light Sensor to Evaluate Microbiological Quality of Goat's Milk

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Abstract

In Thailand, there is a lack of a system to control the quality of raw goat's milk, particularly microbiological quality. This study aimed to investigate the potential of utilising a colourimetric resazurin test to assess microbiological quality and to develop a model to predict milk quality. Raw goat's milk samples underwent a resazurin test, with the resulting colours analysed using a multi-spectrum sensor alongside microbial counts. A database of these values was established, which was used to create a predictive model for milk quality. Subsamples of raw goat's milk from five dairy goat farms were prepared from 17 original samples to achieve microbial counts between 3 and 14 log CFU/ml. A total of 100 datasets comprising digital values and microbial counts were utilised for training a decision tree classifier model, while 20 datasets were employed for model validation. The classifications for milk are divided into three categories: high-quality milk (low microbial loads; ≤ 5.30 log CFU/ml), medium-quality milk (moderate microbial loads; > 5.3-7.0 log CFU/ml), and low-quality milk (high microbial loads; > 7.0 log CFU/ml). The model demonstrates accuracies of 25%, 66.7%, and 100% for high-, medium-, and low-quality milk samples, respectively. This indicates its potential utility for the rapid screening of goat's milk with elevated microbial loads.

Introduction

Goat's milk offers high nutritional value, making it suitable for health-conscious consumers and those allergic to cow's milk (Mordor Intelligence, 2024). However, the lack of practice in quality control, especially for microbiological quality remains a challenge. Current analytical methods that is used to assess cow's milk quality, such as the resazurin and methylene blue reduction tests (Thanasirikul *et al.* (2023), is rarely used to evaluate goat's milk quality and the methods lack the information about relating microorganism levels. To address this problem, this study has been designed to create a system of grading raw goat's milk quality based on a rapid and accurate colourimetric resazurin reduction test.
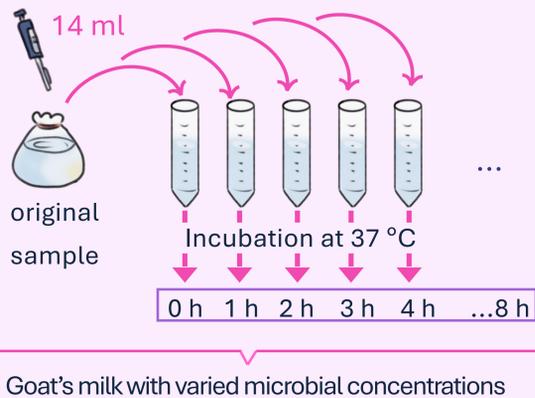
Objectives

- To analyse the digital values of colours resulting from the resazurin reduction test, measured using a multi-spectrum light sensor device, in relation to levels of microorganisms in raw goat's milk.
- To create a database of colour values and microbial counts in raw goat's milk and develop a predictive model for goat's milk quality.
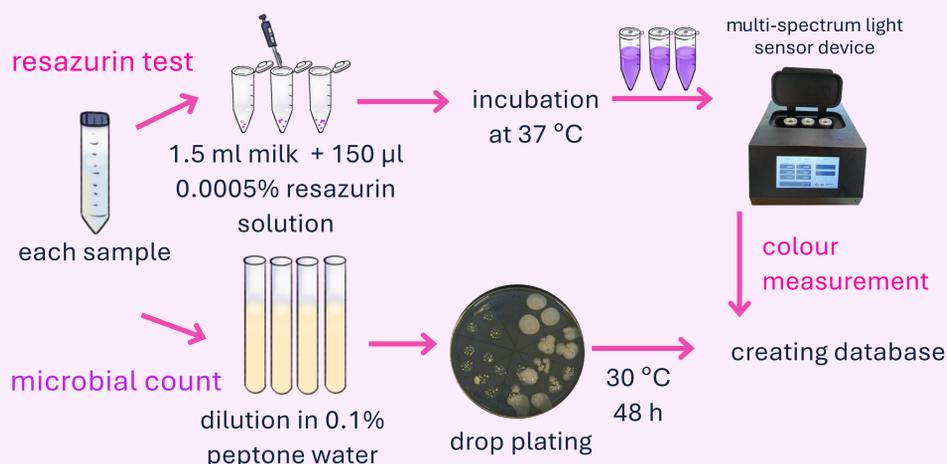
Methods

1 Raw goat's milk

- Boonboon Farm
- Thaworn Dairy Goat Farm, Chiang Mai
- Mae Hia Farm, Faculty of Agriculture, CMU
- Nang Fai Dairy Goat Farm
- Mae Tha Royal Project Development Center

2 Preparing subsamples

14 ml

original sample

Incubation at 37 °C

0 h 1 h 2 h 3 h 4 h …8 h

Goat's milk with varied microbial concentrations

3 Resazurin reduction test and microbial count

resazurin test

each sample

1.5 ml milk + 150 µl 0.0005% resazurin solution

incubation at 37 °C

multi-spectrum light sensor device

colour measurement

creating database

microbial count

dilution in 0.1% peptone water
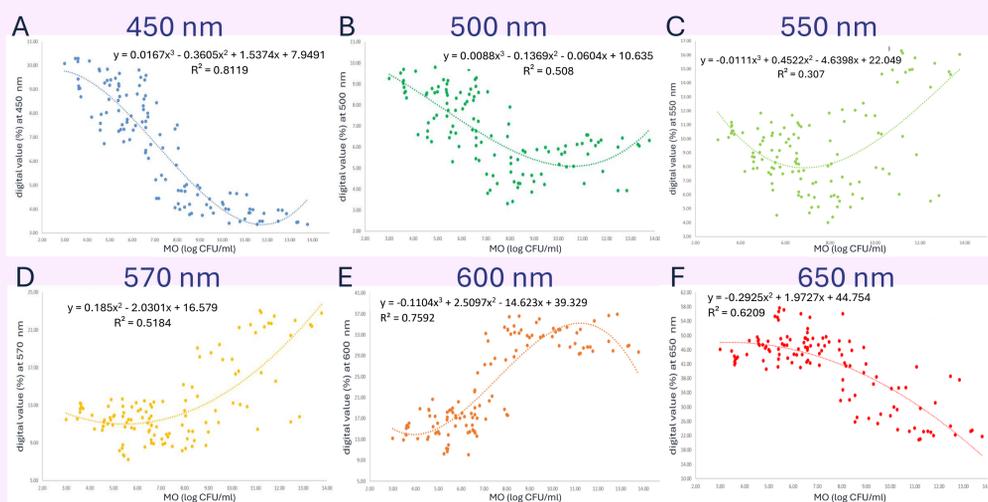
drop plating

30 °C 48 h

4 Formulating predictive model for milk quality
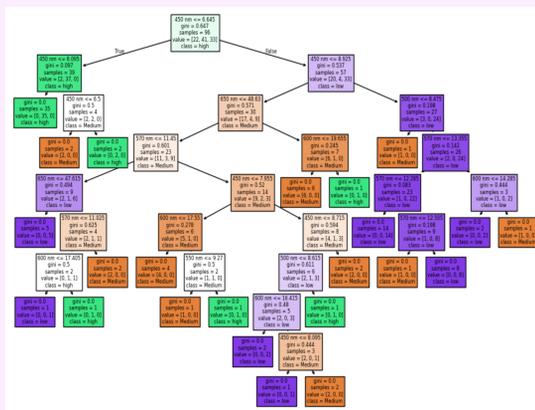
creating using Decision Tree Classifier
- 100 datasets: training
- 20 datasets: testing

Results

- **Digital values (%) from each wavelength and number of microorganisms (MO) (log CFU/ml)**

A 450 nm
$y = 0.0167x^3 - 0.3605x^2 + 1.5374x + 7.9491$
$R^2 = 0.8119$

B 500 nm
$y = 0.0088x^3 - 0.1369x^2 - 0.0604x + 10.635$
$R^2 = 0.508$

C 550 nm
$y = -0.0111x^3 + 0.4522x^2 - 4.6398x + 22.049$
$R^2 = 0.307$

D 570 nm
$y = 0.185x^2 - 2.0301x + 16.579$
$R^2 = 0.5184$

E 600 nm
$y = -0.1104x^3 + 2.5097x^2 - 14.623x + 39.329$
$R^2 = 0.7592$

F 650 nm
$y = -0.2925x^2 + 1.9727x + 44.754$
$R^2 = 0.6209$

- **Predictive model for goat's milk quality** • **Prediction accuracy of Model**

QC class	Prediction accuracy
High-quality milk (≤ 5.30 log CFU/ml)	25 %
Medium-quality milk (> 5.3-7.0 log CFU/ml)	66.7%
Low-quality milk (> 7.0 log CFU/ml)	**100%**

Conclusion

- The digital values (%) resulting from resazurin test at 450 and 600 nm are better correlated with microbial counts in raw goat's milk than at other wavelengths. The correlating values are used to construct a database.
- A predictive model was created from the database, having high prediction accuracy for raw milk with low quality class (MO > 7.0 log CFU/ml). This can be used for rapid screening of milk with high microbial loads.

References

Thanasirikul, C., Patumvan, A., Lipsky, D., Bovonsombut, S., Singjai, P., Boonchieng, E., & Chitov, T. (2023). Rapid assessment and prediction of microbiological quality of raw milk using machine learning based on RGB-colourimetric resazurin assay. International Dairy Journal, 146, 105750. https://doi.org/10.1016/j.idairyj.2023.105750

Mordor Intelligence. (2024). Goat milk products market size & share analysis - Trends, drivers, competitive landscape, and forecasts (2024-2030). Retrieved from https://www.psmarketresearch.com/market-analysis/goat-milk-products-market.

Acknowledgement