STI Focus

SCIENCE, TECHNOLOGY AND INNOVATION

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FOREWORD

As Cambodia moves forward under the Pentagonal Strategy Phase I, led by Samdech Moha Borvor Thipadei HUN MANET, Prime Minister of the Kingdom of Cambodia, technology continues to play a central role in shaping the country's socio-economic development. In response, the Ministry of Industry, Science, Technology & Innovation (MISTI), through the National Institute of Science, Technology and Innovation (NISTI), remains steadfast in its efforts to advance research, foster innovation, and promote STEM education. STI Focus has become a cornerstone in our efforts to communicate scientific progress and insights to the public. NISTI seeks to cultivate a knowledge-driven society in Cambodia by providing a platform for researchers and scholars to share their findings and advance the practical applications of science and technology.

This latest volume presents a diverse collection of articles addressing food safety and innovation, environmental solutions, public health research, and STEM career development. All contributions have been prepared by experts with advanced degrees in their fields, both locally and internationally. The range and depth of topics in this issue highlight the importance of multidisciplinary research in tackling real-world challenges.

I commend all the authors for their dedication and the editor team for their ongoing commitment to excellence. I hope this issue of STI Focus continues to inspire new ideas, informed decision-making, and motivate future contributions from the research community. Whether you are a student, policymaker, entrepreneur, or academic, I am confident you will find valuable insights throughout this publication. Let's work together to build a resilient and sustainable future, based on research and innovation.

Phnom Penh,   August 4,   2025

Minister

HEM Vanndy

EDITORIAL NOTE

It is our distinct pleasure to introduce the first issue of STI Focus for 2025. The issue features a well-curated collection of manuscripts by researchers and professionals from varied fields, reiterating our commitment towards advancing research, innovation, and science literacy. The volume is therefore organized into three sections: "Scientific Findings", "Technology Trends", and "STEM Education and Careers".

The first section includes research like Development of gamma-aminobutyric acid (GABA)-enriched functional yogurt using lactic acid bacteria, Foodborne Pathogen Contamination in Fermented Vegetables Sold in Cambodian Markets: A Screening Study, Development of Beetroot Jam for Supplementation in Yogurt: A Sensory Evaluation of Yogurt, Septic vs. Imhoff Tank: Effective Solutions for Medium-Strength Domestic Wastewater Treatment, Survey Data on Cooking Oil Preferences: A Case Study in Phnom Penh, Cambodia, The Organic Removal from Medium-Strength Domestic Wastewater by Using Various Types of Locally Made Effective Microorganism Mudballs, and Molecular Genetic Identification of Escherichia coli O157:H7 Isolated from Fresh Vegetables in Phnom Penh. The following section is composed of state-of-the-art research including Designing a chlorine dioxide self-generating film as active packaging of cherry tomatoes' shelf life during storage and Enhanced Facial Emotion Recognition: Analyzing Facial Points Using Machine Learning Techniques. Finally, this issue is preceded by a contribution in the STEM Careers section by VP Start.

This issue was thoroughly screened to ensure academic quality and integrity. On behalf of the editor team, we would like to extend our sincerest gratitude to the authors, reviewers, and NISTI officials for their cooperation and generosity. We welcome readers to read the entire issue online via the Ministry of Industry, Science, Technology, & Innovation

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SCIENTIFIC FINDINGS

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Development of Gamma-Aminobutyric Acid-Enriched Functional Yogurt Using Lactic Acid Bacteria

Vann Kimroeun

Master's Degree

Industrial Biotechnology

Khon Kaen University, Thailand

Hov Tavann

Bachelor's Degree

Food Chemistry

International University, Cambodia

Keo Inou

Bachelor's Degree

Food Chemistry

International University, Cambodia

Highlight

- A functional yogurt enriched with gamma-aminobutyric acid (GABA) was successfully developed.
- Fermentation was carried out using a mixed culture of *L. bulgaricus* NBRC111149, *S. thermophilus* NBRC13953, and *P. pentosaceuse* L01903.
- ImageJ software was used for semi-quantitative analysis of GABA content via thin layer chromatography (TLC).

1. Introduction

Yogurt is defined as fermented milk based on the association of lactic acid bacteria (LAB). It helps improve the function of digestive system and reduces the risk of cancers, such as colorectal cancer. Moreover, yogurt provides several other significant health benefits including lowering cholesterol levels and promoting cardiovascular health (Sarıtaş et al., 2024). Because yogurt is naturally made with LAB, it also contains beneficial compounds such as gamma-aminobutyric acid (GABA), vitamin B and exopolysaccharide (EPS) (Hussin et al., 2021).

The biosynthesis of GABA occurs mainly through fermentation by microorganisms, especially *Lactobacillus* and *Pediococcus* species (Cui et al., 2020; Xuan et al., 2024). GABA is synthesized from the precursor glutamate by the glutamate decarboxylase, an enzyme which uses vitamin B6 (pyridoxine) as a coenzyme. GABA is considered as a neurotransmitter which known as a chemical messenger in the brain. It slows down the brain activities by blocking specific signals in the central nervous system. GABA is known for producing a calming effect. It's thought to play a major role in controlling nerve cell hyperactivity associated with anxiety, stress and fear (Icer et al., 2024).

Although a wide variety of yogurt products is available on the market, GABA-enriched yogurts are still limited. For instance, in Cambodia, there are currently no yogurt brands that claim to contain GABA, which may be

due to the absence of GABA-producing strains in their formulation. Most of the available products typically highlight benefits of supporting the digestive system, being rich in calcium or vitamin B. However, none appear to emphasize the presence of GABA, which has the potential to reduce stress and improve sleep quality. Therefore, this research was conducted to develop a functional yogurt enriched with GABA through the utilization of a combination of three different strains of LAB.

2. Materials and Methods

2.1 Yogurt Preparation

Lactobacillus bulgaricus NBRC111149 and *Streptococcus thermophilus* NBRC13953 were purchased from the Biological Resource Center, National Institute of Technology and Evaluation (NBRC), Japan. Whereas, *Pediococcus pentosaceuse* L01903 was isolated by Faculty of Science and Technology, International University, Cambodia. The fresh milk used in this study was purchased from a commercial brand, and whole milk powder was obtained by lyophilizing the fresh milk using freeze dryer, in order to increase the solid content for yogurt production.

The samples were prepared by supplementing 2%, 3%, 4%, 6% and 8% of whole milk powder and 5% of sucrose in 100 mL of milk, respectively. Then, each sample was warmed at 63°C for 30 min. After that, starter cultures of *L. bulgaricus* NBRC111149, *S. thermophilus* NBRC13953, and *P. pentosaceuse* L01903 were inoculated into each sample at a concentration of 9 log CFU/mL with in a volume ratio of 1:1:5. The inoculated samples were subsequently incubated at 37°C until the pH dropped to 4.5 (Liu et al., 2024; Priadi et al., 2020).

2.2 Determination of GABA in Yogurt Production

Two grams of sample were homogenized with 4 ml of 4% (v/v) acetic acid and mixed for 1h at ambient temperature. The supernatant was collected after centrifuge at 4000 rpm for 15 min. 2μL of the sample was spotted onto thin layer chromatography (TLC) (Silica gel 60 F254). The mobile phase was prepared with n-butanol, acetic acid, and deionized water in a volume ratio of 4:1:1. The TLC plate was developed until the solvent front reached about 1cm from the top edge. After development, the plate was left to air-dry and then sprayed with 0.5% (w/v) ninhydrin. The sprayed plate was then heated in an oven at 90 °C for 10 min. The concentration of GABA was analyzed using ImageJ software (Vann et al., 2020).

2.3 Statistical Analysis

Results were prepared using Microsoft Excel 2018 and expressed as mean values with standard deviations (mean ± SD), calculated from triplicate trials. Statistical significance was evaluated by one-way analysis of variance (ANOVA) using SPSS software.

3. Results and Discussion

3.1 Yogurt Preparation

The yogurt production was successfully produced after 72h by using a mixed starter culture of *L. bulgaricus* NBRC111149, *S. thermophilus* NBRC13953, and *P. pentosaceuse* L01903 at a volume ratio of 1:1:5 (v/v/v). The optimal formulation consisted of 3% milk powder and 5% sucrose, as shown in Figure 1.

After 72 h of fermentation, the pH of the yogurt decreased to approximately 4.5. This pH drop indicates that acidic conditions significantly influenced yogurt production through an acid-induced precipitation mechanism

(Wang et al., 2025). During fermentation, LAB has metabolized carbohydrates in the milk, and then produced large amount of lactic acid which was resulted in the pH drop. The decrease of pH could make the milk protein to coagulate and even curd when the pH of the milk was close to the isoelectric point (PI) value. Therefore, protein molecules lost their net charge and began to aggregate and precipitate. This process is responsible for the thickening of milk and the characteristic gel structure of yogurt (Sumi et al., 2023).

However, higher concentrations of whole milk powder (4%, 6%, and 8%) can lead to excessively thick or
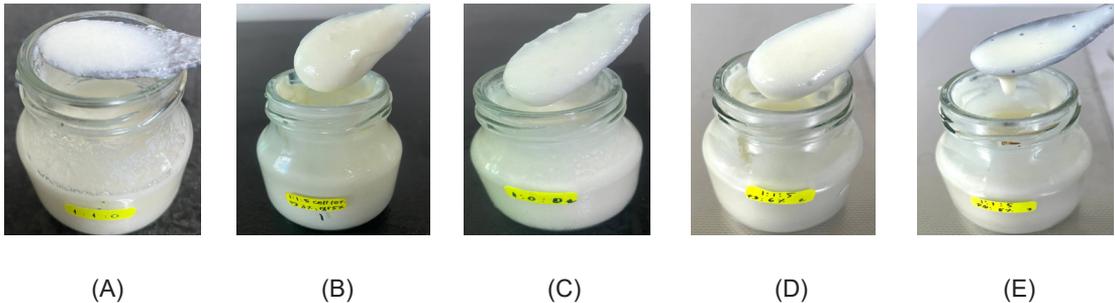

| (A) | (B) | (C) | (D) | (E) |

Figure 1. Appearance of yogurt after 72 h of fermentation. Sample A, B, C, D, and E correspond to the formulations supplemented with 2%, 3%, 4%, 6%, and 8% (w/v) whole milk, respectively.

gummy textures, which may not be desirable for all yogurts. On the other hand, lower concentrations (e.g., 2%) may produce the yogurt that is too runny or lacks creaminess (Arab et al., 2023). A 3% addition of whole milk powder strikes an optimal balance between viscosity and smoothness.

3.2 Determination of GABA in Yogurt Production

The images obtained from TLC paper were used to calculate the concentration of GABA by Image J software. Figure 2A shows the spot of GABA on TLC compared to the control sample which consisted only of the pasteurized milk. The result indicated that the control sample contained no detectable GABA, whereas yogurt fermented with a mixed starter culture for 72 h contained approximately 179.99 mg/L (equivalent to about 18 mg/ 100 mL) of GABA. The increase of GABA levels in yogurt is attributed to the decarboxylation of glutamic acid catalyzed by glutamate decarboxylase (Vann et al., 2020).

However, this concentration was lower than that reported in the previous studies (Anawachkul & Jiamyangyuen, 2009; Fan et al., 2023; Hussin et al., 2021). The GABA content in yogurt depended on the amount of glutamate decarboxylase produced during fermentation. Different LAB strains produced varying level of this enzyme, resulting in different GABA concentration (Yogeswara et al., 2020).

4. Conclusion

This study successfully demonstrated the potential of using a mixed culture of LAB strains to produce GABA-enriched yogurt. The fermentation process, supplemented with 3% whole milk powder and 5% sucrose, yielded a significant GABA concentration of 179.99 mg/L after 72 h. It was also highlight the effectiveness of this LAB combination not only in yogurt fermentation but also in enhancing the functional value through a hundred percent of natural GABA production. In short, these results provided a solid foundation for the manufacturing of GABA-enriched yogurt, offering an economical approach to producing a probiotic-rich dairy food with potential health effects, such as stress reduction and sleep improvement.
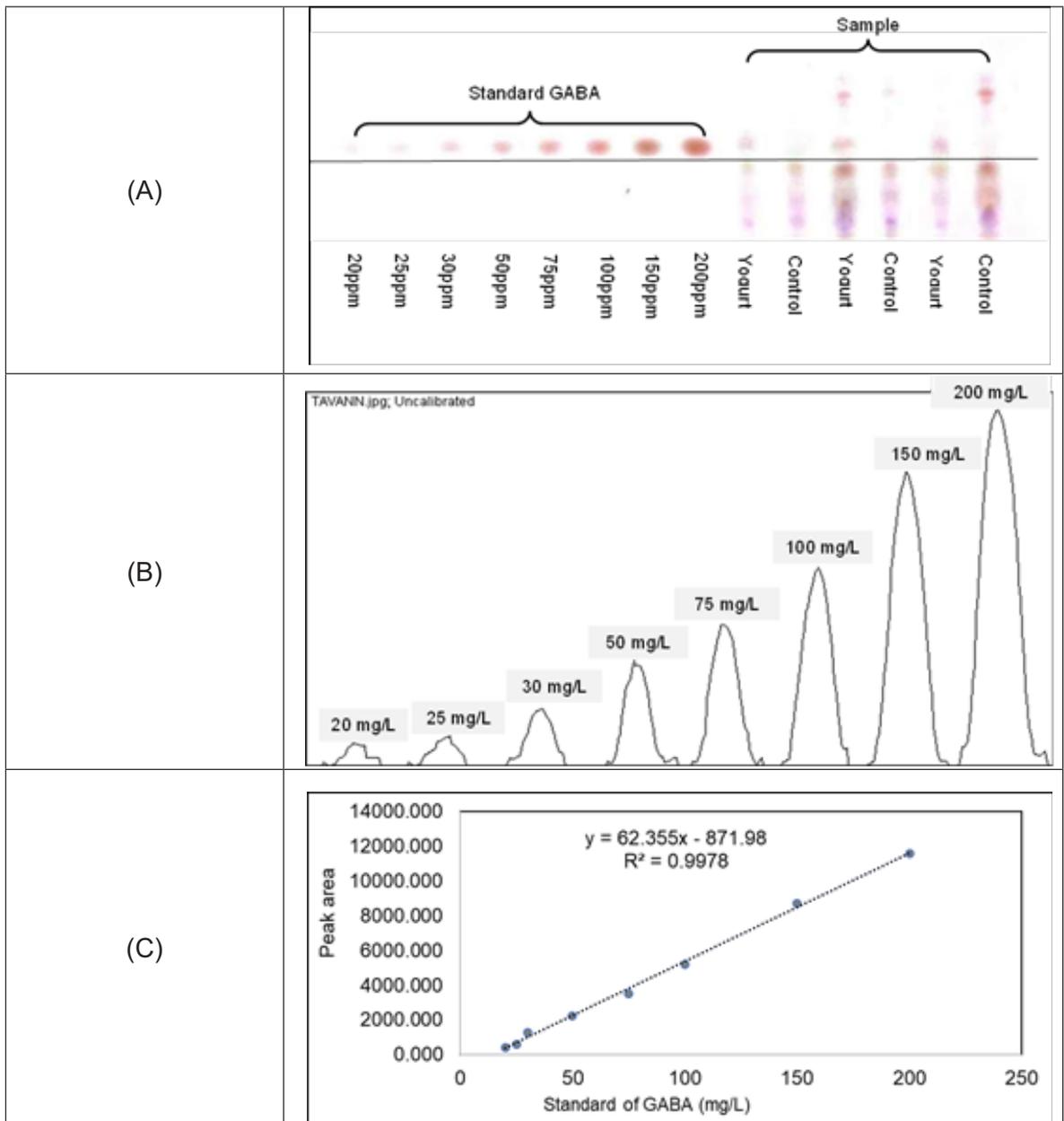
Figure 2. Determination of GABA using ImageJ software. (A) spot of GABA on Thin layer chromatography (TLC) (B) Peak area analysis generated by ImageJ Software (C) Calibration curve of GABA.

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Mrs. Vann Kimroeun is currently a head of Food Chemistry Program at Faculty of Science and Technology, International University, Cambodia. She earned her master's degree in Industrial Biotechnology from Khon Kaen University in Thailand in 2020. Her research interests focus on (1) Food Production, (2) Food Nutrition, and (3) Food Safety.

Foodborne Pathogen Contamination in Fermented Vegetables Sold in Cambodian Markets: A Screening Study

Vuth Sireyvathanak

Master's Degree

Biological Science

Ajou University, Republic of Korea

Doep Sreydy

Master's Student

Microbiology

Royal University of Phnom Penh, Cambodia

Hun Sreymom

Master's Degree

Food Science and Technology

Mae Fah Laung University, Thailand

Ung Sivlin

Master's Degree

Biotechnology

King Mongkut's University of Technology, Thailand

Huoy Laingshun

Ph.D. Candidate

Biomedical Science

Swedish University of Agriculture Sciences, Sweden

Highlight

- Our study evaluated *Salmonella* spp. and *Escherichia coli* prevalence in Cambodian fermented vegetables.
- *E. coli* and *Salmonella* spp. were positive in 70% of the samples collected, with contamination levels ranging from 0.98 to 3.98 ± 1.37 log CFU/g for *E. coli* and 0.20 to 4.74 ± 0.55 log CFU/g for *Salmonella* spp.
- These contamination levels pose a potential health risk, particularly to vulnerable populations.
- No significant differences were observed in contamination levels among samples from different provinces, nor between *E. coli* and Salmonella spp.
- While the direct plate count method may have certain accuracy limitations, the presence of these pathogens in ready-to-eat (RTE) foods raises concerns regarding food safety in Cambodia.

1. Introduction

Cambodian fermented vegetables are a staple food in local cuisine, traditionally made through natural salt fermentation or leftover fish brine to enhance flavor. In the Cambodian context, most fermented vegetables are considered ready-to-eat (RTE) foods, typically consumed without further cooking or preparation (Surya, 2024). Common varieties include pickled cucumbers, mustard greens, wild spider flowers (mormeanh), and papaya (Chrun et al., 2017; Surya, 2024). Fermentation extends shelf life, enhances taste, and provides probiotics, but poor management and hygiene can promote pathogenic bacterial growth (Tan et al., 2024). Foodborne pathogens like *Salmonella* spp. and *E.* coli pose major health risks in Cambodia, where food

safety regulations are still developing (Schwan et al., 2021). A study found a high prevalence of *Salmonella* spp. at 48.4% (138/285) among fresh food products in Phnom Penh, with meats at 71% (53/75), seafood at 64% (32/50), and vegetables at 33% (53/160), respectively (Huoy et al., 2024). Poor hygiene along the food chain highlights the need for better safety measures. In fermented vegetables, *E. coli* indicates fecal contamination and potential pathogenic risks, especially with multidrug-resistant strains (Chrun et al., 2017). However, data on *Salmonella* and *E. coli* in Cambodian fermented vegetables remain scarce.

This study aimed to assess the prevalence of *Salmonella* spp. and *E. coli* in four types of fermented vegetables collected from four provinces Kampong Cham, Kampong Thom, Kandal, and Kampong Speu, Cambodia. The selected location is based on its reputation for producing these fermented foods and its convenient proximity for transporting samples to the laboratory. Understanding contamination of the foodborne pathogen level provides critical insight into the food safety risks of Cambodian fermented vegetables and the broader food ecosystem.

2. Materials and Methods

2.1 Study Area

Samples were collected from four key Cambodian provinces—Kampong Cham, Kampong Thom, Kandal, and Kampong Speu—to represent diverse market practices. Using a cross-sectional approach, 55 fermented vegetable samples were obtained from at least three local markets per province. Samples were purchased directly from random selection vendors. To avoid cross-contamination, the exterior of each sample package was disinfected with 70% ethanol, and stored in a cool box with ice packs for transportation to RUPP laboratory before being analyzed. Table 1 provides a summary of the sampling details, with the sample sizes varying based on the availability of each sample type during the sampling period.

Table 1. Overview of fermented vegetable samples collected from markets across four Cambodian provinces

Sample types	No. of Samples collected in each province				Total no. of samples
	Kampong Thom (KTH)	Kampong Cham (KCH)	Kampong Spue (KSP)	Kandal (KD)	
Fermented Wild spider flower (WSF)	5	3	1	3	12
Fermented Papaya (FP)	5	3	2	3	13
Fermented Cucumber (FC)		3	3	3	9
Fermented Green mustard (FGM)	4	3	6	3	16
Total no. of samples	14	12	12	12	**50**

2.2 Microbiological Analysis

Direct plate count method was used to detect *E. coli* and *Salmonella* spp. in fermented foods under modified conditions (Malorny et al., 2008; O'Brien et al., 2005). 25g of small cutting pieces of the fermented sample was mixed with 225ml buffer peptone water (BPW, Sigma-Aldrich Chemie GmbH, Taufkirchen, Germany), and pre-enrich in an incubator shaker at 37°C for 6 hours for bacterial recovery, then serial dilution (from 10^0 to 10^{-5}). Three selected concentrations (10^0, 10^{-3}, 10^{-5}) were plated on MacConkey Agar (MA, Sigma-Aldrich, Darmstadt, Germany) and incubated at 37°C for 18 hrs. *E. coli* ATCC 25922 and *Salmonella enterica* subspecies *enterica* serotype Typhimurium ATCC 14028 were used as positive control. Colonies plate count

based on colonies morphology and color indicator as instructed in the media manual. *E.* coli appears as pink/red colonies, while *Salmonella* forms colorless colonies. Colony counting determines microbial contamination

Figure 1: Direct Plate Count Method for Detecting *E.* coli and *Salmonella* spp. in Fermented Vegetable Samples.

2.3 Statistical Analysis

Data were analyzed using JASP statistical software. To compare the levels of *E. coli* and *Salmonella* spp. within the same province, a paired sample t-test was performed. This test assessed whether there was a significant difference in the concentrations of the two bacterial species within each province. To evaluate differences in bacterial concentrations between provinces, a one-way analysis of variance (ANOVA) was conducted. The assumptions of normality for the t-test and ANOVA were checked prior to analysis. All tests were conducted at a significance level of 0.05. Results were considered statistically significant when $p < 0.05$.

3. Results and Discussion

Prevalence of *E.* coli and *Salmonella* spp. in fermented food samples

Table 2 and Figure 2 present the prevalence, concentration, and geographic variation of *E.* coli and *Salmonella* spp. in fermented food samples from Cambodia. Analysis of four fermented food types—wild spider flower (WSF), cucumber (FC), green mustard (FGM), and papaya (FP)—revealed widespread microbial contamination, with *E.* coli and *Salmonella* spp. each detected in 70% of 55 samples. *E.* coli levels ranged from 0.98 to 3.98 ± 1.37 log CFU/g, while *Salmonella* spp. ranged from 0.20 to 4.74 ± 0.55 log CFU/g.

Contamination varied by province, with *E. coli* was reported the highest in Kandal (3.98±1.37 log CFU/g) and lowest in Kampong Cham (>0.98 log CFU/g), while *Salmonella* spp. peaked in Kampong Speu (4.74±0.55 log CFU/g) and the lowest was in Kandal (<1 log CFU/g). However, statistical analysis revealed no significant differences ($p > 0.05$) in contamination levels across food types, sampling locations, or bacterial species, with a paired sample t-test used to compare *Salmonella* to *E. coli* within the same province and a one-way ANOVA applied to compare contamination levels between provinces, indicating a consistent microbial risk across all samples.

Table 2. Prevalence and Contamination Levels of *E. coli* and *Salmonella spp.* in Various Fermented Vegetable Samples from Different Provinces.

Sample Type	Fermented Wild spider flower-WSF (pos/total)		Fermented Cucumber-FC (pos/total)		Fermented Green mustard-FGM (pos/total)		Fermented Papaya-FP (pos/total)	
Province	*E.* coli pos/total (log CFU/g)	*Salmonella* spp. pos/total (log CFU/g)	*E.* coli pos/total (log CFU/g)	*Salmonella* spp. pos/total (log CFU/g)	*E.* coli pos/total (log CFU/g)	*Salmonella* spp. pos/total (log CFU/g)	*E.* coli pos/total (log CFU/g)	*Salmonella* spp. pos/total (log CFU/g)
Kampong Thom (KTH)	5/5 (1.61±2.15)	3/5 (4.36±1.16)	4/5 (2.62±1.50)	4/5 (1.91±1.60)	1/4 (1.81)	1/4 (0.56)	5/5 (1.85±1.66)	4/5 (2.90±1.56)
Kandal (KD)	3/3 (3.98±1.37)	3/3 (3.41±1.16)	3/3 (2.00±2.40)	2/3 (2.81)	1/3 (1.55)	1/3 (0.20)	3/3 (2.22±1.64)	2/3 (2.74±0.09)
Kampong Spue (KSP)	1/1 (1.7)	1/1 (3.59)	2/3 (3.72±1.52)	3/3 (4.74±0.55)	1/6 (1.79)	6/6 (4.62±0.82)	2/2 (TNTC)	2/2 (4.05±0.29)
Kampong Cham (KCH)	1/3 (0.98)	1/3 (0.56)	3/3 (1.55±0.48)	3/3 (1.66±0.11)	1/3 (1.33±0.45)	0/3 (N/A)	3/3 (2.58±1.43)	3/3 (2.46±0.99)
Total	**10/12 (2.32±1.29)**	**8/12 (2.98±1.67)**	**12/14 (2.47±0.94)**	**12/14 (2.78±1.40)**	**4/16 (1.62±0.23)**	**8/16 (1.79±2.45)**	**13/13 (2.22±0.37)**	**11/13 (2.70±0.22)**

*Note:
- CFU/g: Colony-Forming Units per gram – represents the number of viable bacteria in one gram of sample.
- N/A (Not Detectable): Indicates no visible bacterial colonies on the plate, suggesting bacterial levels are below the detection limit.
- TNTC (Too Numerous to Count): Refers to excessive bacterial growth, typically observed on plates from dilutions less than 10^{-5}.
- Pos: Denotes the number of positive samples detected out of the total number tested under each condition.

The detected levels of *Escherichia coli* and *Salmonella* spp. in the fermented vegetable samples surpass the microbiological safety standards established by the European Union (EU), the Codex Alimentarius, and other international regulatory bodies. Specifically, *Salmonella* spp. should be absent in 25 grams of ready-to-eat (RTE) foods, according to EU regulations. Similarly, the Codex Alimentarius sets the same standard for *Salmonella* spp. in RTE foods. Regarding *E. coli*, the EU considers its presence in RTE foods as an indicator of poor hygiene practices, although specific limits may vary depending on the food category. The U.S. Food and Drug Administration (FDA) also requires the absence of *Salmonella* spp. in 25 grams of RTE foods (Dias Costa et al., 2023; FDA, 2019; Food and Drug Administration, 2015; Yohans et al., 2022).

Cambodia, as an ASEAN member, aligns its food safety standards with the Codex Alimentarius, following its microbiological criteria and guidelines to ensure food safety and regulatory consistency within the region (FAO/WHO, 2015; FDA, 2019). The detected levels in our study, ranging from 0.98 to 3.98 ± 1.37 log CFU/g for *E. coli* and 0.20 to 4.74 ± 0.55 log CFU/g for *Salmonella* spp., exceed these safety standards, indicating a significant public health concern.

A concentration of 1–2 log CFU/g may not harm healthy individuals but poses serious risks to vulnerable populations, potentially causing severe illnesses (Elbehiry et al., 2023). Chronic exposure can lead to long-term health issues like irritable bowel syndrome (IBS), reactive arthritis, and antimicrobial resistance (AMR) (Zha et al., 2019). The presence of E. coli and *Salmonella* spp. in fermented foods suggests hygiene lapses, inadequate fermentation control, or post-production contamination, requiring urgent intervention (Chrun et al., 2017). Strengthening quality control through GMP, HACCP, and routine microbial testing is essential to ensuring the safety of fermented foods in Cambodia. Additionally, education on microbial contamination, along with training programs on best practices for home-based food business owners and small-scale food producers, is essential to promote proper food handling and mitigate contamination risks (Castro et al., 2024).
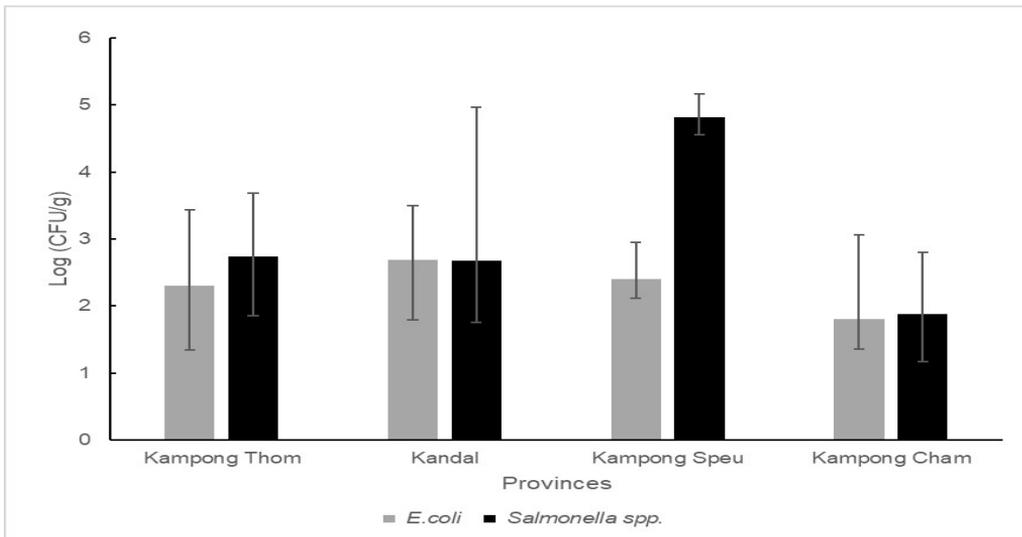

Figure 2. Average Concentration of *E. coli* and *Salmonella* spp. in Each Province.

Data were analyzed using JASP statistical software and compared using a paired sample t-test for the comparison of *E. coli* and *Salmonella* levels within the same province, and a one-way ANOVA for comparison between provinces. The results showed no significant difference between *E. coli* and *Salmonella* spp. levels within the same province ($p > 0.05$), nor between provinces ($p > 0.05$). The X-axis represents the provinces sampled, and the Y-axis displays bacterial contamination levels in Log CFU/g, a logarithmic scale used to express the bacterial concentration in colony-forming units per gram.

4. Conclusion

This study highlights significant microbial contamination in Cambodian fermented vegetables, with *Salmonella* spp. and *Escherichia* coli detected in 70% of all sampled food types across four provinces. It is important to note that detection was carried out using the direct plate count technique, which provides a general indication of contamination levels but has inherent limitations in terms of specificity and sensitivity. For more accurate identification, ISO 6579:2002 is recommended for *Salmonella* spp., while ISO 7251:2005 is the standard for *E.* coli detection. These methods involve multiple steps and utilize highly selective media, offering greater accuracy, though they require substantial resources and funding—often a challenge in resource-limited settings.

Quantitative analysis showed slight variations in microbial concentrations between provinces; however, these differences were not statistically significant. Nonetheless, the findings underscore the urgent need for stricter

food safety regulations, improved hygiene practices, and enhanced microbial control during the fermentation and handling of fermented vegetables. Given the public health risks associated with these pathogens, particularly in ready-to-eat products, immediate action is needed from policymakers and stakeholders to protect consumer health. Special attention should be given to improving safety standards across all levels of the food business ecosystem, including small-scale producers, cottage industries, and homemade food vendors.

Due to limitations in the current study, future cross-sectional research should aim to increase the sample size, broaden the sampling locations, and adopt standardized methods, alongside conducting more detailed risk assessments to generate more robust and actionable insights.

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Mr. Vuth Sireyvathanak is a lecturer and researcher in the Department of Bioengineering, Faculty of Engineering, at the Royal University of Phnom Penh. He holds a Master's degree in Biological Science from the Department of Biological Science, Ajou University, South Korea (September 2024), a Bachelor of Engineering in Bioengineering from the Department of Bioengineering, Faculty of Engineering, Royal University of Phnom Penh, and a Bachelor of Arts in English for Professional Communication from the Department of English, Institute of Foreign Languages, Royal University of Phnom Penh. His research interests encompass food safety, the prevalence of foodborne pathogens, cancer research, drug discovery, water quality, bacteriophage applications, and food product development. Currently, he is pioneering studies on foodborne pathogens, investigating the potential of bacteriophages as a sustainable solution, and developing innovative rice-based products to add value to Cambodia's rice production ecosystem. Through his work, he strives to bridge scientific innovation with real-world impact in public health and food security.

Development of Beetroot Jam for Supplementation in Yogurt

Hun Sreymom

Master's Degree,

Food Science and Technology

Mae Fah Luang University, Thailand

Vong Vannita

Bachelor's Degree

Bioengineering

Royal University of Phnom Penh, Cambodia

Oem Soklinda

Bachelor's Degree

Bioengineering

Royal University of Phnom Penh, Cambodia

Chhay Leaksmy

Bachelor's Degree

Bioengineering

Royal University of Phnom Penh, Cambodia

Highlight

- This study aimed to develop a low sugar jam incorporating Beetroot to promote vegetable-based jams in Cambodia. Additionally, it assessed the sensory and physicochemical properties of the jam over a storage period of 0, 14, and 28 days.
- The optimization process involved developing Beetroot jam using blanching methods with varying sugar concentration of 25, 30, and 35% (w/w). The pH and TSS content are within the standard range, which helps inhibit the growth of microorganisms, and titratable acidity and water activity results of our Beetroot jam offer good quality for consumption or as an ingredient in other products, such as yogurt.
- Following the sensory analysis, the jam prepared with 25% of sugar and added with strawberry and banana aroma (3.33%w/w) were selected as the best formula based on the pH value, titratable acidity, water activity and sensory evaluation.

1. Introduction

Beetroot *(Beta vulgaris L.)* has become increasingly popular as a functional food ingredient due to its nutritional profile. It contains approximately 87.57% water, 9.56% carbohydrates (fiber 29.3%, sugar 70.7%), 1.61% protein, and 0.17% lipids. Additionally, it is a source of essential nutrients such as potassium, choline, vitamin C, betalains and niacin (Ahuja et al., 2015). However, betalains are highly sensitive to factors such as temperature, pH, light, oxygen, and enzymatic activity (Kowalski & Szadzińska, 2014). Jam making, a preservation method ensuring microbial safety, is a promising approach for preserving Beetroot's beneficial compounds This study aims to assess the physicochemical and sensory properties of Beetroot jam formulated with varying aromas and sugar concentrations over the storage period.

2. Materials and Methodology

Fresh beetroot *(Beta vulgaris)* was purchased from Kilo 4 market in Phnom Penh City. All processing steps, including washing, peeling, slicing, and drying, were conducted at the Food Processing Laboratory, Department

of Bio-Engineering, Royal University of Phnom Penh, using food-grade equipment and ingredients. Reagents used for analysis included sodium hydroxide, other are analytical-grade chemicals and received from Bio-Engineering Department.
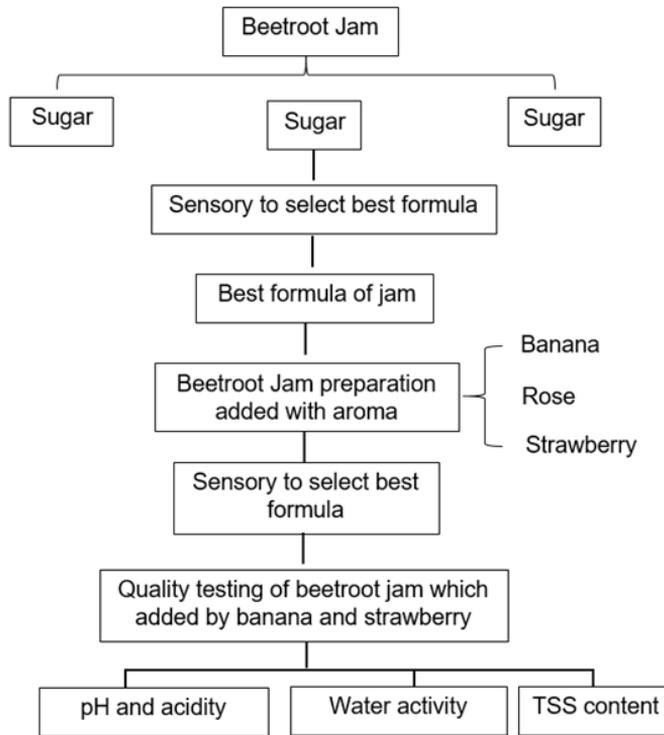

Figure 1. Flow chart of research design

2.1 Beetroot Jam Preparation

The Beetroot was washed, peeled, and cut into pieces around 4-5 cm, and then boiled for 10 minutes. After boiling, it was blended until smooth. The Beetroot was then heated and stirred with water added at a 1:0.25 w/v ratio. Sugar concentrations (25%, 30%, 35%), 2% pectin, and 0.5% citric acid were added as shown in Table 1. The mixture was continuously stirred until it reached a jam-like consistency, with the brix measured between 45-50 °Bx (Perumpuli et al., 2018). All the Beetroot jam samples were store in refrigerator at 4-10 °C. The optimal beetroot jam formulation was prepared based on sensory evaluation. Pectin (2%), citric acid (0.5%), and selected aromas (banana and strawberry) were added to the jam. The best sugar concentration was determined from sensory testing and used in the final formulation.

Table 1. Beetroot jam formulation added with different sugar concentration

Beetroot jam formulations	Ingredients			Ratio water
	Sugar	Pectin	Citric acid	
BRJ-25	25%	2%	0.5%	1:0.25
BRJ-30	30%	2%	0.5%	1:0.25
BRJ-35	35%	2%	0.5%	1:0.25

Table 2. Beetroot jam formulation added with different aromas

Beetroot jam formulations	Ingredients			Ratio water	Aroma
	Sugar	Pectin	Citric acid		
BRJ-B	25%	2%	0.5%	1:0.25	3.33%
BRJ-R	25%	2%	0.5%	1:0.25	3.33%
BRJ-S	25%	2%	0.5%	1:0.25	3.33%

Control; no aroma added, BRJ-B; beetroot jam added with banana aroma, BRJ-R; beetroot jam added with rose aroma, BRJ-S; beetroot jam added with strawberry
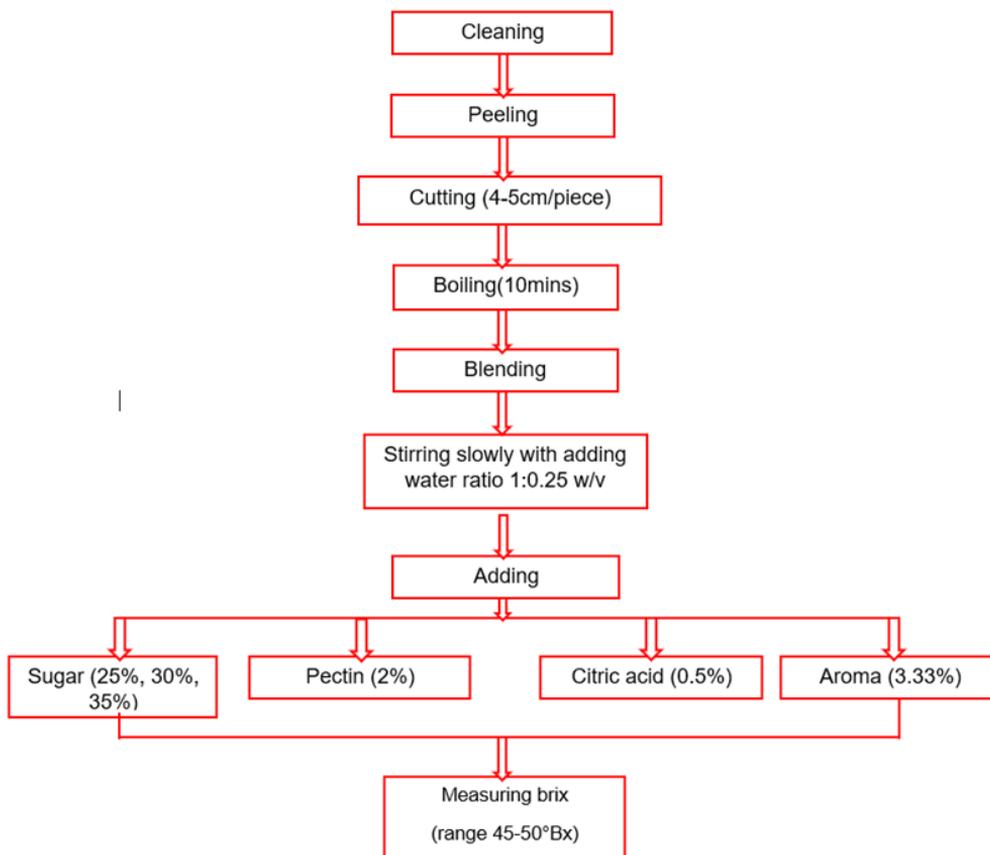
Figure 2. Flowchart of Beetroot Jam Preparation

2.2 Physiochemical Analysis

2.2.1 Total Soluble Solids Content (TSS)

The total soluble solid (TSS) content of raw Beetroot and the jam products were measured using a hand refractometer with slight modifications to the method (Kaur et al., 2022).

2.2.2 pH and Acidity Determination

The pH value was measured using a digital pH meter (Model PHS-2F) following a modified procedure (Nguyen et al., 2014). The acidity value was determined by using titration method (Olugbenga Olufemi Awolu, 2018).

2.2.3 Water Activity

For water activity was measured using water activity analyzer machine (Nguyen et al., 2014).

2.3 Sensory Evaluation

The sensory evaluation was conducted according to Galyuoni using a 7-point hedonic scale with some modification. Fifteen untrained panelists, aged in the range 15-35 years old were selected as panelists and evaluated on the attributes such as color, aroma, taste, sweetness, spread ability, appearance, and general acceptability (Galyuoni, 2022).
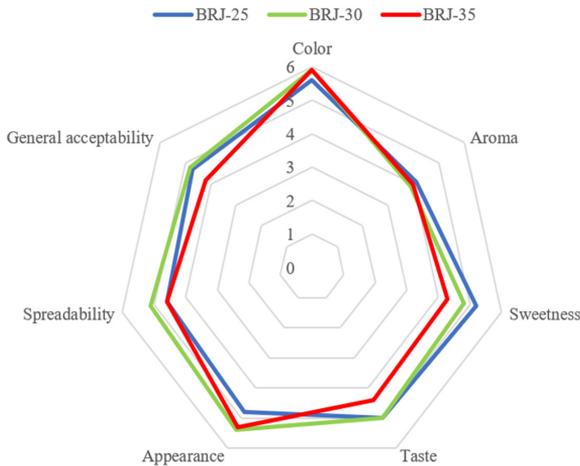

Figure 3. Sensory scores of Beetroot jam with different of sugar concentration

The sensory evaluation results presented in Figure. 3 indicated no significant differences (p>0.05) among all three jam formulations with varying sugar concentrations. However, jam with 30% sugar received the highest preference for most sensory attributes, except aroma, which scored lower compared to BRJ-25 and BRJ-35.

3.1 Sensory Evaluation

The 35% sugar concentration received the lowest preference for all parameters and resulted in an un-spreadable texture. Therefore, the 25% Beetroot jam was chosen as the optimal concentration for aroma evaluation.

The secondary sensory evaluation selected the best artificial aroma for the jam, with the strawberry aroma receiving the highest scores for most attributes and significantly higher general acceptability compared to the rose aroma. Similar studies found that strawberry flavor or aroma enhances consumer acceptability in fruit jams (Uribe-Wandurraga et al., 2021). Thus, the best formulation BRJ-S and BRJ-B were selected for the further study.

3.2 Physiochemical Analysis
3.2.1 TSS

The TSS of the control increased from 49.83°Brix to 50.80°Brix on Day 14, then decreased to 48.23°Brix by Day 28. BRJ-S decreased from 47.33°Brix to 41.30°Brix on Day 14, then control to 51.16°Brix on Day 28. BRJ-B dropped from 47.23°Brix to 44.36°Brix before increasing to 48.50°Brix. According to SLS standards, low sugar jams should have TSS between 45°Bx and 50°Bx. Since the developed jams fall within this range, they can be classified as reduced sugar Beetroot jams (Perumpuli et al., 2018).

3.2.2 pH and Acidity

The pH of all jam samples increased significantly over 28 days. This increase may be due to acid hydrolysis, microbial activity, or ingredient buffering effects. However, all samples remained microbiologically stable (pH < 4.0) due to the inclusion of citric acid and pasteurization process (Uribe-Wandurraga et al., 2021). The acidity fluctuated slightly, with the control stable (0.019 to 0.023), BRJ-S decreasing at Day 14 (0.009) and then increasing, and BRJ-B showing minor variations. These changes could result from organic acid metabolism, ingredient interactions, or microbial activity. Lower acidity can improve preservation and appeal to consumers who prefer sweeter jams (Jribi et al., 2021).

3.2.3 Water Activity (aw)

The water activity of the jam samples showed slight variations, with small fluctuations observed between the different samples. The Control and BRJ-S showed no significant changes (p > 0.05), while BRJ-B exhibited a significant decrease (p < 0.05) Day 28. An aw of approximately 0.9 can result in a softer texture, making the jam more spreadable. Overall, aw values fall within the typical range of 0.82–0.94 for jams and jellies, consistent with the

findings reported by Unribe (2021) (Uribe-Wandurraga et al., 2021). Therefore, our Beetroot jam needs to be refrigerated.

Table 3. Sensory scores of Beetroot jam with different of aromas

Beetroot jam formulations	Parameters						
	Color	Aroma	Sweetness	Taste	Appearance	Spread ability	General acceptability
BRJ-25	6.00 ± 0.8^a	5.00 ± 0.8^a	6.00 ± 1.1^a	5.00 ± 0.8^a	6.00 ± 0.9^a	5.00 ± 1.1^a	6.00 ± 0.8^a
BRJ-30	5.00 ± 0.9^a	3.00 ± 1.6^b	5.00 ± 1.4^a	4.00 ± 1.5^b	5.00 ± 1.1^a	6.00 ± 0.9^a	4.00 ± 1.3^b
BRJ-35	6.00 ± 0.7^a	6.00 ± 1.2^a	6.00 ± 0.8^a	6.00 ± 0.8^a	6.00 ± 0.7^a	6.00 ± 0.8^a	6.00 ± 0.7^a

BRJ-B; beetroot jam added with banana aroma, BRJ-R; beetroot jam added with rose aroma, BRJ-S; beetroot jam added with strawberry aroma. a,b column with different letters are significantly different ($p < 0.05$).

Table 4. TSS content of Beetroot Jam during storage

Beetroot jam formulations	Timeline		
	Day0	Day14	Day28
Control	49.83 ± 0.05^c	50.80 ± 0.17^b	48.23 ± 0.05^a
BRJ-S	47.33 ± 0.30^c	41.30 ± 0.00^b	51.16 ± 0.05^a
BRJ-B	47.23 ± 0.15^c	44.36 ± 0.25^b	48.50 ± 0.30^a

Different superscripts (a–c) within the same row denote significant differences ($p < 0.05$)

Table 5. pH of Beetroot jam during the storage

Beetroot jam formulations	Timeline		
	Day0	Day14	Day28
Control	2.60 ± 0.02^c	3.35 ± 0.02^b	3.40 ± 0.02^a
BRJ-S	2.62 ± 0.01^c	3.37 ± 0.01^b	3.42 ± 0.00^a
BRJ-B	2.29 ± 0.01^c	3.20 ± 0.01^b	3.27 ± 0.00^a

Table 6. Titratable acidity of Beetroot jam during the storage

Beetroot jam formulations	Timeline (%)		
	Day0	Day14	Day28
Control	0.02 ± 0.01^a	0.02 ± 0.00^a	0.02 ± 0.00^a
BRJ-S	0.01 ± 0.00^a	0.01 ± 0.00^a	0.01 ± 0.00^a
BRJ-B	0.02 ± 0.01^a	0.03 ± 0.01^a	0.02 ± 0.01^a

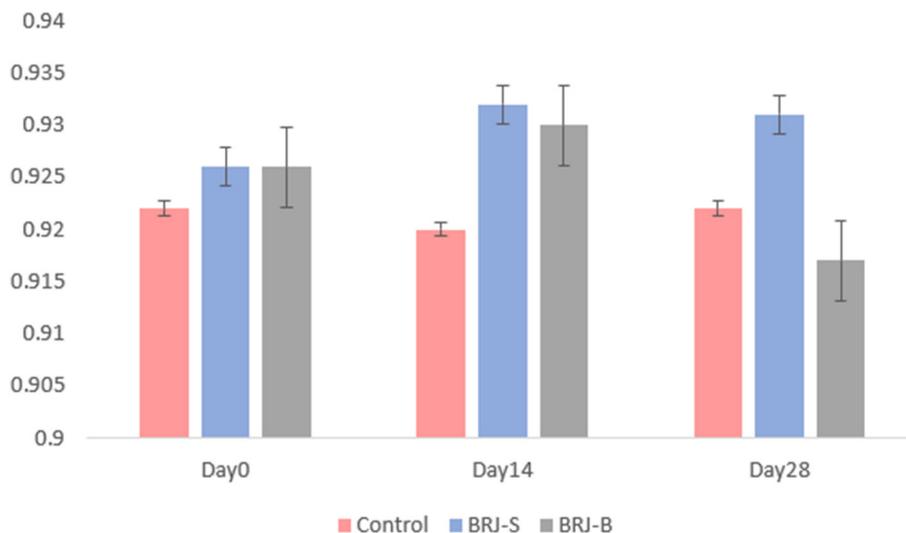* Superscripts (a–c) in the same row indicate significant differences ($p < 0.05$)

Figure 4. Water activity values of beetroot jam during 28 days of storage.
Different letters on bars indicate significant difference (p < 0.05) of the same sample at different day

4. Conclusion

In conclusion, based on the sensory analysis, the jam prepared with 25% of sugar and infused with strawberry and banana aroma (3.33% w/w) was selected as the best. pH and TSS content of Beetroot Jams were within the standard range, which helps inhibit the growth of microorganisms, and titratable acidity and water activity results offered good quality for consumption or as an ingredient in other products, such as yogurt. The product is expected to remain safe and suitable for consumption for more than 28 days under proper storage conditions.

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Ms. Hun Sreymom is currently a lecturer and researcher at the Faculty of Engineering, Department of Bio-engineering. Her research focuses on food product development from agricultural waste (waste utilization), applied microbiology, food safety, and sensory evaluation in food quality control and food product development. She earned her M.Sc. degree in Food Science and Technology from Mae Fah Luang University in Chiang Rai, Thailand, in 2021, after completing her B.Sc. in Bio-Engineering at the Royal University of Phnom Penh, Cambodia, in 2018. She completed her M.Sc. thesis research on "The Effect of Pineapple Waste on the Quality Attributes of Frozen Yogurt," which was supported by a scholarship from the Thailand Scholarship Program. In 2015, she was selected to participate in an exchange cultural program at Fukuoka University in Japan. In 2017, she attended the PEACE Kickoff Symposium at Hiroshima University in Japan. Later that year, she was accepted into the Global Internship Program at the Gwangju Institute of Science and Technology (GIST) in Gwangju, South Korea.

Survey Data on Cooking Oil Preferences: A Case Study in Phnom Penh, Cambodia

Mich Monika

Master's Degree

Agro-industrial Engineering

Institute of Technology of Cambodia, Cambodia

Tan Reasmey

PhD

Bioengineering

Tokyo Institute of Technology, Japan

Kong Sela

Master's Degree

Chemical Engineering

Gadjah Mada University, Indonesia.

Say Manit

Master's Degree

Food Technology

Khon Kaen University/,Thailand

Phal Sivchheng

Master's Degree

Environmental Design

Kanazawa University, Japan

Highlight

- Most of the respondents prefer cooking oil produced from soybeans over other types of oils.
- Retail stores are the preferred place to purchase cooking oil due to their convenience.
- The study provides valuable analysis on the behaviors and preferences of consumers relating to cooking oil.
- These insights can be used to guide the development and marketing of cooking oil in local markets and supermarkets

1. Introduction

Cooking oils are usually extracted from the seeds, kernels, or mesocarp of plant fruits (Ng et al., 2018). Cambodia is an agricultural country that has the possibility of cooking oil production. However, cooking oils sold in the market are still being imported from different foreign countries including Thailand, Vietnam, China, Indonesia, Malaysia, and others (Theary et al., 2013). Based on the observation, many brands of cooking oils have been sold in Cambodia, yet there are no case studies about the information on consumer preference and consumption of those cooking oils. Therefore, this study conducted an online survey to seek basic information related to cooking oil consumption, purchasing, and factors affecting consumer preferences by Cambodians in Phnom Penh, Cambodia.

2. Methodology

The online survey was conducted from 15 March until 20 May 2021. The specifications of the survey design are shown in Table 1. Data from the online survey was imported into the Statistical Package for Social

Science (SPSS) Version 20.0. (SPSS Inc., Chicago, IL, USA). Descriptive statistics were provided for all variables, such as the calculated percentage and the validated percentage (Goldsmith et al., 2010; Phan & Chambers, 2018; Salazar-Ordóñez et al., 2018).

Table 1. Specifications of survey data

Subject	Food preferences
Specific subject area	Consumer preferences
Type of data	Tables, Chart
How the data were acquired	Online survey
No. of latent variable	9
No. of observed variable	60
Data collection	Data was collected using an online survey technique by using a Google form to design an online questionnaire. To collect the data, the survey link was published on Facebook and was also sent directly through Messenger, Telegram, and E-mail, achieving the current situation of cooking oil brands and consumption in Phnom Penh, Cambodia.
Data source	Institute of Technology of Cambodia, Phnom Penh, Cambodia Big city - more than 2,000,000 habitants, Phnom Penh, Cambodia Latitude and longitude from the Institution: 11.570355448529629, 104.89828954455056

3. Results and Discussion

Table 2 presents the profile of respondents followed by gender, age, family size, and status of cooking oil use involved with 9 subscales. From the survey with 1,000 respondents, 64% of respondents were female. They were mostly aged between 15 to 24 years old which represents 57.8% of the total respondents and 42.2% were age between 25 to 64 years old. Small families which refer to families with 1 to 4 members were 53.9%, while large families were 46.1%. In terms of the status of cooking oil use, 98.3% of the respondents used cooking oil to cook food in their daily life.

Table 2. Profile of respondents

Total respondents, n = 1000	Characteristics	n	p (%)
Sex	Female	640	64
	Male	360	36
Age	18-24 years-old	578	57.8
	25-64 years-old	422	42.2
	≥ 65 years-old	0	0
Family size	1-4 people	539	53.9
	≥ 5 people	461	46.1
Status of cooking oil use	Use	983	98.3
	Not use	17	1.7

Table 3 shows the household consumption behavior of respondents. As a result, it showed that 33.2% of respondents used cooking oil every day, 36.7% used 4-5 times per week, 27.6% used 2-3 times per week, and only 2.5% used 1 time per week. Moreover, the respondents who used cooking oil for stir-frying, pan-frying, and deep-frying were 94.7%, 93.9%, and 65.9%, respectively. The consumption behavior of cooking oil is influenced by many factors, especially family size and the education of the head of the family (Ali et al., 2013). Based on the finding, almost 50% of the respondents live in large families and there are only 33.2% of the respondents used cooking oil every day.

Table 3. Household consumption behavior of respondents

Total respondents, n = 983				
Latent	**Observed variables**	**n**	**p (%)**	**Vp (%)**
Frequency of consumption [Ss]	Daily	322	32.8	33.2
	4-5 times per week	356	36.2	36.7
	2-3 times per week	267	27.2	27.6
	1 time per week	24	2.4	2.5
	Mv	14	1.4	-
Using purpose [Ms]	Stir-frying	937	95.3	95.3
	Pan-frying	923	93.9	93.9
	Deep-frying	648	65.9	65.9
	Other	21	2.14	2.14

Note: n: number of respondents selected to observed variables; p: percentage; Vp: valid percentage (percentage of excluding missing value); Mv: missing value; Ss: single-select; Ms: multi-select

Table 4 shows the purchasing behavior of respondents on cooking oils products. As a finding, the frequency of purchasing cooking oil of respondents was different. There were 49.2% of respondents purchased cooking oil once a month and followed by 29.1% who purchased more than once a week, 14% who purchased more than once a month, and only 6.9% who purchased cooking oil less than once a month. Moreover, most respondents usually bought cooking oil from retail stores (73.5%), markets (39.8%), supermarkets (34.8%), marts (18.7%), and wholesale stores (16.2%). The volume of the bottle of cooking oil and its design of the bottle was essential for consumers to attract as it was an innovative product (Goldsmith et al., 2010). As a result of the survey, 42.8% of respondents purchased cooking oil 1L per time and followed by 500mL (19.6%), 750mL (13.3%), 1.5L (22.8%), and 2L (20.1%).

Table 4. Purchasing behavior of respondents

Total respondents, n = 983				
Latent	**Observed variables**	**n**	**p(%)**	**Vp (%)**
Frequency of Purchasing [Ss]	4 times per week	75	7.6	7.7
	3 times per week	43	4.4	4.4
	2 times per week	71	7.3	7.3
	1 time per week	96	9.8	9.8
	1 time per month	484	49.2	49.6
	> 1 time per month	138	14.0	14.2
	< 1 time per month	68	6.9	7.0
	Mv	8	0.8	
Purchasing location [Ms]	Retail store	723	73.5	73.5
	Wholesale store	159	16.2	16.2
	Supermarket	342	34.8	34.8
	Market	391	39.8	39.8
	Mart	184	18.7	18.7

	< 100 mL	20	2.0	2.0
	250 mL	92	9.4	9.4
	350 mL	52	5.3	5.3
	500 mL	193	19.6	19.6
	750 mL	131	13.3	13.3
Volume of purchase per time	1000 mL	421	42.8	42.8
	1500 mL	224	22.8	22.8
	2000 mL	198	20.1	20.1
	3000 mL	45	4.6	4.6
	4000-5000 mL	75	7.6	7.6
	> 5000 mL	20	2.0	2.0

n: number of respondents selected to observed variables; p: percentage; Mv: missing value; Vp: valid percentage (percentage of excluding missing value); Ss: single-select; Ms: multi-select
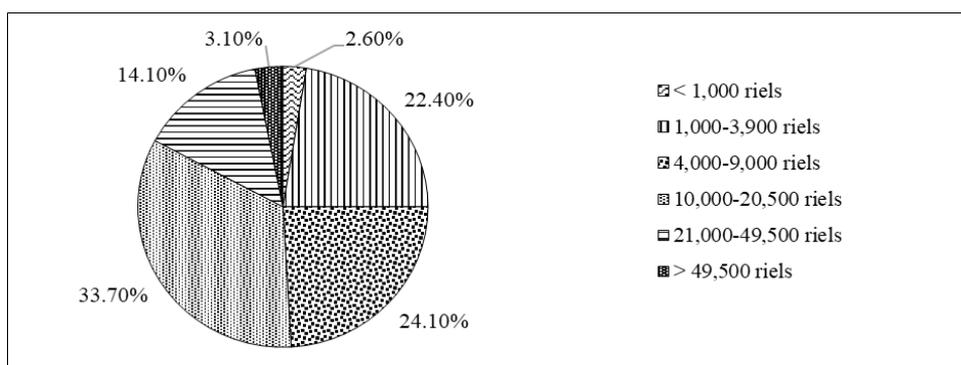

Figure 1. Expense for purchasing cooking oil per time

The expense for purchasing cooking oil per time by the respondents is presented in Fig. 1. Based on the survey results, the expense for purchasing cooking oil per time varied. The respondents who spent 10,000-20,500 riels, 4,000-9,000 riels, 1,000-3,900 riels, and 21,000-49,500 riels per time were 33.7%, 24.1%, 22.4%, and 14.10%, respectively. Thus, the purchasing behavior of consumers is related to consumer behavior and the price also influences purchasing behavior (Narayana et al., 2014). As an agreement, the most frequency of purchasing cooking oil is once a month with a 1L bottle of cooking oil. The frequency and volume of cooking oil which was purchased per time were influenced by household consumption behavior such as using frequency, cooking method, and family size. Moreover, the retail store is the most popular location to purchase cooking oil. The main reason for using retail store service is that it is convenient. Normally, the retail store is easy to find and near the house, because there are many stores in the area (Kumar & Agrawal, 2024) .

Table 5 presents the factors that affected the preferences of respondents for cooking oils. There are many factors affecting household preferences for cooking oil, especially oil brands, aspects preferred, and preferred oil types (Siddiqui et al., 2013; Narayana et al., 2014). In Cambodia, there are many brands of cooking oils sold in the markets. However, only 8 brands of cooking oil that were preferred by the respondents.

Based on the data of the survey, the most popular oil brand is Pb1 which was presented for 82.3%. While Pb2 and Pb3 were presented for 20.75% and 6.1%, respectively. In terms of aspects preferred, the consumers

generally give preference to health benefits (78.2%) and oil quality (76.3%) when it comes to cooking oil. They also give preference to the price (47.1%), packaging (33.3%), and quantity of oil (21.0%) while purchasing cooking oil. However, advertising does not have a significant influence on buyers. Moreover, the most preferred cooking oil is soybean oil which was presented for 78.54% and followed by sunflower oil (30.62%) and olive oil (23.19%). Based on these results, it showed that the popularity of Pb1 and Pb2 was because they were produced from soybean seeds. The main benefits of soybean oil are its high smoking point, which makes it suitable for cooking at high temperatures, its high content of polyunsaturated fats, which are linked with lower cholesterol levels and a lower risk of heart disease, and its presence of omega-3 fatty acids, which are necessary for maintaining good health and preventing chronic disease. Furthermore, compared to palm oil, soybean oil often provides a more neutral flavor profile, which enhances the taste of other ingredients. It is also typically higher in vitamin E, an important antioxidant. Additionally, in many regions, soybean oil is more readily available and cost-effective. While palm oil also has a high smoke point, these additional factors contribute to the widespread preference for and use of soybean oil (Link & Jillian, 2020).

Table 5. Factors affecting the preferences of respondents on cooking oil

Total respondents, n = 983				
Latent	Observed variables	n	p(%)	Vp(%)
Preferred brand [Ms]	Healthy Chef (Pb$_1$)	808	82.2	82.2
	Simply (Pb$_2$)	204	20.6	20.6
	Oleen (Pb$_3$)	60	6.1	6.1
	Sunpark (Pb$_4$)	37	3.8	3.8
	Family Choice (Pb$_5$)	35	3.6	3.6
	Power Chef (Pb$_6$)	20	2.0	2.0
	Orey (Pb$_7$)	18	1.8	1.8
	Queen (Pb$_8$)	16	1.6	1.6
Aspects preferred	Health benefits	769	78.2	78.2
	Quality	750	76.3	76.3
	Price	463	47.1	47.1
	Packaging	327	33.3	33.3
	Quantity	206	21.0	21.0
	Advertisement	91	9.3	9.3
Preferred oil type [Ms]	Soybean	772	78.5	78.5
	Sunflower	301	30.6	30.6
	Olive	228	23.2	23.2
	Sesame	53	5.4	5.4
	Palm fruit	38	3.9	3.9
	Corn	25	2.5	2.5
	Coconut	22	2.2	2.2

Pbi: is the letter used instead of the brand name of the products; n: number of respondents selected to observed variables; p: percentage; Mv: missing value; Vp: valid percentage (percentage of excluding missing value); Ss: single-select; Ms: multi-select

4. Conclusion

It is found that, among of 1,000 respondents in Phnom Penh city, there are 98.3% consumed cooking oil in

their daily life. For consumption behavior, about 69% of respondents used cooking oil almost every day, and their favorite cooking methods were stir-frying and pan-frying. Additionally, the respondents who purchased cooking oil once a month and more than once a month were 49.2% and 43.4%, respectively. The retail stores being the preferred location (73.5%) to buy cooking oil and then the market and supermarket. While, the 1L volume showed the highest demand, aligning with consumer purchasing preferences. Moreover, most of the respondents were prefer cooking oil which was produced from soybean seeds than other types of cooking oil and 50.9% spends more than 10,000 riels at every time of purchase. Moreover, preferred brand, aspects preferred, and preferred cooking oil type are the main factors influencing the preferences and purchasing behavior of the consumers. Therefore, the findings data in this study provided the first overview of cooking oils and revealed detail information relating to a specific brand of cooking oil for daily use of consumers.

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Ms. Mich Monika is currently a full-time lecturer at Faculty of Chemical and Food Engineering of Institute of Technology of Cambodia. She holds a master's degree of Agro-industrial Engineering from Institute of Technology of Cambodia in 2022, following her Bachelor's Degree in Food Science and Technology from the same institution in 2021. Her research focuses on the development of cooking oil process for commercialization in Cambodia. Her work investigates the usage patterns of cooking oil in the Phnom Penh market in Cambodia. Moreover, she delves deeply into techniques for extracting oil from soybean seeds with different methods, making a significant contribution to the sustainable development of Cambodia's agro-industrial sector.

Assessment of One Health Perspectives on Antimicrobial Resistance Among University Students

Be Sokkeang

Master's Degree, Industrial Chemistry

King Mongkut's University of Technology Thonburi (KMUTT),Thailand

Men Kanika

Bachelor's Degree

Science Research, University of Puthisastra, Cambodia

Seng Sochea

Bachelor's Degree

Science Research, University of Puthisastra, Cambodia

Eng Vouchey

Bachelor's Degree

Science Research, University of Puthisastra, Cambodia

Menh Phalla

Bachelor's Degree

Science Research, University of Puthisastra, Cambodia

Highlight

- Universities can identify the gaps in understanding of antimicrobial resistance, which can lead to targeted educational interventions aimed at preventing the spread of resistant infections.
- Understanding AMR is really important and can lead to public health impact, Economic Consequences and Major global health risk.
- It is commonly assumed that university students have a strong understanding of AMR due to their educational background. This study aims to evaluate whether this assumption is true.

1. Introduction

Antimicrobial resistance (AMR) is a major global health concern that occurs when microorganisms, such as bacteria, viruses, fungi, and parasites, develop the ability to survive and thrive despite the presence of antimicrobial drugs designed to kill or inhibit them. This happens through various mechanisms, such as genetic mutations   or the acquisition of resistance genes.

The main causes of AMR include: Overuse and misuse of antimicrobial, poor infection prevention and control and Lack of new antimicrobial development. This study aimed to investigate the general public's KAP (knowledge, altitude and practice) regarding antibiotics use and AMR in the university. By conducting a comprehensive study on the KAP of the general population in university, valuable insights can be obtained to

develop targeted awareness campaigns, educational initiatives, and policy interventions. This research would provide a baseline understanding of the current situation and help identify specific areas where interventions are needed to address knowledge gaps, to dispel misconceptions, and to promote responsible antibiotic use among the general population in the university. The findings of the study will also fill the existing knowledge gap and contribute to global efforts in combating AMR. It will enable healthcare authorities, policymakers, and public health professionals to design evidence-based interventions tailored to the specific needs and challenges faced by the general student's population in universities in Phnom Penh to reduce the burden of AMR, and improve overall healthcare outcomes. The effectiveness of crucial "last resort" antibiotics, such as vancomycin, is diminishing, and turning antimicrobial resistance into a pressing medical crisis. Education plays a crucial role in combating this issue. Recent surveys suggest the need for national competency standards for healthcare students regarding antibiotic use, focusing on infection control, prescribing practices, and teamwork (Azim et al., 2023).

2. Material and Method

2.1. Paper Form

The students who studied at the University of Puthisastra were selected to conduct the interview by using paper form.

2.2. Study Questionnaire

The study questionnaire consisted of six parts. The first part collected general information, including participants' name, age, gender, major, year of study, marital status, current residence, and health insurance status. The second part assessed knowledge about health check-ups, including the frequency of check-ups, sources of information, and understanding of typical medical examinations. The third part focused on participants' experiences with health examinations, including their participation, reasons and past experiences. The fourth part explored personal behaviors such as smoking, alcohol consumption, diet, sleep patterns, overall health, and mental well-being. The fifth section addressed perceptions and attitudes towards medical check-ups, including their importance and preferences for healthcare providers. The final part invited additional comments and suggestions regarding health services.

2.3. Survey by Face to Face

A total of 100 participants from UP were randomly selected and surveyed using paper-based Form questionnaires through face-to-face interactions. Due to certain limitations, 100 people of these approached volunteered and consented to participate in the study. In addition, no students were excluded from the data analysis.

2.4. Participant's Answer

The students who participate have one paper in the paper have some questionnaire that prepare to ask the participant and need to ask them by face to face and every answer keep it in the privacy and the participate have a chance if they don't need to answer the question if they have problem with it.

2.5. Ethical Considerations and Consent

This study has been approved by the University of Puthisastra Research Committee (UPRC). All data were kept confidential, and participants' names were not included in the results. Data will be deleted three years

after the research is completed. It was stored on a computer and will not be accessible to any third parties. Participants signed a consent form agreeing to take part voluntarily, and they were informed that they could choose not to answer any questions they found uncomfortable and had the right to with draw from the study at any time.

2.6. Analyze the Data

The participant's answer will be to analyze their answer by using the excel. And surely their answer was kept in privacy. The descriptive statistic was used to summarize the data. Microsoft Excel was utilized to calculate means and standard deviations, create graphs, and present the data in percentages.

3. Result and Discussion

3.1 Demographic Information

Table 1. The Demographic Information of participants

Sociodemographic Characteristics	Frequency (N=100)	Percentage (%)
Gender		
Male	56	56%
Female	44	44%
Age		
18-20	63	63%
21-23	30	30%
24-26	7	7%
Majors		
Dentistry	25	25%
Nurse	18	18%
Science Research	10	10%
Medicine	14	14%
Pharmacy	8	8%
Medical Laboratory	25	25%
Year of study		
Year 1	13	13%
Year 2	61	61%
Year 3	22	22%
Year 4,5 or above	4	4%

The table 1 showed that the number of female students who participated and answered the survey question is higher than the number of males. Among 100 students, 56% are female students and 44% are male students with the age between 18-20 (63%), 21-23 (30%) and 24-24 (7%). All of these students have different majors of study such as Medicine (14 peoples), Pharmacy (8 peoples), Dentistry (25 peoples), Science Research (10 peoples), Nursing (18 peoples) and Laboratory (25 peoples).

3.2 Knowledge of Antimicrobial Resistance

Figure 1 showed that there are 5 issues that cause antimicrobial resistance. There are: environmental pollution, lack of new antibiotics, overuse of antibiotics in human, poor sanitation and hygiene, and uses of antibiotics in livestock. Among 100 students, 43% of students think that overuses of antibiotics in human is the major cause of AMR. This is the higher percentages. The lower percentage is 4% of students who think

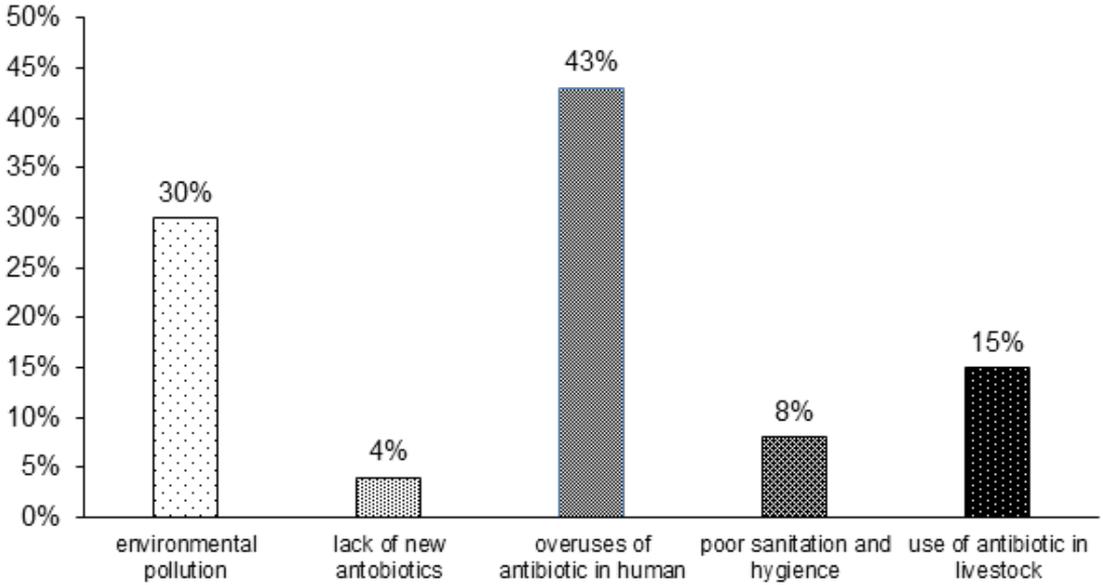that the lack of new antibiotics is the main cause of AMR.

Figure 1. The knowledge of antimicrobial resistance (AMR)

3.3 Behavior Related to Antimicrobials Resistance

Figure 2 presents the result of students who often consulting healthcare professionals before using Antibiotics. There are 5 choices to choose: always, usually, sometimes, rarely and never. The largest percentages is 33% equal to 33 students who are sometimes consulting there health issues with Healthcare professionals before using Antibiotics. There are 24% equally with always and usually consulting with healthcare professionals before using antibiotics. The lowest percentage is 4% present the students are never consulting with healthcare professionals before using antibiotics. According to (Subramaniam & Girish, 2020) Antibiotic resistance genes have been there since ancient times in response to naturally occurring antibiotics. Modern medicine has only driven further evolution of antimicrobial resistance by use, misuse, overuse and abuse of antibiotics.
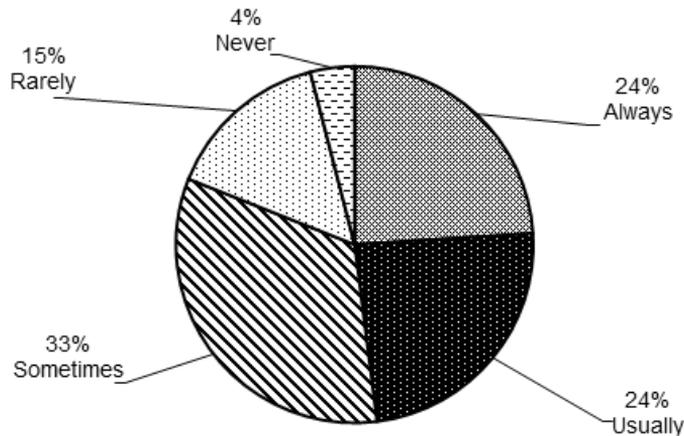
Figure 2. How often do students consult healthcare professionals before using Antibiotics?

3.3.1 Impact of Antibiotics on the Environment

Figure 3 showed how concerned the students are about the impact of antibiotics on the environment. The figure has shown that most of the students are concerned about the impact of antibiotics on the environment and equal to the number of 51 students. According to (Bilal et al., 2019) Reports have demonstrated that antibiotic residues–based contaminants can influence microbial populations by bacteriostatic and bactericidal effects, leading to disappearing key microbial groups associated with ecological activities or affecting their physiological functions.
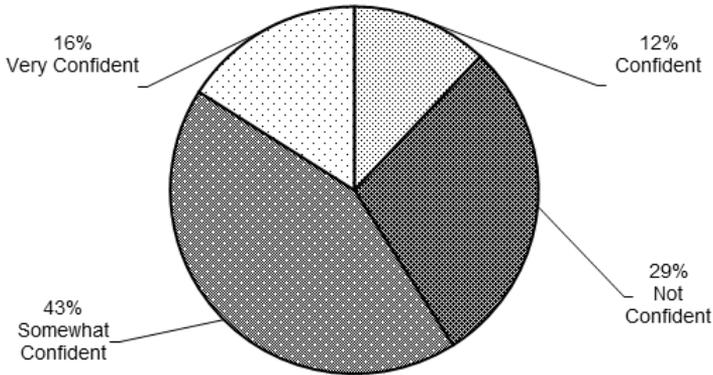
Figure 3. The results of student's concerned about the Impact of AMR on the environment

3.4 One Health Perspective

Figure 4 provides the information about how essential students think that collaboration between human health, veterinary and environment sectors is for tackling AMR. There are 4 choices for them to choose: Slightly essential, very essential, extremely essential and not sure. Most of the students equal to 70% over 100% have chosen that this collaboration is very essential and only 3% are not sure.(Steward Mudenda et al., 2023) AMR is prevalent among humans, animals, and the environment. Successfully addressing AMR calls for a collaborative, multifaceted One Health approach. Despite this, some gaps remain in effectively implementing strategies currently recommended to combat AMR. As a result, it is essential to reinforce the strategies that are deployed to counter AMR across the human, animal, and environmental sectors.
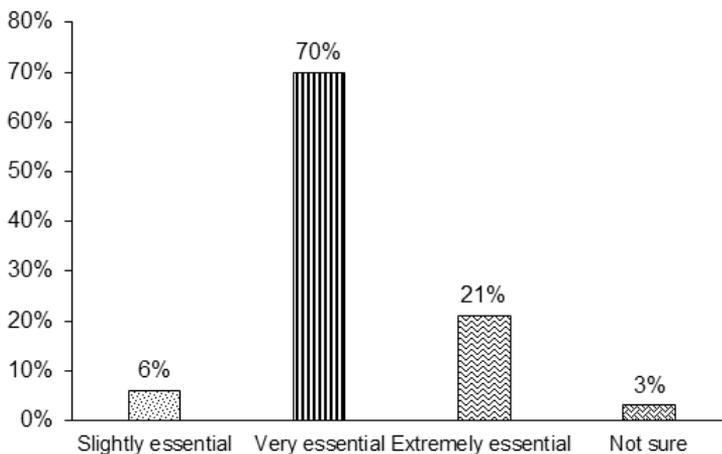

Figure 4. The essentials of students think collaboration between human health, veterinary and environment sectors is for tackling AMR.

3.5 Barriers and Facilitators

The survey provided the data of students' thoughts on how to improve awareness about AMR among students. Most of them provided their recommendations to university to Create more academic courses on AMR and AMR Knowledge need to be on Online source.
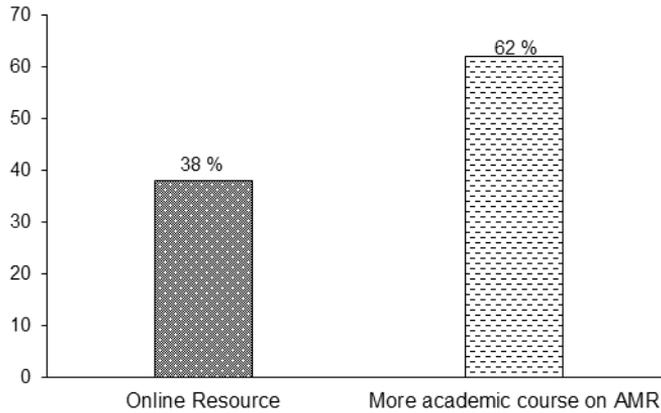

Figure 5. Improve Awareness about AMR among students

4. Conclusion

The interview highlights the importance of addressing antimicrobial resistance (AMR) among university students through an integrated approach that emphasizes education and awareness about antibiotic use and environmental impacts. By promoting responsible antibiotic stewardship, encouraging research, and implementing strong health policies, students can play a vital role in tackling this global health challenge. Adopting a One Health framework enhances student well-being and supports broader public health initiatives for a healthier future.

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Mr. Be Sokkeang is currently a program manager and lecturer of Science Research in the Faculty of Health Sciences and Biotechnology at University of Puthisastra (UP). He holds a Master of Science in the field of Industrial Chemistry from King Mongkut's University of Technology Thonburi in Thailand in 2021, and a Bachelor Degree in Biochemistry in Cambodia at RUPP in 2019. His researches focus on Environmental (including soil, drinking water and wastewater) and food safety (Including microbial and heavy metals). He leads several projects focusing on biomass conversion for pollution removal and use it for agriculture purposes. In addition, he is also working on heavy mental and microbial content in food.

TECHNOLOGY TRENDS

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Designing a Chlorine Dioxide Self-Generating Film as Active Packaging of Cherry Tomato's Shelf Life During Storage

Phal Sophoan

Master's Degree, Packaging Technology

Kasetsart University

Thailand

Kong Sopheaktra

Bachelor's Degree

Food Chemistry

International University, Cambodia

Din Sreylin

Bachelor's Degree

Food Chemistry

International University, Cambodia

Highlight

- The short shelf-life of cherry tomatoes could lead to post-harvest loss during production and the preservation technique through active packaging is concerned.

- The chlorine dioxide self-generating film with various concentration is produced to inhibit the growth of bacteria on cherry tomatoes during storage *(In Vitro and In Vivo study)* and the shelf life investigation as well as ClO2 gas releasing has been conducted.

- The application of chlorine dioxide as antibacterial packaging film on cherry tomatoes showed the significant inhibition to S. aureus and E. coli growth up to 99% which mean the cherry tomatoes still could be managed to be fresh for the whole storage period.

1. Introduction

Food safety and the methods used to preserve food for longevity are major issues in the globalization of food supply and protection around the world. Fresh produce is an important source of human daily food, not only it is also popular and has become a necessity of consumers in the next few decades (Gaikwad, Singh, Shin, & Lee, 2020; Singh, Gaikwad, & Lee, 2020; Sun, Baldwin, & Bai, 2019). The quality of fresh produce (vegetables and fruits) is easily lost between harvest and post-harvest. Lack of knowledge on post-harvest techniques such as harvesting materials, temperature transport during storage, as well as risk of microbial contamination (Yahia, 2019).

Cherry Tomatoes (Solanum lycopersicum var. cerasiforme) or (S. lycopersicum var. cerasiforme) are one of the most popular vegetables in the world. This type of vegetable is popular both in the form of fresh vegetables and tomato drinks, as well as processed foods such as sauces. It contains a large amount of water in the cell, or so-called high humidity, so it can't be stored for long. Moisture can allow microorganisms to grow, and the variability of the tomato metabolism, transportation, harvesting techniques, and storage temperature can greatly affect the quality and physiology of the cherry tomato (Li et al., 2017). The bacteria which mostly lead to disease to cherry tomatoes are Escherichia coli Salmonella sp. Listeria monocytrogenes Staphylococcus

aureus Bacillus cereus and Campylobacter jejuni (Cabrera-Díaz et al., 2018) (Gómez-Aldapa et al., 2013). Many post-harvest techniques are currently being studied to ensure food safety and maintain nutritional quality to increase the shelf life of fresh produce (vegetables and fruits) (Jin-Hua, Mao-Run, Miao-Miao, & Wei, 2007; Singh, Gaikwad, & Lee, 2019). The packaging of fresh products maintains both the quality and shelf life of the product and is also an important part of the agro-food industry. Active packaging is popular because it contains compounds that can fight the growth of microorganisms and inhibit the metabolic reactions of vegetables and fruits (Del Nobile et al., 2023).

2. Materials and Methods

2. 1 Sample Preparation

Cherry tomatoes (Solanum lycopersicum var. cerasiforme)were purchased from a local market (Kromoun market) in Phnom Penh. The samples were selected at full ripeness with no fungal worsening or physiological disorders. The sampling method was conducted separately, first 200g for bacteria isolation and another 200g for quality analysis during storage.

2.2 S. Aureus and E. Coli Isolation from Cherry Tomato

The spread plate method was performed to isolate the spoilage bacteria, S. aureus and E. coli, on mannitol salt agar (MSA) plate and chromogenic coliform agar (CCA) plate, respectively. The streak plate method has been used to purify the isolated bacteria on the same agar plate to avoid contaminating the bacteria, store them in nutrient broth (NB) for further use.

The confirmation tests of S. aureus and E. coli were conducted according to the method below table.

Table A Confirmation tests of S. aureus and E. coli.

Testing Method	Technique	Reference
Gram staining	Microscopical	(Tripathi & Sapra, 2020)
Catalase test	Slide, slant, and tube	(Iwase et al., 2013)
Urea test	Streak plate	(Iwase et al., 2013)

2.3 Active Film Preparation

The acid layer (PEBAX/PEG + citric acid) was prepared using a solution casting method with the concentration of PEG 1.3% (w/v), PEBAX 13 g, and citric acid 1 g.

The barrier layer (PVA) was prepared with PVA (10 g) dissolved in water (90 g) by the casting method.

The active layer (PEBAX/PEG + $NaClO_2$) was prepared with PEG 1.3% (w/v), PEBAX 13 g, and $NaClO_2$ 1.3 and 2.6 g (low and high concentration, respectively), which were separately dissolved in DI water at room temperature (23°C). The film solution containing $NaClO_2$ was cast on the PET container.

The sealing layer (PEBAX/PEG) was prepared from PEBAX and PEG based on the same protocol. The thickness of the active, acid, and sealing layers was maintained at 120 μm, and the thickness of the barrier layer was maintained at 20 μm. All the layers of the film were combined together by using a heat press at 10 kPa pressures for 10 s at 20 °C (TestOne, Seoul, South Korea).

2.4 Antibacterial Activity of Active Film

The antibacterial experiment was carried out with bacterial solution concentrations between 100 to 105 CFU/mL after inoculum and incubated at 37°C for 24 h.

log colony reduction= log CFU A – log CFU B (Eq. 1)

log CFU A= the colonies number of control sample, log CFU B= the colonies number of treatment sample.

a. Determination of Decay Rate

The number of decayed fruits was considered as the fruit decay rate relative to the initial number of fruits in each group. It can be calculated as follows:

$$\text{Decay rate (\%)} = \frac{R_t}{R_0} \times 100 \qquad \text{(Eq. 2)}$$

Where R_t denotes the number of litchis fruits on which the epidermis appears disrupted, with electrolyte leakage and molds, and R_0 indicates the total number of fruits retrieved in each group.

b. Quantification of ClO_2 Gas Released from Active Film

Detection of ClO_2 gas was conducted at the following sampling times: every 1 h for 6 h (detecting the peak concentration), followed by every 12 h for the entire storage period. The ClO_2 gas in the headspace was quantified using a UV–vis spectrophotometer at 360 nm (Shimadzu – UV 2600, Tokyo, Japan).

2.5 Statistical Analysis

One way ANOVA, Turkry's multiple rang test at $p < 0.05$), SPSS 23.0 software (IBM Corporation, Armonk, USA) is used to analyze the data after triplicated done with experiment.

3. Results and Discussion

3.1 Morphology Observation and Confirmation Test of E.coli and S. Aureus

The study data on the observation of the characteristics or appearance of bacteria and the biochemical tests of E.coli and S. aureus bacteria.
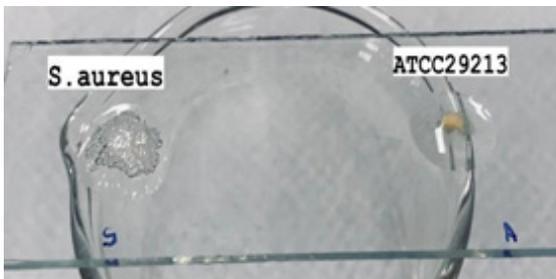

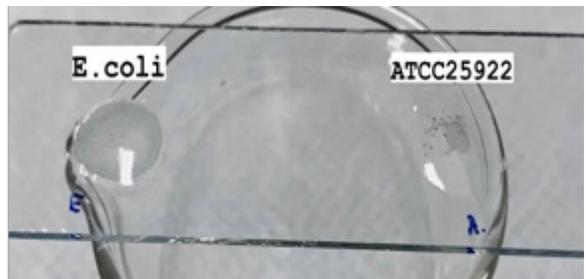Figure3.1 (a) Positive catalysis (+) of *S.aureus* bacteria

Figure 3.1 (b) positive catalysis (+) of *E.coli* bacteria

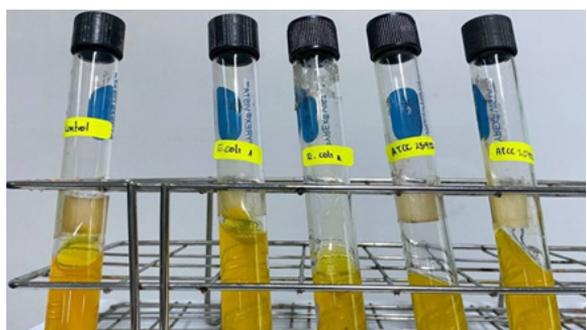Figure 3.2 a. Positive urea (+) of S.aureus bacteria

Figure 3.2 b. Negative urea (+) of bacteria
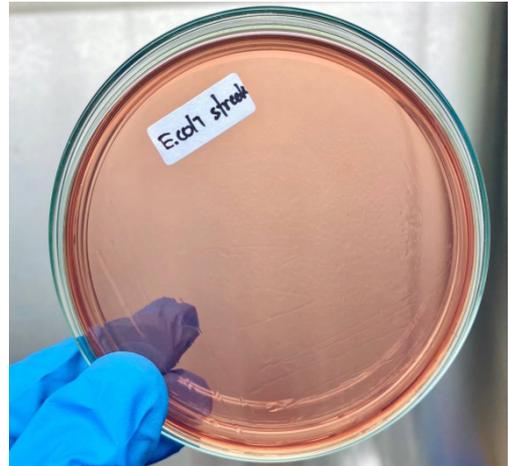
Figure 3.3 a. Manitol synthesis of *S.aureus* bacteria

Figure 3.3 b Mannitol inactivation of *E.coli* bacteria

The microscopic results can be identified as E. coli by the appearance of sticks and pink color because it is a type of bacteria in the negative gram (-). For catalase, E. coli generally produces the enzyme catalase, which breaks down hydrogen peroxide and converts it into water and oxygen in the form of bubbles (Reiner, 2010). Not only that, through urea testing, it can be confirmed that it is E.coli bacteria, as this bacterium cannot produce urea enzymes in the production of Mannitol sugar (Brink, 2010).

The microscopic appearance or shape can be concluded that it is S. aureus bacteria, as it is round and purple, and it is generally a gram-positive bacterium (+). It also showed a positive test on urea and Mannitol glucose because of its ability to produce urea enzymes.

Table 3.1 Testing of bacteria isolated from cherry tomatoes using biochemical confirmation test

Types of bacteria isolations	Bacteria stock (Con-trol)	Gram Stain	Mor-pho-types	Bio-chemical Test		
				Catalase	Urease	Mannitol Fermented
E.coli	ATCC 25922	-	Rod	-	-	-
S. aureus	ATCC 29213	+	Cocci	+	+	+

3.2 Antibacterial Activity of Active Film

The results of tests on the level of efficacy of the active plastic packaging on the antibacterial activity of both E.coli and S. aureus bacteria in the vitro study are shown in Figure 3.3. E.coli , which was the blank control of both conditions (A1 and A2), was 3.8 ± 0.13 logCFU/mL and 3.7 ± 0.11 logCFU/mL, but E.coli, which was tested with both active plastic packs, did not detect the presence of E.coli cells (A1 and A2). For S. aureus bacteria in blank control, both conditions (A1 and A2) were 3.6 ± 0.09 logCFU/mL, where S. aureus bacteria in the test with the active plastic package did not detect the presence of cell counts of S. aureus bacteria in both conditions (A1 and A2).
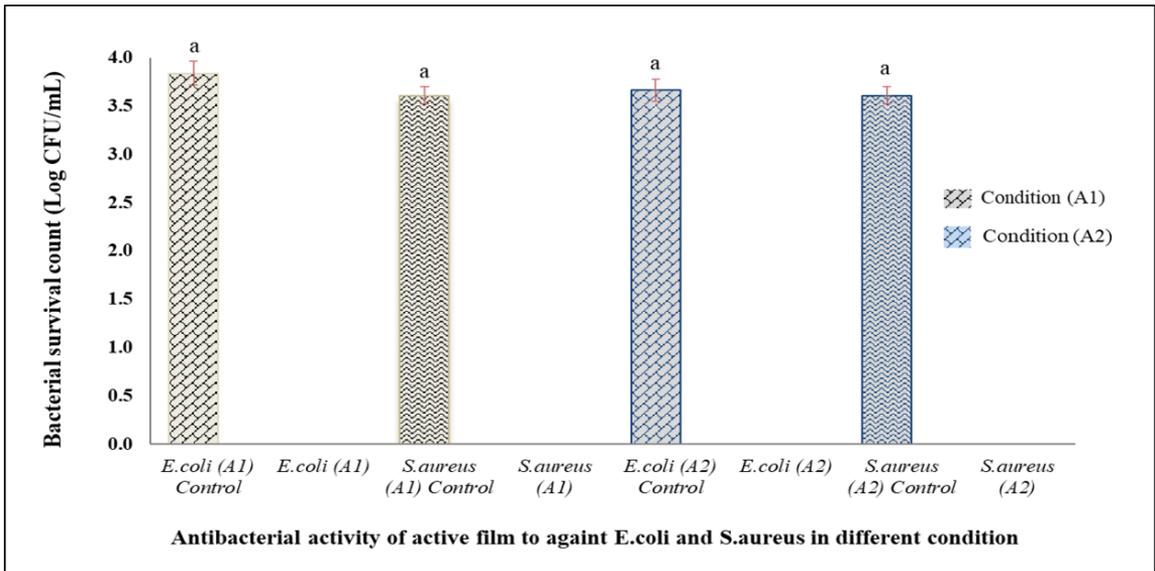
Figure 3.3. Antibacterial activity test of active in different concentration on *E.coli* and *S.aureus* and (A1= 1% NaClO$_2$, A2 = 2% NaClO$_2$).

The results of tests on the effectiveness of active plastic packaging against the growth of two pathogenic bacteria, including E.coli and S. aureus bacteria, were positive in the level of antibacterial activity by releasing chloride dioxide (ClO2) from the active plastic packaging, the presence of growth of both types of bacteria is undetectable level. As for the antibacterial activity of chloride gas (ClO2) is analyzed from the data obtained from (Fig. 3.3), the concentrations of 1% and 2% NaClO2   contained in the active plastic package were highly active that could inhibit the growth of E.coli and S. aureus bacteria with a cell number of about 4 logCFU / mL, and the level of inhibitory efficiency is as high as 99%.   In particular, for the movement of chloride dioxide (ClO2) to antimicrobial activity, chloride (ClO2) directly destroys the cells of the microorganism, which is carried out in the process of bacterial protein synthesis to double self-assembly to extend their life (Benarde, Snow, Olivieri, & Davidson, 1967).

3.3 Decay Rate

The results of the study on the variability of cherry tomatoes during the 12-day storage period are shown in Figure 3.4. An increase in the percentage of rot of cherry tomatoes in both control conditions and conditions containing active plastic packaging over 12 days. The percentage of rot of cherry tomatoes during the 12-day storage period under control conditions increased significantly from 0 to 12 days, with values ranging from (0% ± 0.00a) to (49.65% ± 5.93b). In the case of active plastic packaging, the percentage of rot of cherry tomatoes increased, with the rate of increase being less than the percentage of variation of control conditions from day 0 to 12 between (0% ± 0.00a) and (14.55% ± 7.71a). The percentage of rot of cherry tomatoes in the control condition increased to about 40% higher than the condition containing active plastic packaging.
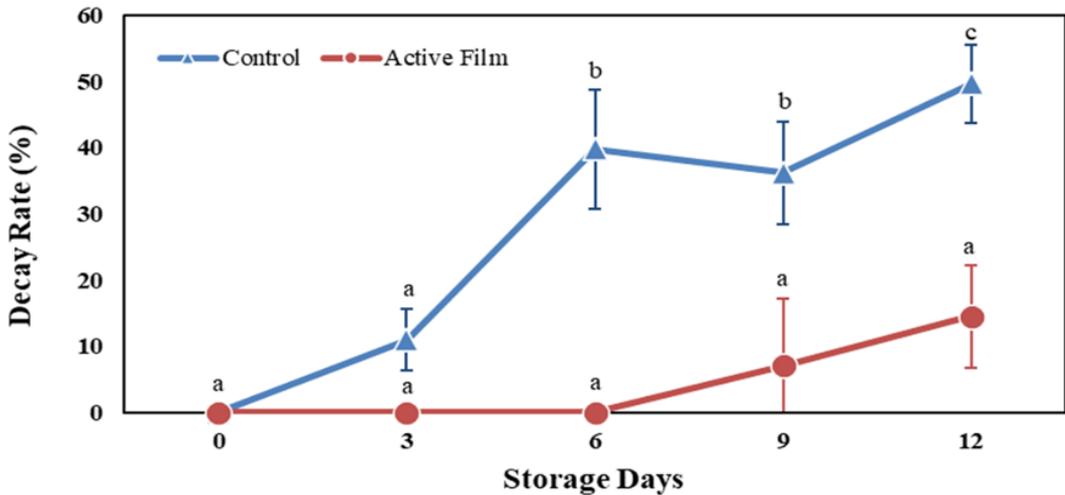
Fig.3.4 Percentage of cherry tomatoes' decay rate during storage for 12 days.

Observing that the percentage of cherry tomato rot in control conditions increased due to the presence of microorganisms such as fungi or bacteria. Not only that, most studies always find the presence of these fungi, Botrytis cinerea Aspergillus spp Penicillium spp Alternaria spp, which often cause disease on cherry tomatoes. In addition, the presence of bacteria (both pathogenic and non-pathogenic), commonly known as (Spoilage bacterial), is also part of the cause of short-lived cherry tomatoes, including bacteria such as Staphylococcus aureus, E.coli, Klebsiella aerogenes, Salmonella enterica, Typhimurium, and Bacillus species are found in different varieties of tomatoes and most are transmitted to tomatoes (Momoh, Aladeyelu, & Tuomokeme, 2020) through contaminated water sources, contaminated soils, and areas exposed to manure (Nwidu, Oveh, Okoriye, & Vaikosen, 2008).

3.4 Quantification of ClO_2 Gas Released from Active Film

The results of the determination of the amount of chloride dioxide (ClO_2) released from the active plastic bag inside the container containing the cherries and stored at room temperature (25ºC) for 12 days of this study are shown in Figure 3.5. In addition, the amount of chloride dioxide (ClO_2) released from the active plastic packaging decreased from the 3rd to the 12th day at different times. For Day 6, the amount of chloride dioxide (ClO2) increased between 2.78 to 3.32 mg /mol. For the control sample and the sample in the box containing the active plastic package, the amount of chloride dioxide (ClO_2) increased equally between 2.75 to 4.15 mg /mol as the amount of chloride dioxide (ClO_2) was converted according to the storage period.

The amount of chloride dioxide (ClO) released from the active plastic bag for 12 days at room temperature (22-25 ℃) ranged from 1.8 mg /mol to 4.15 mg /mol, with the concentration of chloride (ClO_2) similar to the study results in the production (Sadeghi et al., 2020) of active plastic bags capable of releasing chloride dioxide (ClO_2).
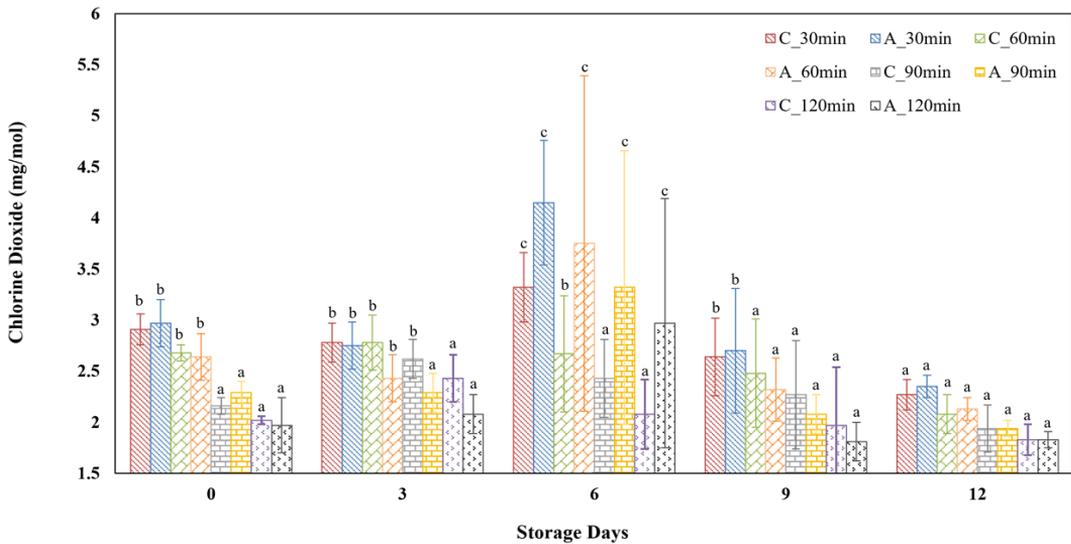
Figure 3.5. Release rate of ClO$_2$ gas from active film into the packaging headspace. (C) refer to control active film without sample, (A) refer to active film package with sample.

4. Conclusion

In conclusion, the chloride dioxide (ClO$_2$) released from the active plastic packaging is capable of inhibiting the growth of E.coli and S. aureus bacteria between 3.8 Log CFU / mL and 3.6 Log CFU / mL, with levels of efficacy in inhibiting the activity of both bacteria up to 99%. The decay rate of cherry tomatoes with active films showed the increasing being less than the percentage from day 0 to 12 was between 0% ± 0.00 to 14.55% ± 7.71, corresponding with the concentration of chloride dioxide (ClO$_2$) released from the active plastic package range from 1.8 mg/mol to 4.15 mg/mol. The results of this study also showed the use of low concentrations of sodium chloride at 1% with the ability to release chloride dioxide (ClO$_2$) at a safe level and be effective in long-term use, as well as prolong the shelf life, quality, and texture of cherry tomatoes.

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Mrs. PHAL Sophoan is currently a lecturer and researcher at Faculty of Science and Technology of International University. She holds a Master Degree in Packaging Technology from Kasetsart University in Thailand in 2019, and an Engineering Degree in Chemical and Food Engineering in Cambodia at Institute of Technology of Cambodia in 2016. Her researches focus on innovation of active packaging for shelf-life extension of post-harvest produce and eco-friendly packaging from agricultural waste. She leads several projects focusing on development of antibacterial packaging film and antifungal film for prolonging the shelf life of cherry tomatoes during storage as well as the eco-friendly paper packaging production from cornhusk blended with chitosan extracted from shrimp shell.

Enhanced Facial Emotion Recognition: Analyzing Facial Points Using Machine Learning Techniques

Khean Vesal

Master's Degree

Artificial Intelligence

Soonchunhyang University, Republic of Korea

Highlight

- The short shelf-life of cherry tomatoes could lead to post-harvest loss during production and the preservation technique through active packaging is concerned.

- The chlorine dioxide self-generating film with various concentration is produced to inhibit the growth of bacteria on cherry tomatoes during storage *(In Vitro and In Vivo study)* and the shelf life investigation as well as ClO2 gas releasing has been conducted.

- The application of chlorine dioxide as antibacterial packaging film on cherry tomatoes showed the significant inhibition to S. aureus and E. coli growth up to 99% which mean the cherry tomatoes still could be managed to be fresh for the whole storage period.

1. Introduction

Facial expressions play a pivotal role in communication, encompassing both verbal and non-verbal forms of interaction. Non-verbal communication heavily relies on facial expressions, making Facial Expression Recognition (FER) a critical component of robotic vision. Moreover, there is a research paper, using deep learning for facial emotion recognition using the emotion dataset, which includes ten target emotions. Data preprocessing is done to convert video data into images (Agung et al., 2024). Identification of facial emotional expressions is crucial for everyday social functioning. Impairments in facial affect recognition have been found among patients with neurological and psychiatric disorders (Geraets et al., 2021). In recent years, FER has garnered substantial attention from researchers in the fields of computer vision and artificial intelligence, owing to its significant impact on both commercial and academic arenas. Its applications span a wide spectrum, including human-robot interaction, healthcare, augmented reality, road safety, virtual reality, deception detection, and surveillance.

Emotion recognition is crucial in cognitive psychology research, but measuring emotions is challenging. Deep learning (DL) techniques have been used for facial expression recognition (FER), but they face challenges like overfitting and complications like occlusion, posture, illumination, and identity bias. This study surveys DL-based methods contributing to FER, analyzing preprocessing, feature extraction, and classification. It explores databases relevant to FER and discusses the current scenario of FER approaches and future directions for facial emotion recognition by machines (Karnati et al., 2023).

In this paper, we aim to explore the potential of facial key points for emotion recognition and evaluate the effectiveness of Machine Learning (ML) models such as, Support Vector Machine (SVM), Random Forest

(RF), Decision Tree (DT). This could benefit areas such as human-computer interaction, healthcare, education, and user experience.

2. Methodology

We proposed ML models to classify emotions based on human facial points. There were three significant blocks: preprocessing, feature extraction, and ML classification. First, we prepared and clean data such as, labeling data, missing data and data scaling. Second, demonstrated feature extraction technique to extract meaningful features from the facial key points and the last one applied ML models to classify emotions. Each block of the proposed method is briefly discussed in the following in Figure 1.

A. Implementation Details

We implemented our emotion recognition system using Python and the scikit-learn library for machine learning tasks. Data was collected from real human subjects using the Meta Quest Pro headset, which captures detailed facial key points in a virtual reality environment. Training and evaluation were conducted on a desktop computer (ID: 1377rq1), which was sufficient for our current scale. This setup enabled us to process the dataset efficiently and achieve high model performance.
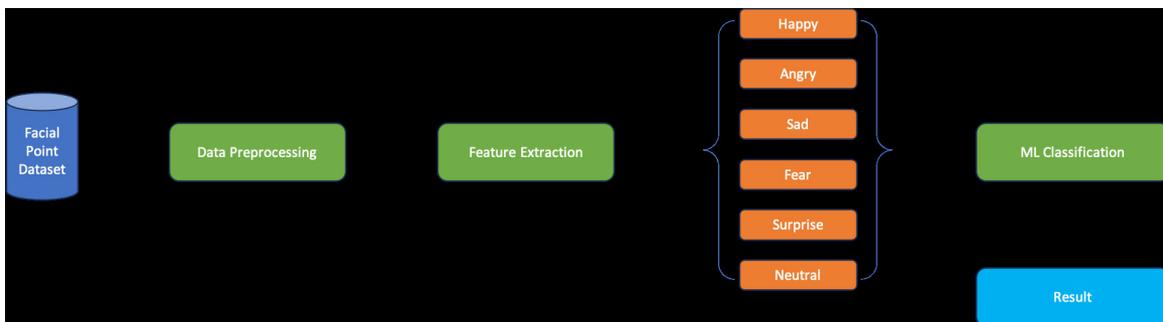

Figure 1 . Our proposed whole flowchart

A.1. Data Preprocessing

Labeling : Assign emotion labels to each data point in the dataset. These labels indicate the emotional expression associated with the corresponding set of facial key points (subject self-reporting). Data Scaling : This step is essential to ensure that all facial key points have a consistent scale, preventing certain key points from disproportionately influencing the ML model due to their numeric values. Z-score scaling facilitates effective learning based on the relative positions of these key points, regardless of their initial numeric ranges, and is particularly important when applied various ML models.

A.2. Feature Extraction

In the feature extraction step, one effective method for capturing facial expressions is computing the distances between specific facial key points, such as the eyes, nose, and mouth. These distances provide meaningful geometric features that reflect changes in facial muscle positions associated with different emotions. For example, the distance between the corners of the mouth can indicate whether a person is smiling. These distances help capture subtle changes in facial geometry, making them powerful indicators for emotion classification using machine learning algorithms.

A.3. ML Classification

In this section, begin by preparing a dataset with labelled facial key points. These points represent various expressions for each of the six emotions, including, happy, angry, sad, surprise, fear and neutral. Various ML models were chosen for its effectiveness in multiple classes classification tasks. It's trained on the preprocessed data to learn patterns in the facial key points associated with different emotions including, happy, angry, sad, surprise, neutral, and fear.

3. Result
3.1. Dataset

Figure 2 . Sample images from where the subjects have described their own emotions

The dataset collected from a Virtual Reality (Meta QuestPro) device, from student in Soonchunhyang University. In our dataset, we have 8 subjects . We have recorded the emotions for each of the subjects with the following emotions: angry, surprise, sad, happy, neutral, and fear. Then save the facial points in a CSV file for each emotion and each subject separately. Each row within this dataset encapsulates numeric values representing facial points, while the dataset encompasses six distinct emotion categories. This dataset provides a rich source of information for developing and training ML models to recognize facial expressions, offering valuable insights into human emotional states within immersive virtual environments. The detail of our dataset is depicting in Figure 2, 3.

3.2. Experimental Result

In our experiments, we achieved an impressive accuracy rate of 99.1%   when applying our machine learning model to the dataset collected from the VR device. This high level of accuracy demonstrates the model's effectiveness in recognizing and classifying emotions based on facial key points. Such results indicate promising prospects for employing this approach in various applications, including human-computer interaction. The result evaluates metrics of a proposed classification model and confusion metrics of the evaluate metrics can be found in Table 1.

Table 1 . Summary of ML models classification results

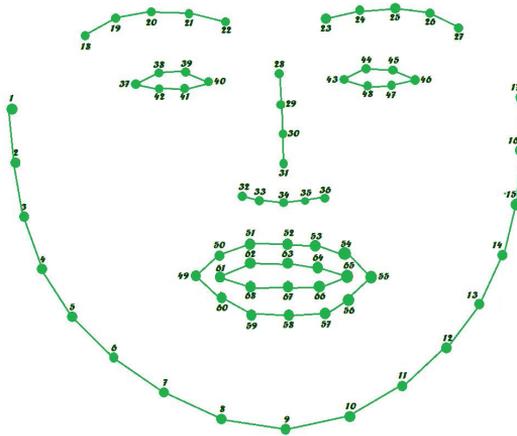| Classifier	Accuracy (%)	Recall Rate (%)	Precision Rate (%)	F1 Score (%)	Time (Sec)
Cubic KNN	98.2 %	99.1 %	99.08 %	99.09 %	9130.6 Sec
Medium KNN	98.23 %	98.48 %	98.48 %	98.48 %	720.32 Sec
SVM	97.6 %	97.58 %	97.63 %	97.60 %	730 Sec
Cubic SVM	**99.1 %**	99.1 %	99.08 %	99.09 %	1182.7 Sec
Medium SVM	95.8 %	95.8 %	95.8 %	95.95 %	908.47 Sec
Medium Tree	68.4 %	68.42 %	69.8 %	69.10 %	**225.68 Sec**

Figure 3. The 68 facial landmarks

4. Conclusion

In this paper, we propose a machine learning-based approach to emotion recognition using a facial key point dataset collected from real human subjects. The dataset was recorded in a controlled virtual reality (VR) environment, where participants were asked to exhibit various emotional expressions including happiness, anger, sadness, fear, surprise, and neutrality. The data, stored in CSV format, contains precise facial landmark coordinates that serve as the foundation for feature extraction. Specifically, we computed geometric features such as Euclidean distances between key points (e.g., between eyes and mouth, or between brows and eyes) to quantify changes in facial structure related to emotional states.

We evaluated several classification models and found that the Support Vector Machine (SVM) achieved the best performance, with an average accuracy of 99.1%. The strong performance of SVM highlights its robustness and effectiveness in handling high-dimensional spatial data from real-world subjects. These results demonstrate the strength of our preprocessing and feature extraction strategy, and the model's ability to generalize well across subjects with natural emotional expressions.

This work contributes to the field of affective computing by providing a reliable and interpretable emotion

classification pipeline based on real facial behaviour. The use of real-subject data increases ecological validity and provides valuable insight for developing emotion-aware applications in VR, human-computer interaction, and digital therapy. In future work, we plan to expand the dataset by collecting data from a larger and more diverse population to improve the model's generalizability. Additionally, we aim to enhance the system by integrating real-time multimodal signals, such as voice and gesture, and compare our approach with deep learning-based techniques for further performance improvements.

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Mr. Khean Vesal is currently a lecturer and researcher at Faculty of Electronic, Department of Applied Mathematics and Statistics of Institute of Technology of Cambodia. He completed M.S degree in Artificial Intelligence from Soonchunhyang University, Republic of Korea in 2024, and a B.S degree in Computer Science and Engineering in Cambodia at RUPP in 2021. His researches focus on Computer Vision applied Medical Imaging, Healthcare and Natural Language Preprocessing (NLP

STEM EDUCATION & CAREERS

From Cambodia Root to Innovation: The Unfolding Story of VP.Start

Figure 1. Research & Development Hub: VP.Start Sen Sok Valley Campus

1. Who are we at VP.Start?

In 2014, a young electrical engineer had some questions. 'What if we had a reliable energy grid in Cambodia? What if we could solve issues with the grid remotely and immediately? What if we could use our existing infrastructure, upgrade it affordably?'

These questions gave birth to an innovative idea, the SIMA Journey. The engineer gathered a few friends in a small rented space and they started chasing their dreams, working late nights and weekends and often packing everything in their car to go to some remote rural locations to test out their ideas. These were the first steps on the SIMA Journey.

2. What is VP.Start's role in the future of Cambodia?

VP.Start's mascots for the SIMA Journey are the Apsara and the Alien.

The Apsara represents our respect for and debt to our Angkorian ancestors and their amazing tradition of innovation through technology. The culmination of this innovative power is Angkor Wat. We intend to honor the Angkorians by raising up a new Angkorian generation today, reviving their innovative mindset.

The Alien represents our willingness to think outside the box, to challenge conventional thinking. We are proud Cambodians and ASEAN citizens but we are global and universal citizens as well.

The SIMA Journey has logically taken VP.Start from electric grid modernization to smart city initiatives including

waste management and efficient street lighting to IoT devices and home automation to cloud computing and the UCN (Universal Connectivity Network) that brings all our diverse innovations together.

From the grid to the city streets,
From the city streets to individual houses and businesses,
From our houses to the cloud, the universe,
This is our mission and our journey

Figure 2. From the ingenuity of Angkorian to the future of innovation through technology

3. What accomplishments are VP.Start especially proud of?
We at VP.Start don't focus on our accomplishments, the past. We have our eyes clearly set on the future, our direction. We believe that we learn more from failures than successes.

That said, our past experiences give us confidence that we are on the right track headed in the right direction. We began by streamlining and upgrading the Cambodian electric grid by implementing our cutting edge eco-solutions (such as RPM Grid Systems) throughout Cambodia in all EDC control rooms and in more than 200 electrical licenses for our customers, but our success is not in selling a product or installing technology.

We find success when a student is able to study without interruption because of dependable electricity and WiFi. We find success when a housewife cooks dinner without fear of a power outage, when a business leader knows that he can depend on electricity to keep his factory running at full capacity, or when a foreign investor decides to invest in Cambodia because they have a trustworthy energy system.

These are the successes that VP.Start is seeking. This is what our SIMA Journey is all about!
Similarly, as we have begun implementing our visionary smart city initiatives in Ta Khmao and in pilot projects elsewhere, we are not primarily focused on garnering huge profits.

Figure 3. VP.Start creats innovative solutions, built entirely from scratch

Our success is when people live in cleaner cities with less trash, better and more efficient traffic systems and lower expenditures. The SIMA Journey means better outcomes for everyone!

4. What are the obstacles that VP.Start faces on the SIMA Journey?
How does VP.Start intend to turn challenges into opportunities?

VP.Start has never been afraid of challenges. Actually, we welcome them. Challenges lead to exponential growth. One challenge is the attitude that many worldwide stakeholders have about Cambodia. They think that Cambodia is a poor, backwards, low educated and backwards nation in an underdeveloped region. That's why we are so proud to be a Cambodian company, an ASEAN company, providing groundbreaking innovations and world-class communication to the global stage.

We don't care what others say about us. We put our efforts and our concentration on our direction and we keep going on our SIMA Journey. "We don't follow the world. Soon the world will follow us.

Figure 4. VP.Start's seamlesss plug-and-play retrofit solutions

5. What is VP.Start's advice for the younger generation?
Our philosophy is simple and three pronged. First of all, we don't care what others think of us or say about us. If you worry about what others think of you, you will never become a leader, a trendsetter, and an innovator. Secondly, we don't care for materialism and material wealth. Innovation is spiritual wealth. Anyone can be materially successful but this will disappear when we leave the earth. Transformative innovation will keep making our world a better place long after we are gone.

Finally, we don't look at the past, our experiences, our achievements, our mistakes. We don't worry about what the future holds, either. We take the next step on our journey today, now.

Are you focused on "now"?
Do you have a clear direction "now"?
Don't wait for tomorrow to become a better version of yourself.
Push yourself out of your comfort zone today, transform yourself right now without making excuses.
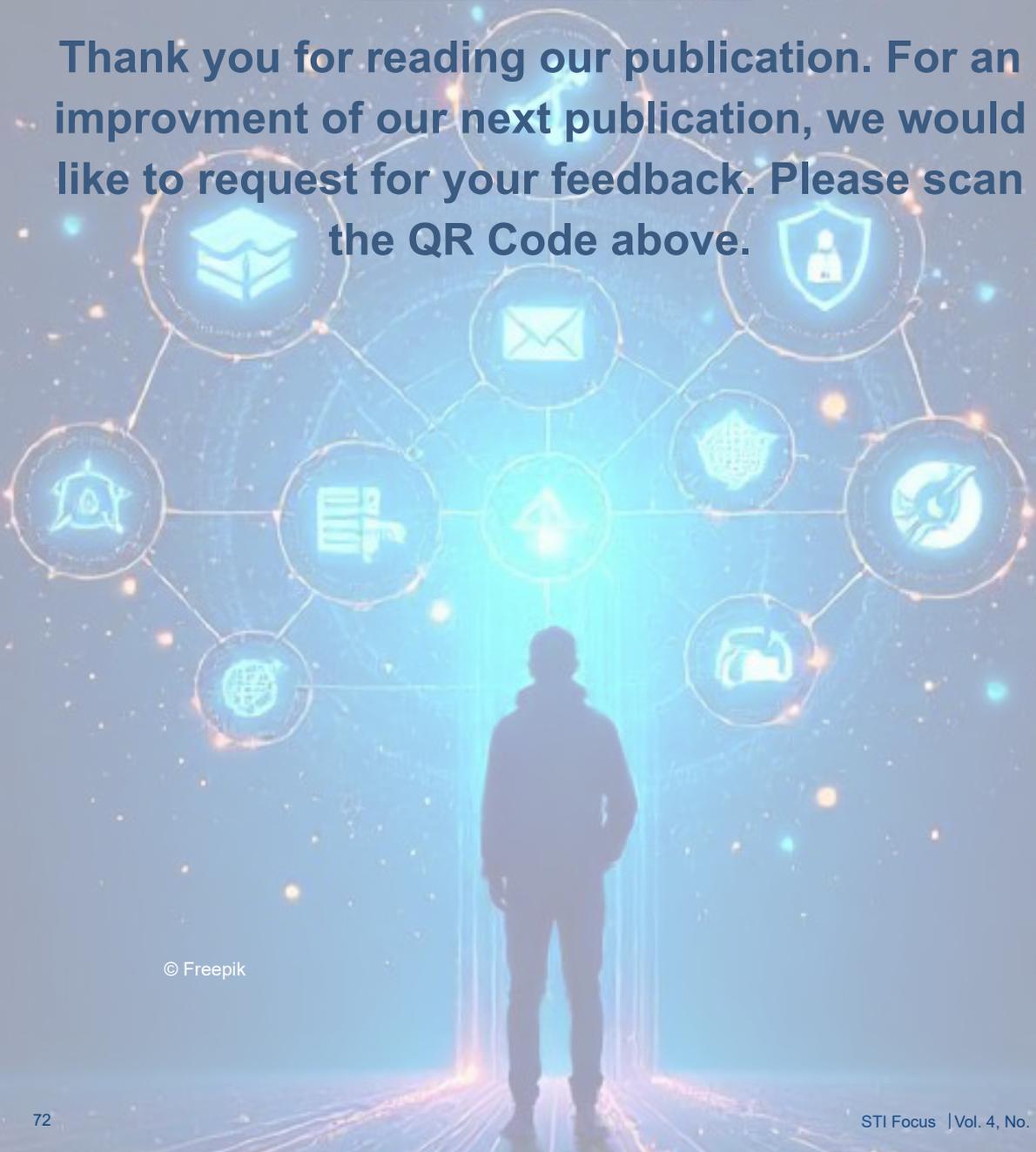
Nothing more and nothing less!
When you walk in your mission towards your direction today, a glorious tomorrow is waiting for you.

Figure 5. VP.Start's Founder and Chief Executive Officer is at VP.Start Sen Sok Valley Campus.

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