Evaluating the Impact of UV-C Radiation on the Shelf life of Strawberry (Fragaria × ananassa Duch)

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ABSTRACT

Background: Strawberries are a major fruit crop in Benguet Province, Philippines, especially in the municipality of La Trinidad. However, their short shelf life and high susceptibility to spoilage present significant challenges for farmers and sellers. The cool climate in Benguet makes it an ideal environment for strawberry cultivation, which is why the fruit is widely grown in the province.

Methods: This study comprised an experimental method that utilized a descriptive quantitative approach for the investigation of the shelf life of strawberries, having a variable of shelf life and parameters of color and mold growth formation, incorporating descriptive statistics and ANOVA for data analysis. One (1) controlled (unexposed) and five (5) treatment groups (exposed) to determine the shelf life variable, with five (5) strawberries in every group stored in a refrigerator, and another set of similar groups one (1) controlled (unexposed) and five (5) treatment groups (exposed) was also used and stored at a room temperature.

Results: Results show that without the use of a refrigerator, the most effective way to delay mold to 3.0 days and color change to 3.0 days is the 2.0 kJ/m², while the least effective is the 1.2 kJ/m² only shifting mold to 2.0 days and color to 2.0 days, which is barely above the 1.6 or 1.9 days of the control. As for refrigeration, the most effective in extending mold formation to 34.3 days and color stability to 26.8 days is 1.2 kJ/m², while the least effective is 1.6 kJ/m² with mold and color change at 14.7 days (even below the 20.5 or 18.8 days of the refrigerated control).

Conclusion: The study revealed that the most effective UVC treatment protocol for extending the shelf life of strawberries was a UV-C dose of 1.2 kJ/m² under refrigerated storage conditions, significantly enhancing mold resistance and color stability. This research explores the impact of different UV-C energies on strawberry color and overall quality, potentially contributing to improved post-harvest handling and storage practices in the region.

KEYWORDS: *UV-C(ultraviolet), radiation, shelf life, strawberries, color change, mold formation, irradiation, fruit, refrigeration, room temperature, preservation techniques*

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INTRODUCTION

BACKGROUND OF THE STUDY

The highest fruit crop production in Benguet province and Baguio City, Philippines, is Strawberry (*Fragaria × ananassa Duch*) (Pinon & Martin, 2018). Strawberries are one of the most commonly produced fruits in the mountain areas of Southeast Asian Countries, including La Trinidad in the Philippines (Nishizawa, 2021). With the well-known climate conditions of Benguet Province, which is uniquely known for its cold weather, strawberry plants require a cold temperature environment, which makes them very prominent in the province. Semi-temperature crops like strawberries require a low temperature, such as 5°C, to produce quality fruit; they become the primary source of employment in agriculture and enhance the economic revenue in Benguet (Parao et al., 2017).

Amid the growing concerns of environmental sustainability and resource conservation, human intervention in preserving consumables has emerged as a critical strategy to mitigate the growing challenges of waste and resource shortages. One of these human interventions is using Ultraviolet C (UV-C). As stated by Hsu et al. (2021), in their perspective of UVC LED, the wavelength of UV radiation in the electromagnetic spectrum covers the wavelength of light and x-rays, encompassing 100 to 400 nm (12.4-3.1 eV). The wavelength range is subdivided into four segments to distinguish their intensity and penetration: UV-A (long-wave ultraviolet/black light), with a wavelength of 315-400 nm; UV-B (medium-wave ultraviolet) has 280–315 nm and known to have the best effects on microorganisms; UV-C (short-wave ultraviolet) has 200–280 nm and offers a straightforward, eco-friendly, and cost-effective nonthermal option and it is the highest energy segment of UV radiation (Sanchez et al., 2021). Lastly, the Vacuum UV (100–200 nm). (Hsu et al., 2021), the UV-A radiation has the longest wavelength occupied, whereas the lowest wavelengths are attributed to UV-B and UV-C radiation, respectively. The Earth's ozone layer absorbs all UV-C and some UV-B radiation, while UV-A and UV-B rays are transmitted through the atmosphere. Thus, most UV rays people encounter are UV-A, with very little UV-B.

Ultraviolet (UV) radiation is widely recognized as a significant environmental hazard that can originate naturally and through anthropogenic sources. In response to its potential harmful effects, many have implemented protective measures to mitigate its impact. Nevertheless, over time, specific communities have increasingly embraced the application of UV radiation, particularly within plant physiology. UV treatments have been effectively assessed for various applications, demonstrating their capacity to enhance the accumulation of several phytochemicals. These include ascorbic acid, carotenoids, glucosinolates, and, notably, phenolic compounds (Darré et al., 2022).

UV light is employed in food production to extend the shelf life and minimize pathogenic microorganisms. Effective results have been observed with UV treatment in prolonging the freshness of fruit juices, beverages, vegetables, fruits, meat, poultry, and seafood, as it destroys microbes and decelerates the ripening process (Csapo et al., 2019). The approach of a nonthermal method utilizing UV-C effectively inactivates various microbial pathogens, including bacteria, fungi, yeasts, molds, and viruses (Tchonkouang et al., 2023). Exposure to UV-C radiation is possible only through artificial sources like lamps or lasers because it does not reach the Earth's surface (Sanchez et al., 2021).

Strawberry (*Fragaria x ananassa*) belongs to the Rosaceae and grows in temperate climates with a fleshy and succulent receptacle fruit (Pereira et al., 2022). Famous for their distinct aroma and vibrant appearance, they are rich in minerals, vitamins such as vitamin C, flavonoids, and antioxidants (Lockhart, 2020). Vibrant color, firmness, texture, and shape are ripe strawberry characteristics (*Fragaria x ananassa*) (Simkova et al., 2024; Li et al., 2020).

Vibrant red is the standard ripe strawberry (*Fragaria x Ananassa*) color. The color ranges from deep burgundy to even lighter shades of this color. The deeper the shade of color, the higher the level of anthocyanins present, which reduces the spoilage rate of the fruit (Li et al., 2022; Lockhart, 2020). Another significant physical parameter to determine if the strawberry is ripe is its firmness because it changes as the fruit ripens (Simkova et al., 2024). When ripe, it is soft and juicy, making it delicate and prone to bruising. Bruising of the fruit affects its overall quality (Hikawa-Endo, 2022). A strawberry has nine (9) shape categories: conic, wedge, square, miscellaneous, globose, globose-conic, conic-wedge, long-conic, and bi-conic. Generally, the ideal shape of a strawberry (Fragaria x ananassa) is either round or conical, with a uniform and smooth surface (Li et al., 2020). As mentioned by Habaragamuwa et al. (2018) the average weight of mature strawberries is 16.1 grams.

The fruits develop spoilage several days after being harvested because of their perishable and delicate nature. The post-harvest decay of strawberry fruit is caused by major pathogens, primarily by *Botrytis cinerea* (a causal agent of gray mold), then *Rhizopus stolonifer* (one of the fastest-growing fungi), *Mucor spp., Colletotrichum spp.,* and *Penicillium spp.* (Feliziani & Romanazzi, 2016). Therefore, suitable storage and packaging for post-harvest handling is required, considering the relatively short shelf life of 5 to 7 days after the harvest (Bugawisan, 2021).

Environmental factors significantly influence fruit development. The surrounding environment and the proximity of a fruit production site determine the quality of the fruit. In fruit, organoleptic parameters (color, taste, texture, smell) determine the characteristics of an acceptable standard. Consumers highly appreciate strawberries for their attributes; numerous research papers have investigated the advantages of consuming strawberries, including the prevention of inflammatory conditions and oxidative stress, lowering the risk of obesity-related ailments and heart disease, and providing protection against different forms of cancer (Afrin et al., 2016). However, cultivation conditions offer a wide variety of chances for the end product of a strawberry and its adaptability to agro-climatic circumstances of an area. Therefore, differences in environmental conditions influence the development of strawberry plants, affecting fruit development and fruit quality, among other characteristics; strawberries respond differently to environmental factors, such as incident light, temperature, and humidity (Cervantes et al., 2020). According to the study of Bian et al. (2014), depending on the species and cultivar, incident light's quantity and quality can have an impact on biosynthesis and the build-up of various phytochemical compounds (such as sugars, carotenoids, phenolic acids, or anthocyanins) at the fruit level. Temperature variations impact strawberry fruit production and quality; below 7 ◦C temperatures increase the probability of malformed fruits and changes in fruit size and color (Ariza et al., 2015).

Low temperatures during the early stages of plant growth can change the permeability of cells, decrease photosynthetic capability, and negatively impact crop development, production, and growth (Jiang et al., 2023). Global climate change has been intensifying in recent years, leading to a significant increase in extreme weather events, including extremely low temperatures, which are expected to become even more frequent (Hoffmann et al., 2022). According to the study carried out by Agüero et al. (2015), the researchers observed that the weight of the fruit is reduced as the temperature increases, and firmness decreases when there is more rainfall in the vicinity and increased temperatures. The redness of the strawberry is evident when it is higher in temperature, but decreases with rainfall.

According to the research conducted by Vinas et al. (2024), UV-C radiation is useful in eliminating microorganisms and extending the shelf life of strawberries by lowering microbial loads; it can also degrade some of the nutrients found in strawberries, including ellagic acid, vitamin C, pelargonidin, and ellagitannins, and lead to structural changes in strawberries. Stability remains in total phenolic content and anthocyanin levels (such as pelargonidin). However, a reduction in antioxidant activity during storage after UV-C treatment is observed. Studies show that after UV-C treatment, fresh-cut strawberries may experience a loss of firmness of up to 46.8% during frozen storage, but the nutritional quality remains intact.

This degradation is likely due to oxidative processes triggered by UV-C exposure, which can affect vitamin C and certain polyphenols. Despite these changes, the use of UV-C can still help maintain overall strawberry quality for several weeks if properly managed. Controlled doses of UV-C should be appropriately administered, combined with other preservation techniques, which are crucial to balance these effects (Gomez et al., 2019; Naradisorn, 2021).

The use of UV-C and vacuum sealing to the standard shelf life of strawberries was increased by 124.42% and 54.41% independently, and the high probability of reducing the spoilage of fresh fruits was proven (Damdam et al., 2023). Preharvest strawberries were also treated with UV-C radiation, specifically with the sensitivity of its leaves and the fruit itself, including the pathogens; the study significantly affected the strawberry plant, specifically on the color. Furthermore, pathogens significantly reduce natural infection (Forges et al., 2020).

Ionizing radiation is one of the most effective ways of terminating microorganisms to enhance safety and hygiene and improve shelf life in the food industry. However, in current days, this method needs to be improved in studies (Danyo et al., 2023). In the research conducted by Vanhaelewyn et al. (2020), UV-C can eliminate or remove the presence of microorganisms present in plants; it, being the most energetic radiation, projects a higher success rate when it comes to microorganism treatments. Due to the nutrients present in every naturally produced fruit, it is one of the major factors that make it susceptible to spoilage and microbial infestations (Pravallika et al., 2022).

UV-C treatments have significant potential in helping to reduce post-harvest diseases in plants, but physiologic alterations are also considered because they are not solely related to germicidal characteristics. For the microorganisms to remain alive, they rely on the dose of UV-C being emitted, which is constrained by the distance from the source (Górny et al., 2024).

Utilizing magnetic fields and UV-C was also evaluated, wherein the plant accelerates the seed germination, including the reproductive growth. EMF impacts the driving of ions, electric dipoles' polarity, water absorption, storage, and ionization. Furthermore, it also alters the permeability of cell membranes, the placement of both protein and lipid regions in the membrane's structure, and the molecular location of charge (Gąstoł & Błaszczyk, 2024).

There are consistent observations suggesting that UV-C treatment can be beneficial in maintaining the ascorbic acid content of the fruits. In the study conducted by Warner et al. (2021), exposure to UV-C radiation resulted in an increase not only in ascorbic acid but also in sucrose and phytochemical profiles in strawberries. On the contrary, UV-C treatment was applied for bitter gourd fruits with an exposure time of 20, 30, and 40 minutes for 16 days. However, the exposure for 40 minutes was unable to maintain ascorbic acid. Instead, it increased vitamin C and aided in preserving firmness, reducing weight loss and decay of stored bitter gourd fruit up to 16 days of storage (Prajapati et al., 2021).

Water-assisted UV-C light (WUV-C) is the alternative sanitizing method. This treatment involves washing strawberries for 1 or 5 min in a tank with 2 or 4 lamps, each UV-C light emitting at 172 W/cm2, or in a chlorine solution (200 ppm, pH 6.5). As a result, the strawberries maintained their quality and nutritional value after the treatments. It also retained its firmness and showed no visible changes in color (Nicolau-Lapeña et al., 2020b)

The study of Yang et al. (2022) utilized DENBA, a new type of technology for cold chain preservation using EMR electrostatic waves from a high voltage electricity (0 V for control group and 500 - 1200 V for uncontrolled) and refrigerator wherein the strawberries were stored for 11 days in a 4°C temperature, the DENBA treated strawberry stored in refrigerator had a promising result in a reduced decay index, firmness, weight loss in comparison to control group.

Postharvest strawberries, including frozen strawberries, are observed for a potential risk of foodborne pathogens. The study showcases the demonstration that refrigeration at a temperature of 4-5°C has effectively slowed down the metabolic processes and extended the shelf-life of the fruit. After a month of frigid storage of strawberries, there have been no nutritional quality alterations. However, a loss of firmness estimated at up to 46.8% was observed (Nicolau-Lapeña et al., 2024). 254 UV-C wavelengths sourced from a lamp are utilized in the study of Pataro et al. (2015), wherein the researchers applied the specified wavelength to tomatoes and apples. The same wavelength has been used in strawberries, blueberries, and other fruits with promising results, explicitly extending shelf life, and has been proven in a similar study by Idzwana et al. (2020).

With the advent of UV-C light, it is considered germicidal, with the exposure of horticulture or the cultivation of crops using artificial non-ionizing radiation UV-C ranges from 180-280 nm with a maximum wavelength of 254 nm. This has been considered to be an alternative fungicide for post-harvest control. Idzwana et al. (2020). Moreover, in Sorica et al.'s study (2015), four different distances from the UVC lamp (50 mm, 75 mm, 100 mm, and 125 mm) were used. In addition, the duration needed to extend the shelf life of fruits and vegetables is 5-15 minutes, with an energy range of 254 nm (Sneha & Patil, 2022).

According to the study of Ledesma et al. (2020), the common strawberries grown in the area include ‘Sweet Charlie’, ‘Chandler’, and ‘Whitney’ sourced from the United States, and ‘Toyonoka’ and '91 ‘Nyoho’ from Japan. La Trinidad farm primarily produces ‘Sweet Charlie’.

PROBLEM, OBJECTIVES, RESEARCH QUESTIONS, AND/OR HYPOTHESIS

PROBLEM

In many studies, UV-C treatment has shown effective results in microbial disinfection in food products. While UVC treatment has shown promising antimicrobial effects when used alongside other preservation methods, more research must be conducted on the precise parameters of UVC dosage for strawberry preservation. Specifically, the appropriate distance, optimal dosage intensity, and unvarying temperature are underexplored. Thus, an accessible method, such as UV-C light, should be maximized.

- The effects of UV-C with varying intensity on the strawberry
- Any significant changes with the duration of shelf life
- The impact of utilizing parameters and shelf life as a variable

RESEARCH QUESTIONS

These selected questions guided the researchers in achieving the research objectives.

1. What are the least and most effective UV-C treatment protocols in extending the shelf life of strawberries?
2. What is the statistical significance of the differences in shelf life between strawberries not subjected to UV-C treatment and those subjected to UV-C treatment protocols when stored at 0° to 4°C and at room temperature?

OBJECTIVES

The researchers aimed to extend the shelf life of strawberries using UV-C treatment and to investigate if UV-C with different energies significantly affects the lifespan of strawberries. It is essential to optimize the critical variable firmness and different UV-C energies. Additionally, to assess significant changes in the physical attributes. UV-C exposure will be used to determine if it improves the quality and lifespan of strawberries after the harvest in La Trinidad, Benguet, which could benefit the improvement of the local product. This study explores the effect of the UVC treatment on strawberry's physical properties:

- To identify the least and most effective UV-C treatment protocols for extending the shelf life of strawberries
- To determine the statistical significance of differences in shelf life between strawberries not subjected to UVC and strawberries subjected to UV treatment protocols and stored at 0° to 4°C and at room temperature.

RESEARCH FRAMEWORK

This study, titled "Evaluating the Impact of UV-C Radiation on the Shelf Life of Strawberries," aimed to prolong the shelf life of strawberries through UV-C treatment and examined notable changes in their physical characteristics.

Figure 1 contains the study's model to illustrate the variables in the problem and give direction to the study as well.

Sufficient knowledge regarding the different techniques and methods of preservation of produce, mainly strawberries, is essential to lengthen the shelf life of the strawberry. The ability to distinguish the impact of UVC on the shelf life of strawberries will serve as a new source of information to manipulate the produce's conditions when affected by different environmental factors─ which technically affect its shelf life.

Figure 2 shows that the study includes two storage temperatures (0° to 4°C and room temperature), each with one control group (the unexposed group stored) and five uncontrolled groups, where the varying distances in each group influence the intensity.

This study used a descriptive-experimental research design. The researchers used Descriptive Analysis to calculate the mean, median, mode, range, variance, and standard deviation of the data collected. The significant difference between the controlled and uncontrolled groups in terms of the extended shelf life of the strawberry was analyzed using the ANOVA test. In addition, a post-hoc test (Tukey's HSD Test) was further used to provide an in-depth analysis of each experimental group from the control group. This research used color and mold growth parameters in determining if different exposure energy levels could affect the strawberry's shelf life at 0° to 4° C and room temperature storage.

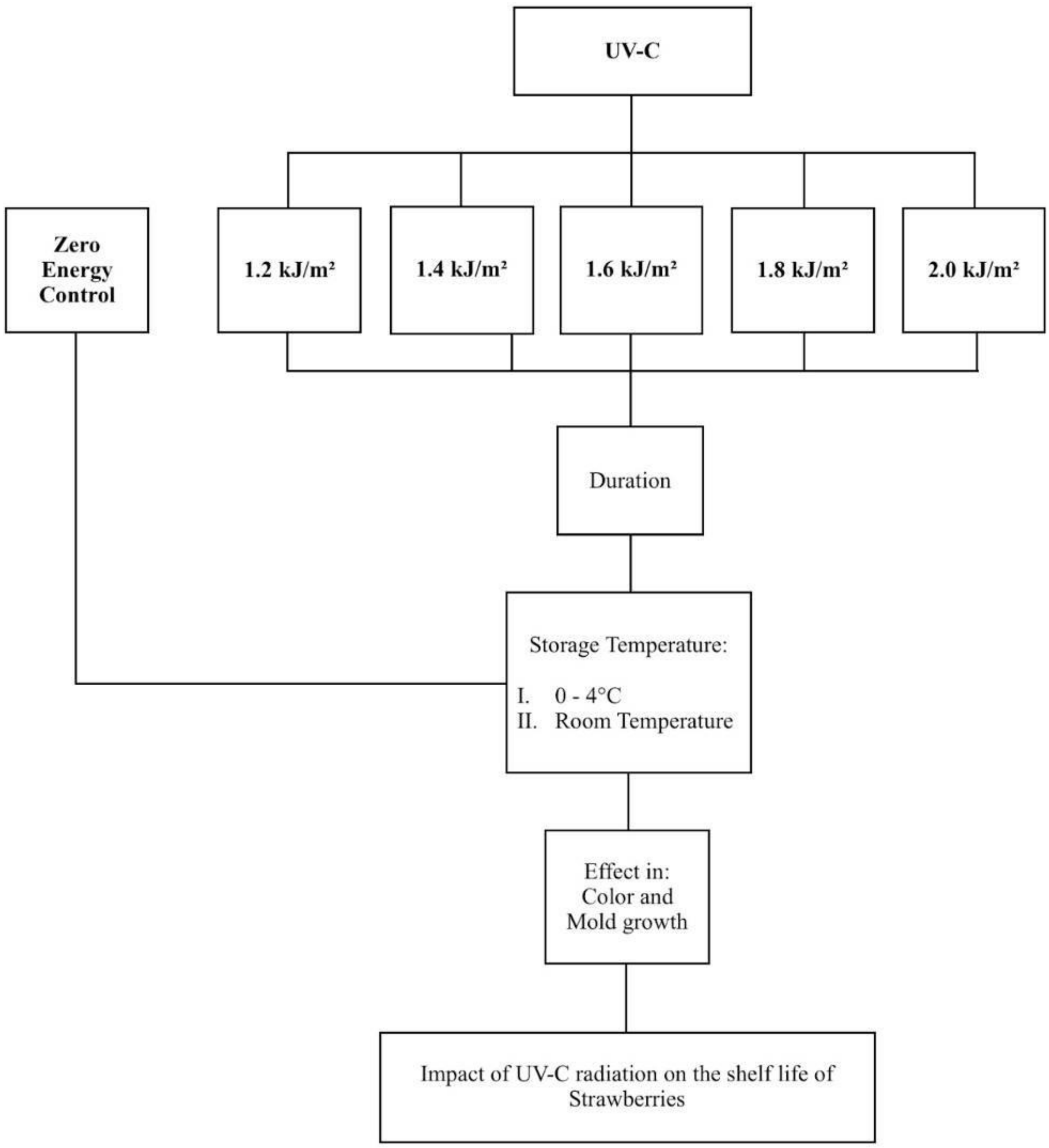
UV-C
Zero Energy Control
1.2 kJ/m²
1.4 kJ/m²
1.6 kJ/m²
1.8 kJ/m²
2.0 kJ/m²
Duration
Storage Temperature:
I. 0 - 4°C
II. Room Temperature
Effect in: Color and Mold growth
Impact of UV-C radiation on the shelf life of Strawberries

Figure 1

INPUT	PROCESS	OUTPUT
Experimental Groups: **I. Stored at 0 - 4°C** ○ Control Group (Unexposed) ○ Uncontrolled Group (same exposure time) • 1.2 kJ/m²; 10 minutes • 1.4 kJ/m²; 10 minutes • 1.6 kJ/m²; 10 minutes • 1.8 kJ/m²; 10 minutes • 2.0 kJ/m²; 10 minutes **II. Stored at room temperature** ○ Control Group (Unexposed) ○ Uncontrolled Group (same exposure time) • 1.2 kJ/m²; 10 minutes • 1.4 kJ/m²; 10 minutes • 1.6 kJ/m²; 10 minutes • 1.8 kJ/m²; 10 minutes • 2.0 kJ/m²; 10 minutes ○ **Variable:** • Shelf life ○ **Parameters:** • Color • Mold growth	**Research Design:** Descriptive Experimental Research **Data Analysis:** 1. Descriptive Statistics 2. ANOVA	The Impact of UV-C radiation on the shelf life of strawberries

Figure 2

SIGNIFICANCE OF THE STUDY

The results of this study will be helpful in the following:

Researchers: The findings of this research will give the present researchers a better understanding of post-harvest technologies, mainly the use of UV-C radiation to preserve strawberries. The researcher's knowledge of food preservation, microbiology, and agricultural science will also improve. Conducting this study will also help them develop critical skills in experimental design and data analysis, which will be valuable for future projects.

Future Researchers: Future researchers will benefit from this study as it provides an essential reference for further exploration of UV-C and other preservation methods in agriculture. It will also provide a basis for further research into the long-term impacts of UVC on strawberries or for improving preservation methods for strawberries and other crops like vegetables. Furthermore, by experimenting with different preservation technology combinations or using similar discoveries for other perishable fruits, researchers can expand on this work in the future. The study encourages creative thinking and improves environmentally friendly food preservation.

Researchers in the Technology Industry: The findings can catalyze a consumer-friendly portable UV-C machine, considering the advantages of UV-C exposure, which can be conceptualized as a marketable aspect.

Producers: The results can assist farmers/producers in finding solutions to regional agricultural problems, such as increasing the shelf-life of strawberries before being sold and limiting the exploitation of modified packages to extend the lifespan of fruits. This strategy could affect strawberry cultivation and preservation in areas like Benguet.

Consumers: This study will aid a new method of preserving strawberries with UV-C, extending the shelf-life of products in the market, limiting the existence of microorganisms, and benefiting the client.

METHODS AND DESIGNS

This research paper comprised an experimental method that utilized a descriptive quantitative approach for the investigation of the shelf life of strawberries produced in La Trinidad, Benguet. Furthermore, it assessed the different UV-C energy levels that were utilized with two sets of storage temperatures, applying different measured energies from UV-C radiation incorporating one (1) controlled (unexposed) and five (5) treatment groups (exposed) to determine the shelf life variable with five(5) strawberries in every group stored in a refrigerator, and another set of similar groups one (1) controlled (unexposed) and five (5) treatment groups (exposed) was also used and stored in a room temperature. A quantitative-experimental design incorporating the ANOVA test was applied to address the effects of UV-C at varied energies. Furthermore, descriptive statistics and a post-hoc test (Tukey's HSD Test) were also utilized to inhibit new comprehensive information favorable to concerned individuals, especially producers, in extending the shelf life of locally produced strawberries.

MATERIALS

Materials and equipment used for this study include the UV-C lamp, UV-C meter, a mini refrigerator, an ice box, a towel, a camera for documentation, one (1) digital weighing balance, 60 pieces of strawberries, a knife or scissors, six (6) pieces of transparent sterilized tubs, distilled water, and kitchen paper towel. A reliable UV-C tool is the Philips UV-C lamp, which offers a simple design with a constant UVC output and a peak of 253.7 nm. This tool breaks down the DNA and, therefore, inactivates the microorganism's reproduction ability. A UV-C meter measures UV-C radiation by displaying UV-C's energy level on the LCD screen. As for the cooling system environment, a refrigerator is a tool that will be used for storing perishable fresh fruits at 40°F (4°C recommended by the Food and Drug Administration (FDA) to maintain the quality, freshness, firmness, and prolonged shelf life of strawberries (Muncan et al., 2022). In the market where strawberry transportation is crucial, a reefer container is utilized to force cool air into the packed strawberries' layers during transportation (Ikegaya et al., 2020). Sweet Charlie strawberries were used as the sample for a total of (60) strawberries that were harvested in La Trinidad, Benguet. Correspondingly, in this experiment, an ice box was used to provide a cool, dry environment for storing the strawberries, particularly due to the immediate unavailability of a refrigerator. Also, a towel was utilized to keep the strawberries dry and served as a barrier from the ice cubes, avoiding direct contact. Before the exposure, the strawberries were washed with distilled water and patted dry afterward. The sterilization of tubs was done with (1) a UV-C exposure.

SAMPLING PLAN

This study selected representative strawberry samples from the La Trinidad Strawberry Farm in Benguet (2601). Samples were collected, washed, and stored in sterile containers. These are then divided into experimental groups based on exposure factors, with the control group included for comparison.

Sample Selection Criteria:

1. Patch Uniformity: All samples were harvested from the same crop to minimize variability due to environmental and growth conditions.
2. Color: Bright, even, red color.
3. Physical appearance: intact green cap or calyx, firm and well-formed, fresh in appearance, and free of visible damage caused by pests.
4. Weight and Size: For comparison, 60 strawberries ranging from 13 to 16 grams were carefully weighted and selected based on uniform size.
5. Visual Quality: Samples selected were free of visible defects such as discoloration, bruises, or fungal growth.

DATA GATHERING PROCEDURE

A. Sample Collection

Strawberry samples were meticulously hand-picked with the guidance of a resident farmer from La Trinidad Strawberry Farm, Benguet 2601, at precisely 6:50 AM. This timing will maximize shelf-life, potentially extending it by half to one day due to the accumulation of photosynthates during harvest. The Department of Agriculture - CAR, located at the Benguet State University (BSU) Compound in La Trinidad, Benguet 2601, suggested that turgidity may be reduced at this time. During the hand-picking of strawberries, the researchers wore food-grade plastic gloves. This precautionary measure was essential to help prevent contamination, as plastic gloves served as a barrier against sweat or other contaminants that might be transferred from the hands to the strawberries. This approach ensured the integrity and safety of the strawberries for subsequent testing and analysis.

B. Selection Criteria

Strawberries were selected from the same crop and classified as Extra Class or superior quality according to the Association of Southeast Asian Nations (ASEAN) Standard for Strawberry (2007). As adopted by the 42nd ASEAN Ministers on Agriculture and Forestry in 2020, the strawberries must exhibit a bright, even red color, have an intact green cap or calyx, be firm and well-formed, appear fresh, and be free from visible pest damage. Sixty pieces of strawberries were carefully chosen from the harvested strawberries, taking note of their uniformity in size and weight, ranging from 13 to 16 grams.

C. Transportation and Storage

The strawberries were placed in an icebox. Three bags of ice cubes (2 kg each) were poured inside the ice box to keep a cool storage temperature for the strawberries during transportation. A towel was placed between the ice cubes and strawberries, serving as a barrier to avoid direct contact. They were transported by car from the strawberry farm back to Baguio, Benguet, for half an hour. Upon arrival at the designated exposure location, the strawberries were stored in labeled sterilized tubs and divided into two storage conditions, each having one control group and five treatment groups. These tubs had their lids on to prevent exposure during storage and experimentation.

D. Sample Preparation

After the strawberries were collected, sixty strawberries were carefully chosen by using the criteria. The strawberries were washed thoroughly with distilled water and were gently patted dry with a clean kitchen paper towel, ensuring they were free of excess moisture. The selected strawberries, weighing approximately 13 to 16 grams, were arranged within a sterilized transparent tub. Each tub will contain five strawberries, spaced evenly to prevent contact.

E. Experimental Grouping

Subsequent to cleaning and drying the strawberries will be divided into two storage groups: (1) an ambient temperature consisting of one control group and five groups treated with UV-C and (2) under refrigeration at a temperature of 0° to 4° Celsius, having one control group and five treatment groups. This division allowed the researchers to analyze different treatment variables in the research process comprehensively.

Exposure Procedure for Strawberries

1. Before beginning the experimentation, the researchers ensured the exposure area met the specific conditions: A closed room with controlled room temperature and minimal lighting (dark environment).
2. Each uncontrolled group was subjected to various energies measured using a UV energy meter with uniform exposure durations for the refrigerated samples. The control group remained unexposed.
    - Group 0: Controlled
    - Group 1: 1.2 kJ/m^2; 10 minutes
    - Group 2: 1.4 kJ/m^2; 10 minutes
    - Group 3: 1.6 kJ/m^2; 10 minutes
    - Group 4: 1.8 kJ/m^2; 10 minutes
    - Group 5: 2.0 kJ/m^2; 10 minutes

    Additionally, one control group and five uncontrolled groups have been utilized and stored at room temperature to look for the difference with the strawberries stored in the refrigerator. With the potential harm of the UV-C, researchers strictly adhere to the precautionary measures in handling to prevent harm.

3. After exposure to UV-C light by a UV-C lamp, each experimental group was reassessed for changes in terms of mold growth and color change if there were any rapid changes.
4. The monitoring phase followed a structured schedule, with observations conducted twice per day, ensuring a 12-hour interval monitoring until strawberries are rotten. Quick documentation of the strawberries' condition was essential, especially for those under refrigeration, that minimized the effect of temperature fluctuations while the door remained open. A systematic assessment of mold presence and color changes was considered to determine if the exposed strawberries have extended their shelf life based on mold growth and color changes.

Thus, the researchers employed a nominal scale scoring system since the visual appearance of the fruit and vegetables is the basis of the consumers in selecting fresh produce. A reliable guide nominal scale for the color of a strawberry was constructed by Nunes (2015) to serve as a basis for determining the color attributes of a strawberry (Figure 3: Table 1). Considering the mold growth of strawberries, the study of El Hamid et al. (2022) utilized UV light to protect post-harvest strawberries from molds. A scale for gathering data was formulated to get the mold attributes relative to UV exposure.

This study made use of a checklist, which is a tool commonly used in observation. A checklist is a prepared list of items, requirements, behaviors, actions, or skills, the presence or absence of which are ticked or marked as yes/no for both groups of strawberries inside the refrigerator and out at room temperature. To gather accurate data, the study employed this checklist to monitor and observe the impact of different exposure factors on the shelf-life of strawberries per tub under two distinct storage temperatures. The findings from each observation were recorded on the researchers' checklist in Figure 4: Table 2 and 3.

5. After the monitoring and observation period, a careful analysis has been conducted. The two different sets of groups were evaluated based on the color and mold across all samples and the effect of UV-C's varied distances applied. This assessment determined the effects of UVC exposure on the fruit's physical characteristics. It concluded whether exposure to higher levels of UV-C energy resulted in a prolonged shelf-life of the strawberries.

TREATMENT AND ANALYSIS OF DATA

In order to measure the preserving capability of UV-C radiation in terms of the shelf life of the strawberries, this experimental research measured one variable, which is the shelf life of strawberries, and the parameters being color and mold growth. These tools helped the researchers thoroughly analyze the effects of different treatment variables and draw meaningful conclusions from the data. Below is an overview of the statistical methods the researchers used:

1. The researchers used descriptive statistics to determine the least and most effective UV-C treatment protocols. This approach helped the researchers summarize and describe the main features of the data they collected. Key factors such as duration, intensity, and frequency of UV-C exposure were assessed. Descriptive statistics will enable the researchers to:
   - Calculate means, medians, and modes to identify central tendencies in the data.
   - Determine the range, variance, and standard deviation to assess the dispersion and variability of treatment effects.
   - Use graphical representations like histograms and box plots to visually interpret data patterns and outliers.
2. Statistical significance of differences in shelf life between strawberries subjected to a controlled UV-C treatment protocol and strawberries stored in an uncontrolled environment, the researchers utilized ANOVA (Analysis of Variance). ANOVA is a powerful statistical method that enabled the researchers to:
   - Test for differences between the means of multiple groups to understand if the observed variations are statistically significant.
   - Determine the influence of one or more factors by comparing the variance among groups relative to the variance within groups.
   - Additionally, Tukey's HSD Test as a post-hoc was used to assess the differences across treatment groups and the result was significant. Relatively, the aforementioned statistical tool was used with Tukey's HSD to maintain the reliability of the result in this experiment.

Interpretation:

- Small effect size ($d = 0.2$): Minimal impact
- Medium effect size ($d = 0.5$): Moderate impact
- Large effect size ($d = 0.8$ or greater):Significant impact

SCOPE AND DELIMITATION

This study focused on assessing the effects of UV-C radiation on the shelf life of strawberries harvested from the La Trinidad, Benguet Strawberry Farm. Specifically, it evaluated different doses of UV-C radiation. It also aims to determine which treatment dose is most and least effective in prolonging the shelf life, and a statistically significant difference between treated and untreated strawberries under the specified storage conditions.

The research focused on locally sourced strawberries from the Strawberry farm located in La Trinidad, Benguet, Philippines. The strawberries were harvested from plants that were planted at the same time. Only freshly picked strawberries, handled with gloves, were chosen. They were stored immediately in an ice box filled with ice, avoiding direct contact with the ice to maintain freshness. The storage area contained only strawberries to prevent contamination. Additionally, This experiment is limited to organically cultivated strawberries to assess potential differences in UV-C efficacy due to the cultivation methods.

Before storage and experimentation, strawberries were washed with clean water for 5 minutes (Wang et al., 2023). They must meet specific quality criteria for ripeness, including color and size. This study examined the effects of UV-C radiation at varying distances with constant exposure time in every uncontrolled group. Furthermore, during exposure to UV-C, it was significant to use a dark room to block other sources of light, which could have altered the total dose received during exposure time. Furthermore, observations were limited to mold growth and color due to limited equipment.

RESULTS AND DISCUSSION

UV-C Dose (kJ/m²)	Storage	Mold Formation (days)	Color-change (days)
Control (No UV-C)	**Without** refrigeration	1.6	1.9
1.2 kJ/m²	**Without** refrigeration	2.0	2.0
1.4 kJ/m²	**Without** refrigeration	2.2	2.3
1.6 kJ/m²	**Without** refrigeration	2.5	2.4
1.8 kJ/m²	**Without** refrigeration	3.0	2.8
2.0 kJ/m²	**Without** refrigeration	3.0	3.0
Control (No UV-C)	**With** refrigeration	20.5	18.8
1.2 kJ/m²	**With** refrigeration	34.3	26.8
1.4 kJ/m²	**With** refrigeration	22.2	17.0
1.6 kJ/m²	**With** refrigeration	14.7	14.7
1.8 kJ/m²	**With** refrigeration	23.7	20.8
2.0 kJ/m²	**With** refrigeration	23.1	22.0

Table 5.1 Group-mean shelf-life for mold formation and color change under each UV-C dose and storage condition.

Table 5.1 shows the most and least effective dosages for extending the shelf life of strawberries. Strawberries stored in a non-refrigerated environment with a 2.0 kJ/m² UV-C exposure became the most effective protocol, delaying mold to 3.0 days and color change to 3.0 days. However, a UV-C dose of 1.2 kJ/m² only shifts mold to 2.0 days and color to 2.0 days (barely above the 1.6 / 1.9 days of the control).

On the contrary, 1.2 kJ/m² of dosage was recorded as the most efficient energy in prolonging the shelf life of the strawberry with refrigeration. The said energy extended the mold by 34.3 days, having color stability to 26.8 days. For the least efficient dosage under a refrigerated environment, 1.6 kJ/m² showed the earliest significant change on day 14.7 both in mold growth and color change, which is notably shorter than the refrigerated control values (No UV-C) of 20.5 and 18.8 days these data was taken with a total days of observation was conducted for 41.5 days. It is evident in this paper that refrigerated strawberries had a longer shelf life, having a mean of 34.3 days, compared to strawberries stored at room temperature. Thus, refrigeration alone, even without the exposure to UV-C, extended shelf life from 1.6 days (ambient) to 20.5 days (chilled), displaying slowed microbial growth and metabolic responses.

The factors of mold formation and color change are key in determining the effectiveness of UV-C treatment protocols for extending strawberries' shelf life. Color is a crucial aesthetic attribute that consumers associate with taste, nutritional value, and freshness, serving as an important quality indicator for breeders and industry professionals (Thole et al., 2020). Da Silva Simão et al. (2022) noted that color change in fruit products during storage significantly affects shelf life. Mold growth, especially in strawberries, indicates shelf life due to their susceptibility to fungal infections, which can lead to rapid declines in appearance and texture (Nakata & Izumi, 2020). Refrigeration significantly extends shelf life, increasing it from about 1.6 days at room temperature to 20.5 days in chilled environments. Studies indicate that storing strawberries at 4-5°C slows metabolic processes and preserves nutritional quality for a month, although physical changes can occur (Nicolau-Lapeña et al., 2024).

Microbial growth can occur rapidly at ambient temperature, making effective inactivation crucial. Higher UV-C doses of 2.0 kJ/m² are often necessary to significantly inactivate spoilage fungi, potentially extending the mold formation period from the usual 1.6 days to around 3 days. Alternatively, lower doses ranging from 1.2 to 1.4 kJ/m² may be used. However, they offer only marginal extensions of about 0.4 to 0.6 days due to the quick germination of surviving spores in warm, humid conditions. In colder temperatures, however, chilling effectively suppresses most fungal activity, allowing low UV-C doses of 1.2 kJ/m² to increase shelf life from approximately 20.5 to 34.3 days significantly.

The results indicate that high doses of UV radiation (for instance, 1.6 kJ/m²) may negatively impact shelf life under refrigeration, potentially reducing it to approximately 14.7 days. This effect is likely attributed to the damage caused to the fruit's cuticle and cell membranes, which can accelerate discoloration and facilitate secondary microbial invasion. It is noteworthy that color stability often correlates with mold delay, as both are indicators of tissue integrity and microbial presence. In terms of ambient storage, only the highest UV dose (2.0 kJ/m²) achieved a minor extension in mold delay for color, observing a difference of 3 days. Conversely, under refrigeration, a UV dose of 1.2 kJ/m² provided optimal color retention, lasting around 26.8 days. In contrast, the mid-range UV dose of 1.6 kJ/m² appears to have contributed to premature browning and discoloration, further suggesting photodamage's influence. These findings highlight a nuanced, non-linear relationship between UV dosage and shelf life. Under cold storage conditions, lower UV doses tend to maximize benefits, while higher UV doses may be necessary to achieve notable shelf-life extensions in ambient conditions.

In living cells, close contact with various proteins means UV-C light can trigger damaging interactions between these genetic molecules and their neighboring proteins. A specific type of damage caused by UV-C involves the formation of unwanted chemical bonds (cross-links) between the building blocks of proteins (amino acids) and the damaged components of DNA. (Dorbani et al., 2025).The UV-C light can damage the DNA structure. (Nicolau-Lapeña et al., 2024). UV-C light rapidly weakens as it goes deeper into tissue. However, overuse of UV-C might lead to microbial resistance. (Dai et al., 2012)

According to Hamanaka (2016), low UV-C induces a mild stress response in the fruit, activating defense mechanisms like phenolic compounds and antioxidants. These responses enhance fruit resilience without causing tissue damage. González-Aguilar et al. (2022) observed that combining high UV-C doses with refrigeration can lead to tissue browning and softening due to UV-induced stress responses, counteracting the benefits of cold storage. It was said that higher doses unexpectedly reduced the shelf life under refrigerated conditions, leading to earlier mold formation and color degradation compared to lower doses (Pan & Zhu, 2015). According to Pala & Dönmez, 2016, while low-dose UV-C treatment delayed microbial spoilage on fresh produce, its effects were short-lived in the absence of refrigeration due to faster physiological degradation. Syamaladevi et al. (2020) also reported that UV-C doses below 1.5 kJ/m² had minimal impact on the quality of strawberries when stored at room temperature, as metabolic and enzymatic activities remained high despite microbial reduction.

Storage Condition	**ANOVA F (df=5,24)**	**p-value**	**Significant?**
Room Temperature	1.711	0.170	No
4°C (Refrigerated)	13.988	<0.001	Yes

Table 5.2 Mold Formation Shelf-life

Table 5.2 showed that UV treatment under ambient conditions had no statistically significant effect on mold delay ($p=0.170$). In contrast, the strawberries stored in a refrigerated environment with UV treatment did have a significant effect ($p < 0.001$).

In line with the results, UV-C treatment works much better when combined with cold storage (Refrigeration), as chilling (0-4°C) already slows mold growth and spoilage, making it harder for microbes to grow. According to Feliziani & Romanazzi (2016), maintaining low temperatures is essential for enhancing the post-harvest longevity of various fruits and vegetables. Wherein, cold storage is crucial in emphasizing preservation methods which can significantly reduce decay rates

Dose (kJ/m^2)	MeanΔ (days) vs. Control	p-adj	Significant?
1.2	+13.8	0.0001	Yes
1.4	+1.7	0.980	No
1.6	-5.8	0.195	No
1.8	+3.2	0.769	No
2.0	+2.6	0.886	No

Table 5.3 Tukey's HSD (4°C only; control = 0 kJ/m² vs each UV dose)

Table 5.3 shows that 1.2 kJ/m^2 has the most significant result, having +13.8 mean days of shelf life with a p-adj value of 0.0001. The distinct differences with other exposure factors where the result showed no significance in shelf life preservation

Adding a low dose of UV-C (1.2 kJ/m^2) in this study before refrigeration kills or weakens leftover surface fungi. For optimal outcomes, employing a pre-chill treatment of 1.2 kJ/m^2 of UV-C is advisable. This approach can significantly enhance both the mold-free and color-stable storage duration, as evidenced by statistical validation. However, as indicated by the results, too high UV-C exposure damages the external protective barrier of the strawberries, and it is crucial to maintain the specific dosage and the time required to optimize the benefits of the said matter.

Storage Condition	ANOVA F (df=5,24)	p-value	Significant?
Room Temperature	1.556	0.210	No
4°C (Refrigerated)	7.008	<0.001	Yes

Table 5.4 Color-Change Shelf-life

Table 5.4 showed strawberries stored under room temperature treated with UV-C has no significant effect on color stability having a p-value of 0.210. On the other hand, strawberries stored within the 4°C temperature display a significant effect ($p < 0.001$).

The use of color is one of the primary parameters in assessing the shelf life of strawberry, within the process of storage color changes from bright red to dull red and eventually brown emphasizing spoilage. As mentioned by Lee et al. (2015), color change is significant as an immediate and observable indicator in terms of a microbial and chemical spoilage especially with perishable goods. Additionally, rapid changes in color are generally associated with oxidation, chemical/enzymatic reactions, or any possible microbial growth that would contribute to the faster spoilage.

Dose (kJ/m²)	MeanΔ (days) vs. Control	p-adj	Significant?
1.2	+8.0	0.018	Yes
1.4	-1.8	0.965	No
1.6	-4.1	0.476	No
1.8	+2.0	0.946	No
2.0	+3.2	0.717	No

Table 5.5 Tukey's HSD (4°C only; control vs each UV dose)

At ambient conditions, strawberries spoil and discolor rapidly due to warm-temperature fungal growth and oxidative enzyme activityStrawberries' natural wound opening allows mold spores to enter causing cell-wall degradation (Vilanova et al., 2017). This will cause water loss and collapsed strawberries which are visible signs of spoilage (Rivera et., al 2020).. Even the highest UV-C doses (2.0 kJ/m²) only marginally delayed mold or browning (by ~1–1.4 days), and these differences were not statistically significant (ANOVA $p > 0.05$, all Tukey $p > 0.2$).

In a warm, moist environment, the surviving spores and damaged tissue likely recover too quickly for UV to have a meaningful impact. It follows the findings of Idzwana (2021) that high exposure energy can increase the shelf life of strawberries but the high dose utilized under room temperature only allowed 3 days mold delay; however too high exposure could impede the effectiveness of the UV-C. Its practical significance is questionable given the typical 5-7 days lifespan of strawberries (Bugawisan, 2021). Because of the use of UVC stored in a room temperature, the strawberries were rapidly degraded because of intense heat coming from the uvc and the external heat exposure which have overwhelmed the strawberries' heat related stress and capacity to adopt the positive effects of UVC. In addition, temperature fluctuations caused a drastic change in the shelf life of strawberries, increasing its spoilage rate. As mentioned by Martins et al. (2002), Temperature fluctuations substantially reduce strawberries' shelf life; fluctuations increase strawberry decay by approximately 50%.

CONCLUSION

The main goal of this study is to evaluate the effectiveness of the UV-C in terms of prolonging the shelf life of strawberries. The findings revealed that a UV-C dose of 1.2 kJ/m², when combined with refrigerated storage (0° to 4°C), was the most effective treatment in extending the shelf life of strawberries. This specific protocol significantly delayed mold growth and preserved the fruit's color quality over time, highlighting its potential as a practical postharvest intervention for improving strawberry freshness and marketability.

There is a significant difference in extending the shelf life of strawberries stored at 0˚C—4˚C, which lasts 34.3 days, compared to unrefrigerated strawberries, which last only 3.0 days. This result shows that the constant storage temperature of strawberries is critical in delaying mold growth and color stability, and extending shelf life.

RECOMMENDATION

Future researchers investigating the effects of UV-C exposure are encouraged to conduct further thorough experiments utilizing a range of UV-C doses between 1.0 kJ/m^2 and 1.2 kJ/m^2, incorporating incremental variations at decimal intervals. This approach will allow for a more precise analysis of potential differences or significant effects within this dosage range in prolonging shelf life of strawberries. Furthermore, additional parameters including shriveling/regression analysis and phytochemical analysis would significantly contribute not just to the reliability of the data gathered but also to address different criteria in shelf life. Additionally, additional experimental trials would help to improve and integrate the results of extending shelf life in fruits especially with strawberries.

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ANNEXES

A. EXPECTED OUTCOME & DISSEMINATION

The data and findings from this research are intended to be published as a significant article in the Radiology Journal, contributing further advancements to reliable study in regards to UV-C effects, aiming to expand its exposure to a broader audience, including academic researchers, professionals in different industries, and to establish agricultural ascent. By utilizing publication, accessible dissemination is observed as this paper strives to promote adequate/sufficient knowledge by maximizing the usage of UV-C to extend strawberry shelf-life, especially for local farmers suffering from fruit spoilage.

B. LINE ITEM BUDGET

This research section shows the expected budget/expenses for conducting this study.

BUDGET ITEM	PARTICULARS	ESTIMATED COST
I. Materials/Supplies		
1.1 Printing	1.1.1 Background of the Study - References (Php.2/pc. x 30)	Php.60.00
1.2 Paper	1.2.2 Coupon Bond (Php.195 x 1 ream)	Php.195.00
1.3 Mini Fridge	1.3.3 Fujidenzo Mini Fridge (Php. 5,498.00 x 1pc)	Php. 5,498.00
1.4 Strawberry	1.4.4 1kg of Strawberry (Php. 300 x 1kg)	Php. 1,200.00
1.5 UV Lamp	1.5.5 220V T5 Double Tube Ultraviolet Germicidal Dust Mite UVC Ozone double - sterilized UV Quartz Lamp (Connection Line Set) (Php. 593.00 x 2pcs) + (Merchandise Protection Php.23.00)	Php. 1,202.00
1.6 UV Meter	1.6.6 Bought from online (Php. 12,999.00 x 1pc) + (Php. 399.00 merchandise protection)	Php. 13,398.00
1.7 Binding	1.7.7 Research Binding (Php. 50 x1pc)	Php. 50.00
1.8 Gloves	1.8.8 Poly plastic gloves for	Php. 40.00

	handling food bought from the grocery (Php. 40.00 x 1 box)	
1.9 Ice box	1.9.9Ice cooler box for harvested strawberries (Php 623.75 x 1 pc)	Php 623.75
1.10 Ice cubes	1.10.10 Ice cubes for ice box (Php 30.00 x 8 pcs)	Php 240.00
1.11 Towel	1.11.11 Towel for Ice box (130.00 x 1 pc)	Php 130.00
1.12 Container Tubs	1.12.12 Container Tubs (plastic) for storage of strawberries (	
1.13.13 Weighing Scale	1.13.13 Weighing scale for weighing strawberries (Php 150.00 x 1 pc)	Php 150.00
1.14.14 Water	1.14.14 Distilled Water for washing the strawberries (Php 60 x 1 pc)	Php 60.00
II. Food		
2.1 Figaro Coffee	2.1.1 Figaro Coffee for Panelists (Php 140.00 x 4 pcs)	Php. 560.00
2.2 McDonalds	2.2.2 Contribution	Php. 270.00
III. Others		
3.1 Technical Staff Fee	3.1.1 Statistician (Php. 3,000 x 1)	Php. 3,000.00
		ESTIMATED TOTAL: Php. 26,676.75

C. GANTT CHART

Activities	1st Semester					2nd Semester				
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
A. Project Planning										
1. Project Discussion										
2. Identifying and conceptualizing topic area and research title.										
3. Finalizing research topic and research title.										
4. Gathering and corroborating Review of Related Literature.										
5. Trend, Problem, and Issue Writing										
6. Background of the study writing										
7. Research problem, research objectives, research questions, and significance of the study writing.										
8. Methodology Writing										
9. Revisions of Background of the study and Methodology										
10.. Finalizing Background of the Study and Methodology										
11. Research										

Project Proposal										
B. Data Collection, Analysis, Interpretation, and Conclusion										
1. Prepare Proposed Project Manuscript										
2. Submission of Manuscript for REC approval										
3. Gathering of Materials and Equipment										
4. Conducting the experiment (observation and monitoring data collection)										
5. Statistics										
6. Data Analysis and Interpretation										
7. Research Writing										
8. Finalizing Results and Discussions										
9. Conclusion and Recommendation										
10. Initial Defense and Presentation of Research										
11. Finalization of Research Paper										
12. Final Defense										

APPENDICES

D. LETTER OF REQUEST TO ACQUIRE UV-C METER

SAINT LOUIS UNIVERSITY
A Bonifacio Street
2600 Baguio City, Philippines
Tel Nos (+6374) 442.3043 • 443.2001 • 444.8246 to 48
Fax (+6374) 442.2842
www.slu.edu.ph

Member
- Association of Southeast Asian Institutions of Higher Learning (ASAIHL)
- Association of Southeast and East Asian Catholic Colleges and Universities (ASEACCU)
- Association of Catholic Universities of the Philippines (ACUP)
- Catholic Educational Association of the Philippines (CEAP)
- International Federation of Catholic Universities (IFCU)
- Philippine Association of Colleges and Universities (PACU)
- Philippine Accrediting Association of Schools, Colleges and Universities (PAASCU)

School of Nursing, Allied Health and Biological Sciences
DEPARTMENT OF RADIOLOGIC TECHNOLOGY

6 March 2025

Joshua C. Agar
Assistant Professor
Institute of Civil Engineering
University of the Philippines Diliman
Roxas Ave, Diliman, Quezon City, Metro Manila

Dear Professor Agar,

I hope this message finds you well. My name is *Glenford V. Gamilde*, from Saint Louis University-Baguio, and I am writing to you in my capacity as the faculty research promoter for an exciting research project being conducted by my team. Our research group includes the following members: Vince Lauren G. Acosta, Sirach Mae S. Salazar, Jeorge Carl O. Atawe, Marianne P. Santos, Jerone Clint P. Capito, JohnStephen S. Tabas, Katrina Mariano, Renoa Roice L. Ventanilla, and Nathalie D. Padaoan.

Our research is entitled ***"EVALUATING THE IMPACT OF UVC RADIATION ON THE SHELF LIFE OF STRAWBERRY (Fragaria × ananassa)."*** The objectives of our study are as follows:

- To identify the least and most effective UV-C treatment protocols for extending the shelf life of strawberries.
- To evaluate the effectiveness of UV-C irradiation in extending the shelf life of strawberries stored at 0-4°C, comparing treated and untreated samples over a defined period.
- To determine the statistical significance of differences in shelf life between strawberries subjected to a controlled UV-C treatment protocol and those stored in an uncontrolled environment.

For the successful execution of our study, we require a reliable ***Ultraviolet C (UV-C) meter*** to ensure precise measurement of UV-C energy exposure on strawberries. Specifically, the strawberries will be exposed to energy levels of 1.2 kJ/m², 1.4 kJ/m², 1.6 kJ/m², 1.8 kJ/m², and 2.0 kJ/m².

We kindly request your assistance in borrowing or renting a UV-C meter from your esteemed institution. Your support will be invaluable in achieving the objectives of our project and contributing to advancements in post-harvest technology.

Please let us know if there are any forms we need to fill out or procedures we must follow to facilitate this request. We are more than willing to discuss this further at your convenience.

Thank you very much for considering our request. We look forward to your positive response.

Warm regards,

Glenford V. Gamilde, RRT (RPO), MPH-EPI
Faculty Research Promoter
Saint Louis University - School of Nursing, Allied Health and Biological Sciences
Department of Radiologic Technology
gvgamilde@slu.edu.ph

Research Group Members:

Vince Lauren G. Acosta	JohnStephen S. Tabas
Sirach Mae S. Salazar	Katrina Mariano
Jeorge Carl O. Atawe	Renoa Roice L. Ventanilla
Marianne P. Santos	Nathalie D. Padaoan
Jerone Clint P. Capito	

E. LETTER TO CONDUCT STUDY OUTSIDE UNIVERSITY

SAINT LOUIS UNIVERSITY
A Bonifacio Street
2600 Baguio City, Philippines
Tel Nos (+6374) 442.3043 • 443.2001 • 444.8246 to 48
Fax (+6374) 442.2842
www.slu.edu.ph

Member
- Association of Southeast Asian Institutions of Higher Learning (ASAIHL)
- Association of Southeast and East Asian Catholic Colleges and Universities (ASEACCU)
- Association of Catholic Universities of the Philippines (ACUP)
- Catholic Educational Association of the Philippines (CEAP)
- International Federation of Catholic Universities (IFCU)
- Philippine Association of Colleges and Universities (PACU)
- Philippine Accrediting Association of Schools, Colleges and Universities (PAASCU)

School of Nursing, Allied Health and Biological Sciences
DEPARTMENT OF RADIOLOGIC TECHNOLOGY

10 March 2025

Ann P. Opiña, RMT, Ph.D. Approved
Dean 11 Mar 2025
Saint Louis University
School of Nursing, Allied Health, and Biological Sciences (SONAHBS)

Dionisio Noel T. Valbuena, RRT (RPO), MAEM
Head, Department of Radiologic Technology
Saint Louis University
School of Nursing, Allied Health, and Biological Sciences (SONAHBS)

Dear Ma'am/Sir,

I hope this message finds you well. My name is Glenford V. Gamilde, and I am a faculty research promoter. I am writing to seek your approval to conduct a research study outside the university premises. Our study, entitled "Evaluating the Impact of UVC Radiation on the Shelf Life of Strawberry (Fragaria × ananassa)," is an exciting initiative undertaken by our research team.

Our dedicated research group consists of the following members:
- Vince Lauren G. Acosta
- Sirach Mae S. Salazar
- Jeorge Carl O. Atawe
- Marianne P. Santos
- Jerone Clint P. Capito
- JohnStephen S. Tabas
- Katrina Mariano
- Renoa Roice L. Ventanilla
- Nathalie D. Padaoan

The primary objectives of our study are:
1. To identify the least and most effective UV-C treatment protocols for extending the shelf life of strawberries.
2. To evaluate the effectiveness of UV-C irradiation in extending the shelf life of strawberries stored at 0-4°C, comparing treated and untreated samples over a defined period.
3. To determine the statistical significance of differences in shelf life between strawberries subjected to a controlled UV-C treatment protocol and those stored in an uncontrolled environment.

For the successful execution of our study, we require a reliable Ultraviolet C (UV-C) meter to ensure precise measurement of UV-C energy exposure on strawberries. The strawberries will be exposed to energy levels of 1.2 kJ/m², 1.4 kJ/m², 1.6 kJ/m², 1.8 kJ/m², and 2.0 kJ/m². Due to equipment and space constraints within the university, we propose to conduct parts of our research at an off-campus location, specifically under the supervision of our Faculty Research Promoter at the residence of our team leader.

We kindly request your approval to conduct this portion of our research outside the university. We believe this will enable us to utilize the necessary equipment effectively and ensure the integrity of our research findings. We are committed to adhering to all safety and ethical guidelines throughout the research process.

Thank you for considering our request. We are eager to contribute valuable insights to the field of agricultural and radiological science through this project and look forward to your favorable response.

F. RESEARCH ETHICS COMMITTEE APPROVAL

CONTROLLED

Saint Louis University
University Research & Innovation Center
Research Ethics Committee

Document Code	FM-URI-068
Revision No.	00
Effectivity	nov 17, 2023
Page	1 of 1

CERTIFICATE OF EXEMPTION FROM REVIEW

Date **28 January 2025**

To: (Name of PI) **GLENFORD V. GAMILDE**

Protocol No.	Protocol Title
SLU-REC 2025-050	**EVALUATING THE IMPACT OF UVC RADIATION ON THE SHELF LIFE OF STRAWBERRY**

This is to acknowledge the submission of the following documents

- ✓ Protocol summary sheet
- ✓ Certification from the Panel members
- ✓ Letter of request
- ✓ Gannt chart
- ✓ CV of the Principal Investigator
- ✓ Line- item budget

After a preliminary review of the above documents, the Research Ethics Committee deemed it appropriate that the above proposal be EXEMPTED FROM REVIEW.

This means that the study may be implemented without undergoing an expedited or full review. Neither will the proponents be required to submit further documents to the committee as long as there is **NO** amendment nor alteration in the protocol that will change the nature of the study nor the level of risk involved.

Responsibilities of investigator/s after the protocol approval:

- ➢ Seek approval from SLU-REC for any protocol/document amendment after this date
- ➢ Report protocol deviation/violation
- ➢ Abide by the principles of good clinical practice and ethical research
- ➢ Comply with all relevant international and national guidelines and regulations
- ➢ Submit final report after completion of study
- ➢ Others: ____________________

For the SLU-REC:

SLU REC Chairperson	Signature	Date
Rainier Moreno-Lacalle		28 January 2025

Received by:

Principal Investigator	Signature	Date
GLENFORD V. GAMILDE		3 February 2025

G. MOLD FORMATION: DAILY OBSERVATION TALLY SHEET

MOLD FORMATION CHECKLIST

WITHOUT REFRIGERATOR

DAY	TIME	1.2 kJ/m^2					1.4 kJ/m^2					1.6 kJ/m^2					1.8 kJ/m^2					2.0 kJ/m^2					CONTROL				
		Strawberry					Strawberry					Strawberry					Strawberry					Strawberry					Strawberry				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
13-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
14-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	y	n	y	y	y	n	n	n	y	n	n	n	n	n	y	y	n	n	n	n	n	n	n	n	y	y	n	y	y
15-Mar	7AM	n	-	n	-	-	-	y	n	y	-	y	y	n	y	y	-	-	n	n	n	n	n	n	n	n	-	-	y	-	-
	7PM	y	-	n	-	-	-	-	n	-	-	-	-	n	-	-	-	-	n	n	n	y	y	n	n	n	-	-	-	-	-
16-Mar	7AM	-	-	y	-	-	-	-	n	-	-	-	-	n	-	-	-	-	n	n	n	-	-	n	y	y	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	n	-	-	-	-	n	-	-	-	-	n	y	y	-	-	n	-	-	-	-	-	-	-
17-Mar	7AM	-	-	-	-	-	-	-	y	-	-	-	-	n	-	-	-	-	n	-	-	-	-	y	-	-	-	-	-	-	-
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18-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	y	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	2.	1.	3	1.	1.	1.	2	4	2	1.	2	2	4.	2	2	1.	1.	5	3.	3.	2.	2.	4	3	3	1.	1.	2	1.	1.
19-Mar	7AM					2					2.2					2.5					3					3					1.6
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

WITH REFRIGERATOR

DAY	TIME	1.2 kJ/m^2					1.4 kJ/m^2					1.6 kJ/m^2					1.8 kJ/m^2					2.0 kJ/m^2					CONTROL				
		Strawberry					Strawberry					Strawberry					Strawberry					Strawberry					Strawberry				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
13-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
14-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
15-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
16-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
17-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
18-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
19-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
20-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
21-Mar	7AM	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
22-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
23-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
24-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
25-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
26-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
27-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
28-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	y	n	y	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
29-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	-	n	-	-	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	-	n	-	-	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n

30-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-Apr	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM																														
13-Apr	7AM																														
	7PM																														
14-Apr	7AM																														
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15-Apr	7AM																														
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16-Apr	7AM																														
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24-Apr	7AM																														
	7PM																														
26-Apr	7AM																														
	7PM																														

30-Mar	7AM	n	n	n	n	n	n	n	n	n	n	-	-	n	-	-	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	n	n	n	-	-	n	-	-	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n
31-Mar	7AM	n	n	n	n	n	n	n	y	n	n	-	-	n	-	-	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	-	n	n	-	-	y	-	-	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n
1-Apr	7AM	n	n	n	n	n	n	n	-	n	n	-	-	-	-	-	n	n	n	n	n	-	n	n	n	n	n	n	n	n	n
	7PM	n	n	n	n	n	n	n	-	n	n	-	-	-	-	-	n	n	n	n	n	-	n	n	n	n	y	y	n	n	n
2-Apr	7AM	n	n	n	n	n	n	n	-	n	n	-	-	-	-	-	n	y	y	y	n	-	n	n	n	n	-	-	n	n	n
	7PM	n	n	n	n	n	n	n	-	n	n	-	-	-	-	-	n	-	-	-	n	-	n	n	n	n	-	-	y	n	y
3-Apr	7AM	n	n	n	n	n	n	n	-	n	n	-	-	-	-	-	n	-	-	-	n	-	n	n	n	n	-	-	-	n	-
	7PM	n	n	n	n	n	n	y	-	n	y	-	-	-	-	-	n	-	-	-	n	-	n	n	n	n	-	-	-	n	-
4-Apr	7AM	n	n	n	n	n	n	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	n	n	n	n	-	-	-	n	-
	7PM	n	n	n	n	n	n	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	y	n	n	n	-	-	-	y	-
5-Apr	7AM	n	n	n	n	n	n	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	n	n	-	-	-	-	-
	7PM	n	n	n	n	n	y	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	y	n	-	-	-	-	-
6-Apr	7AM	n	n	n	n	n	-	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	-	n	-	-	-	-	-
	7PM	n	n	n	n	n	-	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	-	n	-	-	-	-	-
7-Apr	7AM	n	n	n	n	n	-	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	-	n	-	-	-	-	-
	7PM	n	n	n	n	n	-	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	-	n	-	-	-	-	-
8-Apr	7AM	n	n	n	n	n	-	-	-	n	-	-	-	-	-	-	n	-	-	-	n	-	-	n	-	n	-	-	-	-	-
	7PM	n	n	n	n	n	-	-	-	y	-	-	-	-	-	-	n	-	-	-	n	-	-	n	-	y	-	-	-	-	-
9-Apr	7AM	n	n	n	n	n	-	-	-	-	-	-	-	-	-	-	n	-	-	-	n	-	-	y	-	-	-	-	-	-	-
	7PM	n	n	n	n	n	-	-	-	-	-	-	-	-	-	-	n	-	-	-	n	-	-	-	-	-	-	-	-	-	-
10-Apr	7AM	n	n	n	n	n	-	-	-	-	-	-	-	-	-	-	n	-	-	-	n	-	-	-	-	-	-	-	-	-	-
	7PM	n	n	n	n	n	-	-	-	-	-	-	-	-	-	-	n	-	-	-	n	-	-	-	-	-	-	-	-	-	-
11-Apr	7AM	n	n	n	n	n	-	-	-	-	-	-	-	-	-	-	n	-	-	-	n	-	-	-	-	-	-	-	-	-	-
	7PM	n	y	n	n	n	-	-	-	-	-	-	-	-	-	-	y	-	-	-	y	-	-	-	-	-	-	-	-	-	-
12-Apr	7AM	n	-	n	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	n	-	n	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13-Apr	7AM	n	-	n	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	n	-	n	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14-Apr	7AM	n	-	n	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	n	-	n	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-Apr	7AM	n	-	n	n	y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	n	-	n	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-Apr	7AM	y	-	y	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-Apr	7AM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-Apr	7AM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-Apr	7AM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-Apr	7AM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-Apr	7AM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-Apr	7AM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Apr	7AM	-	-	-	y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	34	29	34	41	33	23	21	18	26	21	8.	15	18	15	15	29	20	20	20	29	16	22	27	23	26	19	19	20	22	20
24-Apr	7AM	23.08333333					20.84					20.5					22.43333333					21.8					20.5				
	7PM																														
25-Apr	7AM																														
	7PM																														

H. COLOR CHANGE: DAILY TALLY SHEET

CHANGE IN COLOR CHECKLIST

WITHOUT REFRIGERATOR

DAY	TIME	1.2 kJ/m^2					1.4 kJ/m^2					1.6 kJ/m^2					1.8 kJ/m^2					2.0 kJ/m^2					CONTROL				
		Strawberry					Strawberry					Strawberry					Strawberry					Strawberry					Strawberry				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
13-Mar	7AM	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	3	3	3	3	3
	7PM	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3
14-Mar	7AM	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	1	1	2	3	3
	7PM	2	-	2	-	-	2	2	2	2	-	-	2	2	2	-	2	2	2	2	2	3	3	3	3	3	-	-	-	2	3
15-Mar	7AM	2	-	2	-	-	2	2	-	2	-	-	2	2	2	-	2	2	2	2	2	3	3	3	3	3	-	-	-	-	2
	7PM	-	-	2	-	-	2	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	2	2	2	-	-	-	-	2
16-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	2
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	-
17-Mar	7AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-Mar	7AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
19-Mar	7AM	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	2	2	3	3	4	4	4	4	4	2	1	2	3	4
	7PM	2	0	3	1	0	3	2	2	2	0	0	2	5	2	0	2	3	6	2	2	0	0	3	1	1	0	1	1	1	3
20-Mar	7AM	2.5	1.5	3	1.5	1.5	3	2.5	2	2.5	1.5	1.5	2.5	4	2.5	1.5	2.5	2.5	4	2.5	2.5	2.5	2.5	4	3	3	1	1	1.5	2	3.5
	7PM					2					2.3					2.4					2.8					3					1.8
21-Mar	7AM																														
	7PM																														
22-Mar	7AM																														
	7PM																														
23-Mar	7AM																														
	7PM																														
24-Mar	7AM																														
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28-Mar	7AM																														
	7PM																														
29-Mar	7AM																														
	7PM																														
30-Mar	7AM																														
	7PM																														
31-Mar	7AM																														
	7PM																														
1-Apr	7AM																														
	7PM																														

WITH REFRIGERATOR

DAY	TIME	1.2 kJ/m^2					1.4 kJ/m^2					1.6 kJ/m^2					1.8 kJ/m^2					2.0 kJ/m^2					CONTROL				
		Strawberry					Strawberry					Strawberry					Strawberry					Strawberry					Strawberry				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
13-Mar	7AM	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4
	7PM	3	2	3	3	3	2	3	3	3	3	3	2	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
14-Mar	7AM	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	7PM	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15-Mar	7AM	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2
	7PM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	2	2
16-Mar	7AM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	2	2
	7PM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2
17-Mar	7AM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2
	7PM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2
18-Mar	7AM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2
	7PM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2
19-Mar	7AM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2
	7PM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	3	3	2	2
20-Mar	7AM	2	2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	3	3	2	2
	7PM	2	2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	3	2	2
21-Mar	7AM	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	3	2	2
	7PM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
22-Mar	7AM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
	7PM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
23-Mar	7AM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
	7PM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
24-Mar	7AM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
	7PM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
25-Mar	7AM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2
	7PM	2	2	2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	2	3	3	3	3	3	2	3	2	2	2	2	2
26-Mar	7AM	2	2	2	2	2	2	2	1	2	2	-	2	2	2	2	2	2	2	3	3	3	3	2	2	3	2	2	2	2	2
	7PM	2	2	2	2	2	2	2	1	2	2	-	2	2	2	2	2	2	2	3	3	3	3	2	2	3	2	2	2	2	2
27-Mar	7AM	2	2	2	2	2	2	2	1	2	2	-	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2
	7PM	2	2	2	2	2	2	2	1	2	2	-	2	2	2	2	2	2	2	3	3	2	3	2	2	2	2	2	2	2	2
28-Mar	7AM	2	2	2	2	2	2	1	1	2	2	-	2	2	2	2	2	2	2	3	3	2	3	2	2	2	2	2	2	2	2
	7PM	2	2	2	2	2	2	1	1	2	2	-	-	2	-	-	2	2	2	3	3	2	3	2	2	2	2	2	2	2	2
29-Mar	7AM	2	2	2	2	2	2	1	1	2	2	-	-	2	-	-	1	2	2	3	3	2	3	2	2	2	2	1	2	2	2
	7PM	2	2	2	2	2	2	1	1	2	2	-	-	2	-	-	1	2	2	3	3	-	3	2	2	2	2	1	2	2	2
30-Mar	7AM	2	2	2	2	2	2	1	1	2	2	-	-	2	-	-	1	2	2	3	3	-	3	2	2	2	2	1	2	2	2
	7PM	2	2	2	2	2	2	1	1	2	1	-	-	2	-	-	1	2	2	3	3	-	3	2	2	2	2	1	1	2	2
31-Mar	7AM	2	2	2	2	2	2	1	-	2	1	-	-	2	-	-	1	2	2	3	3	-	3	2	2	2	2	1	1	2	2
	7PM	2	2	2	2	2	2	1	-	2	1	-	-	-	-	-	1	2	2	3	3	-	2	2	2	2	2	1	1	2	2
1-Apr	7AM	2	2	2	2	2	2	1	-	2	1	-	-	-	-	-	1	2	2	3	3	-	2	2	2	2	2	1	1	2	2
	7PM	2	2	2	2	2	1	1	-	2	1	-	-	-	-	-	1	-	-	-	3	-	2	2	2	2	2	1	1	1	1

2-Apr	7AM																														
	7PM																														
3-Apr	7AM																														
	7PM																														
4-Apr	7AM																														
	7PM																														
5-Apr	7AM																														
	7PM																														
6-Apr	7AM																														
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7-Apr	7AM																														
	7PM																														
8-Apr	7AM																														
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9-Apr	7AM																														
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10-Apr	7AM																														
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11-Apr	7AM																														
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18-Apr	7AM																														
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24-Apr	7AM																														
	7PM																														
25-Apr	7AM																														
	7PM																														

2-Apr	7AM	2	2	2	2	2	1	1	-	1	1	-	-	-	-	-	1	-	-	-	3	-	2	2	2	2	2	1	1	1	1
	7PM	2	2	2	2	2	1	1	-	1	1	-	-	-	-	-	1	-	-	-	3	-	2	2	2	2	2	1	1	1	1
3-Apr	7AM	2	2	2	2	2	1	1	-	1	1	-	-	-	-	-	1	-	-	-	3	-	2	2	2	2	2	1	1	1	1
	7PM	2	2	2	2	2	1	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	1	2	1	2	1	1	1	1	1
4-Apr	7AM	2	1	2	2	2	1	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	1	2	1	1	1	1	1
	7PM	2	1	2	2	2	1	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	1	2	1	1	1	1	1
5-Apr	7AM	2	1	2	2	2	1	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	1	2	1	1	1	1	1
	7PM	2	1	2	2	2	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	-	2	-	-	1	1	1
6-Apr	7AM	2	1	2	2	2	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	-	2	-	-	1	1	1
	7PM	2	1	2	2	2	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	-	1	-	-	-	1	-
7-Apr	7AM	2	1	2	2	2	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	-	1	-	-	-	1	-
	7PM	2	1	2	2	2	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	2	-	1	-	-	-	1	-
8-Apr	7AM	2	1	2	1	2	-	-	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	1	-	1	-	-	-	1	-
	7PM	2	1	1	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	1	-	-	-	-	-	-	-
9-Apr	7AM	2	1	1	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
	7PM	2	1	1	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
10-Apr	7AM	2	1	1	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
	7PM	2	1	1	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
11-Apr	7AM	2	1	1	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
	7PM	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
12-Apr	7AM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13-Apr	7AM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14-Apr	7AM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-Apr	7AM	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7PM	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-Apr	7AM	1		1	1	-																									
	7PM				1																										
17-Apr	7AM				1																										
	7PM				1																										
18-Apr	7AM				1																										
	7PM				1																										
19-Apr	7AM				1																										
	7PM				1																										
20-Apr	7AM				1																										
	7PM				1																										
21-Apr	7AM				1																										
	7PM				1																										
22-Apr	7AM				1																										
	7PM				1																										
23-Apr	7AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
24-Apr	7AM	5	1	5	5	15	4	17	5	5	5	16	4	5	5	5	2	4	7	39	43	28	36	25	24	27	12	14	16	3	3
	7PM	55	43	48	47	44	35	13	21	35	30	1	27	32	26	26	30	35	32	0	16	4	6	26	18	21	30	17	18	35	35
25-Apr	7AM	30	22	26.	26	29.	19.	15	13	20	17.	8.5	15.	18.	15.	15.	16	19.	19.	19.	29.	16.	21.	26	21.	24.	21.	16	17.	18.	19.
	7PM					26.8					17					14.7					20.8					22					18.8

I. MOLD FORMATION CHECKLIST

Score and Description					
	1 Very Poor	2 Poor	3 Acceptable	4 Good	5 Excellent
Color	Very dark purplish-red to brown	Very dark red with purplish spots	Entirely Red with faint, noticeable discoloration	Fully Bright Red	No change

Figure 3: Table 1

J. COLOR CHANGE CHECKLIST

Figure 4: Table 2
Inside the Refrigerator

Day	**Parameter**	**A. Control**	**B. 1.2** kJ/m^2	**C. 1.4** kJ/m^2	**D. 1.6** kJ/m^2	**E. 1.8** kJ/m^2	**F. 2.0** kJ/m^2
Day #	Color Change (1-5)						
	Mold Formation (y/n)						
Day #	Color Change (1-5)						
	Mold Formation (y/n)						
Day #	Color Change (1-5)						
	Mold Formation (y/n)						
Day #	Color Change (1-5)						
	Mold Formation (y/n)						

Figure 4: Table 3 Room temperature							
Day	**Parameter**	**A. Control**	**B. 1.2** kJ/m^2	**C. 1.4** kJ/m^2	**D. 1.6** kJ/m^2	**E. 1.8** kJ/m^2	**F. 2.0** kJ/m^2
Day #	Color Change (1-5)						
	Mold Formation (y/n)						
Day #	Color Change (1-5)						
	Mold Formation (y/n)						
Day #	Color Change (1-5)						
	Mold Formation (y/n)						
Day #	Color Change (1-5)						
	Mold Formation (y/n)						

I. IMAGES FOR EQUIPMENTS/TOOLS USED

Image 1. Weighing scale

Image 2. Transparent tubs

Image 3. UV -C meter

Image 4. UV- C light

Image 5. Ice cooler box

Image 6. Towel

Image 7. Disposable gloves

Image 8. Refrigerator

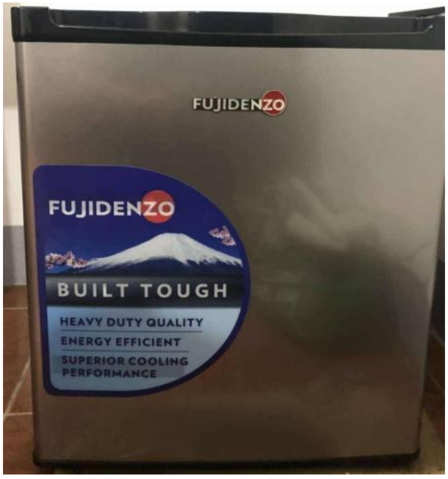

Image 9. Distilled water

Image 10. Ice Cubes

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- THEFIGURESANDDOCUMENTATIONS.zip