Indonesia International Institute for Life Sciences

ENRICHMENT PROGRAM REPORT

Effect of Storage Temperature Towards Physicochemical and Microbial Properties of Plant-Based Cheese Sauce at PT. Organik Adil Sejahtera (Green Rebel)

STUDY PROGRAM
Food Technology

THALIA CHANDRA
19010217

Syahnazia Adinda Firdayanti
(Field Supervisor)
Desak Putu Ariska Pradnya Dewi, S.T.P., M.Sc. (EP Supervisor)

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By
Thalia Chandra
19010217

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EP Supervisor: Desak Putu Ariska Pradnya Dewi, S.T.P., M.Sc.
Field Supervisor: Syahnazia Adinda Firdayanti

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Desak Putu Ariska, M.Sc. 22/12/2022

Syahnazia Adinda Firdayanti
QCQA Assistant Manager

Desak Putu Ariska, M.Sc. 30/01/23

INSTITUT BIO SCIENTIA INTERNASIONAL INDONESIA

Jl. Pulomas Barat Kav. 88 Jakarta Timur 13210 Indonesia
+6221 295 67888, +6221 295 67899, +6221 296 17296
www.i3l.ac.id

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We hereby declare that this final thesis project is from student's own work. The final project/thesis has been read and presented to i3L's Examination Committee. The final project/thesis has been found to be satisfactory and accepted as part of the requirements needed to obtain an i3L bachelor's degree.

Names and signature of examination committee members present:

1	Thesis Supervisor	: Desak P.A.P.D. S.T.P., M.Sc.	Approved
2	Field Supervisor	: Syahnazia Adinda Firdayanti	Approved
3	Lead Assessor	: Muhammad A.M. B.Sc., M.Sc.	Approved
4	Assessor 2	: Widya I. S.T.P., M.Sc.	Approved

Acknowledged by,

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ABSTRACT

PT. Organik Adil Sejahtera (Green Rebel) is a branch company of Indonesia leading plant-based eatery chain, focused on providing demand from B2B and for ready-to-cook frozen meals. Responsible for products' quality, QC/QA department monitors the process starting from incoming raw material inspection, base and product organoleptic testing, until complaint and CAPA filing. GMP audit and assisting pest monitoring also included to maintain standard. All these activities were allowed to learn from as an intern. Recently launched, plant-based cheese sauce (PBCS) acquired constant order. Limited freezer space provided cause possibility observation in alternative storage of chilled temperature (4℃) with consideration of reducing expense on storage. PBCS physicochemical stability (pH, Aw, viscosity, and color) and microbial analysis were performed to assess stability in possible chilled storage (4℃) as compared to frozen stored samples at -18 ℃. Water activity and viscosity were hardly affected by storage temperature in the PBCS sample as both samples remained stable for two months. However, significant differences ($p<0.05$) are observed in pH and color parameters. Microbial analysis based on peraturan BPOM no.13 tahun 2019 provided results within the standard. Major limitation of this experiment is the failure of maintaining storage temperature for both samples, hence, possibility of significant differences in pH and color is inconclusive.

Keyword: Physicochemical, Microbial, plant-based cheese sauce, Storage Temperature

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Jakarta, 21th December 2022

Thalia Chandra

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LIST OF ABBREVIATIONS

Aw	Water Activity
B2B	Business to Business
B2C	Business to Consumer
CAPA	Corrective and Preventive Action
COO	Chief Operating Officer
ERP	Enterprise resource planning
FEFO	First Expired, First Out
FIFO	First in, First Out
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Point
IVS	Indonesia Vegetarian Society
NBS	National Bureau of Standards
PBCS	Plant-Based Cheese Sauce
PPIC	Production Planning and Inventory Control
QC	Quality Control
QA	Quality Assurance
RnD	Research and Development

CHAPTER 1*:* INTRODUCTION

1. Company Introduction

1.1. A Brief History of Host Company

In November 2013, a remarkable dedication to trendsetting constructive eating habits of a young vegetarian couple - Max and Helga - manifested into a plant-based oriented start-up food company known as PT. Hijau Adil Bahagia. Commercially branded as Burgreens, PT. Hijau Adil Bahagia rises and expands along with the inclining interest in healthy lifestyle through the years. Serving plant-based modified Asian and Western cuisines, Burgreens has succeeded in establishing eatery chains in Jakarta, Bandung, Bali, Tangerang, and Bekasi. In September 2020, Burgreens launched PT. Organik Adil Sejahtera as a branch company specialized in B2B and frozen meals under the name of Green Rebel. Through Green Rebel's existence, the company managed to partner with renowned brands such as IKEA, Sushi Tei, Fore, and many more. The next year, Green Rebel began to register for certifications such as HALAL Assurance System, HACCP, GMP, and most recently, IVS. Certifications improve the company’s credibility and aid in enabling export agreement. Currently, Green Rebel products have arrived in Malaysia, Singapore, and Philippines; future potential export possibilities are secured and expected.

1.2. Vision and Mission

Leading plant-based food chain in Indonesia and over Southeast Asia has been PT. Hijau Adil Bahagia vision at heart. In the effort to embody their vision, PT. Hijau Adil Bahagia also accommodates consumers, local farmers, and underprivileged women with empowerment, education, and most importantly, enjoyable yet healthy and sustainable meals as their missions.

1.3. The Main Activity

As one unity, Pt. hijau adil bahagia (Burgreens) and Pt. Organik Adil Sejahtera (Green Rebel) serves plant-based food for motivated consumers. Burgreens concentrates on a plant-based eatery chains and catering business. Green Rebel, on the other hand, focuses on providing plant-based food as ordered by business partners (B2B) and distributing ready-to-cook frozen meals (B2C). Burgreens services include dine-in,

take-away, and delivery through online platforms such as Go-Food and GrabFood. Frozen meals, on the other hand, are available in supermarkets, online shopping platforms (e.g. Shopee and Tokopedia), and the restaurant outlet itself. Example of finished product of Burgreens and Green Rebel attached as **Figure 1.**

(a) (b) (c)

Figure 1. Example of Finished Products, (a) Maranggi Satay Platter, (b) B2B Maranggi Satay, (c) B2C (frozen meal) Shroom Balls.

1.4. Organizational Structure

Burgreens/Green Rebel Central Kitchen organizational structure is depicted in **Figure 2.** It consists of boards of directors, including COO and RnD Director; supply chain head; and staff of existing departments (i.e. QC/QA, production, PPIC, procurement, warehouse, and logistics). Managers or assistant managers of the Central Kitchen departments hold responsibilities towards the supply chain head before being accountable towards the boards of directors. The RnD department is exclusively under direct supervision of the RnD director who is also the co-founder of the company.

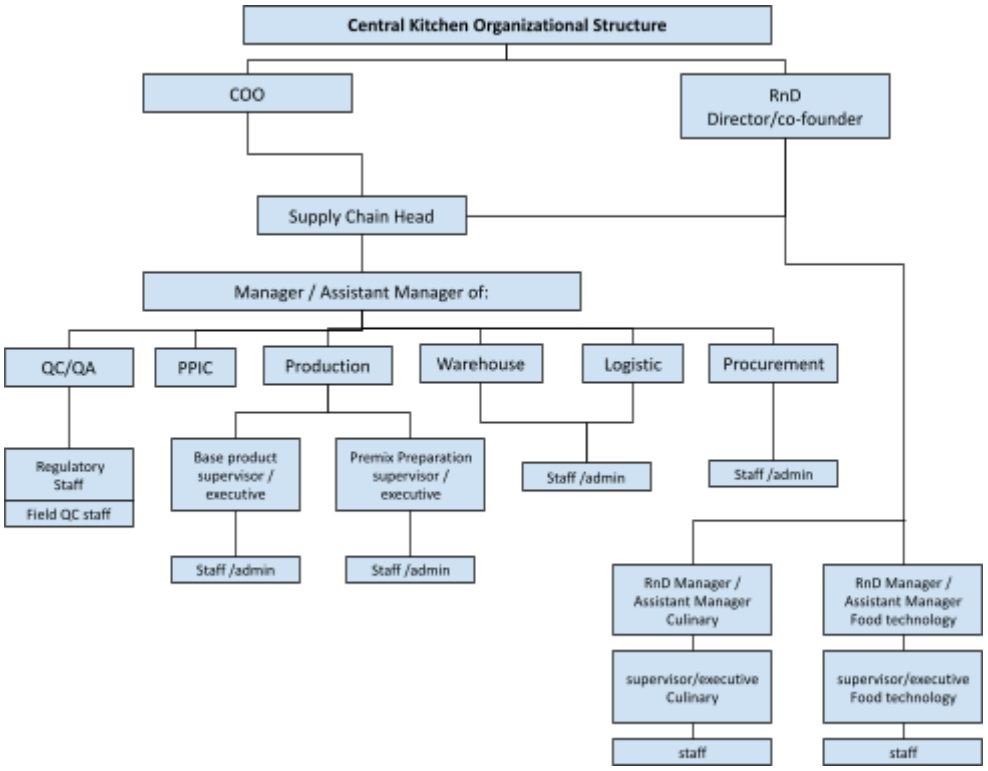

Figure 2. Organizational Structure of PT.Hijau Adil Bahagia & PT. Organik Adil Sejahtera (shared function) Central Kitchen

1.5. QC/QA Department

Quality assurance and quality control cohesively function as a single department under supervision of QC/QA Assistant Manager. The QC/QA department's working domain generally tackles product's quality related issues. The staff can be specified into field QC/QA and Regulatory QC personnel (refer to **Figure 3**). Field QC monitors production flow to ensure the process and goods follow the qualifications; QA focuses on qualities, system, and standard verification including necessary training and audit along with documentation; Regulatory QC handles certification application and other regulatory related affairs. Each element in the department concentrates on their primary role but overlapping responsibilities happens. All in all, the essence of the department prioritizes food safety towards beloved customers of Burgreens and Green Rebel.

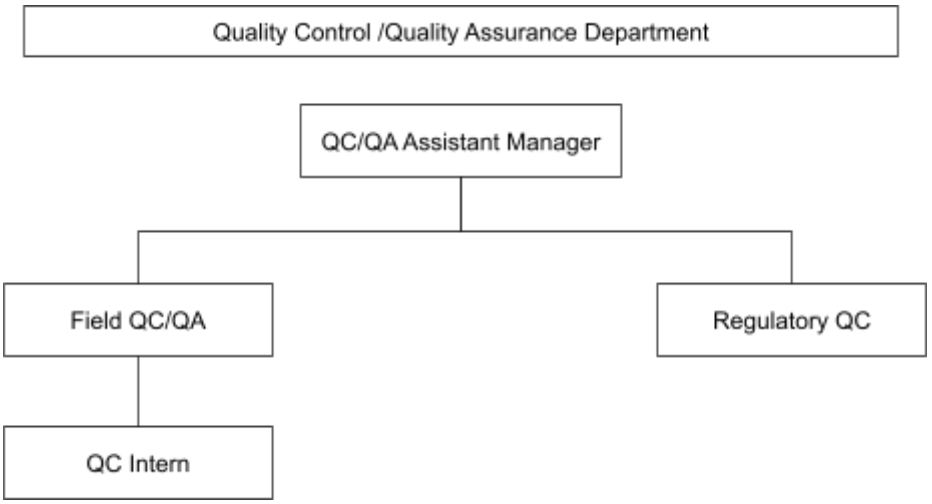

Figure 3. Organizational Structure of Quality Control/Quality Assurance Department at PT.Hijau Adil Bahagia & PT. Organik Adil Sejahtera (shared function) Central Kitchen

CHAPTER 2*:* INTERNSHIP ACTIVITIES

2. INTERNSHIP ACTIVITIES

2.1. Working conditions

The QC/QA department worked alternately in 2 shifts. The first shift started at 8 a.m. until 6 p.m. with a total of one and a half hour break in between; the second shift started from 11 a.m. until 9 p.m. with the same break duration. First shift workers were required to join the briefing session on the first hour of work; notes on briefing content will be shared through communication groups for other shift workers. In the effort to increase working efficiency and duration, the shift expanded into 3 working schedules on 13 October 2022: 7 a.m. - 5 p.m.; 11 a.m. - 9 p.m.; and 1 p.m.- 11 p.m. On 2nd November 2022, only representatives of each department were required to join the briefing. This modification intends to keep the flow of the process undisrupted.

For 5 months of internships (8 July 2022 - 30 November 2022), the author had full-time on-site work with the majority of morning shifts. There were regular activities filling in the working hours such as filing complaints and CAPA, organoleptic validation, inspecting new coming raw materials, assisting pest control, and assisting monthly GMP internal audits. Additionally, minor activities such as aid in label checking, registering article code, and stock opname were also included. Activities incorporated in the product processing flow are depicted in **Appendix 4.**

2.2. Daily activities and Lesson Learnt

2.2.1. New-Coming Raw Material Inspection

As an intern, field QC full responsibilities were handed during raw material inspection. In cooperation with warehouse personnel, field QC receives and inspects the compatibility of quantity and quality with the agreement document and product specification respectively. Weighing and manual counting regulates incoming product quantity. The quality, however, is assessed by matching individual standards against visual evaluation. Rejecting poor quality materials is included in the jurisdiction of field QC. Fresh and hygienic raw materials positively contribute towards organoleptic

and microbiological aspects in the end product if processed appropriately, therefore, is accepted.

Products checked at Central Kitchen are purple cabbage, peeled onions, brioche buns, gluten free loaf, champignon mushroom, vegan donut, and tortilla. Aside from visible critical food safety indications (i.e. free from contaminants such as mold, slimy substances, and foreign objects), different qualifications for different materials are explained in more detail in **Appendix 1.**

Nonconformity in raw materials frequently happens in peeled onions due to budding, moldy, bruises, and withered. Others rarely delivered with problems but the major defect on supplies are: white colored holes for purple cabbage, insufficient air pressure on brioche buns packaging, loss sealing for gluten free bread, small size for mushrooms, inadequate size for donuts, and loss sealing on tortilla (allowing ants to enter and contaminate the product). Nonconformity ingredients should be rejected, noted, returned, and reported. That way, the product can be exchanged for standard compliance ones.

Field supervisor, senior Field QC, and assisting warehouse personnel contributed the most to the author's experience and knowledge gain. The author learnt the incoming products specification during the experiences as well as tolerance limit on defect incoming product. Although the limit line tends to be vague and subjective, the author grasped few consistent decisions on several occurrences. For example, minor tear on tortilla edge is acceptable as it will not interfere with wrapping process, and minor bruises on mushroom and few small white holes on purple cabbage could be trimmed. As long as the defect does not concern food safety, slight imperfections can be tolerated especially under urgency of processing.

2.2.2. Outlet Complaints and Corrective & Preventive Action (CAPA) form

In the response for minimalistic automation, complaints and CAPA from QC outlets are recorded in the shape of online forms and reports. This way, the Central Kitchen QC/QA department can reduce the number of defects

reaching customers, prevent similar problems, and improve the adapted system.

Through numerous control and monitoring actions at the central kitchen, even arriving products at outlets still lack qualifications occasionally. If the arriving products do not achieve the agreed quality, a structured complaint is made and sent towards Central Kitchen QC/QA personnel. Investigation fills the time between complaint and end decision. It could be through organoleptic validation of retain samples or stock on hands, or confirmation with the complaint submitter and related division such as warehouse and RnD. The duration of this on-process status depends on the severity of the problem, responsiveness of the relevant division, and the speed of the QC to trace the data. End decision statement marks the finished investigation and the process continues with filing the CAPA form (**Appendix 4.**). On a weekly schedule, complaints are reported in summarized charts and printed CAPA related to production are posted on QC board. Within the activity flow, the author was responsible for filing complaints, investigating, creating weekly recap reports, and updating QC board.

Among the complaints category, decreasing/noncompliance product quality often rank the highest (refer to **Appendix 5**.). Once in a while, human error (e.g. failure in reserving retain samples or product record, miscommunication with warehouse division, etc) may hold back investigation. To minimize such issues, several attempts have been made. For example, adding field QC personnel for a more thorough inspection throughout the processing chain and better work distribution, increase the frequency of QC/QA logbook cross check with production's, as well as providing the warehouse department with an announcement board to pin sticky notes on problematic batches.

From this activity, the author realizes the importance of documentation and traceability as well as their efficacy during complaints. With the guidance of field supervisor and senior QC personnel, the author learnt the steps of complaint product investigation along with steps when encountering a failed batch. The author understood the significance of the CAPA form to acquire

lessons from previous mistakes, continue improving, and prevent similar problems from happening.

2.2.3. Plant-based Meat Base and Product Organoleptic Validation

According to **Appendix 1.**, the author was responsible for organoleptic testing at Central Kitchen, securing retain samples, and noting the results into the logbook. The test proceeds by evaluating appearance, taste, odor, and mouthfeel. The results act as the main reasoning on multi-level decisions - from whether the next step can go forward until the considerations in adjustment of the products' shelf life. This step aims to confirm the quality of the goods along with registering data for product traceability.

Goods that undergo validation include meat analogue bases, semi-finished product, finished product, and unidentified product; general standards for organoleptically accepted product are listed in **Appendix 2.** Prior to further processing steps into various menus, meat analogue bases should be tested to avoid energy and ingredient waste in case of spoilage. After the processing step is finished and the product has cooled down, validation is done once again. In this step, retain samples are also taken, recorded, and stored in QC freezer. Aside from organoleptic testing in the production site, the test also runs after the product has arrived at the restaurants. In case of incoming complaint from outlet QC personnel, stock of finished product and retain samples are validated. Validating finished goods without identity is necessary to provide appropriate decisions for the product.

At the end of every validation, data will be recorded in both manual logbook and computerized file. Possible deviation on optimum storage conditions and processing standard procedure for all stages in product processing promote the organoleptic validation essentiality. Products without identity caused by undetected production default also add the importance of this activity.

With a daily task as a validator, the author improved her ability to recognize hints of quality degradation and spoiled products. During this opportunity,

the author also trained her senses, memorized the normal taste of each product, and understood the necessity of sampling in validation. Aside from that, the author also gains insights on options available to deal with unsatisfactory organoleptic evaluation.

2.2.4. Assisting Pest Monitoring

Third-party pest control personnel visit production plans on a biweekly schedule. During the monitoring period, the QC/QA department is responsible for company and observation of monitoring devices such as insect lamps, mouse traps, and cockroach traps. After monitoring, the current situation including progress and problems is contained in a report under supervision of assisting personnel. The report is then sent to head divisions through official emails. If the condition is considered as severe and requested, QC can communicate the findings in person. Allocated time had been prepared for intern personnel to fully learn and implement this workflow through the pest control personnel himself all through the internship period.

Each installed monitoring device possesses a different way of functioning. Insect lamps equipped with replaceable adhesive boards attract insects by emitting certain light wavelengths. As the flying insects (e.g. fruit fly, moths, mosquitoes) approach the light and eventually perch on the checkered adhesive board. Cockroach traps utilize food pellet infused pheromones placed on the center of adhesive to attract roaming cockroaches. Mouse traps are boxes with/without highly poisonous food pellets. Mouse traps with toxicants are placed outside the building. Increased reports of cockroaches demand intense monitoring along with additional treatment such as low toxicity powdered or injected semisolid cockroach poison.

Chiller and freezer room especially obtained a lot of comments from pest control personnel due to accidental fallen leftover food on the ground which disrupt monitoring observation as it acts as a source of food for possible pests. Fortunately, at the time of internships, no commotion-worthy pest related cases occur.

Accompanying pest control personnel once every two weeks affect positively on the author's recollection of monitoring devices location in the manufacturing plant. Through conversation with the personnel, the author also gain knowledge about functioning process the device and past experiences of pest cases from the personnel at burgreens

2.2.5. Assisting GMP Internal Audit

Every month, QC/QA department personnel sweep through every corner of the production plan and storage room for GMP internal audit. The audit starts with a checklist of GMP requirements. A score is generated based on the compliance of related divisions with GMP. The findings are then input into GMP CAPA form. After filing the CAPA, QC communicates with the head or personnel from related divisions to avoid escalation of findings in the next audit. The head of related divisions should file the root cause and follow up actions on the violations in CAPA form. The audit is executed on a monthly schedule.

The author got the opportunity to comprehend the flow of the audit and help to ease the workload only in the first two months of internships. The author is extremely grateful for the experience starting from examining through the production line and storage areas until assisting in filling the checklist and CAPA. Through this activity, the author's memory on GMP is refreshed.

2.2.6. Other Minor Activities

Minor activities passed to the intern includes aid in labels checking, registering article code on the ERP system, and stock opname. They are categorized this way due to a small portion of the time required to finish or they happened rarely (e.g. once a month). As labels manufacturing date, expiration date, and lot number are input manually, high probability of fault is expected. Hence, labels are commonly checked multiple times by QC, production team, and warehouse team. Registering article code is required for new supplied products. It is common to register the article code on the ERP (Enterprise resource planning) system once or twice a month depending

on the procurement. Stock opname intended to re-calculate and record the actual goods or material in comparison to the data. Sometimes, stock opname could be an opportunity for QC to confirm the quality of stored product specifically, the quality of packaging, packing size, implementation of FIFO and FEFO system, along with expiry date of stored product.

The author realizes even minor activities held a great importance to daily activities of the industry. Mislabeling is a fatal fault and considered as nonconformity although the content is fine. This causes economic loss. Article code should also cannot be taken lightly as it is the unique identity of materials and ingredients and is required for internal distribution during the production. Stock opname minimize the possibility of corruption and sabotage, as well as the trajectory source for future planning and procurement.

2.3. Courses Theory and Actual Practice

The divided subtopics are related to 'Food Safety and Toxicology' as well as 'Quality Management and Food Legislation' courses

2.3.1. Traceability : Labeling and Lot Coding System

The first lesson during the internship program is about the label and lot coding for products. As explained in the course TLM (Teaching and Learning Material), essential information included in product labels contain name of the product, GTIN, date of manufacture, expiration date, batch identification code (Lot number), contact details, volume or quantity of the product, and allergen information. In B2B product cases, HALAL and BPOM certified logos are also included in the label only in the first two months of internships. For the product distributed to Burgreens eatery chain itself, however, only labeled with simple identification information including date of manufacture, expiration date, and lot number. In ready-to-cook frozen meals, most of the information has already been printed in the box packaging except for production date, expiration date, and lot number which will be added to the packaging when production happens. Supplied products also are labeled in

the company, though it only consists of arrival date, expiration date, and lot number. labeling and lot number assigning highly correlates to the traceability of the product.

Internship experiences have proven the course emphasis on traceability; to track the product at any stages, forward and backward, allow the company to counter potential risk, discover and stop happening problems, take corrective measures and learn from past accidents. Efforts to function traceability in the product started from incoming raw material, organoleptic validation, retain sample collection, label creation, and other essential data recorded by all divisions in contact with product (e.g. date of distribution or product temperature) shall not be underestimated. As has been warned by the course, traceability is extremely helpful during incoming complaints and investigation of nonconformity.

2.3.2. Monitoring and Managing Quality

As estimated by the learnt courses, industrial food processing commonly monitors contaminants using metal detectors for physical metal contaminants, and cooking time and temperature for biological contaminants. It is true that indirect methods such as monitoring cooking time and temperature require validation, therefore, microbial enumeration is done. In Green Rebel cases, by partnering with third-party laboratories services.

To monitor and manage product quality, one must first define the quality of the product itself. The courses were accurate to state that defining quality requires collaboration of different departments and from the QA/QC perspective, following legal requirements is the way to define the product quality. Plan to maintain the defining qualities throughout the process is then devised, implemented, and verified. The way QA contributes to the quality management is through proposed quality management strategies (e.g. HACCP plan). On the other hand, QC inspect and test the achieving defining qualities.

2.3.3. Good Manufacturing Practices (GMP)

GMP in food manufacturing plans assure major reduction of total hazard and is implemented to manage food safety concerns. GMP guides the food manufacturer on things to consider starting from facilities design, equipment, transportation, maintenance, product information, personnel, and way of processing; during the internal audit, all these things will be assessed and taken seriously and responsibly by all related departments. Aside from those, training for personnels also conducted for better hygiene cultures. During the internships, all these learning materials are observable practice in the company. Collaboration in maintaining GMP has been a daily task for each department.

2.4. Difficulties During Internship

As an intern first-timer, the author considers adapting to work life, duration, and environment is difficult. However, figuring the workflow is on another level. In addition, the author struggled to clear her confusement in one go due to extreme workload on other senior QC/QA members and field supervisor; the author felt guilty for weighing them down and taking much of their time especially during a tight deadline or appearance of unexpected problems.

The author understands that all processes require time, hence, the author kept trying patiently to adapt and understand the job description. Attempts on grasping the workflow include asking for advice, offering any forms of help, and following senior QC personnels. In the effort to seek guidance without interrupting their focus, the author keeps her questions and re-express her confusement on a rather less hectic period, except for urgent questions.

On the first two weeks of meat alternative bases were trusted to the author due to working shifts alteration and exporting activity, the author had difficulties in determining the taste deemed as normal since the author was still inexperienced and the amount was considerable. Any ambiguous flavor was confirmed with the field supervisor or production team. As to the amount, the author took brief rest times in between to avoid sensory fatigue and maintain sensory sensitivity.

CHAPTER 3*:* PROJECT DESCRIPTION

3. PROJECT DESCRIPTION

3.1. Introduction

Dairy companies have realized the opportunity and taken interest in cheese sauce production due to consumer demand (Szafrańska & Sołowiej, 2020). The sauce compliments the appearance and flavor of meals in food businesses (Shalaby et al., 2017). Cheese sauce commonly manufactured from cheese ingredients (e.g. cheese powder, natural cheese, dried dairy ingredients, etc), fat source, flavorants, texturing agent, water, and emulsifier (Shalaby et al., 2017; Szafrańska et al., 2021). With the rise of plant-based eating habits, Green Rebel eventually launched Plant-based cheese sauce (PBCS) or Cheeze sauce in July 2022 after numerous trials and researches. This newly developed product quickly owns its share in the production timeline as it is requested constantly. Proposed by the company co-founder, plant-based cheese sauce (PBCS) was available for projects since little is known about the product.

PBCS is a cheese-flavored sauce product with bright yellow-orange color, thick but pourable consistency, and a maximum of 6 months storage on frozen temperature as the shelf life. However, the proportion of other obvious temperature sensitive products are dominating due to the frozen meal-oriented market of Green Rebel. Shifting to chilled storage conditions help to free up some space and reduce the cost of storage but it also comes with high risk of food safety issues. Therefore, this study intended to assess and compare the stability of physicochemical characteristics (i.e. pH, water activity, viscosity, and color) on frozen and chilled temperature for 2 months with microbial analysis as supporting data. 2 months duration is viewed as the optimum observation period considering the duration of internship left from the starting point. pH and water activity were chosen as primary monitoring on potential microbial activity, while viscosity and color measurement relates with consumer acceptability on product.

3.2. The Scope of Project

- To conduct, assess, and compare weekly physicochemical analysis (pH, water activity, viscosity, and color) on fresh-made PBCS samples stored in frozen (-18 ℃) and chilled (4 ℃) temperature for 2 months

- To arrange external laboratory service for PBCS microbial test on 3 different time points (Week 0, Week 4, and Week 8) in observation period

3.3. Objectives

The project aims to assess and compare the stability of physicochemical characteristics (pH, water activity, viscosity, and color) of plant-based cheese sauce stored in frozen (-18 ℃) and chilled (4℃) temperatures during 2 months of observation with external microbial test results as supporting data.

3.4. Hypothesis

To assess stability in each sample,

H0: There are no significant differences in the means of pH, Aw, viscosity, and color within the chilled stored (4℃) PBCS samples and frozen stored (-18℃) PBCS samples during weekly observation of 2 months of period.

H1: There are significant differences in the means of pH, Aw, viscosity, and color within the chilled stored (4℃) PBCS samples and frozen stored (-18℃) PBCS samples during weekly observation of 2 months of period.

To compare the stability between each sample,

H0: There are no significant differences in the means of pH, Aw, viscosity, and color between the chilled stored (4℃) PBCS samples and frozen stored (-18℃) PBCS samples during weekly observation of 2 months of period.

H1: There are significant differences in the means of pH, Aw, viscosity, and color between the chilled stored (4℃) PBCS samples and frozen stored (-18℃) PBCS samples during weekly observation of 2 months of period.

3.5. Problem Formulation

- How are the physicochemical and microbial changes chilled (4℃) PBCS for a 2 months storage period?
- How are the physicochemical and microbial changes frozen stored (-18℃) PBCS for a 2 months storage period?
- How are the physicochemical and microbial changes in chilled stored (4℃) PBCS compared to frozen stored (-18℃) PBCS during 2 months storage?

3.6. Methodology

To achieve the objective, PBCS samples were prepared and stored according to the assigned temperatures. Physicochemical analyses were performed weekly every

Friday for 2 months duration starting from 30 September 2022 at I3L food laboratory. Microbial analyses were performed by an external laboratory service on week 0, week 4, and week 8 of 2 months durations

3.6.1. Sample Preparation

Plant-Based Cheese Sauce (PBCS) was processed by manual continuous mixing of PBCS premix, water, and oil on the Central Kitchen processing room's stove for two hours with a temperature of at least 90 ℃ . PBCS was then cooled down using blast-freeze for an hour and heat sealed in a pouch. Samples intended for external microbial analysis were packed in 100 grams and for physicochemical analysis were packed in 450 grams. Samples were filled and sealed manually at Central Kitchen's packing room on September 29, 2022. Samples were stored accordingly. Prior use, thawing was done by leaving the samples in room temperature until both reach equilibrium.

3.6.2. Sample Storage

Samples for physicochemical analysis were stored at I3L kitchen's chiller and freezer on the 6th floor sensory preparation room. Samples for microbial analysis were stored at Burgreens Central Kitchen warehouse's upright freezer and chiller. Storage temperatures for both analyses were adjusted to be as similar as possible with chilled temperature at 4 ℃ and frozen temperature at -18 ℃. Prior to analyses, both physicochemical and microbial samples were thawed by letting the samples rest at room temperature for ± 5 H. These efforts intended to obtain reflecting results on both physicochemical and microbiological.

3.6.3. Water Activity (Aw) Analysis

Using calibrated Water Activity Meter Decagon Pawkit, water activity of PBCS technical replication in both storage temperatures was evaluated at ambient temperature (±25 ℃). Water activity of a product directly affects microbial activity (Hamad, 2012).

3.6.4. Color analysis

Calibrated spectral colorimeter Cs-410 sensor was wrapped using cling wrap and immersed in plated PBCS. Three replicates measured for each sample. The analysis output were in L*a*b* color space system. Incapability of high accuracy comparison using human naked eye leads to the utilization of a mechanical device called colorimeter to assess and quantify the color based on the system (Hu et al., 2017). Physical characteristics, especially colors, highly affect consumer acceptability of a product (Shalaby et al., 2017).

3.6.5. pH Analysis

Each sample was divided into 3 tubes as replicates and measured with a calibrated pH meter spear eutech. The importance of pH analysis lies in the relation with the safety and quality attributes of foods (Vijayakumar & Adedeji, 2017). The continuous measurement is especially considered to be primary monitoring in food safety as microbial growth and pH affect each other (Ratzke & Gore, 2018).

3.6.6. Viscosity Analysis

Viscosity affects the appearance and behavior of liquid food. Far from the anticipated way of behaving, it causes product rejection by consumers (Kutter et al, 2011). To assess the consistency of flow resistant behavior, analysis was performed using viscometer B-one Touch with 100 rpm for 30 seconds setting using L-3 spindle. Each sample divided into 3 centrifuge tubes replicates.

3.6.7. Microbial Analysis

Mbrio Food Laboratory was trusted as an external service to perform microbial analysis. Located at Jl. Pulo Armin No.33, Bogor, prepared frozen and chilled samples were sent on Week 0, Week 4, and week 8 from Burgreens Central Kitchen storage. As discussed with the company, the PBCS samples were analyzed according to peraturan BPOM for microbial safety standards. However, the replications differ among sampling points (5

replicates on initial analysis and no replicate for the others). The inclusion of microbial analysis intended to support possible outcome of physicochemical changes and act as a flashlight on safety concerns regarding the product as it gives illustration on samples' microbial load before, during, and after the storage.

3.6.8. Statistical Analysis

Triplicate measurements of physicochemical analysis parameters were processed using IBM SPSS Statistics Version 26. Each set of data was normality and sphericity tested. To discover any significant changes in a parameter per sample over the observation period, one way repeated measures ANOVA or Friedman test was used depending on the normality. Significant difference ($p<0.05$) between chilled sample and frozen sample in a parameter at a particular timestamp was discovered using independent sample T-Test or Mann Whitney U test, depending on the normality of the data.

3.7. *Result & Discussion*

3.7.1. Physicochemical Analysis

3.7.1.1. pH Analysis

Week 7 and Week 8 analysis of chilled samples had significantly lower pH compared to the previous weeks. Significant differences ($p<0.05$) observed between the frozen and chilled samples in Week 7 and Week 8 with pH of chilled samples significantly lower than frozen samples. Up until Week 6, pH among and between chilled and frozen samples themselves mostly remained stable. For more detail, refer to **Table 1.**

Table 1. pH Result of PBCS Stored Under Different Temperatures and Observe Weekly for 2 Months

Analysis	Storage	W0	W1	W2	W3	W4	W5	W6	W7	W8
pH	C	5.13 ± 0.01^{ab}	5.11± 0.01^{a}	5.14± 0.01^{b}	5.15± 0.02^{ab}	5.14± 0.00^{b}	5.14± 0.01^{b}	5.11± 0.01^{a}	5.04± 0.01^{cx}	5.04± 0.01^{cx}
	F	5.13± 0.01^{ac}	5.12± 0.01^{abc}	5.13± 0.02^{abc}	5.14± 0.02^{ac}	5.13± 0.02^{ac}	5.15± 0.01^{a}	5.12± 0.01^{ac}	5.10± 0.01^{bx}	5.11± 0.01^{bcx}

^{abcde} = indicate significant differences on mean value with complete different superscripts in a row.

^{x}= indicate significant differences on a certain parameter measurement between the two samples (chilled and frozen) at one particular time point.

According to Asano et al. (2015), dairy cheese sauce with a pH range of 5.3-5.8 is highly preferable but is still favored in the range of 5.0-6.0. Although the pH of both samples fluctuated, pH readings still exist in the acceptable range of common cheese sauce. Based on the pH, however, PBCS is categorized as low acid food (pH > 4.6), a condition in which all microorganisms are able to thrive (Garg, 2019). This condition poses a risky stand on chilled storage temperature.

pH change acts as an alert and the primary reason for its monitoring relates to food safety concern (Vijayakumar & Adedeji, 2017). Supported by microbial analysis, the significant pH change is potentially caused by microorganisms. Not to mention, malfunction

in the I3L chiller and freezer storage in the middle of the observation period increase the chance of pH drop by microorganism. Chilled samples yield significantly lower pH than frozen at the end analysis. This is possibly caused by shorter duration required to reach optimal microbial growth temperature. Ratzke & Gore (2018) comprehensively explained that microorganisms possess the ability to alter pH of their environment, either through metabolism by-product or enzymes. The temperature abuse triggered microbial growth. As the appropriate storage temperature returned, the slow metabolism or enzymatic activity accumulated and caused a significant decrease of pH.

3.7.1.2. Water Activity (Aw) Analysis

No significant differences ($p>0.05$) in water activity of each sample for 8 weeks of observation nor when both compared with each other at any time stamps (refer to **Table 2.)**. Water activity properties of the samples reflect stability in both storage temperatures for at least 2 months.

Table 2. Aw Result of PBCS Stored Under Different Temperatures and Observe Weekly for 2 Months

Analysis	Storage	W0	W1	W2	W3	W4	W5	W6	W7	W8
Aw	C	0.983±0.003^{a}	0.987±0.003^{a}	0.977±0.003^{a}	0.970±0.009^{a}	0.983.±0.003^{a}	0.980.±0.006^{a}	0.980±0.006^{a}	0.973±0.003^{a}	0.977±0.003^{a}
	F	0.983±0.003^{a}	0.987±0.003^{a}	0.970±0.006^{a}	0.973±0.012^{a}	0.973±0.003^{a}	0.973±0.007^{a}	0.977.±0.003^{a}	0.973±0.003^{a}	0.973±0.009^{a}

^{abcde} = indicate significant differences on mean value with complete different superscripts in a row.

^{x}= indicate significant differences on a certain parameter measurement between the two samples (chilled and frozen) at one particular time point.

Water activity is undoubtedly an essential factor controlling microbial growth inside food (Hamad, 2012). It represents the available water in food for microbial cells to transport nutrients and waste, as well as aid chemical reactions in the cells (Hamad, 2012). Water activity above 0.90 is deemed as optimum condition for most microbial growth especially spoilage ones (Hamad, 2012). Unfortunately, PBCS possesses Aw in the range of 0.97-0.99, which is regarded as high water activity food. Corresponding to the obtained result, a study by Szafrańska et al. (2021) presented similar results for dairy cheese sauce. No inhibition in microbial activity through pH and water activity in cheese sauce may raise food safety concerns to the product without frozen storage. Adding preservatives to the product extends the shelf stability of products with high moisture content and water activity (Saad et al., 2015). Powder form could also be an alternative for even more stable shelf-life. Depending on the expense exerted, these alternatives may or may not be a good idea for higher temperature storage to ensure safety and stability.

Although it was insignificant, fluctuation in water activity can be influenced by relative humidity and temperature during the analysis. The increase and decrease in water activity depends on the nature of RH equilibrium tendencies between food surrounding and environment (Kong & Singh, 2016). Temperature of analysis also affects water activity depending on the food product tested. Syamaladevi et al. (2016) tested Aw of peanut butter and all purpose flour at elevated temperature and both reacted differently; peanut butter had a decreased Aw and all purpose flour increased. Another factor worth considering is the variation in calibration method of the water activity meter itself may cause ups and downs of water activity measurement. Thus, controlling constant relative humidity of storage, temperature of analysis, and calibration procedure is essential in water activity measurement.

3.7.1.3. Viscosity Analysis

No significant differences ($p>0.05$) in each sample viscosity for 2 months nor when both compared (refer to **Table 3.**). Negligible changes in both sample viscosity over time as well as resemblant fluctuation in one another indicate decent stability unaffected by storage temperature for at least 2 months.

Table 3. Viscosity Result of PBCS Stored Under Different Temperatures and Observe Weekly for 2 Months

Analysis	Storage	W0	W1	W2	W3	W4	W5	W6	W7	W8
Viscosity (Pa.s)	C	8.19± 0.22^{a}	8.20± 0.13^{a}	8.14± 0.07^{a}	8.17± 0.06^{a}	8.17± 0.05^{a}	8.11± 0.02^{a}	8.17± 0.28^{a}	8.23 ± 0.05^{a}	8.41± 0.09^{a}
	F	8.19± 0.22^{a}	8.13± 0.10^{a}	8.14± 0.04^{a}	8.14± 0.04^{a}	8.17± 0.05^{a}	8.09± 0.02^{a}	8.2± 0.12^{a}	8.16± 0.03^{a}	8.23± 0.06

^{abcde} = indicate significant differences on mean value with complete different superscripts in a row.
^{x}= indicate significant differences on a certain parameter measurement between the two samples (chilled and frozen) at one particular time point.

Viscosity of cheese sauce product is determined by source of protein used (Saad et al., 2016) and incorporation of hydrocolloids with certain types under particular concentration (Kurova et al., 2022). Saad et al. (2016) mentioned that during the storage, shift in viscosity relates with any interaction between existing components that may influence the protein-starch mixture. For example, protein hydrolysis may reduce viscosity or starch retrogradation that may increase in viscosity (Karim et al., 2000; Saad et al., 2016). Multiple freeze-thaw cycles and moisture migration increase the starch retrogradation, hence, indirectly affecting viscosity as well (Kong & Singh, 2016). Depending on the type of microbial contaminant, changes in texture of food (e.g. viscosity) may happen as the consequences of protein/carbohydrates degradation (Gram et al., 2002). During the analysis, temperature of measurement should also be considered. Lower temperature causes the kinetic energy of the

molecule to decrease, hence the viscosity measurement will come up with a more viscous reading.

3.7.1.4. Color Analysis

Color analysis using L*a*b* color space composed of individual analysis of L*, a*, and b*. For the last three weeks, L* of chilled samples, a* and b* in both samples were significantly different ($p<0.05$) compared to the first month of observation of the same product. By the first week of storage, chilled and frozen samples were significantly different ($p<0.05$) on L* until the end of observation, same with b* but it was by the sixth week. Lastly, from **Table 4**, significant difference ($p<0.05$) on a* between the samples observed on Week 8 only and no significant difference ($p>0.05$) in L* of frozen samples over the week. The overall color difference from initial and end of both samples were calculated (refer to **Appendix 7**.) using formulation on **Appendix 6**. The ΔE values were then converted into National Bureau of Standard (NBS) scale to indicate the level of color changes (refer to **Appendix 9**) based on formula in **Appendix 8** with the result of 8.999 for chilled samples NBS converted color and 7.1710 for frozen ones .

Table 4. L*a*b* Color Result of PBCS Stored Under Different Temperatures and Observe Weekly for 2 Months

Analysis	Storage	W0	W1	W2	W3	W4	W5	W6	W7	W8
L*	C	66.19± 0.34^{a}	68.2± 0.07^{bx}	68.29± 0.33^{bx}	68.64± 0.26^{bcx}	70.03± 0.62^{bcdx}	70.51± 0.43^{cdex}	71.13± 0.18^{dex}	71.48± 0.50^{ex}	71.49± 0.45^{dex}
	F	66.19± 0.34	68.9± 0.47^{x}	67.53± 0.33^{x}	67.77± 0.03^{x}	67.82± 0.04^{x}	67.83± 0.05^{x}	67.95± 0.16^{x}	68.07± 0.22^{x}	68.31± 0.54^{x}
a*	C	12.81± 0.13^{a}	12.07± 0.08^{ab}	11.73± 0.03^{b}	11.55± 0.11^{b}	10.55± 0.17^{c}	10.52± 0.04^{c}	8.75± 0.21^{d}	9.48± 0.06^{d}	9.03± 0.12^{dx}
	F	12.81± 0.13^{a}	12.33± 0.10^{a}	11.77± 0.31^{abe}	11.59± 0.07^{b}	10.51± 0.10^{c}	10.27± 0.10^{ce}	9.03± 0.03^{d}	10.14± 0.34^{bcde}	10.09± 0.21^{cex}
b*	C	39.07±	37.72±	37.53±	36.76±	35.97±	35.77±	32.09±	31.35±	31.14±

	0.69[a]	0.84[b]	0.56[ab]	0.24[abx]	0.45[b]	0.53[ab]	0.17[cx]	0.17[dx]	0.13[dx]
F	39.07± 0.69[ab]	38.71± 0.04[a]	38.71± 0.07[a]	38.49± 0.16[ax]	35.72± 0.24[bcd]	35.75± 0.54[ce]	34.27± 1.02[ex]	33.85± 1.01[dx]	33.06± 0.17[ex]

[abcde] = indicate significant differences on mean value with complete different superscripts in a row.

[x]= indicate significant differences on a certain parameter measurement between the two samples (chilled and frozen) at one particular time point.

In CIE L*a*b* color space, L* represents the range of lightness from 0 (black) to 100 (white); *a** is the redness, from green (*−a**) to red (*+a**); and *b** is the yellowness, from blue (*−b**) to yellow (*+b**) (Flamminii et al., 2020). Chilled storage temperature seems to be highly affecting L* as the significant increase in lightness only observed in chilled samples over the times. Frozen and chilled samples were both significantly less red and less yellow in the last three weeks compared to the first month. In comparison between chilled and frozen samples, redness was altered in a similar trend until Week 7 as a significant difference ($p<0.05$) started by the next week.

NBS system categorize the value in the respect to color differences as follows : 0.0–0.5 means trace changes, 0.5-1.5 means slight changes, 1.5-3.0 means noticeable changes, 3.0-6.0 means appreciable changes, 6.0-12.0 means visible changes, and 12.0 or more indicates remarkable changes or changes to other color (Inami et al., 2015). Based on the categories, PBCS samples for chilled and frozen temperature possess visible color changes by the end of observation compared to fresh production.

Suitable and stable color highly determines consumer acceptance of a food product (Shalaby et al., 2017). Unsuitable color and severe color changes on food products may lead to unnecessary waste and low purchasability in the market. Therefore, industries considered this physical characteristic to be essential in product quality. The stability of both natural and synthetic color depend on several factors such as pH, heat treatment, light exposure, oxygen exposure,

moisture, microbial activity, storage, and interaction with certain components inside the food matrices (Cortez et al., 2017; Weigel et al.,2018;Selig et al., 2020; Nedamani, 2022). Anthocyanin could best describe the pH factor towards color through structural change at different pH (Ibrahim et al., 2011); example of the effect of light and oxygen exposure towards stability can be described by photosensitive carotenoids in which its structure promotes antioxidant effect, hence most color degradation happen through oxidation (Atencio et al., 2022). Giménez et al. (2015) observed that the increase in temperature followed by an increased rate of color degradation and each colorant possesses their own thermal stability. Microbial contributions to color degradation shall not be underestimated; Sakthika et al. (2021) stated that azo dyes are degradable by strains of microorganisms either as carbon and nitrogen source or using reductases. Decrease of moisture content during storage results in the increase of viscosity and enhancement of color intensity, this happened in cheese sauce analysis by Shalaby et al. (2017). Storage affects the color changes through influencing and supporting other factors, for instance, optimum temperature for microbial growth and enhancing oxidation reaction. Interaction with components in food matrices could be detrimental or beneficial depending on the components itself. Antioxidants may work synergistically with oxygen reactive colorants and protect the color (Atencio et al., 2022).

Factors that have high probability of causing color degradation in this case are light, oxygen, and microorganism as the product was packed in transparent packaging, sealed without vacuum condition, and TPC results show increase in microbial load. Depending on the main source of the problem, shifting to a more suitable and stable colorant or adding antimicrobial and antioxidant could be a solution.

3.7.2. Microbial Analysis

External service on microbial analysis was arranged at three time stamps : Week 0 (initial), Week 4 (middle), and Week 8 (end). The analyses were performed using methods from and were compared against Peraturan BPOM no. 13 tahun 2019 category 12.6.2 (non-emulsion sauce). Plant-based food products standard are rarely described in regulations since they are novel. Supported by company, most of Green Rebel products, including PBCS, have been utilizing available food regulations for safety standardization although the accuracy to pinpoint main safety issue is debatable due to difference in ingredients. The microbial analysis consisted of Total Plate Count (TPC), Enterobacteriaceae, and Salmonella spp. with a limit of 10^4-10^5 colony/g, 10-10^2 colony/g, and negative/25 g respectively. As summarized in **Table 5.**, the amount of colonies in all samples belong in the safe range.

Table 5. External Laboratory Service Microbial Analysis Result of PBCS Samples Stored Under Different Storage Temperatures

Parameter	Storage Temperature	Week 0*	Week 4	Week 8	BPOM Standard**
Total Plate Count (cfu/g)	Chilled	<1.6x10^1	3.2 x10^2	1.5 x 10^3	10^4 - 10^5 cfu/g
	Frozen	<1.6x10^1	3.9x10^2	1.2 x 10^3	
Enterobacteriaceae (cfu/g)	Chilled	<1.0x10^1	<1.0x10^1	<1.0x10^1	10 - 10^2 cfu/g
	Frozen	<1.0x10^1	<1.0x10^1	<1.0x10^1	
Salmonella spp. (per 25 g)	Chilled	Negative	Negative	Negative	Negative per 25 g
	Frozen	Negative	Negative	Negative	

*Only Samples from the initial point were tested in 5 replicates, the rest time stamps were tested without replication

**BPOM no.13 tahun 2019 food category 12.6.2 Non-emulsion Sauce.

TPC is renowned as a basic method to enumerate aerobic culturable mesophilic bacteria, yeast, and mold using non-selective growing media. In general, enumeration using this method requires prior serial dilution, inoculation, and incubation (Isnawaida et al., 2021). Its function to estimate

microorganism quantity has its own flaws which lacks in specificity of the possible growing microbes aside from aerobic and mesophilic characteristics. Erkmen (2022) deemed plate count as beneficial to denote lack of hygiene and unsuitable temperature storage. Frozen temperature at -18 ℃ is supposed to majorly stop microbial growth, even reduce the number of mesophilic during the storage, and temperature below 5 ℃ is expected to retard the growth (Russel et al., 1994; Erkmen & Bozoglu, 2016). However, the rise of the microbial load over the time in both samples leave the outcome of chilled storage temperature possibilities inconclusive under perspective of safety. Suspicion upon ineffective cooling systems arise on chilled samples as the frozen ones' microbial growth continues during storage. If that is not the case, then at least the currently used chiller temperature is possibly a poor alternative for PBCS storage.

PBCS processing includes 2 hours of cooking with a temperature at least 90 ℃. The time and temperature is considered sufficient to kill microorganisms in the product as it surpasses most heat treatments, such as HTST, pasteurization, LTLT. As 60-71℃ is adequate to eliminate most yeast and mold (Breidt & Costilow, 2004), possible sources of growing colonies on TPC are existing spore-forming microorganism from ingredients and microorganism contamination in between cooling and packing period either from personnel, equipment, or environment.

Enterobacteriaceae enumeration highly indicates hygiene status and occurring contamination post- heat treatment of food products (Halkman & Halkman, 2014; Mladenović et al., 2021). The poor resistance to heat makes it feasible. At low level, Enterobacteriaceae does not pose safety concern and is still allowed (Cordier, 2006). Minimum level of detected Enterobacteriaceae from PBCS sample show adequate sanitary of anything that surface contacted with the sample.

Salmonella sp. is categorized as Enterobacteriaceae and it is one of the most common food poisoning microbiological contaminants (Kareem & Al-Ezee, 2020; Soon et al., 2020). Minimum heat treatment such as pasteurization is sufficient to exterminate Salmonella (Silva & Gibbs, 2012). Negative results

reflect sufficient heat treatment; sanitary equipment, personnel, and water source; as well as suitable storage conditions as opposed to risk factors of contamination (Ibram et al., 2007; Appling et al., 2018).

Ingredients of food products determine the potential risk of microbial contamination. Aside from that, method and media of analysis correlates with the observable microorganisms. However, since the PBCS ingredients are unable to be disclosed, characteristics to narrow down the microbial suspect only comes from changes during this 2 months storage period. TPC showed growing detected colonies displayed following possible characteristics: mesophilic, spore-forming ability, low acid production, color degrading ability, and aerobic. Further isolation for more targeted microorganisms is recommended.

The shortcomings of this test include: differences in storage placement with physicochemical test samples, different intervals of repeated measures, lack of replication except for initial testing, and possible storage failure during observation periods. Aside from overcoming limitations for the future studies, suggestion to identify main pathogenic microbes on plant-based cheese sauce hopefully applicable for higher microorganism detection accuracy and specificity concerning safety on this certain product. Through all the limitations, these results shall be supporting data.

3.8. Conclusion & Recommendations

3.8.1. Conclusion

To conclude the project, no significant difference observed within and between the samples in viscosity and water activity for 2 months. On the other hand, there are significant difference within and between the samples in pH and color with pH still in the range of normal cheese sauce. Therefore, if color is not major parameter considered by clients, chilled temperature is feasible for 2 months storage. Looking through the microbial results, the product is unexpectedly projecting food safety standard after 2 months of chilled storage according to BPOM no 13 year 2019 though it require extended analysis aligned with the appropriate method and replication. There is a possibilities of pH and color changes being inconclusive due to

substantial flaw in this experiment which is storage malfunction.

3.8.2. Recommendation

Continuation of this project may include variation in possible storage temperature and addition of sensory analysis over the storage period to discover at which point sensorial properties are deemed unacceptable. A more frequent microbial analysis during the observation period is suggested for better troubleshooting on changes caused by microbial activity. In any suggestion of future project development taken, the limitations on this project advised to be avoided.

CHAPTER 4*:* SELF REFLECTION

Five months of internship felt like a passing wind; brief yet refreshing. This internship has let the author gain insights on the process of making CAPA, the ways of tracing products and internal GMP audit, as well as pivot table utilization. These skills allow the author to ease the documentation method using available resources and have basic skills as field QC. Aside from those practical skills, the author's soft skills such as problem-solving, adaptability, and critical thinking were enhanced. These soft skills allow the author to blend with new working opportunities and tackle unexpected problems on future employment. The author sure learns and grows a lot from this opportunity, however, the feeling of inadequacy lingers.

During the internships, the author realizes that she has yet fully understood the unspoken rules of work ethics and is slow on summarizing data. However, the author kept eager to learn from her mistakes, sufficiently initiative, and responsible in her job.

I3L has considerable contribution to the author’s internship experience. Starting from providing attentive supervision, related courses, and not to mention, soft skills seminars to become a better individual. The author is extremely grateful for her I3L supervisor as she has always been considerate and full of insightful advice for the author. Courses from I3L also aid the author with basic knowledge along with common phrases in the field of food technology workforce. BRIGHT sessions have taught the author essential soft skills such as communication and important information such as things needed for internship preparation. I3L values also play a role in the author’s daily activity during the internship. It gave the author motivation to keep learning new things and adapting to the workplace situation; to keep striving to become a better student, intern, and friend towards the author’s colleagues; as well as owning her mistakes and taking a chance to correct and improve them. With more experience in the field and workforce, the author could not help but respect and look up to other QC/QA department personnel, especially the author’s field supervisor, who has shown such a degree of professionalism, leadership, and yet warm personality.

The author is satisfied with the effort she made to aid anyone in her power during the internships. Even in the simplest shape such as resolving questions in google document and sheets operation, inputting data, and aid in packing the product during a hectic period; the author is content and grateful.

CHAPTER 5: INTERNSHIP CONCLUSION & RECOMMENDATION

In conclusion, the author successfully fulfilled the goals of the internship and this report is the outcome and evidence of the author's experience. The internship offers a taste of joining the workforce as Quality Control officer and leaves a deep impression on the author's life. A short experience rich with new things and friends.

The author would like to suggest I3L provide an earlier EP briefing in case it is still applicable for the next cohort. It would also be a good idea to provide the next cohort with a history of previous internship placement done by I3L students so the lower cohort student knows who to contact for questions.

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APPENDICES

Appendix 1. Incoming Product Specifications

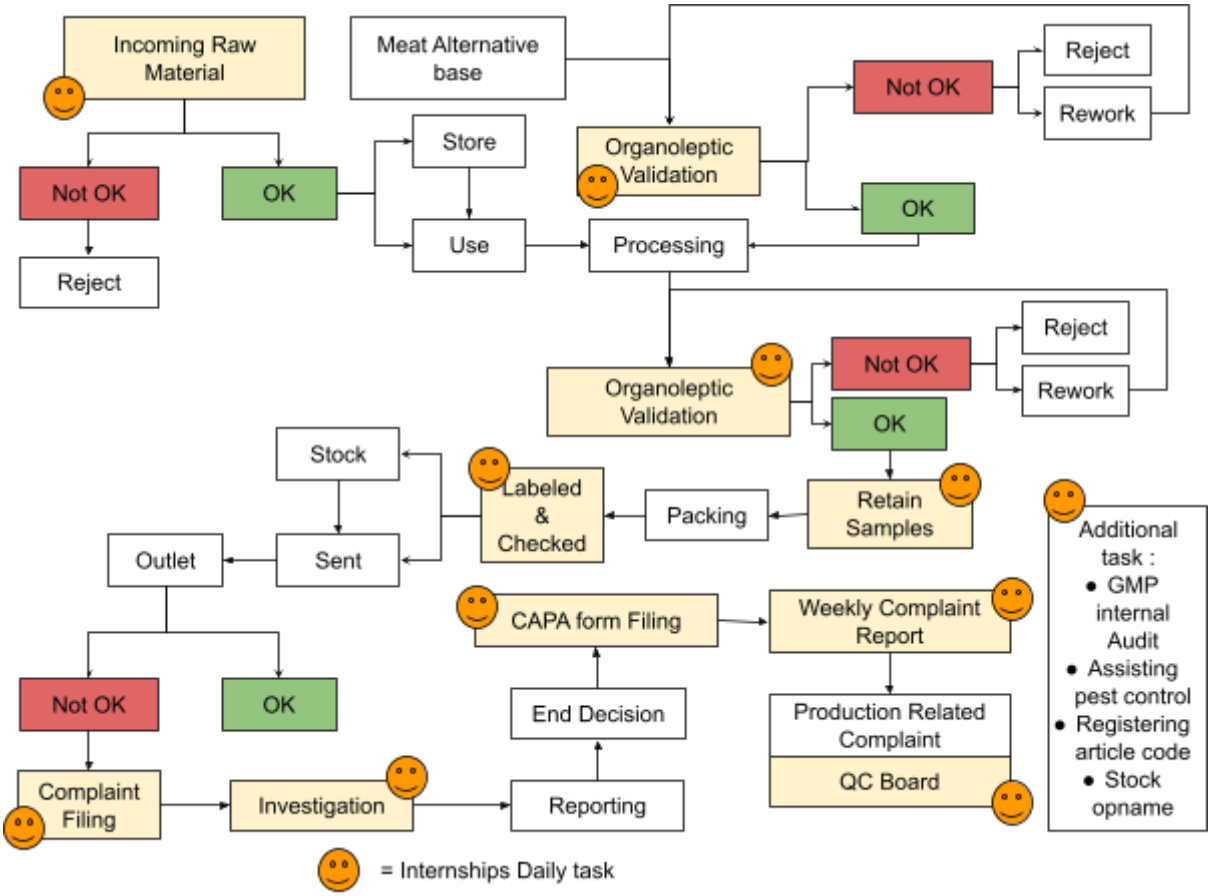
Product	Qualifications	
	Qualities	Quantity
Purple Cabbage	● Round in shape with clean cut on stem ● Bright purple in color ● Free from physical injuries (e.g. bruise and cuts) and white color holes ● Free from dirt ● Covered in cling wrap with the stem covered with paper	1 piece per pack Minimum weight 300 gr per pcs
Brioche Buns (Regular & Mini)	● Half cut ● Sealed with sufficient air pressure ● Round in shape ● Free from uneven scorched area	6 buns per pack
Peeled Onion	● Free from physical injuries (bruises) ● No budding ● Clean cut on stem ● Fresh, not yet withered	N/A
Gluten Free Bread	● Clean cut ● Heat sealed	1 loaf per pack
Champignon Mushroom	● Free from dirt ● Broken White in color ● Clean cut on stem ● Sufficient size ● Free from physical injuries (bruises)	N/A
Vegan Donut	● Min 7.5 cm in diameter	9 donuts per cardboard box

Tortilla	● Free from physical injuries (e.g. holes and tears) ● Golden brown or white in color ● Packed in a heat-sealed LDPE ● Diameter min. 27 cm	10 pieces per pack

Appendix 2. General Standard of Organoleptically Validated Products

Product Category		General Standard			
		Appearance	Taste	Odor	Mouthfeel
Meat Analogue Base	Chick'n Base	Cream in color; free from slimy substance; shaped accordingly; free from dark spots	Chicken flavored; Free from spoiled acidic taste	Normal odor, free from spoiled acidic smell, free from rancidity	Not mushy, textured, juicy
	Beefless Base	Dark brown in color; free from slimy substance; shaped accordingly	Beef-flavored; free from bitter taste; free from spoiled acidic taste		Not mushy, textured, juicy
Semi-Finished Product, Finished Product, Unidentified	Sauces, dressings, & Soups	Normal color; free from mold	Normal taste, free from spoiled acidic taste		Appropriate consistency
	Meat Analogue	Normal color; free			Not mushy, textured,

Product	Products	from slimy substance			juicy
	Drinks	Normal color			Appropriate consistency
	Dalgona	Normal color; free from mold and yellow spots			Creamy, fluffy
	Others : condiments, desserts (brownies bar, cookies), gyoza, wrap, etc.	Normal color; free from mold			Not mushy, Normal texture



Appendix 3. Regular activities in Processing Flow as QC Intern in Burgreens-Green Rebel QC/QA Department

BURGREENS		FORM CAPA	No	FRM.QEAS.01.03
Prepared by	Dinda		First Issue Date	01/04/21
Reviewed by	Harri		Rev. #	
Approved by	Max		Rev. Date	

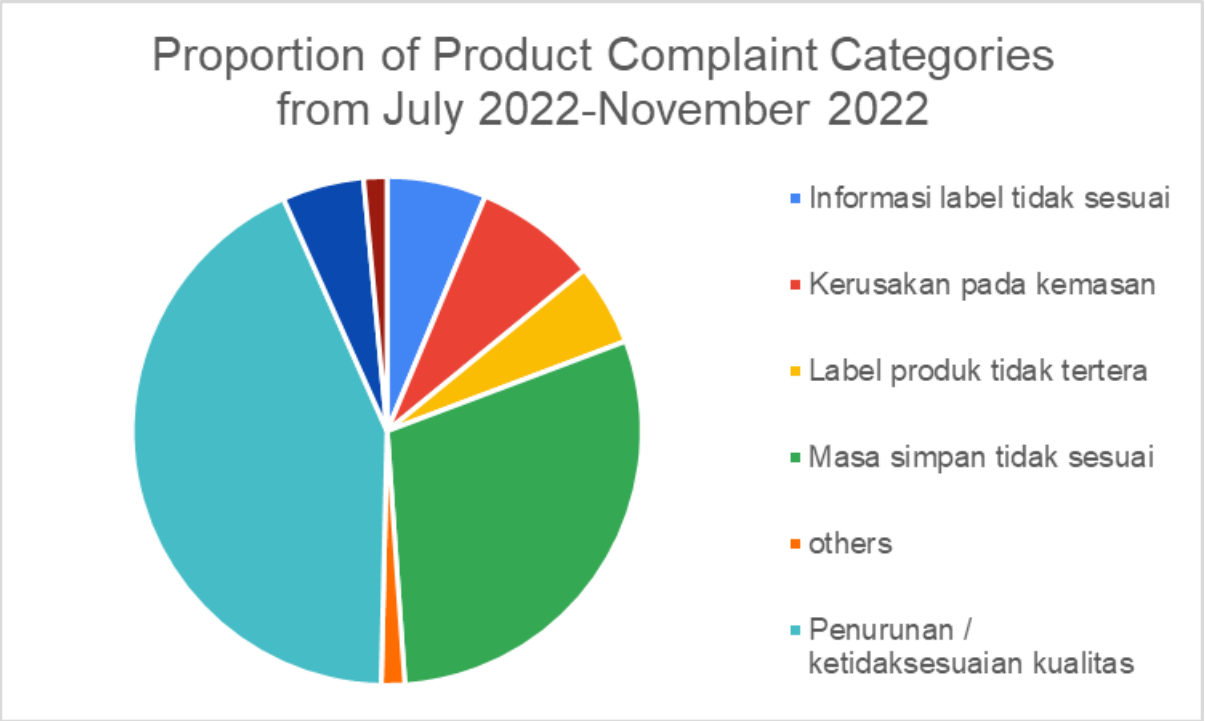
Issue Date: **Department:**

Product Description		**Pictures**
Product Name:		
Batch Number:		
Arrival Date:		
Quantity:		
Report Category:		
Issue Detail: **Containment Action:**		

Possible root cause	**Department Responsible / PIC**

Corrective action	**End Decision**	**Approval**

Appendix 4. Burgreens CAPA form



Appendix 5. Proportion of Product Complaint Categories from July 2022-November 2022

$$\Delta E = \sqrt{(L1 - L2)^2 + (a * 1 - a * 2)^2 + (b * 1 - b * 2)^2}$$

Appendix 6. Formula of ΔE for La*b* color space

$\Delta E\ chilled = \sqrt{(66.19 - 71.49)^2 + (12.81 - 9.03)^2 + (39.07 - 31.14)^2}$ $\Delta E\ chilled = 9.781$
$\Delta E\ frozen = \sqrt{(66.19 - 68.31)^2 + (12.81 - 10.09)^2 + (39.07 - 32.08)^2}$ $\Delta E\ frozen = 7.794$

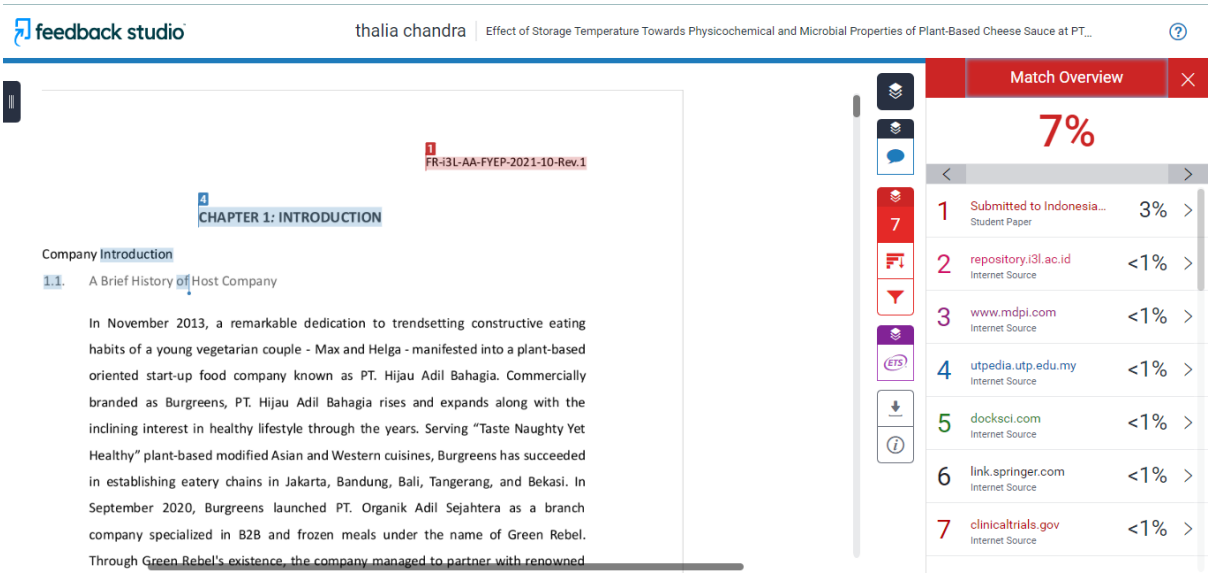
Appendix 7. ΔE of Chilled and Frozen Storage Temperature PBCS on Week 0 - Week 8

$$\text{NBS units} = \Delta E \times 0.92$$

Appendix 8. Formula of NBS unit conversion

NBS units Chilled Samples = 9.781 x 0.92 = 8.999 NBS units Frozen Samples = 7.794 x 0.92 = 7.170

Appendix 9. Calculation of NBS converted Chilled and Frozen Samples Color on Week 0 - Week 8



Appendix 10. Turnitin Plagiarism Check