Summary: Efficiency Optimization Management of New Dragon Fruit Products in Vietnam

The Summary of

A Dissertation Presented to The Faculty of The Graduate School

European International University (EIU).

in Paris, France

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Management

By Nguyen Manh Ngoc Bao

Thesis Advisor Prof. Dr William Wong

Disclaimer: This summary intends to provide an overview of the key findings and conclusions of the full research paper. Due to the concise nature of this summary, some details and nuances may not be fully captured. Readers are encouraged to refer to the complete research paper for comprehensive information and analytical insights. This summary does not encompass the full breadth of the research and should not be used as the sole basis for evaluating the depth or quality of the research.

Background of Study

The food processing industry, vital for meeting customer demand and optimizing organizational efficiency and productivity, underscores the importance of process and cost management. Such management not only boosts return on investment (ROI), sustainability, and market shares but also upholds business ethics and corporate social responsibility.

However, the neglect of transforming food waste into valuable alternative products is a common oversight, contributing to a significant global issue. For instance, fruits and vegetables account for 42 percent of food waste, with an estimated 1,555 million tons wasted annually. Addressing this issue is imperative, especially considering projections of increasing food loss and waste globally, particularly in Asia.

The urgency to tackle food waste aligns with the UN's Sustainable Development Goals, which aim to halve food loss and waste by 2030. Innovative initiatives to repurpose agricultural waste not only yield economic benefits but also fulfill global social responsibility, aligning with new energy and environmental policies (Duque-Acevedo et al., 2020).

Against this backdrop, this research study focuses on optimizing the properties of dragon fruit and its by-products through structured scientific investigations. Dragon fruit, a prominent agricultural product in Vietnam, serves as the subject for experimental exploration. Specifically, this study aims to leverage agricultural waste to enhance economic growth, particularly in Long An Province, Southern Vietnam, given its strategic position within the Southern Key Economic Region.

Long An Province offers an ideal setting for such research, given its agricultural prominence and potential economic contributions. By transforming dragon fruit waste into value-added products like jam and snacks, this research seeks to bolster economic growth sustainably while addressing industrial productivity challenges.

Through a laboratory-based approach utilizing experimental factorial design, this study aims to inform operational managerial decisions and solutions within the food processing industry. By optimizing production parameters and process design, the research endeavors to generate market-demand by-products that meet quality expectations.

Efficiency and effectiveness in this context encompass not only production yield but also the quality of by-product output. This study aims to balance profitability and sustainability, contributing to national economic growth through innovative solutions in the food industry.

In summary, this research seeks to explore processing optimization methodologies for dragon fruit by-products, offering insights into engineering process managerial decisions and fostering economic growth and sustainability in Vietnam's food industry.

Problem statement

Waste poses significant implications for cost, quality, and productivity. This section outlines key problem scenarios and project aims, starting with an exploration of the agricultural and socio-economic landscape in Long An Province. Understanding raw materials and extraction techniques is pivotal for optimizing food processing solutions, analyzing product yield outcomes across different experimental treatments.

The research scope seeks to grasp the contemporary scenario of agricultural and socio-economic supply chain activities, from upstream agricultural environments to downstream market demand, retailers, and consumer end. Special focus is placed on dragon fruit plantation and by-product consumption dynamics in Long An Province, Vietnam, alongside insights into global food waste and agricultural raw product understandings.

Additionally, the research context delves into the properties and biochemical characteristics of relevant raw materials, ingredients, and carriers used.Agricultural waste, comprising residues from the growing and processing of raw agricultural products, presents significant challenges and opportunities. Estimates suggest that approximately 998 million tonnes of agricultural waste are produced yearly, with organic wastes accounting for up to 80 percent of total solid wastes generated. Dragon fruit peel is explored as a potential resource for reducing fruit waste while increasing economic value in the food processing industry.

Long An Province's favorable soil and climate conditions make it an ideal location for fruit material sourcing, with dragon fruit emerging as a valuable export material. However, unqualified dragon fruits and their peels contribute to economic waste if not utilized effectively. By transforming dragon fruit peel into valuable by-products such as jam and snacks, opportunities for economic growth and waste reduction are identified.

Jams, a popular food product, are produced by preserving fruits with added pectin as a gelling agent. However, processed products like jams tend to have lower nutritional values compared to fresh fruits. This study aims to develop a new jam product made from the flesh of white dragon fruits, addressing the gap in nutritional content and consumer demand for natural, vitamin-rich snacks.

In summary, this study investigates physiochemical extraction of pectin from white dragon fruit peel and the development of a new jam product made from dragon fruit flesh. Through an exploration of dragon fruit's bio-chemical features and physiochemical extraction techniques, this research aims to contribute to process management and waste reduction in the food processing industry.

Raw Materials, Ingredients, and Extraction Techniques

(a) Coconut Oil:

Coconut oil, also known as coconut butter, is derived from fresh coconut meat, milk, or residue and is renowned for its functional and nutraceutical benefits. It contains high levels of low molecular weight saturated fatty acids, particularly Lauric and Palmitic acid, making it versatile for various applications.

Production methods range from smoke drying to wet extraction, with virgin coconut oil (VCO) extracted directly from coconut milk being increasingly favored for its retention of beneficial components. This study aims to investigate the chemical composition of organic and virgin coconut oil available in the market.

(b) Pectins:

Pectins, plant cell wall structural polysaccharides, serve as gelling agents, thickeners, emulsifiers, and stabilizers in the food and beverage industry. Dragon fruit, rich in pectin, presents an opportunity for extraction. Various methods, including conventional extraction and ultrasound-assisted extraction (UAE), have been explored for pectin extraction. However, no ultrasonic method has been applied to extract pectin from white dragon fruit peels, highlighting a gap in research.

(c) Ultrasound-assisted Extraction:

Ultrasound-assisted extraction (UAE) offers a green and economically viable alternative to conventional techniques for food and natural products. It involves localized high temperature and pressure spots that modify the structural, functional, and bioactive properties of pectin. UAE has shown shorter extraction times, higher yields, and increased antioxidant activity compared to other methods. Despite its potential, UAE has not been extensively studied for pectin extraction from white dragon fruit peels.

(d) Liposome:

Liposomes, small artificial vesicles, are promising systems for drug delivery due to their size, hydrophobic, and hydrophilic character. In this study, liposomes serve as a phase separator to stabilize virgin coconut oil (OVCO) and dragon fruit peel (DFP) pectin components. Liposome encapsulation offers a means to entrap unstable compounds and shield their functionality, enhancing efficiency in resource and process design.

Overall, this research investigates the chemical composition of coconut oil, the extraction of pectin from dragon fruit, and the application of liposomes as a phase separator, aiming to optimize processes and maximize value proposition in agro-waste and food processing waste management.

General Objective

To develop solutions of optimization products from dragon fruits in the food processing industry at Vietnam, based on the understandings of the following specific objectives:

Specific Objectives:

1. To develop new fruit Jam which made from flesh of white dragon fruit in Vietnam.
2. To develop new fruit snack which made from dragon fruit peel in Vietnam.
3. To extract new resource pectin from dragon fruit peel.
4. To study the optimal condition for extracting dragon fruit peel pectin by using conventional extraction method (CE) and ultrasound-assisted extraction (UAE) at various extraction condition 45, 60 and 75^{o}C for 30 and 60 min.
5. To optimize the conditions for producing liposome in corporation with OVCO and DFP pectin and investigate its properties. The properties of liposome and its application in functional ingredient for beverage is also investigated.
6. To evaluate the possibility for using the liposome solution as a healthy natural creamer in black tea.

The ultimate research goal is to maximize both process productivity and efficiency, in which, to the maximum extent as far as possible, to obtain the highest quality end product output using the available resources from the dragon fruits. This will be summarized via the Paradigm of Study in the following section 1.4.

PARADIGM OF STUDY

Overall, the scenario of the research planning using the Input-Process-Output paradigm model is showed in Table 1.2.

Table 1.2 Paradigm of the Study

Inputs	Process	Outputs
• Determine issues and opportunities relating to dragon fruits with respect to economic and value propositional return • Market potential and consumer behavior towards products derived from dragon fruits •Literature review on related raw material properties, food processing techniques and equipment capabilities and selection in food processing	•Perform chemical analysis on raw material properties • Experimental Design with food processing process flow under different treatment factors and settings • Carry out consumer taste preference to determine the favorite choice of new products derived from dragon fruits and related raw material.	Findings on the optimum chemical and health benefits of selection of raw material, and processed products; in which processing methods, techniques and treatment settings required to get quality products demanded by consumers

Significance of the Study

This research aims to contribute both commercially and environmentally by transforming dragon fruit waste into useful products, aligning with global calls for sustainable resource management. In Vietnam, agriculture drives economic growth and poverty reduction, emphasizing the importance of enhancing productivity. Long An Province is significant due to its productivity compared to other regions, highlighting the need to address regional disparities for balanced development. By leveraging agricultural waste for value creation, this study can improve agricultural Total Factor Productivity (TFP), crucial for poverty alleviation and agricultural expansion, benefiting both Long An Province and Vietnam as a whole.

Literature Review

Food Waste and its Impacts

The global crisis of environmental degradation, exacerbated by population growth and increased demand for natural resources, necessitates urgent structural reform in the world economy to mitigate negative impacts on soil, air, and water resources. Agriculture, responsible for a significant share of greenhouse gas emissions, faces challenges in sustainability and development. Circular economic models emphasize resource efficiency and waste reduction, offering alternatives to traditional linear production practices.

Food wastage, comprising food loss and food waste, poses significant socio-economic and environmental challenges. Food loss occurs primarily during production, storage, and transportation, while food waste happens at the consumption stage. Factors contributing to food waste include infrastructure limitations, retailer standards, and consumer behavior, with globalization playing a role in exacerbating the issue.

Globally, an estimated 1.3 billion tonnes of food are wasted annually, costing trillions of dollars and placing immense strain on freshwater and land resources. The carbon footprint of food waste is substantial, with significant greenhouse gas emissions and land degradation. Misinterpretation of food labeling, consumer habits, and rigorous standards contribute to food waste along the supply chain.

As the global population continues to rise, food waste is projected to increase, highlighting the need for research and initiatives aimed at salvaging food waste and promoting sustainable consumption practices.

Importance of Dragon Fruit Waste Management

In Southeast Asia, agriculture plays a significant role in the economy, with countries like Thailand and Vietnam being major exporters. Vietnam's agricultural sector has seen substantial growth, driven in part by policy reforms. While rice remains a staple crop, other commodities like dragon fruits have gained prominence.

Understanding the concept of quality is crucial in assessing waste. Quality, often synonymous with excellence, encompasses meeting customer requirements and expectations. Taguchi's Quality Loss Function highlights the cost incurred when products deviate from desired values, emphasizing the importance of meeting customer needs.

Customer satisfaction extends beyond basic quality to include performance and excitement quality, as outlined in Kano's model. Delighting customers involves surpassing expectations, creating value-added surprises.

Dragon fruit, a popular tropical fruit, is grown extensively in Vietnam. Despite its popularity, a significant portion of dragon fruit is wasted, particularly the peel, which accounts for 25-30% of the fruit's weight. This waste poses environmental challenges. Extracting pectin from dragon fruit peels offers a solution to both reduce waste and enhance the value of agricultural by-products, contributing to environmental protection efforts.

Food processing involves various methods to transform agricultural products into different forms of food, ranging from basic grinding to complex industrial processes. As consumer demands evolve, food and beverage manufacturers must enhance their production capabilities to meet changing needs and preferences, including the expectation for mass customization.

A process can be defined as any meaningful activity that utilizes time, involving a combination of labor, machines, tools, and methods to manufacture a product. Process capability refers to the normal behavior of a process when operating under statistical control. Variation within a process can be attributed to inherent or intermittent causes, with the goal of process improvement being the elimination or reduction of these causes.

Process capability studies (PCS) assess the accuracy and precision of production mechanisms, focusing on repeatability, reproducibility, and stability. Accuracy relates to the deviation of measurements from the true value, while precision concerns the agreement among individual measurements. Reproducibility measures the variation in measurements made by different operators, while stability assesses the performance of a measuring system over time.

Taguchi's approach to quality improvement emphasizes defining quality losses as deviations from the target and designing quality into the product. Addressing process capability issues often requires a formal statistical investigation known as design of experiments (DOE), that identifies critical process variables and their effects on process output, which will be discussed below.

Design of Experiment (DOE)

As a battery of test, a DOE is designed to methodically build understanding and enhance the predictability of a process. A DOE is a well-developed plan to sort out important variables or combination of variables that influence the process. DOE helps to understand effects of the factors and interactions that impact the output of a process. In other words, the main purpose of having DOE is to investigate the process system capability (PSC) to optimize the process output – the yield results, while minimize the input resources and setting the best-fit process variables. A DOE may use continuous and/or discrete factors. Continuous factor is one (such as feed rate, temperature change, etc) whose levels can vary continuously, while a discrete factor will have a predetermined finite number of levels (such as supplier A or Supplier B).

The types of DOEs include:
(i) Screening DOEs, which ignore most of the higher order interaction effects so that the process team personnel can narrow the candidate factors down to the most important ones.

(ii) Characterization DOEs, which evaluate mainly factors and interactions to provide a prediction equation.

(iii) Optimizing DOEs, which sue more complex design such as Response Surface Methodology or iterative simple designs such as evolutionary operation or plant experimentation to determine the optimum set of factors.

(iv) Confirming DOEs, where experiments are done to ensure that the prediction equation matches reality.

It can be done either off-line or on-line design of experiment. For off-line DOE, the simplest type is “one-factor-at-a-time” experiment, ranging up to factorial, Taguchi, and nested design of experiment (Fasser & Brettner, 1992).

The process output performance are responses that a researcher would like to investigate. Very often, this is called the yield of process or yield of product. The yield is the manifestation of the quality built into the product while undergoes a series of value-added process. The dependent response can be formulated and represented by the prediction equation that could include compounding effects, or solely as the main and/or interaction effects of a particular factor, between two or among several factors in combinations. For example, the yield equation, y, for a 2^k design, the prediction equation for a two-factor case be presented as follows:

$$Y = \text{grand mean} + ß_1 x_1 + ß_2 x_2 + ß_3 x_1 * x_2)$$

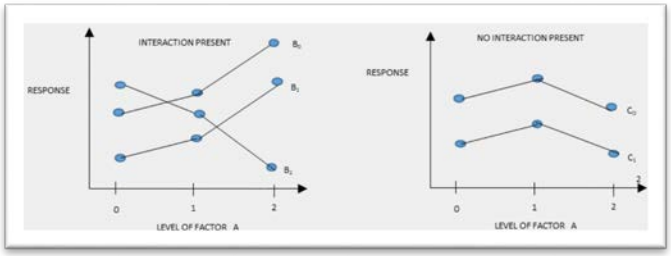


Figure 2.8 Response yield curves showing presence or absence of interaction

Raw Material and Biochemical Elements Needed For The Research

Coconut Oil:

Coconut oil, derived from the seeds of the coconut palm, is rich in molecular weight saturated fatty acids, particularly Lauric acid. It possesses unique properties such as high vitamin E content, resistance to rancidity, and antibacterial qualities. Commonly produced from copra through refining processes, virgin coconut oil (VCO) obtained via a wet process from coconut milk is considered advantageous due to its retained beneficial components. Despite its high saturated fat content, coconut oil contains medium-chain triacylglycerols beneficial to health. Traditionally used for beauty enhancement and minor ailments, VCO shows potential as an anti-obesity treatment.

Dragon Fruit and Peel:

Dragon fruit, a tropical fruit of the cactus family, is widely cultivated in Vietnam and exhibits high vitamin C content and antioxidant properties. The fruit comes in red or white flesh varieties and contains essential minerals and vitamins. Dragon fruit peel, often discarded, holds potential as a natural colorant, thickening agent, and source of pectin. Studies suggest that dragon fruit seeds contain high amounts of oil, vitamin E, and essential fatty acids, contributing to its nutritional value. The fruit and its components offer various health benefits and potential applications in food and cosmetic industries.

Extraction of Pectin:

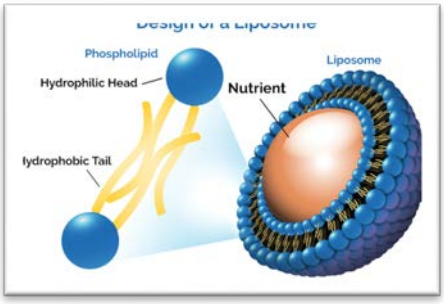
Pectin, a complex polysaccharide found in fruits and vegetables, is categorized into high-methoxyl (HM) and low-methoxyl (LM) types based on its degree of esterification. HM pectin forms irreversible gels suitable for jams, while LM pectin forms heat-reversible gels ideal for bakery products. Pectin is widely used in the food industry as a thickener, stabilizer, and fat substitute, and its demand has increased globally. Pectin can be extracted from various sources, including fruit wastes, with the price ranging from 10-20 USD per kilogram.

Ultrasound-Assisted Extraction Method:

Ultrasound, a non-audible frequency form of energy, induces acoustic cavitation in liquids, leading to physical forces like vibration, heating, and microjet formation. It has shown promise in improving food processing and preservation, including extraction techniques. Ultrasound-assisted extraction, combined with other methods, enhances pectin extraction efficiency while maintaining physicochemical characteristics. This study aims to optimize pectin extraction from dragon fruit peel using ultrasound and agitation with citric acid as the extraction solvent.

The Role of Functional Compounds: Incorporation of Liposomes:

Liposomes, spherical vesicles composed of lipid bilayers, offer an attractive encapsulation system for functional compounds due to their biocompatibility and ability to encapsulate both hydrophilic and lipophilic substances. In the food industry, liposomes are used to stabilize and protect bioactive compounds like polyphenols, improving their solubility, bioavailability, and antioxidant properties. Studies have shown that liposomal encapsulation enhances the efficacy and safety of various bioactive compounds, making them promising for functional food applications.



Potential Market of Dragon Fruit By-Products Fruit in Vietnam:

The global market for fruit jams is expected to grow significantly, with Vietnam emerging as a potential market worth several tens of millions of dollars in the future. As Vietnam moves towards industrialization, there's a shift towards Western-style breakfast habits, including bread with fruit jam. Similarly, the snack market in Vietnam is thriving, with increasing demand driven by changes in lifestyle, rising incomes, and higher purchasing power. Savory snacks, especially those made from natural ingredients like dragon fruit peel, present new opportunities in Vietnam's snack market, where consumer awareness about health and wellness is on the rise.

Theoretical Framework

The theoretical framework for this research is showed in Figure 2.13.

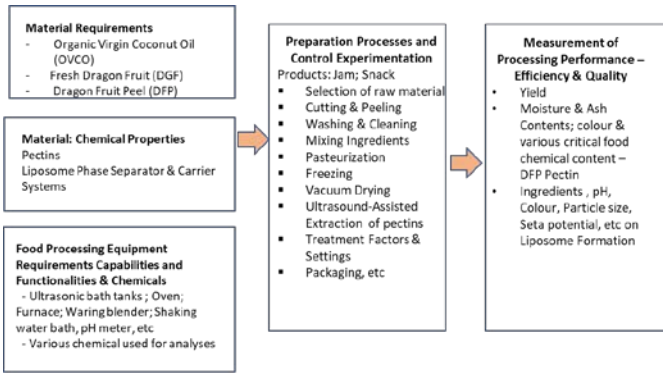


Figure 2.13 The theoretical framework

Research Methodology

In doing this research, the overall three elements of the production system are recognized, as showed in Figure 3.1.

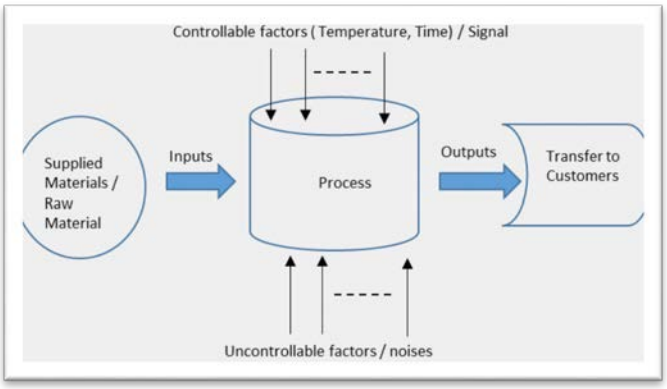


Figure 3.1 Primary elements to be considered in the production system

Figure 3.2 illustrate the bigger picture of the methodology framework possible for quality by design involve the new product or new process development and its subsequent continuous improvement after new product released. For this research study, the researcher focused on the use of design of experiments (DOE) aims to gain the optimization of the process capability development to product the jam and snack products from the raw material of dragon fruits.

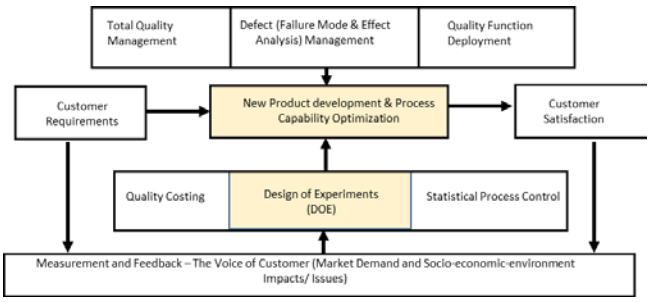


Figure 3.2 The methodology framework strategy used in this research

In term of project development, Figure 3.3 showed the 9-step new product development process flow used in this research. This flow chart can also be used for the continuous quality improvement process in long term, even after this research study end. The actual process flow details will be described in section 3.2 onwards.

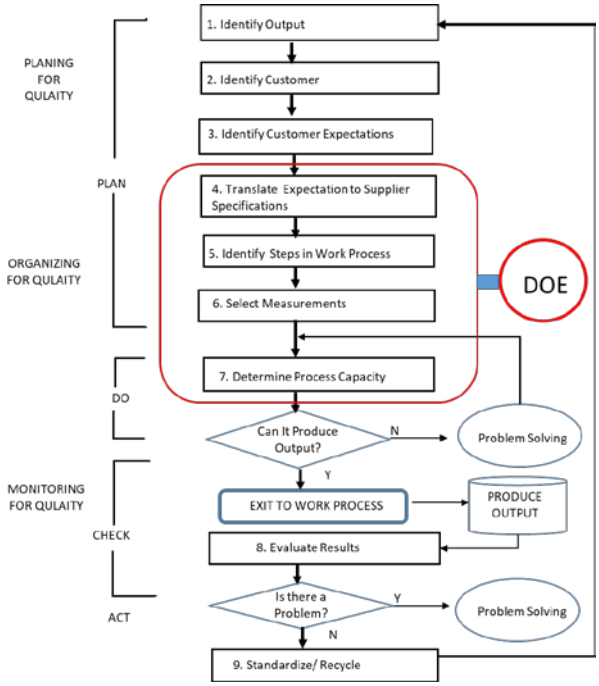
For this research, the factorial design of experiment (DOE) is used. Corresponds to the highlighted red box as indicated in Figure 3.3, the method for designing and conducting experiments the following four basic steps:

(i) *Identify factors/ variables* (extraction equipment type, temperature and time) and *quality characteristics* (the process output yield of pectin and its associated physiochemical properties) to achieve consumers' liking.

(ii) *Design experiment.* The number of treatment levels and corresponding experimental array settings for each factor are determined.

(iii) *Conduct experiment.* Each trial condition in the array is conducted and performance data is carefully recorded. Randomization to guard against uncontrolled time trends is observed.

(iv) *Analyze results*. Experimental data is typically subjected to analysis of yield and tolerances (residual analysis), and test of statistical significance. Each factor is analyzed to determine if it influences the mean value or variation of performance.



In this experimental research, precise control over agricultural input quality and machinery calibration is crucial. Data collection occurs during evaluation of raw material properties, throughout food processing, and during quality measurements. Input material quality attributes are assessed by researchers and trained personnel, ensuring accuracy and consistency. Typically, 3-5 runs per treatment combination are conducted. The study takes place in scientific laboratories and kitchen

environments. Key inquiry questions are used for beverage tasting surveys at various locations. Personal information is omitted to maintain naturalistic feedback. Equipment serves both as a production tool and a control factor, alongside temperature and time, influencing process outputs and ingredient properties.

Raw Material & Chemicals

Raw Material:

- Commercial and organic coconut oil (cold pressed method)
- Dragon fruits (Hylocereus undatus)
- Volume: Approximately 500 kg
- Yield: 70% flesh, 30% peel
- Fruit preparation:
- Fruits washed with tap water and dried
- Fresh peel separated from flesh fruit and cut into small pieces (5x5 cm^2)
- Peel dried in hot air oven for 4 hours at 50°C
- Dried peel ground into powder and stored at ambient temperature, sealed to avoid humidity and sunlight exposure-Citrus pectin (purchased from Bronson & Jacobs International Co., Ltd), used as control
- Organic black tea

Chemicals:

Analysis	Chemicals
Iodine Value	Cyclohexane, Wiji solution, Iodine solution, Sodium thiosulfate solution, Starch solution
Peroxide Value	Acetic acid-Chloroform, Potassium Iodine, Sodium thiosulfate solution
Total Phenolic Content	n-Hexane, Methanol, Folin-Ciocatteau reagent, Sodium carbonate, Galic acid
Antioxidant Activity	1,1-diphenyl-2-picrylhydrazyl (DPPH), Methanol
Proximate Dragon Fruit Peel	Potassium sulphate, Potassium hydroxide, Sodium hydroxide, Petroleum ether, Sulfuric acid, Boric acid, Hydrochloric acid, Phenolphthalein, Copper sulphate
Extraction of Pectin	Citric acid, Ethanol
Determination Degree Esterification of Pectin	Isopropanol, Sodium Hydroxide, Acid Clohydric
Antioxidant of Pectin	Methanol, 1,1-diphenyl-2-picrylhydrazyl (DPPH)
Antioxidant of Liposome	Methanol, 1,1-diphenyl-2-picrylhydrazyl (DPPH)

[For conciseness, full details of the methodology have been omitted from this summary. Interested readers are encouraged to consult the full paper for comprehensive information.]

DATA ANALYSIS AND RESULTS

Processing Technology On Dragon Fruit Jam

Following Processing Technology, dragon fruit jam was successfully processed. There was a little bit different about selection of raw materials and mixing sugar step. Dragon fruit Jam had mixed 2 kinds of sugar instead of sugar unique. It helped to expand target customers and the product was healthier.

Step	Description
1. Selection of Raw Materials	- Choose ripe dragon fruits, with a ratio of white to red dragon fruit of 8:2. - Remove deep or partially damaged marks, using damaged fruit after removing the affected parts.
2. Washing	Quickly wash the fruit with clean water.
3. Peeling and Collecting the Flesh	- Remove the dragon peel and collect the flesh to make jam.
4. Cutting	Puree the fruit flesh to facilitate cooking, avoiding grinding to prevent breaking the dragon fruit seeds.
5. Mixing with Sugar	- Heat the fruit flesh to 40-50°C and dissolve it with a mixture of crystal sugar sucrose and stevia sugar in a ratio of 3:7. - Concentrate the suspension-sugar mixture to a dry matter content of 65%.
6. Adjusting pH and Adding Pectin	- Cool the solution to 75-80°C, then adjust the pH to 3.0 with saturated citric acid solution. - Keep the solution temperature at 75-80°C and add additional pectin in an amount of 1-2% of the total mixture to support the freezing process.
7. Concentrate Cooking	Simmer the mixture and add citric acid to create acidity, and pectin to thicken the jam.
8. Pasteurization	Pass the product through a pasteurization machine to prolong shelf life and minimize harmful microorganisms.
9. Filtering	- Heat the solution to 40-50°C, then filter it through filter cloth to obtain a clear solution containing pectin. - Determine the dried fruit extract content by Brix measurement.
10. Packaging Jam	Pour the hot jam into bottles or plastic cups, being careful not to create air bubbles inside the gel structure.
11. Freezing	- Keep the product at room temperature for at least 12 hours to form a good gel structure. - For a more durable gel structure, freeze at a temperature between 10-20°C, shortening the freezing time.



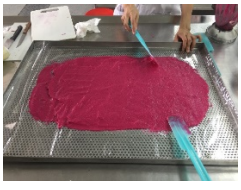


Processing Technology On Dragon Fruit Snack

Following Processing Technology, dragon fruit Snack was successfully processed. The product had the good appearance and perfectly taste. But there were some difficulties when processing with large amount in industry processing. In this method, it showed that dragon fruit peel was not only the by-product but also the ingredient to develop the new food snack in food innovation. It helped to improve value of product and changed product from devalued material to have value in the market.

Step	Description
1. Raw Materials	Main material: Fresh dragon fruit Requirements: - Should not be rotten, and should not have wide spread pests and diseases. - Post-harvest ingredients should be well preserved. Auxiliary materials: Sugar, Salt, MSG, Cheese powder
2. Washing	Remove impurities (soil, sand) adhering to the surface of the skin.
3. Peeling	Remove the thin crust and dragon fruit belt to extract the flesh of the shell.
4. Blanching	Reduce the viscosity and pungent odor of dragon fruit shell, and preserve the pre-treatment color before drying.
5. Adding sugar	Add sugar to reduce the salinity of dragon fruit shells.
6. Restructuring	Puree the shell to change the surface structure.
7. Drying	Reduce the water activity of the product and make it crispy.
8. Shaping	Purpose: Fixed size, length snack to facilitate packaging and transportation. Can create shapes such as spiral or triangle.
9. Frying	Purpose: Create a crunchy texture, reduce moisture to 2-3% for storage. Temperature and time settings: 175°C and 5 seconds respectively.
10. Seasoning	Purpose: Add specific flavor to the product. Method: Coat the product surface at a temperature of 50-60°C.
11. Vacuum Packaging	Purpose: Protect the product from air, moisture, temperature, and microorganisms, preserving its properties and enhancing hygiene.










Quality of The Organic Virgin Coconut Oil (OVCO)

The quality of OVCO was investigated as below:

Iodine Value of OVCO

The iodine value was used to measure the degree of unsaturation of fats and oils. It was expressed as the number of grams of iodine absorbed by 100 g of the fat under the test condition used. The low content of iodine value indicated that VCO had a high degree of saturation which led to effective resistance to oxidative rancidity. The iodine value of OVCO was 7.23 ± 0.54. According Sanders (2003), IV of ground nut oil was higher than 25. Hence, it had high unsaturated fatty acid bonds and easy rancidity. In this research, IV of OVCO was lower than 10 and considered as low Iodine value in oil. It led to the conclusion that OVCO was high degree of saturation and stable in term of resistance of oxidative rancidity.

Table 4.1 Chemical properties of OVCO

Parameter	OVCO
Iodine value (%)	7.23 ± 0.54
Peroxide Value (mEq oxygen/kg)	0.58 ± 0.24

Peroxide Value of OVCO

The peroxide value was a measure of the concentration of peroxides and hydroperoxide form in the initial stage of lipid oxidation. The number of peroxides presented in vegetable oils reflected its oxidative level and thus its tendency to become rancid. Therefore, OVCO had a low rate of oxidation due to its low content of unsaturated fatty (Table 4.1). Unsaturated fatty acid would react with oxygen to form peroxides. Oils with high peroxide values were unstable and became rancid (as shown in Table 4.1) ($p < 0.05$). The peroxide value of OVCO was 0.58 mEq/kg. The spoilage of fats and oils during storage is called rancidity and is associated with the production of foul odours. A rancid taste often begins to be noticeable when the peroxide value is between 20 and 40 mEq/kg (Ekwenye, 2006). PV of OVCO considered as low PV in oil properties (lower than 1 mEq/kg). The low peroxide values indicated that the OVCO sample was more stable against oxidation. The lower peroxide value also indicated the freshness of the sample.

Total Phenolic Content in OVCO

Phenolic compounds are potential natural antioxidants found in foods (Parr and Bolwell, 2000). VCO is also a source of phenolic compounds, and this study found that the contents varied based on coconut varieties and oil extraction processes. The total phenolic content of OVCO (TPC) was 6.37 mg GAE/100g oil (Table 4.2). The total phenolic contents for OVCO considered too high because the production process the OVCO was processed with extraction of both testa and copra. This result was in accordance with the research of Seneviratne *et al*. (2009) who stated that phenolic contents also vary with the composition of endosperm. Moreover, Testa, a by-product from the coconut processing industry is getting wasted. A study was carried out by Appaiah *et al*. (2014) to utilize testa as a source of edible oil. These studies indicated that the coconut oil from coconut testa contained more of natural antioxidants such as tocopherols, tocotrienols and phenolics compared to coconut kernel oil and may confer health benefits. Oils from testa were richer in mono-unsaturates and polyunsaturates than other coconut oil samples. The total phenolic acids and tocopherol content of coconut oils from testa also were higher than other samples.

Table 4.2 Total phenolic content and IC50 value of OVCO

Parameter	OVCO
Polyphenol (mg GAE/100g oil)	6.37 ± 1.15

Antioxidant capacity of OVCO using DPPH radical-scavenging activity

Approaches can be used to study radical scavenging activity of compounds as DPPH. Scavenging of DPPH radicals is mechanized by the donation of hydrogen atom to the unpaired electron of nitrogen bridge causing the purple color turn to yellowish. It is well accepted that the phenolic content significantly influences the antioxidant activities (Othman et al., 2014; Qader et al., 2011; Wong et al., 2006). According Penprapai and Intharit (2017) the radical scavenging of DPPH was positively correlated to the phenolic content. Phenolic compound had important roles on inhibitory effect of antioxidant agent. The oil extracts were able to reduce the stability of radical DPPH to a yellow color, which meant that the oil possessed hydrogen-donating capabilities and acted as antioxidants. OVCO was able to reduce the initial DPPH radical concentration by 50% and IC50 of about 0.55 ± 0.01 g/ml antioxidant capacity (Figure 4.12).

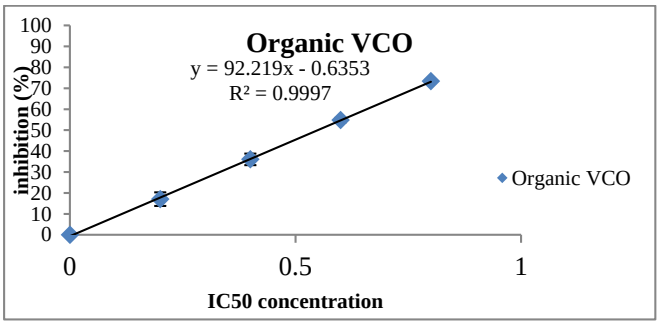


Figure 4.12 IC50 concentration of organic VCO

Effect of CE and UAE At Different Conditions on Physiochemical Properties and Antioxidant Activity of Pectin From White *Dragon Fruit Peel (DFP)*

In this part, physicochemical properties of DFP pectin were analyzed in various condition as follows based on the basic Factorial Design of Experiment (DoE) statistical approach.

Effect of extraction condition on production yield

The yield of dragon fruit peel (DFP) is studied using factorial design of experiment with 3 factors, namely the (i) Extraction method – either by the ultrasound-assisted extraction (UAE) or conventional extraction (CE); (ii) Temperature (T) with 3 levels (45, 60 and 750C); and (iii) Duration (D) with 2 levels (30 and 60 min).

The yield of dragon fruit peel (DFP) pectin extracted with ultrasound-assisted extraction (UAE) and conventional extraction (CE) varied from 4.98 to 19.48% (dry basis), depending on the extraction conditions (Figure 4.13).

The highest yield (19.48 ± 2.95%) was obtained when extracting with UAE at 75°C for 60 minutes; while the lowest yield (4.98 ± 0.25%) was obtained with CE at 45°C for 30 minutes. The differential effect of UAE and CE on yield was detected. The yield of pectin extracted from DFP by CE for 30 min at 45, 60 and 75°C were 4.98, 8.42 and 10.44%, respectively. Similarly, the yield when extracted by CE for 60 min at 45°C, and at 75°C were 6.51 and 12.35%, respectively. Pectin yield increased as extraction time and temperature treatment combination increased. This might occur because according Schemin *et al.* (2005), who has reported that the calcium–pectin linkage in protopectin was thermally reversible when the incubating temperature ranged from 46 to 74 °C with an extrinsic calcium source (Fu and Rao, 1999) or from 5 to 85 °C with an intrinsic calcium source (Gilsenan *et al*., 2000). The explanation is that when dragon fruit peel was extracted at high temperature, the molecular motion of the pectin molecules was enhanced, resulting in structural tangling of molecular chains that would cause more junction zones to be exposed to the free calcium ions, thus have a greater effect on the release of soluble pectin from the insoluble pectin, by enhancing hydrolysis of pectin, in comparison with low temperature (Iijima *et al*., 2002).

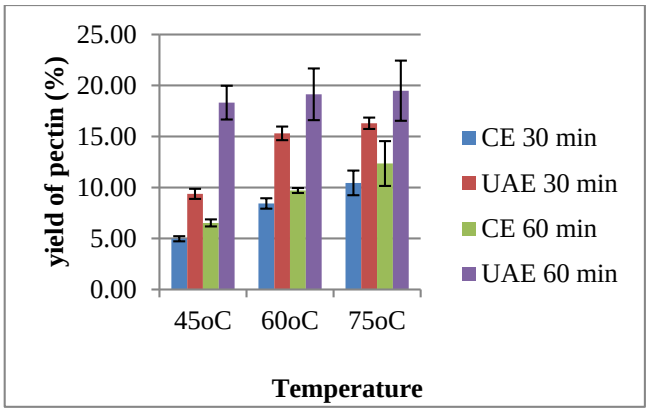


Figure 1.13 The yield content (%) of DFP pectin extracted with different extraction time (30 and 60 min) and temperature (45, 60 and 75°C) using CE and UAE method

By UAE, the yield of pectin extracted from dragon fruit peel for 30 min at 45°C, 60°C and 75°C were 9.38, 15.30 and

16.30%, respectively. Similar to CE, the yield of pectin increased when extraction time increased from 30 to 60 min and temperature increased from 45 to 75°C. However, the effect of time and temperature on the yield of pectin extraction by UAE was more significant than that of CE. The percentage of pectin extracted by UAE was higher than that of CE. The ultrasound has a high pressure which is throughout solvent and effect to tissue of dragon fruit peel. Moreover, the ultrasound will destroy tissue on surface and inside of cell wall dragon fruit peel, so that it helps to release easier solubility substance. Some studies have explained the mechanism of ultrasound-assisted extraction through exploring the effect of ultrasound on the vegetal materials. These studies observed the disruption of cell structure of vegetal tissue exposed to ultrasound and concluded that ultrasound waves increase the accessibility of the solvent to the internal particle structure, thereby facilitating the release of the cell contents (Anese *et al.*, 2013; Supardan *et al*., 2011). Moreover, it was reported that ultrasound also enhanced tissue hydration and swelling during steeping, which was deemed to be responsible for the increases of extraction yield in a short time (Toma *et al.*, 2001).

Effect of extraction condition on moisture and ash contents of DFP pectin

With the factorial DOE, Table 4.3 showed the results of the moisture and ash content of DFP pectin extracted by CE and UAE with various conditions, under the similar treatment combinations as explained in 4.4.1. Moisture content ranged from 5.02 ± 0.65% to 7.83 ± 0.68%. The lowest moisture content by CE was 5.02 % and the highest moisture content was 7.83%. The results indicated that moisture content increased as the extraction time increased from 30 to 60 min. In contrast, moisture decreased when upping the temperature from 45 to 75ºC. The moisture contents of pectin samples were similar when comparing between CE, UAE and control sample. The obtained values of all samples (5.02% - 7.83%) were lower than 10% which can be considered as low moisture content pectin. According to Mohamadzadeh *et al*. (2010), it was noted that high moisture content could enhance the growth of microorganisms and produce pectinase enzymes that can affect pectin quality. The moisture contents found in the pectin samples were low, therefore, microorganism growth and enzyme production will be minimum.

Table 4.3 Moisture and ash content (%) of DFP pectin extracted by CE and UAE with various condition.

Properties	Methods	Temp	Time (min)	
			30	60
Moisture of DFP pectin (%)	CE	45ºC	6.24 ± 0.42^{bcB}	7.51 ± 0.72^{abA}
		60ºC	7.30 ± 0.68^{aB}	7.83 ± 0.68^{aA}
		75ºC	5.02 ± 0.65^{dB}	5.74 ± 0.49^{dA}
	UAE	45ºC	6.63 ± 0.22^{abB}	7.10 ± 0.55^{abcA}
		60ºC	5.16 ± 0.94^{dB}	6.58 ± 0.60^{bcdA}
		75ºC	5.38 ± 0.33^{cdB}	6.23 ± 0.76^{cdA}
	Control		5.37 ± 0.29	
Ash of DFP pectin (%)	CE	45ºC	3.69 ± 0.40^{xyX}	3.41 ± 0.08^{xyY}
		60ºC	3.34 ± 0.43^{yX}	3.22 ± 0.30^{xyzY}
		75ºC	3.82 ± 0.71^{xyX}	3.58 ± 0.21^{xyY}
	UAE	45ºC	3.31 ± 0.41^{yX}	3.15 ± 0.45^{yzY}
		60ºC	3.13 ± 0.17^{yX}	2.66 ± 0.33^{zY}
		75ºC	4.17 ± 0.56^{xX}	3.83 ± 0.70^{xY}
	Control		3.77 ± 0.43	

Note. Values are expressed as mean ± standard deviation (n = 6).
$^{A-B,\ X-Y}$ Means with different letters within a row are significantly different ($p \leq 0.05$).
$^{a-d,\ x-z}$ Means with different letters within a column are significantly different ($p \leq 0.05$).
CE is conventional extraction.
UAE is ultrasound-assisted extraction.
*Control is commercial pectin which is different with all of values in table.

Low ash content (below 10 %) is one of the good criteria for gel formation (Ismail *et al*., 2012). The ash content indicates the purity of the pectin. The lower ash content, the higher level of purity pectin. Ash content of all samples was ranged from 2.66 – 4.17% which was two time lower than 10%. From these results, pectin extracted from both CE and UAE can be classified as high purity pectin.

Effect of extraction condition on color of DFP pectin

Color of pectin is an important parameter as it affects the appearance of the gel produced. Furthermore, highly colored pectin may contain polyphenols (Baississe *et al*., 2010) or other water-soluble pigments trapped inside the pectin during precipitation. Different extraction conditions (time and temperature) influence the pectin color. The results of the CIE L*, a* and b* parameters study are shown in Figure 4.14 (a) to Figure 4.14 (c) respectively.

Figure 4.5 (a)-(c) showed the color measurement as L*, a* and b* respectively of DFP pectin extracted with different extraction time (30 and 60 min) and temperature (45, 60 and 75°C) using CE and UAE.

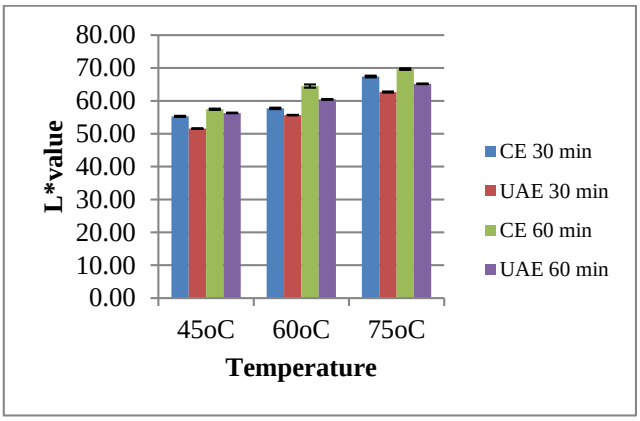


Figure 4.14 (a) L* values of DFP pectin

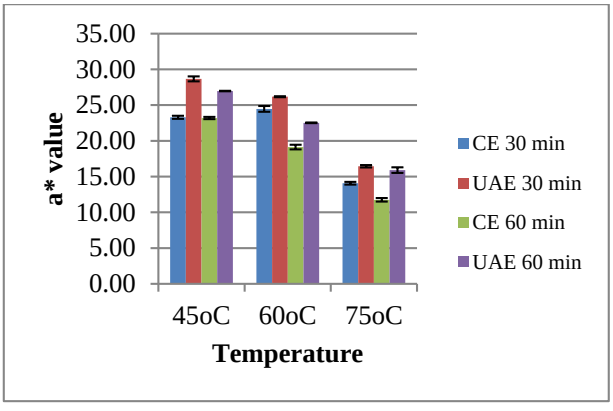


Figure 4.14 (b) a* values of DFP pectin

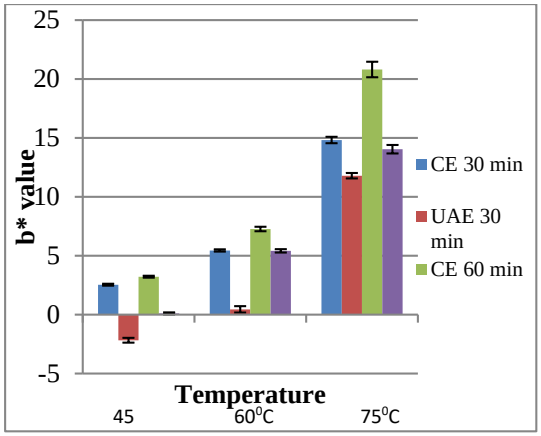


Figure 4.14 (c) b^* values of DFP pectin

As can be seen from Figure 4.14 (a), L* values of extracted pectin samples decreased in all extraction conditions, whereas a* value significantly increased. The yellowness b* value of all samples was significantly lower than control. These results indicated that pectin extracted from dragon fruit peel contented a huge amount of pigment and polyphenols. Differences were observed particularly on the color of ultrasonic extracted samples. Lightness increased when extraction temperature increased. It means that high temperature destroys the pigment. Similarly, the increase of extraction time destroyed water-soluble components, thus increased lightness of pectin samples. a* value of all samples extracted by UAE was higher than samples extracted by CE at the same temperature and time. Overall, the a* values of pectin control (9.47 ± 0.37) was lower than all DFP pectin extracted by both UAE and CE methods. This result coincided with Mohamad Zahari *et al.* (2016) who reported that DFP pectin showed greater values for redness compared control pectin. This is because dragon fruit peel, which has darker and redness appearance, causes a more redness pectin product to be produced.

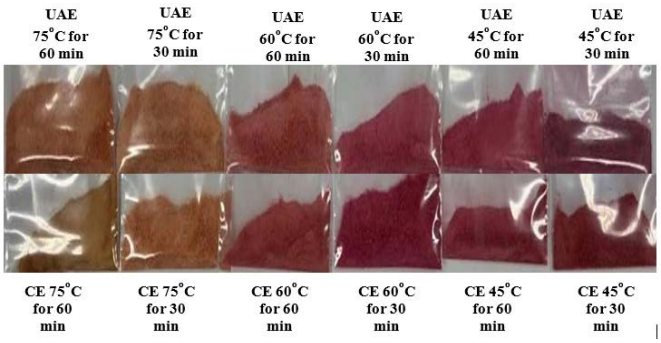


Figure 4.15 Color of DFP pectin powder with various treatments

Effect of extraction condition on equivalent weight of DPF pectin

Equivalent weight of pectin extracted from dragon fruit peel (DFP) using citric acid at various condition was found to range from 305.75 ± 6.43 to 446.41 ± 11.40g (Table 4.4). There was a significant difference between control and DFP pectin. All equivalent weight of DFP pectin samples was lower than that of citrus pectin control (445.59 ± 16.49) except sample at 45°C in 30 min by CE (446.41 ± 11.40). This result showed that the produced pectin was partial degradation. Additionally, the results showed that extraction conditions (time, temperature) did not affect the equivalent weight of extracted samples. According to Norazelina *et al.*(2012), the equivalent weight of DFP pectin was range from 475.64 to 713.99 which was higher than all equivalent weight value in this research. However, pectin with the equivalent or combining weight in the range of 250-350 will form the gel in the presence of calcium or magnesium ion regardless of whether sugar is or is not present. This low EW was advantage characteristic of pectin when application in food. It does not need anymore the sugar in forming gelling (Aksel *et al.*, 1941). This parameter as reported in literature varies in a wide range depending on the method and the nature of the fruits used for extraction. The increased or decreased of the equivalent weight might be also dependent upon the amount of free acid (Wahengbam *et al.*, 2014).

Table 3.4 Chemical composition of DFP pectin extracted by CE and UAE with various conditions

Properties	Method	Temp	Time (min)	
			30	**60**
Equivalent weight (EW) (g)	**CE**	45°C	446.41 ± 11.40^{aA}	371.95 ± 6.09^{cB}
		60°C	357.85 ± 19.70^{cA}	393.67 ± 4.31^{bA}
		75°C	392.61 ± 0.80^{bA}	305.75 ± 6.43^{eB}
	UAE	45°C	343.72 ± 15.39^{cA}	381.77 ± 1.07^{bcA}
		60°C	351.03 ± 2.41^{cA}	340.25 ± 14.30^{dA}
		75°C	312.79 ± 3.35^{dB}	416.40 ± 10.35^{aA}
	Control		445.59 ± 16.49	
Methoxyl (%)	**CE**	45°C	5.65 ± 0.01^{ghG}	6.54 ± 0.24^{fF}
		60°C	6.15 ± 0.72^{fgF}	6.10 ± 0.40^{fG}
	UAE	75°C	6.76 ± 0.03^{fF}	3.69 ± 0.18^{iF}
		45°C	5.46 ± 0.44^{ghG}	6.47 ± 0.11^{fF}
		60°C	5.15 ± 0.26^{iF}	4.86 ± 0.26^{gF}
		75°C	5.44 ± 0.15^{ghF}	4.27 ± 0.06^{hG}
	Control		4.59 ± 0.13	
DE (%)	**CE**	45°C	49.87 ± 0.48^{xX}	43.93 ± 0.54^{xY}
		60°C	41.37 ± 4.05^{yX}	43.51 ± 1.72^{xX}
		75°C	46.06 ± 0.05^{xX}	26.57 ± 0.65^{zY}
	UAE	45°C	37.64 ± 0.86^{yzY}	44.31 ± 0.47^{xX}
		60°C	36.80 ± 0.99^{zX}	34.78 ± 2.15^{yX}
		75°C	35.44 ± 0.88^{zX}	36.41 ± 0.84^{yX}
	Control		39.73 ± 1.57	
AUA (%)	**CE**	45°C	64.29 ± 0.74^{oN}	84.47 ± 2.15^{mM}
		60°C	84.21 ± 1.37^{mnM}	79.35 ± 1.78^{noM}
		75°C	83.25 ± 0.06^{mnM}	78.54 ± 2.21^{oM}
	UAE	45°C	82.30 ± 4.75^{mnM}	82.83 ± 0.47^{mnM}
		60°C	79.40 ± 1.83^{nM}	79.38 ± 0.70^{noM}
		75°C	87.19 ± 0.27^{mM}	66.55 ± 0.70^{pN}
	Control		65.60 ± 0.71	

Note. Values are expressed as mean ± standard deviation (n = 4).

$^{A-B, F-G, M-N, X-Y}$Means with different letters within a row are significantly different ($p \leq 0.05$).
$^{a-d, f-i, m-p, x-z}$ Means with different letters within a column are significantly different ($p \leq 0.05$).
CE is conventional extraction.
UAE is ultrasound-assisted extraction.
*Control is commercial pectin which is different with all of values in table.

Effect of extraction condition on methoxyl content of DPF pectin

Methoxyl content is defined as the number of moles of methyl alcohol in 100 mol galacturonic acid. Methoxyl content of pectin is important to control the gel strength, the setting time, the sensitivity to metal ions and to determine the functional properties of pectin solutions and ability of the pectin to form gels (Constenla and Lozano, 2003). Spreading quality and sugar binding capacity of pectin are increased with increase methoxyl content (Madhav and Pushpalatha, 2002). Methoxyl content of pectin varies from 0.2-12% depending on the source and mode of extraction (Aina *et al*., 2012). Table 4 showed that the methoxyl content of DFP pectinranged from 3.69 ± 0.18% to 6.76 ± 0.03%. The methoxyl contents of DFP pectin extracted at various conditions by CE and UAE were similar tothe study of Ismail *et al*.(2012) who also reported methoxyl content of DFP pectinranged from 2.98% to 4.34%. Methoxyl content of commercial pectins generally varies from 8-11% and can form high sugar gels (> 65% sugar). On the other hand, low methoxyl pectin (less than 7.0%) can form gels with lower concentrations of sugars. The methoxyl content value from all samples in this study indicated as low methoxyl pectin (LMP).

Effect of extraction condition on degree of esterification (DE) of DFP pectin

Similar to methoxyl content, DE can be used to classify LMP with DE ≤50% and high methoxyl pectin with DE >50%. The DE of pectin extracted from DFP by CE and UAE was ranged from 26.57 ± 0.65% to 49.87 ± 0.48% (Table 4.4) and can be categorized as LMP. It is the same with citrus pectin control (39%). These results were consistent with the study from Ismail *et al*. (2012) who reported DE from DFP pectin ranged from 31.05-46.96% as LMP.

Effect of extraction condition on total Anhydrouronic acid content (AUA) of DFP pectin

AUA content indicates the purity of the extracted pectin and is suggested to be not less than 65% (Food Chemical Codex, 1996). Table 4.4 showed the AUA content obtained from all extraction conditions by both CE and UAE ranged from 65.29-87.19% (Table 4.4) which was higher than 65%. The results indicated that all extracted samples were higher in purity as compared with control citrus pectin. In this study, the results of AUA content was higher than pectin from dragon fruit peel (45.25-52.45%) which was reported by Ismail *et al.* (2012) and 39.11% reported by Muhammad *et al*. (2014).

Effect of extraction condition on antioxidant activity of DFP pectin by DPPH and ABTS method

The results from Table 4.5 showed the antioxidant activity of DFP pectin extracted by CE and UAE was range from 12.52 ± 0.40 to 51.58 ± 0.30 mg GAE/100g.

DFP pectin contained the highest antioxidant activity when extracted by UAE at 45ºC for 30 min while the lowest antioxidant was obtained at 75ºC for 60 min by CE. When extraction time and temperature increased, the amount of antioxidant decreased. The amount of antioxidant activity of all DFP pectin samples was higher than citrus pectin (control) analyzed by DPPH and ABTS method. The color of the dragon fruit comes from the betalain pigments, betacyanins and betaxanthins which are also known as antioxidants (Priatni and Pradita, 2015).

The results showed that antioxidant activity of DFP pectin extracted by UAE was higher than that of DFP pectin extracted by CE at the same extraction conditions. This study was aligned with the study of Annegowda *et al*. (2010), who reported that a higher amount of antioxidant constituents could be observed by using UAE. It was explained that the extract obtained of ultrasonic exhibits significant amounts of polyphenol and betacyanin contents. According to Ma *et al*. (2018), UAE treatment can change the structure of betacyanin by altering beta structures. It also revealed that ultrasonicated betacyanin contained larger aggregates than untreated samples. UAE treatment can be used to improve antioxidant activities through varying the ultrasound treatment conditions. Moreover, CE using orbital shaker at high temperature involves longer extraction hours and hence resulted in degradation of heat-sensitive bioactive compounds (Ramli, Ismail, and Rahmat, 2014). This result also aligned with the results of color measurement which showed the redness (a*) of UAE was higher than CE, and the highest a* was also obtained by UAE at 45ºC for 30 min.

Table 4.5 Antioxidant activity of DFP pectin by DPPH and ABTS method with various condition

Antioxidant Method	Method	Temp	Time (min)	
			30	**60**
Antioxidant of Dragon fruit pectin by DPPH (mgGAE/100g)	**CE**	45ºC	31.61 ± 1.08^{dA}	26.10 ± 1.13^{bB}
		60ºC	28.33 ± 0.56^{eA}	23.57 ± 1.40^{cB}
		75ºC	22.33 ± 0.34^{fA}	12.52 ± 0.40^{fB}
	UAE	45ºC	51.58 ± 0.30^{aA}	33.55 ± 1.07^{aB}
		60ºC	32.77 ± 0.57^{bA}	21.43 ± 0.48^{dB}
		75ºC	24.40 ± 1.07^{cA}	16.60 ± 0.86^{eB}
	Control		13.42 ± 0.68	
Antioxidant of Dragon fruit pectin by ABTS (mgGAE/100g)	**CE**	45ºC	32.00 ± 0.23^{nM}	23.34 ± 0.75^{nN}
		60ºC	20.36 ± 0.14^{pM}	17.93 ± 0.68^{pN}
		75ºC	16.10 ± 0.62^{rM}	7.38 ± 0.68^{rN}
	UAE	45ºC	39.81 ± 1.43^{mM}	27.87 ± 1.11^{mN}
		60ºC	25.74 ± 0.49^{oM}	19.62 ± 1.16^{oN}
		75ºC	17.28 ± 1.29^{qM}	13.85 ± 1.29^{qN}
	Control		5.72 ± 1.56	

Note. Values are expressed as mean ± standard deviation (n = 6).

$^{A-B, M-N}$ Means with different letters within a row are significantly different ($p \leq 0.05$).
$^{a-g, m-s}$ Means with different letters within a column are significantly different ($p \leq 0.05$).

CE is conventional extraction.
AE is ultrasound-assisted extraction.
*Control is commercial pectin which is different with all of values in table.

Effect of ingredients on liposome formation by incorporating OVCO with DFP pectin for using as a healthy natural coffee creamer in black tea

In this study, there are 3 liposome solutions including PL, PLO and PLOP which were investigated and analyzed followings:

pH value of liposome solution

Table 4.6 indicated that pH value of liposome sample ranged from 3.97 to 5.98. The pH value of PL and PLO was no significant difference, but the pH value of PLOP was lowest (3.97 ± 0.05). It could be explained by the low pH of pectin (pH=3.5) was added to PLOP sample, According to Rytömaa, Mustonen and Kinnunen (1992), the results from this study were acceptable for liposome properties. The standard pH value of liposome should range from 4 to 7 (Rytömaa, Mustonen and Kinnunen, 1992).

Table 4.6 Physical properties of liposome solution

Treatment	pH value	Viscosity (cP)	Zeta potential (mV)	Particle Size (µm)
PL	5.92 ± 0.07^{a}	14.33 ± 2.08^{b}	-158.6 ± 7.20^{b}	0.57 ± 0.06^{c}
PLO	5.98 ± 0.07^{a}	16 ± 1.00^{b}	-181.7 ± 5.60^{a}	2.62 ± 0.41^{b}
PLOP	3.97 ± 0.05^{b}	20.42 ± 1.53^{a}	-94.0 ± 4.29^{c}	3.49 ± 0.63^{a}

Note. Values are expressed as mean ± standard deviation (n = 6).
$^{a-c}$ Means with different letters within a column are significantly different ($p \leq 0.05$).
PL: Phospholipid liposome; PLO: Phospholipid was entrapped with OVCO.
PLOP: Phospholipid was entrapped with OVCO and combined DFP pectin.

Viscosity of liposome solution

The viscosity of PL was lowest in all treatments (14.33 ± 2.08 cP). Besides, viscosity of PLO (16 ± 1.00) was higher than PL while the viscosity of PLOP was the highest value (20.42 ± 1.53). These results indicated when liposome was prepared by organic virgin coconut oil entrapped with phospholipids, the viscosity of liposome increased. The viscosity of PLOP was the highest value. According to Kar and Arslan, (1999), pectin was created viscosity when dissolving with water in solution so that it positively affected liposome viscosity in this research.

Zeta potential of liposome solution

The zeta potential of liposome is very important. It gives information on the charge of the particles and the tendency of the particles in a formulation to aggregate or to remain discrete. Particles with zeta potentials of more than +30 mV or less than −30 mV are normally considered stable (Honary and Zahir, 2013). In this research, zeta potential of PL was lower than PLO but higher than PLOP. Zeta potential of PLO was highest (-181.7 ± 5.60 mV). In contrast, zeta potential of PLOP was lowest (-94.0 ± 4.29 mV). These results indicated that when pectin was combined in liposome, it reduced stability of liposome solution. According to the study of Lu and Gao (2010), the most important factor that affects zeta potential is the pH of the medium. From a theoretical viewpoint, zeta potential is the electric potential in the interfacial double layer of a dispersed particle or droplet versus a point in the continuous phase away from the interface. In other words, low pH will affect the potential difference between the mobile dispersion medium and the stationary layer of the dispersion medium attached to the dispersed particle. DFP pectin had low pH so that liposome combining with DFP pectin was decreased pH value in the solution, then reduced the zeta potential value. Overall, the zeta potential of all of liposome treatments was lower than -30 mV. It indicated that all of liposome in this research was stable and could be applied in food system.

Particle size of liposome solution

The results from Table 4.6 indicated that particle size of liposome was increased gradually when entrapped with organic coconut oil and combined with pectin. Particle size of PL was smallest (0.57 ± 0.06 µm) while particle size of PLOP was the largest (3.49 ± 0.63µm). For many physical and biological studies, the average size and size distribution (polydispersity) of the liposomes used as an important parameter for determining liposome stability, circulation longevity and biodistribution. For parenteral applications the optimal size range appears to be between 20 and 5000 nm and more preferably between 80 and 200 nm (Nagayasu *et al.*, 1999). The results of this study showed that the particle size of all liposome samples was smaller than 5000 nm. Therefore, the samples prepared by entrapped with organic coconut oil and combined with DFP pectin (PLOP) could be considered as liposome.

Color of liposome solution

The results of the CIE L*, a* and b*were shown in Table 4.7. As can be seen, the lightness L* values of liposome increased from PL, PLO and PLOP. PL sample had the lowest lightness (40.28 ± 0.68). There was significantly difference between lightness of PL, PLO and PLOP. The yellowness of all liposome samples was significantly different. The b* value of PLO and PLOP samples was higher than P. Besides that, the a* value of PLOP was the highest in all of liposome samples. The a* value also showed that the redness of PLOP sample was much more than other samples. This result could be explained by effective of DFP pectin color to liposome sample (Figure 4.16).

Table 4.7 The color (L*, a* and b* value) of liposome solution

	Color		
	L*	**a***	**b***
PL	40.28 ± 0.68^{c}	-6.48 ± 0.25^{c}	-6.60 ± 0.77^{c}
PLO	77.59 ± 0.19^{a}	-2.52 ± 0.10^{b}	11.45 ± 0.29^{a}
PLOP	75.82 ± 0.18^{b}	4.12 ± 0.12^{a}	10.65 ± 0.16^{b}

Note. Values are expressed as mean ± standard deviation (n = 6).

[a-c] Means with different letters within a row are significantly different ($p \leq 0.05$).
PL: Phospholipid liposome.
PLO: Phospholipid was entrapped with OVCO.
PLOP: Phospholipid was entrapped with OVCO and combined DFP pectin.



PL **PLO** **PLO**

Figure 4.16 Color of liposome solution

Antioxidant activity of liposome solution by DPPH and ABTS

The results from Table 4.8 showed the antioxidant activity of liposome sample was range from 54.83 ± 0.75 to 92.25 ± 0.98mg GAE/100g by DPPH essay and was range from 41.76 ± 0.84 to 81.36 ± 1.28 mg GAE/100g by ABTS essay.

Table 4.8 Antioxidant activity of liposome using DPPH and ABTS assay

Treatment	Antioxidant of Liposome by DPPH (mgGAE/100g)	Antioxidant of Liposome by ABTS (mgGAE/100g)
PL	54.83 ± 0.75[c]	41.76 ± 0.84[c]
PLO	69.70 ± 0.50[b]	58.77 ± 1.74[b]
LOP	92.25 ± 0.98[a]	81.36 ± 1.28[a]

Note. Values are expressed as mean ± standard deviation (n = 6).

[a-c] Means with different letters within a row are significantly different ($p \leq 0.05$).
PL: Phospholipid liposome.
PLO: Phospholipid was entrapped with OVCO.
PLOP: Phospholipid was entrapped with OVCO and combined DFP pectin.

The results showed that the antioxidant activity of PLO sample was higher than that of PL by DPPH and ABTS. It was explained that organic virgin coconut oil (OVCO) contained a large amount of total phenolic content which was responsible of antioxidant activity in OVCO. So that, liposome made by entrapped OVCO (PLO) increased antioxidant activity. In addition, antioxidant activity of PLOP was highest among samples (92.25 ± 0.98 by DPPH and 81.36 ± 1.28 ABTS) because PLOP was made by entrapping of OVCO phospholipid and DFP pectin. DFP pectin contained large amount of antioxidant activity from the betalain pigments, betacyanins, and betaxanthins (Priatni and Pradita, 2015). The color of the dragon fruit comes from the betalain pigments, betacyanins and betaxanthins which are also known as antioxidants (Priatni and Pradita, 2015). It was explained by the results in second column in Table 4.8.

Fatty acid composition of liposome solution

According to Table 4.9, the fatty acid composition of PL contained some fatty acid chains such as Palmitic acid, Stearic acid, cis-9-Oleic acid cis-9,12-Linoleic acid alpha-linoleic acid and omega-3,6, 9 which was from phospholipid. In contrast, the fatty acid composition of PLO and PLOP had the same fatty acid component and has more five fatty acid chain including Caproic acid, Caprylic acid, Capric acid, Lauric acid and Myristic acid compared to PL. These fatty acids come from fatty acid composition of coconut oil (Liau *et al.*, 2011). There was the same fatty acid composition between PLO and PLOP. It was demonstrated that combining pectin to liposome did not change fatty acid component of liposomes.

Table 4. 9 Fatty acid composition of liposome

Fatty acid composition (g/100g)	PL (g/100g)	PLO (g/100g)	PLOP (g/100g)
Caproic acid (C6:0)	-	1	1
Caprylic acid (C8:0)	-	15	14
Capric acid (C10:0)	-	12	12
Lauric acid (C12:0)	-	98	92
Myristic acid (C14:0)	-	39	37
Palmitic acid (C16:0)	24	43	41
Stearic acid (C18:0)	4	10	10
Saturated Fat	28	218	207
cis-9-Oleic acid (C18:1n9c)	19	33	31
Monounsaturated fatty acid	19	33	31
cis-9,12-Linoleic acid (C18:2n6)	81	88	81
alpha-Linoleic acid (C18:3n3)	6	6	6
Polyunsaturated fatty acid	87	94	87
Unsaturated fat	106	127	118
Omega-3	5.78	6.02	5.53
Omega-6	81.31	87.63	80.78
Omega-9	19.12	32.88	31.28

Application of liposome solution as a healthy natural coffee cream by adding to black tea drinking.

The mean hedonic scores for the 3 black tea samples, given by our student panel in Table 4.10, ranged between 5.68 and 6.88. 4% of sugar added sample had lower liking score compared to 6%. This result was significantly different from 6% sugar added in Table 4.10. The amount of liposome added did not affect to appearance, color, viscosity and tea flavor but affected to sourness and sweetness of black tea samples. The added amount of liposome to black tea was from 10 to 30%. 10% liposome added sample received the highest score of sourness and sweetness. 30% add liposome samples had lowest liking score of sourness and overall liking.

Table 4.10 Liking score of black tea 4% sugar with different concentration liposome solution

Sample 4% sugar	10% liposome	20% liposome	30% liposome
Appearance[ns]	7.03 ± 1.61	6.88 ± 1.57	6.93 ± 1.07
Color[ns]	6.93 ± 1.53	6.85 ± 1.49	6.85 ± 0.95
Viscosity[ns]	6.85 ± 1.33	6.83 ± 1.34	6.83 ± 0.75
Tea flavor[ns]	7.30 ± 1.04	6.58 ± 1.30	6.18 ± 1.24
Sourness	6.83 ± 1.45[a]	6.18 ± 1.96[a]	5.40 ± 1.53[b]
Sweetness	6.90 ± 1.32[a]	6.70 ± 1.34[ab]	6.28 ± 1.30[b]
Overall liking	6.88 ± 1.5[a]	6.23 ± 1.91[ab]	5.68 ± 1.37[b]

Note. Values are expressed as mean ± standard deviation (n = 40).

[a-b] means within the same row with different letters are significantly different ($p \leq 0.05$).
[ns] no significant difference.

For 4% of sugar black tea (Table 4.11), only 10% added liposome showed high percentage (higher than 80%) of tea flavor and sourness. Sweetness of all samples was percieved as "too low" (below 40%) while sourness was significantly considered as "too much" 82.5% with adding 30% PLOP. This result indicated that 4% of sugar was not suitable for the liposome added black tea samples.

Table 4.11 JAR of sensory black tea with 4% sugar

4% sugar	10% PLOP			20% PLOP			30% PLOP		
	Tea flavor	Sourness	Sweetness	Tea flavor	Sourness	Sweetness	Tea flavor	Sourness	Sweetness
Not enough	12.5	7.5	32.5	50	7.5	35	65	12.5	40
JAR	**87.5**	**80**	60	50	47.5	55	35	5	57.5
Too much	0	12.5	7.5	0	45	10	0	**82.5**	2.5

Note. PLOP is Phospholipid was entrapped with OVCO and combined DFP pectin
JAR is "Just About Right" Scale

The 6% of sugar added was chosen after the preliminary test (Table 4.12).

Liposome PLOP was chosen for developing black tea beverage because there are many benefits which showed in properties of liposome in part 3. The mean hedonic scores for the 3 black tea samples, given to our student panel, ranged between 6 and 7 on the nine-point scale (Table 12). Generally, the amount of liposome added did not affect to appearance, color , viscosity and sweetness of black tea samples. The added amount of liposome to black tea is from 10 to 30%. As showed in Table 12 10% liposome added sample received the highest score of tea flavor and sourness. 30% add liposome samples had lowest liking score of sourness and overall liking. It could be explained by the change in pH of samples as liposome was added. Liposome had low pH value (3.97) when more liposome was added the sourness increased and consequently affected to consumer perception. Although black tea sample with 20% of liposome had lower score in case of tea flavor compared to 10% sample, its sourness and overall liking was insignificant difference with 10% sample. Based on overall liking score, 10% and 20% sample were the most acceptable. More than 20% of liposome, liking score is decreased significantly. In conclusion, the amount of liposome added to black tea should be less than 20% to ensure the high acceptance from consumers.

Table 4.12 Liking score of black tea 6% sugar with different concentration liposome solution

Sample 6% sugar	10% liposome	20% liposome	30% liposome
Appearance^{ns}	7.33 ± 0.92	6.95 ± 1.04	6.93 ± 0.97
Color^{ns}	7.23 ± 1.14	6.85 ± 1.14	6.85 ± 0.95
Viscosity^{ns}	7.00 ± 0.93	7.13 ± 0.85	6.98 ± 1.00
Tea flavor	7.43 ± 0.98^{a}	6.93 ± 0.94^{b}	6.48 ± 1.40^{b}
Sourness	7.03 ± 0.86^{a}	6.63 ± 1.08^{ab}	6.20 ± 1.04^{b}
Sweetness^{ns}	7.03 ± 0.86	6.93 ± 0.83	6.83 ± 0.90
Overall liking	7.13 ± 0.82^{a}	7.03 ± 0.89^{a}	6.50 ± 0.91^{b}

Note. Values are expressed as mean ± standard deviation (n = 40).
$^{a-b}$ means within the same row with different letters are significantly different ($p \leq 0.05$).
^{ns} no significant difference.

Table 4.13 summarizes the percentage JAR scores indicates significance of the deviation from scale mid-point. Values of 1, 2 or 3 were assigned to the categories “not enough”, “just-about-right” or “too much” in the JAR assessments, respectively. For sample with 10% of added liposome, perceived tea flavor, sourness and sweetness were “just-about-right” (72.5 - 92.5%) whereas sample with 20 and 30% added liposome was generally judged as being “just-about-right” in sweetness (80%) and "too much" in sourness (40 and 37.5%, respectively). In sample with 20 and 30% added liposome, whereas tea flavor ratings was showed "JAR" with 67.5 and 57.5%, respectively. These results indicated that 10% and 20% were acceptable level of liposome added to black tea at 6% of sugar.

Table 4.13 JAR of sensory black tea with 6% sugar

6% sugar	10% PLOP			20% PLOP			30% PLOP		
	Tea flavor	Sourness	Sweetness	Tea flavor	Sourness	Sweetness	Tea flavor	Sourness	Sweetness
Not enough	7.5	17.5	10	32.5	5	10	42.5	12.5	20
JAR	**92.5**	**75**	**72.5**	67.5	52.5	**80**	57.5	47.5	**80**
Too much	0	7.5	17.5	0	40	10	0	37.5	0

Note. PLOP is Phospholipid was entrapped with OVCO and combined DFP pectin
JAR is "Just About Right" Scale

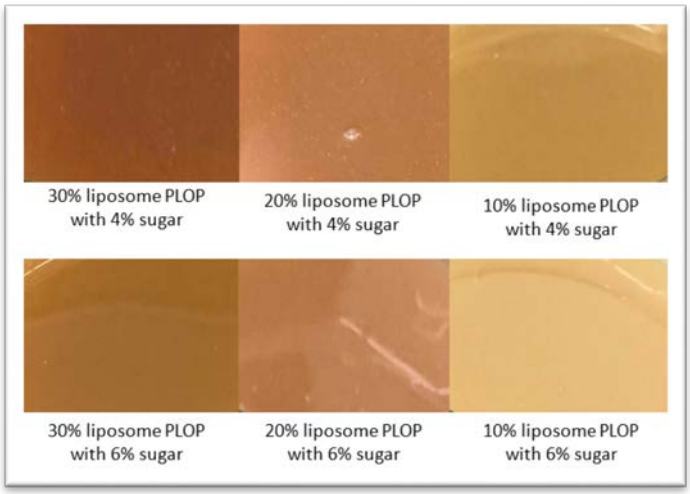


Figure 4.17 Black tea with natural cream from liposome with various conditions

CONCLUSION AND RECOMMENDATIONS

Summary Discussion on Research Results

Through the teamwork with research assistants, the process technicians, and the supplier of the raw material, the research work has been conducted successfully.

1. Dragon fruit jam was successfully developed from both white and red dragon fruit flesh, enhancing color appeal and consumer preference with a mix of sucrose and isomalt sugars.
2. Dragon fruit snack was innovatively crafted from dragon fruit peel, contributing to waste reduction and environmental sustainability while offering a new market product.

3. Organic virgin coconut oil (OVCO) exhibited stability with high antioxidant properties, making it a promising ingredient for food products.
4. Ultrasonic-assisted extraction (UAE) proved efficient in extracting pectin from dragon fruit peel, showing comparable properties to commercial pectin with enhanced antioxidant activity.
5. Pectin-liposome complex (PLOP) demonstrated superior properties, including high antioxidant activity, making it a potential functional ingredient.
6. PLOP was selected as a natural coffee creamer for black tea application, with optimal ratios enhancing sensory appeal and consumer preference.

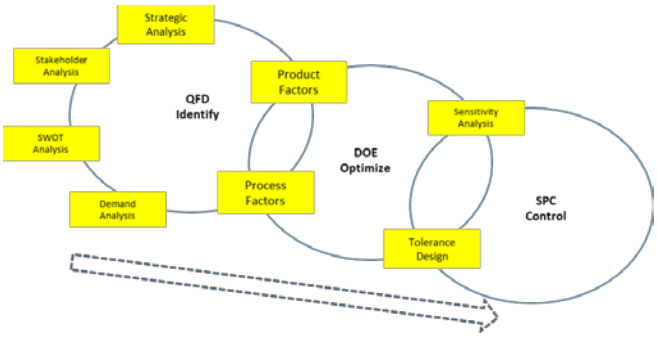
Conclusion

The research successfully demonstrates the potential for food processing from agricultural waste, particularly dragon fruits in Vietnam. Utilizing factorial design of experiments, quality and productivity were investigated, yielding positive outcomes. Further improvements and contributions to knowledge are envisioned for future research endeavors.

Suggestion and Recommendation for Further Future Research

1. Expansion of Research Scope: Encourage further research in similar methodologies across different agricultural sectors, not limited to Long An Province, Vietnam, but extending to other active agricultural regions. Researchers worldwide are encouraged to adopt similar approaches based on the findings of this study.

2. Socio-Economic Sustainability: Emphasize the importance of quality and productivity in socio-economic development. Advocacy for continuous improvement strategies like Total Quality Management (TQM), Quality Function Deployment (QFD), and Statistical Process Control to enhance productivity and quality control, aiming for international market penetration.



3. Entrepreneurship and Franchising: Research into Just-in-Time (JIT) methodologies to optimize product and process efficiency, reducing waste and meeting customer demands promptly. JIT principles aim to produce with minimal waste and meet customer requirements precisely.

4. Lifelong Learning: Encourage researchers to continue lifelong learning through action research, focusing on quality management and process optimization using advanced experimental designs and statistical analyses.

5. Adaptability in Production: Highlight the need for adaptability in full-scale production settings. Suggest employing online Evolutionary Operation (EVOP) Design of Experiments (DOE) to adjust processes to changing manufacturing environments effectively.

6. Standardization and Collaboration: Advocate for standard process knowledge preservation through collaborative efforts. Encourage authorities to mediate and publish reliable process parameters continuously to strengthen the food processing industry's success and maintain product quality.

In conclusion, future research should focus on expanding the scope of experimentation, embracing TQM principles, fostering entrepreneurship, leveraging continuous learning, adapting to real-world scenarios, and standardizing process knowledge to drive innovation and sustainability in the food processing industry.

REFERENCE

Abang, Z. D. N., N. A. Makhtar, J. Y. M. Mohdand and I. I. Muhamad. 2015. Efficiency and thermal stability of encapsulated anthocyanins from red dragon fruit (*Hylocereus Polyrhizus*) using microwave-assisted technique**. Chemical Engineering,** 43: 127-132.

Aina, V.O., M. M. Barau, O. A. Mamman, A. Zakari, H. Haruna, M. S. Hauwa Umar and Y. B. Abba. 2012. Extraction and characterization of pectin from peels of lemon (Citrus limon), grape fruit (Citrus paradise) and sweet orange (Citrus sinensis**). British Journal of Pharmacology and Toxicology,** 3(6): 259-262.

Agamuthu, P. 2009. Challenges and opportunities in agro-waste management: An Asian perspective. **In Inaugural Meeting of First Regional 3R Forum in Asia,** 23: 11-12.

Akao, Yoji, (ed). 1990. **Quality function deployment: Integrating customer requirements into product design.** Translated by Glenn H. Mazur. Cambridge, Mass.: Productivity Press.

Aksel G. Olsen, Summit and Ellis R. Fehlberg, and N. .L. Rutherford. 1941. Assignors to **General Foods Corporation, New York Delaware, a corporation of No Drawing**. Serial No. 374,400.

Ali, A., X. Y. Lim, C. H. Chong, S. H. Mah and B. L. Chua. 2018. Ultrasound-assisted extraction of natural antioxidants from betel leaves (Piper betle). Extraction kinetics and modeling. **Separation Science and Technology**, 53(14): 2192-2205.

Andreas ,W. and V. U. Karola. 2011. Liposome technology for industrial purposes. **J Drug Deliv,** 2011**:** 9.

Anese, M., G. Mirolo, P. Beraldo and G. Lippe. 2013. Effect of ultrasound treatments of tomato pulp on microstructure and lycopene in vitro bio accessibility. **Food Chemistry,** 136: 458–463.

Annegowda, H. V., L. N. Anwar, M. N.Mordi, S. Ramanathan and S. M. Mansor. 2010. Influence of sonication on the phenolic content and antioxidant activity of Terminalia catappa L. leaves. **Pharmacognosy Research**, 2(6): 368-373. doi: 10.4103/0974-8490.75457.

AOAC. 1998. **Official methods of analysis of AOAC international.** Washington, D.C: Association of Official Analytical Chemists.

_____. 2000. **Official methods of analysis 17th ed**. Gaithersburg, MD, USA.

_____. 2016. **Official methods of analysis of AOAC international**. AOAC international.

AOCS. 2004. Official Methods and Recommended Practices of the AOCS, 6th Edition**, American Oil Chemists' Society,** Champaign.

Appaiah, P., L. Sunil, P. K. Prasanth Kumar and A.G. Gopala Krishna. 2014. Composition of coconut testa, coconut kernel and its oil. **Journal of the American Oil Chemists' Society**, 91(6): 917-924.

Assunção, M.L., H. S. Ferreira, AF. dos Santos., C. R. Cabral and T. M. M. T. Florêncio. 2009. Effects of Dietary Coconut Oil on the Biochemical and Anthropometric Profiles of Women Presenting Abdominal Obesity. **Lipids,** 44: 593-601.

Atrooz, O. M. 2011. Effects of alkylresorcinolic lipids obtained from acetonic extract of Jordanian wheat grains on liposome properties. **Int J Biol Chem,** 5(5):314–321.

Augustin, M.A. and L. Sanguansri. 2012. Challenges in developing delivery systems for food additives, nutraceuticals and dietary supplements. **In Encapsulation technologies and delivery systems for food ingredients and nutraceuticals** (pp. 19-48). Woodhead Publishing.

Babbie, E. R. (2010). **The Practice of Social Research** (12th ed.). Belmont, CA: Wadsworth.

Bagherian, H., F.A. Zokaee, A. Fouladitajar and M. Mohtashamy. 2011. Comparisons between conventional, microwave- and ultrasound-assisted methods for extraction of pectin from grapefruit. **Chemical Engineering and Processing: Process Intensification,** 50(11-12): 1237-1243.

Baississe, S., H. Ghannem, D. Fahloul and A. Lekbir. 2010. Comparison of structure and emulsifying activity of pectin extracted from apple pomace and apricot pulp. **World Journal of Dairy & Food Sciences**, 5(1): 79-84.

Banerjee, R. 2001. Liposomes: applications in medicine. **Journal of Biomaterials applications**, 16(1): 3-21.

Bangham, A.D. , J. C. Glover., S. Hollingshead and B. A. Pethica. 1962. The surface properties of some neoplastic cells. **Biochemical Journal**, 84(3): 513.

_____, A.D., M. M. Standish and G. Weissmann. 1965. The action of steroids and streptolysin S on the permeability of phospholipid structures to cations. **Journal of molecular biology,** 13(1): 253-IN28.

Bedawey, A. A., E. H. Mansour, M. S. Zakyand and A. A. Hassan. 2010. Characteristics of antioxidant isolated from some plant sources. **Food and Nutrition Sciences, 1**: 5.

Benech, RO., EE. Kheadr, R. Laridi, C. Lacroix and I. Fliss. 2002. Inhibition of Listeria innocua in cheddar cheese by addition of nisin Z in liposomes or by in situ production in mixed culture**. Applied Environ Microbiol**, 68: 3683–3690.

Bennet, William L. 1997. A vision and a view," The next 50 years: Future food trends". **ASQC's 51st Annual Quality Congress Proceedings**. ASQC.

Bennick, A., 2002. Interaction of plant polyphenols with salivary proteins. **Critical Reviews in Oral Biology and Medicine**, 13(2): 184-196.

Blomsma, F., G. Brennan. 2017. The emergence of circular economy: a new framing around prolonging resource productivity. **J. Ind. Ecol.,** 21, pp. 603-614,

Brown and Root, 1997. Environmental review of national solid waste management plan. **Interim report submitted to the Government of Mauritius**, 15(3): 24-30.

Bracco, S., O. Calicioglu, M. Gomez San Juan, A. Flammini. 2018. Assessing the contribution of bioeconomy to the total economy: a review of national frameworks. **Sustainability**, 10, pp.1698.

Canteri-Schemin, M. H., H. C. R.Fertonani, N. Waszczynskyj and G. Wosiacki 2005. Extraction of pectin from apple pomace. **Brazilian Archives of Biology and Technology**, 48(2): 259-266.

Çağdaş, M., A. D. Sezer and S. Bucak, 2014. Liposomes as potential drug carrier systems for drug delivery. **In Application of Nanotechnology in Drug Delivery**. IntechOpen.

Codex, F. C. 1996. Committee on Food Chemicals Codex. **Food and Nutrition Board, Institute of Medicine, National Academy of Sciences.** Published: National Academy Press, Washington, DC.

Chandrapala, J., C. Oliver, S. Kentish and M. Ashokkumar. 2012. Ultrasonics in food processing – Food quality assurance and food safety. **Trends in Food Science and Technology,** 26(2): 88-98.

Che M. Y. B. and A. M. Marina. 2006. Medium chain triaclglycerol, pp. 2756. In Shahidi F., ed. **Nutraceutical and specialty lipids and their co-products**. Boca Raton, FL: Taylor and Francis Group.

Chemat, F., H. Zille and M. K. Khan. 2011. Applications of ultrasound in food technology: Processing, preservation and extraction. **Ultrasonics Sonochemistry**, 18(4): 813-835.

Chen, H. M., X. Fu and Z. G. Luo. 2015. Properties and extraction of pectin-enriched materials from sugar beet pulp by ultrasonic-assisted treatment combined with subcritical water. **Food chemistry**, 168: 302-310.

Chrai, SS., R. Murari and A. Imran. 2001. Liposomes: a review. **Bio Pharm**, 14(11): 10–14.

Constenla, D. and J. Lozano. 2003. Kinetic model of pectin demethylation. **Latin American Applied Research**, 33(2): 91-95.

Daniel Picard (editor). 2002. The black belt memory jogger. Six Sigma Academy. GOAL/ QPC.

Da Silva, J. A. L. and M. A. Rao. 1995. Rheology of structure development in high methoxyl pectin/sugar systems. **Food Technology**, 49: 70-72.

DebMandal, M. and S. Mandal. 2011. Coconut (Cocos nucifera L.: Arecaceae): in health promotion and disease prevention. **Asian Pacific Journal of Tropical Medicine**, 4(3): 241-247.

Dietz,T; Börner., J; Förster, J.J., Braun, J.V. 2018. Governance of the bioeconomy: a global comparative study of national bioeconomy strategies. **Sustainability**, 10 (9). pp.3190,

E. Halisçelik, M.A. Soytas. 2019. Sustainable development from millennium 2015 to sustainable development goals 2030. **Sustain. Dev.,** 27. pp. 545-572.

E. Vaz, C. Joanaz de Melo, C. Pinto. 2017. Environmental history in the making, volume 6
Environmental History, Springer International Publishing, Switzerland.

Ebrahim, S., G. A. Peyman and P. J. Lee. 2005. Applications of liposomes in ophthalmology. **Survey of ophthalmology**, 50(2): 167-182.

Egbaria, K. and N. Weiner. 1990. Liposomes as a topical drug delivery system. **Advanced drug delivery reviews**, 5(3): 287-300.

Ekwenye, U. N. 2006. Chemical characteristics of palm oil biodeterioration. **Biokemistri**, 18(2).

Emaga, T. H., S. N. Ronkart, C. Robert, B. Wathelet and M. Paquot. 2008. Characterisation of pectins extracted from banana peels (Musa AAA) under different conditions using an experimental design. **Food Chemistry**, 108(2): 463-471.

European Environment Agency (EEA). 2017. **Circular by Design: Products in the Circular Economy**

Esben Hegnsholt, Shalini Unnikrishnan, Matias Pollmann-Larsen, Bjorg Askelsdottir, and Marine Gerard, Boston Consulting Group (BCG). 2018. **Why Is One-Third of the World's Food Being Lost or Wasted?**
https://www.bcg.com/publications/2018/tackling-1.6-billion-ton-food-loss-and-waste-crisis

Faravash, R. S. and F. Z. Ashtiani. 2008. The influence of acid volume, ethanol-to-extract ratio and acid-washing time on the yield of pectic substances extraction from peach pomace. **Food Hydrocolloids**, 22: 196-202.

Fasser, Y., & Brettner, D. 1992. **Process improvement in the electronics industry**. Wiley series in systems engineering, John Wiley & sons, Inc.

Food and Agriculture Organization of the United Nations (FAO). 2004. **About Food Loss and Food Waste**. http://www.fao.org/food-loss-and-food-waste/en/. Accessed on 22 May 2021.

Food and Agriculture Organization of the United Nations (FAO). 2017a. Strategic Work of FAO for **Sustainable Food and Agriculture** (2017). http://www.fao.org/3/a-i6488e.pdf, Accessed 9th Jul 2021

Food and Agriculture Organization of the United Nations (FAO). 2017b. **The State of Food and Agriculture Leveraging Food Systems for Inclusive Rural Transformation.**
http://www.fao.org/3/a-i7658e.pdf, Accessed 9th Jul 2021.

Food and Agriculture Organization of the United Nations (FAO) & Organization for Economic Co-operation and Development (OECD). 2019. Background Notes on Sustainable, Productive and Resilient Agro-Food Systems: Value Chains, Human Capital, and the 2030 Agenda. ***A Report to the G20 Agriculture Deputies.***

Fu, J. T. and M. A. Rao. 1999. The influence of sucrose and sorbitol on gel–sol transition of low-methoxyl pectin+ Ca2+ gels. **Food Hydrocolloids**, 13(5): 371-380.

Fukuda-Parr, S. 2016. From the Millennium Development Goals to the Sustainable Development Goals: shifts in purpose, concept, and politics of global goal setting for development. **Gend. Dev**., 24: 43-52.

German, J. B. and C. J. Dillard. 2004. Saturated fats: what dietary intake?. **The American Journal of Clinical Nutrition**, 80(3): 550-559.

Gilsenan, P. M., R. K. Richardson and E. R. Morris. 2000. Thermally reversible acid-induced gelation of low-methoxy pectin. **Carbohydrate Polymers**, 41(4): 339-349.

Górecki,J., P. Núñez-Cacho, F.A. Corpas-Iglesias, V. Molina. 2019. How to convince players in construction market? Strategies for effective implementation of circular economy in construction sector. **Cogent Eng**, 6, pp. 1-22,

Gregoriadis, G. 2007. Liposome technology. Liposome preparation and related techniques (3rd ed., Vol. I). **New York: Informa Healthcare Inc**.

Gutfinger, T. 1981. Polyphenols in olive oils. **J Am Oil Chem Soc**, 58: 966–968.

Harivaindaram, K. V., O. P. S. Rebecca and S. Chandran. 2008. Study of optimal temperature, pH and stability of dragon fruit (*Hylocereuspolyrhizus*) peel for use as potential natural colorant. **Pakistan Journal of Biological Sciences,** 11(18): 2259-2263.

Hauser, John R., and Don Clausing. 1988. The house of quality. **Harvard Business Review** 88(3): 63-73.

Henry, Mason; David, Martin; Maxwell Luthy and Delia Dumitrescu. 2017**. Trend driven innovation.** John Wiley & son, Inc. New Jersey.

Ho Dinh Bao, 2014. Provincial Total Factor Productivity in Vietnamese Agriculture and Its Determinants. **Journal of Economics and Development**, 16(2): 5-20.

Hofmeiter Kurt R., Christi Walters., and Gongos, John. 1996. Discovering customer wow's. **ASQC's 50th Annual Quality Congress. Proceedings** (May 13-15, 1996). ASQC.

Honary, S. and F. Zahir. 2013. Effect of zeta potential on the properties of nano-drug delivery systems-a review (part 1). **Trop. J. Pharm. Res**, 12: 255-264.

Iijima, M., T. Hatakeyama, K. Nakamura and H. Hatakeyama. 2002. Effect of annealing on calcium pectin gel formation by thermo mechanical analysis. **Journal of Thermal Analysis and Calorimetry**, 70(3): 815.

Isailović, B. D., I. T. Kostić, A. Zvonar, V. B.Đorđević, M. Gašperlin, V. A. Nedović and B. M. Bugarski. 2013. Resveratrol loaded liposomes produced by different techniques. **Innovative Food Science & Emerging Technologies**, 19: 181-189

Ismail N. S. M., N. Ramli, N. M. Hani and Z. Meon. 2012. Extraction and characterization of pectin from dragon fruit (Hylocereuspolyrhizus) using various extraction conditions, **Malaysiana Science (In Malay)**, 41 (1): 41-45.

Israelachvili, J. N., S. Marčelja and R. G. Horn. 1980. Physical principles of membrane organization. **Quarterly reviews of biophysics**, 13(2): 121-200.

Jaafar, R. A., A. Ridhwan, N. Z. C. Mahmod and R. Vasudevan. 2009. Proximate analysis of dragon fruit (Hylecereuspolyhizus). **American Journal of Applied Sciences**, 6(7): 1341-1346.

Kalapathy, U. and A. Proctor. 2001. Effect of acid extraction and alcohol precipitation conditions on the yield and purity of soy hull pectin. **Food Chemistry**, 73: 393-396.

Kar, F. and N. Arslan. 1999. Effect of temperature and concentration on viscosity of orange peel pectin solutions and intrinsic viscosity–molecular weight relationship. **Carbohydrate Polymers**, 40(4): 277-284.

Kellaway, I. W. and S. J. Farr. 1990. Liposomes as drug delivery systems to the lung. **Advanced Drug Delivery Reviews**, 5(1-2): 149-161.

Keller, B. C. 2001. Liposomes in nutrition. **Trends in Food Science and Technology**, 12(1): 25-31.

Knorr, D., M. Zenker, V. Heinz and D. U. Lee. 2004.Applications and potential of ultrasonics in food processing. **Trends in Food Science and Technology**, 15(5): 261-266.

Kratchanova, M., E. Pavlova and I. Panchev. 2004. The effect of microwave heating of fresh orange peels on the fruit tissue and quality of extracted pectin. **Carbohydrate polymers**, 56(2): 181-185.

Krishna, A.G., R. Gaurav, B. A. Singh, P. P. Kumar, and C. Preeti, 2010. Coconut oil: chemistry, production and its applications-a review. **Indian Coconut Journal**, 53(3): 15-27.

Kurita, O., T. Fujiwara and E. Yamazaki. 2008. Characterization of the pectin extracted from citrus peel in the presence of citric acid. **Carbohydrate** Polymers, 74(3): 725-730

Lasic, D. D. and D. Papahadjopoulos. 1995. Liposomes revisited. **Science**, 267(5202): 1275-1277.

D. D. 1998. Novel applications of liposomes. **Trends in Biotechnology**, 16(7): 307-321.

Laura Depta- Reset Editorial. 2018. **Global Food Waste and its Environmental Impact.** https://en.reset.org/knowledge/global-food-waste-and-its-environmental-impact-09122018

Le Bellec, F., F. Vaillant and E. Imbert. 2006. Pitahaya (*Hylocereus spp.*): A new fruit crop, a market with a future. **Fruits Journal**, 61: 237-250.

Levigne, S., M. C. Ralet and J. F. Thibault. 2002. Characterisation of pectins extracted from fresh sugar beet under different conditions using an experimental design. **Carbohydrate Polymers**, 49: 145-153.

Li, G. and K.C. Chang. 1997. Viscosity and gelling characteristics of sunflower pectin as affected by chemical and physical factors. **Agricultural and Food Chemistry**, 45: 4785-4789.

Lian, T. and R. J. Ho. 2001. Trends and developments in liposome drug delivery systems. **Journal of Pharmaceutical Sciences**, 90(6): 667-680.

Liau, K. M., Y. Y. Lee, C. K. Chen and A. H. G. Rasool. 2011. An open-label pilot study to assess the efficacy and safety of virgin coconut oil in reducing visceral adiposity. **ISRN Pharmacology**.

Lichtenberg, D. and Y. Barenholz. 1998. **Liposomes: Preparation, characterization, and preservation.** New York: John Wiley.

Lin, C. B. and C. Y. Cze. 2018. Drying kinetics and optimisation of pectin extraction from banana peels via response surface methodology. **Paper presented at the MATEC Web of Conferences**.

Liu, Y., J. Shi and T. Langrish. 2006. Water-based extraction of pectin from flavedo and albedo of orange peels. **Chemical Engineering Journal**, 120(3): 203-209.

Lu, G. W. and P. Gao. 2010. CHAPTER 3 - Emulsions and Microemulsions for Topical and Transdermal Drug Delivery. In V. S. Kulkarni (Ed.), **Handbook of Non-Invasive Drug Delivery Systems** (pp. 59-94). Boston: William Andrew Publishing.

Ma, S., X. Yang, C. Wang and M. Guo. 2018. Effect of ultrasound treatment on antioxidant activity and structure of β-Lactoglobulin using the Box–Behnken design. **CyTA - Journal of Food**, 16(1): 596-606. doi: 10.1080/19476337.2018.1441909.

Mai Huong Giang, Tran Dang Xuan, Bui Huy Trung, and Mai Thanh Que. 2019. **Total Factor Productivity of Agricultural Firms in Vietnam and Its Relevant Determinants.** *Economies* 2019, *7*(1): 4. doi.org/10.3390/economies7010004). online https://www.mdpi.com/2227-7099/7/1/4/htm. Accessed on 22 April 2021.

Madhav, A. and P. B. Pushpalatha. 2002. Characterization of pectin extracted from different fruit wastes, **Journal of Tropical Agriculture**, 40(1-2): 53-55.

Marina, A. M., M. Y. B. Che, S. A. H. Nazimah and I. Amin. 2009. Chemical Properties of Virgin Coconut Oil. **Journal of the American Oil Chemists' Society**, 86(4): 301-307.
Masmoudi, M., S. Besbes, S. Chaabouni, M. Robert, C. Paquot, M. Blecker and C. Attia. 2008. Optimization of pectin extraction from lemon by-product with acidified date juice using response surface methodology. **Carbohydrate Polymer**, 74: 185-192.

Maurer, N., D. B. Fenske and P. R. Cullis. 2001. Developments in liposomal drug delivery systems. **Expert Opinion on Biological Therapy**, 1(6): 923-947.

May, C.D. 1990. Industrial pectins: sources, production and applications. **Carbohydrate Polymer**, 12: 79-99.

Mazo, Michael, J. 1996. Product development through design of experiment. **ASQC's 50th Annual Quality Congress Proceeding.** American Society for Quality Control (ASQC).

McLinn, James, A. 1994. Improving the product development process. **48th Annual Quality Congress Proceedings,** American Society for Quality Control (ASQC).

Michalek, S. M., N. K. Childers, J. Katz, F.R. Denys, A. K. Berry, J. H. Eldridge, J. R. McGhee and R. Curtiss. 1989. Liposomes as oral adjuvants. **In New Strategies for Oral Immunization** (pp. 51-58). Springer, Berlin, Heidelberg.

Minjares-Fuentes, R., A.Femenia, M. C. Garau, M. G. Candelas-Cadillo, S. Simal and C. Rosselló. 2016. Ultrasound-assisted extraction of hemicelluloses from grape pomace using response surface methodology. **Carbohydrate Polymers**, 138: 180-191.

_____, R., A. Femenia, M. Garau, J. Meza-Velázquez, S. Simaland and C. Rosselló. 2014. Ultrasound-assisted extraction of pectins from grape pomace using citric acid: a response surface methodology approach. **Carbohydrate Polymers**, 106: 179-189.

Mizote, A., H. Odagir, K. Toei and K. Tanaka. 1975. Determination of residues of carboxylic acids (mainly galacturonic acid) and their degree of esterification in industrial pectins by colloid titration with Cat-Floc. **Analysis Journal**, 100: 822-827.

Mizuno, Shigeru, (ed). 1988. **Management for quality improvement: The seven new QC Tools**. Cambridge, Mass.: Productivity Press.

Mohamad Z., N. Izalin, S. Muhammad, S. Kharidah, Bakar, Jamilah and M. Noranizan. 2016. *Functional properties of pectin from dragon fruit (Hylocereuspolyrhizus) peel and its sensory attributes.* **Journal of Tropical Agriculture and Food Science**, 44 (1): 95-101. ISSN 1394-9829; ESSN: 2289-9650.

Mohamadzadeh, J., A. R. Sadeghi-Mahoonak, M. Yaghbani and M. Aalami. 2010. Extraction of pectin from sunflower head residues of selected iranian cultivars. **World Applied Science Journal**, 8(1): 21-24.

Mohamed, S. and Z. Hasan. 1995. Extraction and characterization of pectin from various tropical agro wastes. **ASEAN Food Journal**, 10(2): 143– 150.

Molyneux, P. 2003. The use of stable free radical diphenyl-picrylhydrazyl (DPPH) for estimating antioxidant activity**. Journal of Science and Technology**, 26 (2): 211-219.

Molina-Moreno, V., J. Leyva-Díaz, F. Llorens-Montes, F. Cortés-García. 2017. Design of indicators of circular economy as instruments for the evaluation of sustainability and efficiency in wastewater from pig farming industry. **Water,** 9. p. 653,

Mónica Duque-Acevedo; Luis J. Belmonte-Ureñab, Francisco Joaquín Cortés-Garcíac, and Francisco Camacho-Ferrea, 2020. Agricultural waste: Review of the evolution, approaches and perspectives on alternative uses. **Global Ecology and Conservation**.

(22), https://doi.org/10.1016/j.gecco.2020.e00902

Move for Hunger. 2021. **The environmental impact of food waste.** https://moveforhunger.org/the-environmental-impact-of-food-waste. Accessed on 9th July 2021.

Muhammad, K., N. I. M. Zahari, S. P. Gannasin, N. M. Adzahan and J. Bakar. 2014. High methoxyl pectin from dragon fruit (Hylocereuspolyrhizus) peel. **Food Hydrocolloid**, 42: 289-297.

Munshi, Kersi F., and McIntyre, Dan S. 1994. **ASQC's 48th Annual Quality Congress Proceedings.** May 24-26, 1994. American Society for Quality Control (ASQC).

Nagayasu A, K. Uchiyama and H. Kiwada. 1999. The size of liposomes: a factor which affects their targeting efficiency to tumors and therapeutic activity of liposomal antitumor drugs. **Adv Drug Deliv Rev**, 40(1–2): 75–87.

Nedovic, V., A. Kalusevic, V. Manojlovic, S. Levic and B. Bugarski. 2011. An overview of encapsulation technologies for food applications. **Procedia Food Science**, 1: 1806-1815.

Netherlands Worldwide. 2019. **About Agriculture in ASEAN**. Available Source: https://www.netherlandsworldwide.nl/doing-business-in-southeast-asia-asean/key-sectors-in-asean/agriculture, May 24, 2019.

Norazelina, S M., Ismail, R. Nazaruddin, M. Norziah, Hani and M. Zainudin. 2012. Extraction and Characterization of Pectin from Dragon Fruit (Hylocereuspolyrhizus) using Various Extraction Conditions. **Sains Malaysiana**, 41(1): 41–45.

Núñez-Cacho, P., V. Molina-Moreno., F.A. Corpas-Iglesias., F.J. Cortés-García. 2018.
Family businesses transitioning to a circular economy model: the case of "Mercadona
Sustainability, 10, pp. 538

Obi, F. O., B.O. Ugwuishiwu and J.N. Nwakaire. 2016. Agricultural waste concept, generation, utilization and management. **Nigerian Journal of Technology**, 35(4): 957-964.

Oakland, John. S., Robert J. Oakland, Robert J., Turner, Michael A. Turner. 2020. **Total Quality Management and Operational Excellence: Text with Cases** (5th Edition). Routledge.

Oliveira, C. D. E., D. Giordani, R. Lutckemier, P.D. Gurak, F. Cladera-Olivera and L. D. F. Marczak. 2016. Extraction of pectin from passion fruit peel assisted by ultrasound. **LWT - Food Science and Technology**, 71: 110-115.

Othman, A., N. J. Mukhtar, N. S. Ismail and S. K. Chang. 2014. Phenolics, flavonoids content and antioxidant activities of 4 Malaysian herbal plants. **International Food Research Journal**, 21(2): 759.

Owens, H. S., R. M. McCready, A. D. Shepard, T. H. Schultz, E. L. Pippen, H. A. Swenson, J. C.Miers, R. F. Erlandsen and W. D. Maclay. 1952. Methods used at Western Regional Research Laboratory for Extraction of Pectic Materials. **USDA Bur. Agric. Ind. Chem**, 18(2): 7-9.

Pagan, J., A. Ibarz, M.Llorca, A. Pagan and , G. Barbosa-Cánovas. 2001. Extraction and characterization of pectin from stored peach pomace. **Food Research International**, 34(7): 605-612.

Panouillé, M., J. F. Thibault and E. Bonnin. 2006. Cellulase and protease preparations can extract pectins from various plant byproducts. **Journal of Agricultural and Food** Chemistry, 54(23): 8926-8935.

Parr, A. J. and G. P. Bolwell. 2000. Phenols in the plant and in man. The potential for possible nutritional enhancement of the diet by modifying the phenols content or profile. **Journal of the Science of Food and Agriculture,** 80(7): 985-1012.

Penprapai, P. and S. Intharit. 2017. Total phenolic content and antioxidant activity of coconut oil enriched with some extracts of curcuma species in Thailand. **The Journal of Applied Science**, 16: 48-54

Pernetti, M., K. F van Malssen, E. Flöter and A. Bot. 2007. Structuring of edible oils by alternatives to crystalline fat. **Current Opinion in Colloid and Interface Science,** 12: 221- 231.

Phebe, D., M. K. Chew,A. A. Suraini, O. M. Lai and O. A. Janna. 2009. Red-fleshed pitaya (*Hylocereuspolyrhizus*) fruit colour and betacyanin content depend on maturity. **International Food Research Journal**, 16: 233-242.

Prakash Maran, K. Swathi, P. Jeevitha, J. Jayalakshmi and G. Ashvini. 2015. Microwave-assisted extraction of pectic polysaccharide from waste mango peel. **Carbohydrate Polymers**, 123: 67-71.

Priatni, S. and A. Pradita . 2015. Stability study of betacyanin extract from red dragon fruit (*Hylocereuspolyrhizus*) peels. **Procedia Chemistry**, 16: 438-444.

Qader, S. W., M. A. Abdulla, L. S. Chua, N. Najim, M. M. Zain and S. Hamdan. 2011. Antioxidant, total phenolic content and cytotoxicity evaluation of selected Malaysian plants. **Molecules**, 16(4): 3433-3443.

Ramli, N. S., P. Ismail and A. Rahmat . 2014. Influence of conventional and ultrasonic-assisted extraction on phenolic contents, betacyanin contents, and antioxidant capacity of red dragon fruit (*Hylocereuspolyrhizus*). **The Scientific World Journal**.

Rashidinejad, A., E. J. Birch, D. Sun-Waterhouse and D. W. Everett. 2014. Delivery of green tea catechin and

epigallocatechin gallate in liposomes incorporated into low-fat hard cheese. **Food chemistry**, 156: 176-183.

Re, R., N. Pellegrini, A. Proteggente, A. Pannala, M. Yang and and C. Rice-Evans. 1999. Antioxidant activity applying an improved ABTS radical cation decolorization assay. **Free radical biology and medicine**, 26(9-10): 1231-1237.

Rogers, J.A. and K.E.Anderson. 1998. The potential of liposomes in oral drug delivery. **Critical Reviews™ in Therapeutic Drug Carrier Systems**, 15(5): 2-9.

Ronald G. Day. 1994. Put "Quality in your business plan: Use the QFD matrix concept to insure focus. **ASQC 48th Quality Congress Proceedings.** American Society for Quality Control (ASQC).

Rytömaa, M., P. Mustonen and P. K. Kinnunen. 1992. Reversible, nonionic, and pH-dependent association of cytochrome c with cardiolipin-phosphatidylcholine liposomes. **Journal of Biological Chemistry**, 267(31): 22243-22248.

Sabancı, S., C. Celebi and F. Icier. 2014. Rheological properties of Sübye: A traditional beverage. **Acad Food J**, 12: 11-15.

Sakai, T., T. Sakamoto, J. Hallaert and E. J. Vandamme. 1993. Pectin, pectinase and protopectinase: Production, properties and applications. **Applied Microbiological**, 39: 231-294.

Samad, A., Y. Sultana and M. Aqil. 2007. Liposomal drug delivery systems: an update review. **Current drug delivery**, 4(4): 297-305.

Sanders, T. H. 2003. Ground nut oil. In B. Caballero (Ed.), **Encyclopedia of Food Sciences and Nutrition (Second Edition),** : 2967-2974. Oxford: Academic Press.

Schemin, M. H. C., H. C. R. Fertonani, N. Waszczynskyjand , G. Wosiacki. 2005. Extraction of pectin from apple pomace. **Brazilian Archives of Biology and Technology**, 48(2): 259-266.

Schreier, H., R. J. Gonzalez-Rothi and A. A. Stecenko. 1993. Pulmonary delivery of liposomes. **Journal of Controlled Release**, 24(1-3): 209-223.

Seixas, F. L., D. L. Fukuda, F. R.Turbiani, P. S. Garcia, L. d. O. Carmen, S.Jagadevan and M. L.Gimenes. 2014. Extraction of pectin from passion fruit peel (Passiflora edulis f. flavicarpa) by microwave-induced heating. **Food Hydrocolloids**, 38: 186-192.

Seneviratne, K. N., C. D. HapuarachchI and S. Ekanayake. 2009. Comparison of the phenolic-dependent antioxidant properties of coconut oil extracted under cold and hot conditions. **Food Chemistry**, 114(4): 1444-1449.

Shehata ,T., K. Ogawara, K. Higaki and T. Kimura. 2008. Prolongation of residence time of liposome by surface-modification with mixture of hydrophilic polymers. **Int J Pharm**, 359: 272–279.

Shimada, K., K. Fujikawa, K. Yaharaand and T. Nakamura. 1992. Antioxidative properties of xanthan on the autoxidation of soybean oil in cyclodextrin emulsion. **Journal of agricultural and food chemistry**, 40(6): 945-948.

St. Onge, M. P. and P. J. H. Jones. 2002. Physiological Effects of Medium-Chain Triglycerides: Potential Agents in the Prevention of Obesity**. Journal of Nutrition**, 132: 329–332.

Stintzing, F. C., A. Schieber and R. Carle. 2003. Evaluation of colour properties and chemical quality parameters of cactus juices. **European Food Research and Technology**, 216: 303-311.

_____, F.C., A. Schieber and R. Carle. 2002. Betacyanins in fruits from red-purple pitaya, Hylocereuspolyrhizus (*Weber*) Britton and Rose. **Food Chemistry**, 77: 101-106.

Supardan, M. D., A. Fuadi, P. N. Alam and N. Arpi. 2011. Solvent extraction of Ginger Oleoresin using ultrasound. **MAKARA of Science Series**, 15 (2): 163–167.

Sullivan, Lawarence P. 1986. Quality function deployment. **Quality Progress** 19(6):39-50.

Taguchi, Genichi. 1981. Online quality control during production. **Japanese Standards Associations**, p.1

Takahashi, M., S. Uechi, K. Takara, Y. Asikin and K. Wada. 2009. Evaluation of an oral carrier system in rats: bioavailability and antioxidant properties of liposome-encapsulated curcumin. **Journal of Agricultural and Food Chemistry**, 57(19): 9141-9146.

Tang, P., C. Wong and K. Woo. 2011. Optimization of pectin extraction from peel of dragon fruit (*Hylocereus polyrhizus*). **Asian Journal of Biological Sciences**, 4(2): 189-195.

Tenore, G. C., E. Novellino and A. Basile. 2012. Nutraceutical potential and antioxidant benefits of red pitaya (*Hylocereus polyrhizus*) extracts. **Journal of Functional Foods**, 4: 129-136.

Thirugnanasambandham, K., V. Sivakumar and J. Prakash Maran. 2014. Process optimization and analysis of microwave assisted extraction of pectin from dragon fruit peel. **Carbohydrate Polymers**, 112: 622-626.

Tien Loc Vu, Khee Giap Tan, Trieu Duong Luu Nguyen, and Duy Nguyen. 2019. Balanced, Sustainable and Competitiveness Enhancement Study for Vietnam: A Critical Evaluation with Development Potentials, p.184. **World Scientific Series** - Asia Competitiveness Institute. doi.org/10.1142/11064.

Tingmin Koe. 2018. Why production capability is as important as product innovation to meet customization and

convenient demand. **Gulford Manufacturing Newsletter** 2018.

Toma, M., M.Vinatoru, L. Paniwnyk and T. J. Mason. 2001. Investigation of the effects of ultrasound on vegetal tissues during solvent extraction. **Ultrasonics Sonochemistry**, 8 (2): 137–142.

Vanitha, T. and M. Khan. 2019. **Role of Pectin in Food Processing and Food Packaging Pectins-Extraction, Purification, Characterization and Applications**: IntechOpen.

Valenti, F., S.M.C. Porto, R. Selvaggi, B. Pecorino. 2019. Co-digestion of by-products and agricultural residues: a bioeconomy perspective for a Mediterranean feedstock mixture. **Sci. Total Environ**., 700. p. 134440.

Wahengbam, E., R. Shukla, K. Bala, A. Kumar , A. Mishra, K. Chandra Yadav and A. Professor. 2014. Extraction of Pectin from Citrus Fruit Peel and Its Utilization in Preparation of Jelly. **International Journal of Engineering Research**, 3(5).

Wang, J., B. Sun, Y. Liu and H. Zhang. 2014. Optimisation of ultrasound-assisted enzymatic extraction of arabinoxylan from wheat bran. **Food chemistry**, 150: 482-488.

_____, W., W. Chen, M. Lv. R. Zou, D. Wang, F. Hou and D. Liu. 2018. Applications of power ultrasound in oriented modification and degradation of pectin: A review. **Journal of Food Engineering**, 234: 98-107. doi: https://doi.org/10.1016/j.jfoodeng.2018.04.016

_____, W., X. Ma, Y. Xu, Y. Cao, Z. Jiang, T. Ding and D. Liu . 2015. Ultrasound-assisted heating extraction of pectin from grapefruit peel: Optimization and comparison with the conventional method. **Food Chemistry**, 178: 106-114.

Wong, S. P., L. P. Leong and J. H. W. Koh. 2006. Antioxidant activities of aqueous extracts of selected plants. **Food Chemistry**, 99(4): 775-783.

Xu, Y., L. Zhang, Y.Bailina, Z. Ge, T. Ding, X. Ye and D. Liu . 2014. Effects of ultrasound and/or heating on the extraction of pectin from grapefruit peel. **Journal of Food Engineering**, 126: 72-81.

Yapo, B. M. 2009. Biochemical characteristics and gelling capacity of pectin from yellow passion fruit rind as affected by acid extractant nature**. Journal of Agricultural and Food Chemistry**, 57(4): 1572-1578.

Yuangyai, C., and H.B. Nembhard. 2015. **Design of experiments in Emerging Nanotechnologies for Manufacturing** (Second Edition).

Zhang, L., X. Ye, T. Ding, X. Sun, Y. Xu and D. Liu. 2013. Ultrasound effects on the degradation kinetics, structure and rheological properties of apple pectin. **Ultrasonics Sonochemistry**, 20(1): 222-231.

_____, S., H. Wang and M. J. Zhu. 2019. A sensitive GC/MS detection method for analyzing microbial metabolites short chain fatty acids in fecal and serum samples. **Talanta**, 196: 249-254.