Chapter 1

Introduction

1.1 Background

An indigenous plant called red fruit (*Pandanus conoideus* Lam.) grows in Indonesia's Papua Region and Papua New Guinea. *Pandanus conoideus*' red fruit oil (RFO), a product of drupe extraction, includes a variety of beneficial substances, including vitamins, vitamin B1, tocopherol, and carotenoids (Murtiningrum et al., 2019; Sarungallo et al., 2015). The red fruit oil (RFO) RFO contains high amounts of unsaturated lipids of >40% dominated by oleic acid and has a carotenoid content of 3027-19959 ng/mg (Rohman et al., 2012; Sarungallo et al., 2015) higher than known sources of carotenoids such as carrots and tomatoes. High carotenoid content of RFO results in the distinct characteristic of possessing a deep red to orange color that could be used as a source of natural colorant.

Encapsulation is a method to increase applicability of carotenoids (FEDERZONI et al., 2019; and Kaur et al., 2021). Various encapsulation processes of bioactive compounds are available including freeze-drying, spray drying, nanoencapsulation and co-crystallization. A development of a safe, simple and cost-effective method of encapsulation is necessary for heat and light-sensitive carotenoids. The encapsulation process of co-crystallization is reported to provide an economical substitute to preserve bioactive compounds in forms of a stabilized powder (Lopez-Cordoba, Deladino, Agudelo-Mesa, & Martino, 2014). According to Sanjay, Manohar, & Bhanudas (2014), encapsulation using co-crystallization with sucrose is able to improve dispersibility, dissolution, hygroscopicity, hydration, homogeneity, thermal stability as well as anti-caking properties. The mechanism of encapsulation using the co-crystallization process includes embedding active ingredients into a conglomerate of crystals

(Bhandari et al., 1998). Sucrose, commonly used as a primary ingredient is transformed into an agglomerated, irregular and micro-sized crystal that provides a porous base for the incorporation of the active ingredients (Deladino et al., 2007). Several studies (FEDERZONI et al., 2019; and Kaur et al., 2021) have reported the stability of co-crystallization on carotenoids as well as its ability to expand the application of carotenoids as an antioxidant source and natural colorant available in powdered form. However, the stability and shelf life of co-crystallized RFO remains unknown.

Furthermore, in reference to the application of co-crystallized red fruit oil as a natural colorant, the degree of rancidity, carotenoid degradation, moisture content and color loss are perceptible indicators of decline in quality. Degree of oxidation based on peroxide value analysis as well as color loss based on color and total carotenoid measurement are observable measures of quality degradation. Understanding shelf life estimation based on degradation kinetics is essential for creating techniques that can keep the quality parameters stable. Furthermore, moisture content is an important parameter in the quality assurance of powdered samples to maintain the flow properties of the product. Low moisture content may prevent caking, clumping and spoilage through microbial growth. These quality parameters are analyzed throughout a storage period to assess its stability and shelf life estimation.

A period of time in which a product is able to retain its physical, chemical, sensorial properties and safety is considered as the shelf life of a food product (Phimolsiripol & Suppakul, 2016). These factors are dependent on four major aspects including storage conditions, formulation, processing and packaging (Sousa Gallagher et al., 2011). Storage and distribution conditions are the two important factors that may affect the deterioration and quality of food products. The shelf life testing of a food product aims to describe the deterioration and degradation rates of physical and chemical properties. Methods including extended storage studies (ESS) and accelerated shelf life testing (ASLT) are available for shelf life determination. The determination of shelf life based on extended storage study is based on the degradation of quality parameters of a food product when samples are stored at an environmental condition that mimics actual storage conditions on the market shelf (Calligaris et al., 2019). Environmental factors to mimic actual storage conditions include light exposure, temperature and relative humidity. On the contrary, the ASLT allows an estimation of shelf life based on accelerated shelf life conditions in which food products are a combination or a single factor of high temperature, oxygen concentration, excessive light exposure and relative humidity. Accelerated condition allows deterioration of physical and chemical properties at a higher rate hence shortens the shelf life testing period. Shorter testing period of ASLT leads to better suitability to implement in various food products. Shelf life estimation is based on the application of food products, packaging as well as accelerated factors that is calculated in reference to the critical limit of a quality parameter. A critical limit of a quality parameter may vary in reference to the application of a food product and its acceptability.

Successful studies by Sathivel et al. (2008) and Sarunggalo et al. (2018) indicate that ASLT techniques are appropriate for oil products. According to Sarunggalo et al. (2018), RFO degradation kinetics based on free fatty acid content, peroxide value, and carotenoid are based on storage temperatures of 60, 75, and 90°C. Total carotenoid content decreases using first order kinetics, whilst free fatty acid content and peroxide value deteriorate using zero order kinetics. The same set of storage temperatures are used to evaluate the quantitative degradation of co-crystallized RFO in line with the prior study’s usage of high temperature to degrade red fruit oil.

As limited studies regarding the stability of co-crystallized product are available, the aim of the research is to observe and measure the stability of encapsulated RFO through co-crystallization based on formation of peroxide value, moisture content and, color based on shelf life estimation using Arrhenius model.

1.2 Objectives

The research aims to:

A. Evaluate the effect of temperature to the total carotenoid content, peroxide value, moisture content and color of co-crystallized RFO stored in accelerated condition.
B. Assess the degradation kinetics of co-crystallized RFO in terms of carotenoid content, peroxide value, moisture content and color stored in three different temperatures by using zero and first order.
C. Predict the shelf life of co-crystallized RFO in terms of carotenoid content, peroxide value, moisture content and color using accelerated shelf-life testing (ASLT) stored in temperature 20 and 25°C in a HDPE bottle.

1.3 Scope of Study

The scope of research includes literature review, purchasing of red fruit oil, production of co-crystallized RFO, storage, observation and data analysis. Samples are stored at temperatures of 55, 65 and 75°C in which analysis of carotenoid content, peroxide value, moisture content and color are conducted every 3 days over a 21 days of storage period. Data are analyzed using statistical analysis, assessment of degradation kinetics using zero- and first-order reaction kinetics as well as shelf life estimation when co-crystal samples are stored at optimal temperature of 20 and 25 °C using the Arrhenius equation.

1.4 Problem Formulation

A. What is the effect of storage temperature on the shelf life of co-crystallized RFO?

B. What is the effect of temperature on the degradation kinetics of co-crystallized RFO?

C. What is the shelf life of co-crystallized RFO in terms of carotenoid content, peroxide value, moisture content and color?

D. What is the shelf life of co-crystallized RFO based on the critical parameter?

1.5 Hypothesis

H_0: There are no significant differences in the carotenoid content, peroxide value, moisture content and color of co-crystallized RFO stored at temperatures of 55, 65 and 75°C throughout the 21 days of accelerated storage period.

H_1: There are significant differences in the carotenoid content, peroxide value, moisture content and color of co-crystallized RFO stored at temperatures of 55, 65 and 75°C throughout the 21 days of accelerated storage period.

H_0: Temperature will have a zero order reaction with total carotenoid content, peroxide value, moisture content and color.

H_1: Temperature will have a first order reaction with total carotenoid content, peroxide value, moisture content and color.

H_0: Increase in temperature does not affect the shelf life period of co-crystallized RFO.

H_1: Increase in temperature affects the shelf life period of co-crystallized RFO.

1.6 Expected Outcome

The expected outcome of the study is:

A. To provide information regarding the stability and estimation of the shelf life period of co-crystallized RFO