Chapter 1

Introduction

1.1 Background

The red fruit (*Pandanus conoideus* Lam) is a native fruit species from the Papua Islands, Indonesia, and is red in color with an unusual shape (Rohman et al., 2012). The red fruit itself is rich in oil, containing 11.2 - 30.7% of fat content, which could be extracted from the fruit (Sarungallo et al., 2015; Rohman et al., 2012). The oil contains active bio compounds such as β-carotene and α-tocopherol and is high in antioxidants, oleic and linoleic acid, fats, and fibers (Sirait et al., 2021). These compounds provide health benefits such as decreasing the chances of lung cancer in smoking men, killing cancer cells, and reducing blood sugar, making red fruit oil a functional food ingredient (Oeji, 2015; Sarungallo et al., 2015; Sirait et al., 2021). Red fruit oil (RFO) has been found to have also been found to prevent cardiovascular disease, increasing high-density lipids while also reducing the risk of hypertension (Rohman et al., 2012). RFO is obtained through various extraction methods, such as rendering, hydraulic press, or solvent extraction (Sarungallo et al., 2015). In the local communities, RFO is utilized for traditional medicinal applications, consumption, and as natural food colorant (Sirait et al., 2021).

Natural food colorants have been increasing in popularity due to their superiority in terms of health and properties (Rozylo, 2020). Natural food colorants are essential in increasing the attraction of food, as the color of food indicates the quality of the food in terms of freshness, wholesomeness, and readiness for consumption (Gordon et al., 1983). The increased usage of natural food colorants in the food industry is due to the consumers' awareness and demand for natural food colors, especially those with health benefits (Mohamad et al., 2019). Natural colorants can be found in various natural foods, such as fruits and vegetables, that contain pigments anthocyanin, carotenoids, and chlorophyll (Lea & Henry, 2003). Carotenoids are the most prevalent of all the natural pigments, providing the colors light yellow to dark red (Gordon et al., 1983). In red fruit oil, the red color is obtained from the total carotenoid contained as a pigment (Wijaya et al., 2020). In particular, 12,000 ppm of carotenoid is found in red fruit oil, whereas 1.980 µg of β-carotene is found in 100 g of the red fruit oil extract (Sirait et al., 2021; Wijaya et al., 2020). The high amount of β-carotene makes red fruit oil a rich source of red pigment, which has been widely applied in foods (Tharukliling et al., 2021) and drinks (Wijaya et al., 2020). However, natural color pigments have lower stability and shelf life. Thus, processing is required to extend its shelf-life and to increase the ease of application (Mohamad et al., 2019; Rozylo, 2020).

In the food industry, encapsulation methods are commonly done through spray or freeze drying. The application of freeze drying helps retain the quality of products, such as their biological, nutritional, and physical properties, including taste, color, and appearance, as the degradation of thermolabile compounds is minimized (Rozylo, 2020). Freeze drying provides higher quality dried products than other drying methods in terms of its antioxidant activities, oxidative stability, and color stability (Nowak & Jakub, 2020; Rozylo, 2020; Silva et al., 2019). In addition, lipid encapsulation also eases handling and increases the application when in powder form (Cittadini et al., 2022). Materials such as maltodextrin (MD) and whey protein isolate (WPI) are popular encapsulating agents due to their film-forming capability, high solubility, and low viscosity (Papoutsis et al., 2018; Pudziuvelyte et al., 2020). Prior to this study, the application of encapsulation of red fruit oil with freeze drying had been done, where carotenoids and color properties were observed for over four weeks (Mas et al., 2023). The study found that the stability of carotenoids was achieved with no significant differences when encapsulated with MD and WPI with the proportion of 1:3, in which the formulation will be applied in this study as a continuation of the study, as mentioned earlier. Although the stability was observed, the shelf-life of the freeze-dried RFO was not determined. Therefore, this study will attempt to estimate the shelf life of freeze-dried RFO.

Shelf life is the time in which food remains safe, and can retain its physicochemical and functional properties, and complies with the label's requirements for storage (Man, 2004). Shelf life is an essential consideration for consumers in determining if the food is still appropriate for consumption, where acceptable shelf life is expected to maintain the required characteristics of the product (Manzocco et al., 2012). Shelf-life tests are done to evaluate the food's safety and determine the food's end-of-shelf life. They are generally specific to each product as it reflects the quality characteristics of the products (Man, 2004; Mizrahi, 2004). Manzocco et al. (2012) stated that shelf-life estimation can be done through individual or combined tests such as chemical analysis, physical testing, and microbiological examination. However, since foods' actual shelf lives are extensive, the food industry utilizes accelerated shelf-life testing (ASLT), a method to assess the food's shelf life in a shorter amount of time under conditions that allow for faster deterioration of foods (Calligaris et al., 2019; Mizrahi, 2004). Environmental conditions that could be accelerating factors include temperature, relative humidity, light intensity, as well as gas partial pressure (Calligaris et al., 2019). Increasing temperature is widely used in reducing the quality of foods, as the temperature is easily modified and controlled during tests (Manzacco et al., 2012). Temperature as an accelerating factor also allows for the data to be observed with Arrhenius modelling, which can be applied to predict the shelf life of food products in ambient temperatures (Man, 2004). In most cases, data obtained is put in a function of storage time to describe the degradation in specific quality indicators (Calligaris et al., 2019). According to Sarungallo et al. (2018), increased storage time and temperature affects the quality of red fruit oil, especially regarding its peroxide value, free fatty acids, and carotenoid content. The same study explored the properties of red fruit oil within 15 days of storage at storage temperatures of 60°C, 75°C, and 90°C. This study covers the accelerated shelf-life testing of freeze-dried red fruit oil based on their total carotenoid content, peroxide value, moisture, and color after storage for 21 days at temperatures 55°C, 65°C, and 75°C.

1.2 Objectives

The objectives of this study are to:

a. Observe the stability of freeze-dried red fruit oil at 55°C, 65°C, and 75°C during 21 days of storage in terms of peroxide value, total carotenoid content, moisture content, and color.
b. Determine the degradation kinetics of the freeze-dried red fruit oil through the parameters peroxide value, total carotenoid content, moisture content, and color.
c. Estimate the shelf life of freeze-dried red fruit oil at storage conditions of 20°C and 25°C.

1.3 Problem Formulation

Following with the project's background, the problem formulation of this research is as follows:

a. What are the physicochemical properties such as peroxide value, total carotenoid content, moisture content, and color of freeze-dried red fruit oil produced?
b. What changes can be observed after storage for 21 days at elevated temperatures to mentioned qualities?
c. How does it affect the degradation kinetics, and what is the estimated shelf life of freeze-dried red fruit oil?

1.4 Scope of Study

The scope of this research is as follows:

a. Commercial RFO samples obtained from Agro Herbal Husada, Malang, Indonesia, which are freeze-dried in i3L laboratory.
b. 15 g of freeze-dried red fruit oil samples placed in a 50-mL HDPE semi-transparent bottle.

c. Analysis of peroxide value, total carotenoid content, moisture content, color every 3 days for 21 days of storage at three temperature points of 55°C, 65°C, and 75°C.
d. Observation of the degradation kinetics based on the zero-order and first-order reaction.
e. Estimation of shelf life of products at storage temperatures of 20°C and 25°C.

1.5 Hypothesis

The hypotheses of the study are as follows:

1. Hypothesis 1

   H_0 = there is no significant difference in the peroxide value of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

   H_1 = there is a significant difference in the peroxide value of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

2. Hypothesis 2

   H_0 = there is no significant difference in the total carotenoid content of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

   H_1 = there is a significant difference in the total carotenoid content of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

3. Hypothesis 3

   H_0 = there is no significant difference in the moisture content of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

   H_1 = there is a significant difference in the moisture content of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

4. Hypothesis 4

   H_0 = there is no significant difference in the color of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

   H_1 = there is a significant difference in the color of the freeze-dried red fruit oil after 21 days of storage in accelerated conditions.

5. Hypothesis 5

   H_0 = degradation kinetics for all parameters follows zero-order reactions

   H_1 = degradation kinetics for all parameters follows first-order reactions

1.6 Significance of Study

This research will allow for further insight regarding the properties of freeze-dried RFO concerning its peroxide value, total carotenoid content, moisture content, color, and stability at elevated temperatures after storage for 21 days. The data obtained will allow for shelf-life estimation in freeze-dried RFO based on the degradation of the previously-mentioned four parameters. For these reasons, this research will cover the knowledge gap on freeze-dried RFO's properties and stability while predicting the shelf-life. It is also hoped that by increasing the knowledge of freeze-dried RFO, the application can be diversified in the food industry while establishing the importance of one of Indonesia's native fruits.