CHAPTER 1

INTRODUCTION

1.1. Background

An adequate intake of micronutrients is necessary for an individual's normal growth and development as it plays an important part in the maintenance, health optimization, and prevention of diseases in human metabolism and physiology (Shergill-Bonner, 2017). Despite the importance, micronutrient deficiency is one of the major concerns in most developing countries, including Indonesia, particularly among children and pregnant women (Ernawati et al., 2021). The deficiencies may increase several health risks, which includes mortality, morbidity, infectious diseases, decreased work productivity, low birth weight and size, birth defects, pregnancy loss and preterm delivery (Bailey, West, & Black, 2015; Cetin et al., 2019; Gernand et al., 2016). During pregnancy, lack consumption of staple food might lead in vitamin A, C, E, B2, B6, B9, B12, iron, and zinc insufficiency (Zerfu & Ayele, 2013; Shergill-Bonner, 2017).

Food fortification, which is the addition of nutrients throughout food processing to enhance the nutritional value of a certain target population, has been chosen as a global nutrition intervention program among several interventions developed to prevent micronutrient deficiency due to its ability to reach a broad population of people and a safe and cost-effective strategy (Olson et al., 2021; Dewi & Mahmudiono, 2021). Besides, it is currently being promoted as an intervention program for prevention and reduction of maternal micronutrient deficiency as it could assist in providing nutrient sufficiency and directly impact pregnancy along with its outcomes ("Micronutrients", 2022; Yakoob, Khan & Bhutta, 2010). In several previous studies, pregnant women who consumed fortified products showed a lower risk of delivering infants with neural tube defects (NTD), increased birth weight, and reduced preterm delivery (Yang & Huffman, 2010; Blencower et al., 2010).

In this study, cookies are chosen as the fortified snack considering Indonesia's high demand, lifestyle, and acceptance of biscuit products (Soyfan & Mercilia, 2018). Cookies are characterized as a compact, flat food product with a high fat and sugar content with a low water content that leads to longer shelf life (Caballero, Finglas, & Toldrá, 2015). Therefore, due to frequent negative health impacts on cookies consumption, there have been numerous inventions and improvisations to healthier options including by fortification of micronutrients (Kulthe, Lande, & Thorat, 2017; Ishera, Mahendran, & Roshana, 2021). According to a previous study, pregnant women who consumed fortified cookies had greater hemoglobin and folic acid level (Sayuti, 2002).

To achieve successful food fortification, the amount of nutrients fortified needs to be sufficient and fulfilling, yet, during preparation, processing, and storage, micronutrients can be

diminished or lost due to light, temperature, water, heat, acid, alkaline, oxygen, and other nutrients exposure (Ayelign, Urga & Retta, 2012). Analyzing vitamin C stability in food products is essential considering that vitamin C has the most sensitivity to loss and changes towards temperature; Thus, it is commonly employed as an indication of the overall nutrients (Herawati et al., 2015; Hiatt, Taylor & Maurer, 2010). A previous study stated that higher storage temperatures have a significant effect on vitamin C stability, as increased temperatures cause greater chemical instability over time (Jutkus et al., 2015). Although no previous research has specifically evaluated vitamin C stability in cookies during storage, yet, fortified cereals stored at room temperature for 12 months lost 40% of their vitamin C content (Lekov, 2006). On contrary to vitamin C, iron has been known to have great stability even when exposed to extreme temperature, heat, pH, and light (Kramer, 1977; Sharma et al., 2020); However, iron deficiency still affects more than 50% of pregnant women (Triharini et al., 2018). As vitamin C is one of the essential vitamins required by the human body to protect body tissues from free radicals (Sinbad et al., 2019), avoid pregnancy complications, as well as the prevention of anemia and low birth weight due to lack of iron consumption (Kiondo et al., 2014; Triharini et al., 2018), it is important to analyze the micronutrient stability.

Furthermore, it is necessary to conduct physicochemical analysis and shelf life testing to ensure optimum product quality. Several previous studies discovered that different storage temperature has significantly affected the texture and crispness of the cookie due to an increase in moisture and water activity (Sharma & Riar, 2020; Hapsari, 2014, Popov-Raljić et al., 2013). Besides, shelf life refers to the period of time food can be kept in specified conditions before it starts deteriorating and becoming unsafe and unsuitable for consumption (Fu & Labuza, 1997). Although several parameters can be used to predict shelf life, temperature is one of the factors that influence food quality, and chemical reactions are often also affected by it (Calligaris et al., 2007; Manzocco et al., 2020). During storage, a high-fat product is more prone to lipid oxidation, which can generate undesirable odor and off-flavors; Therefore, rancidity must always be considered (Caruso et al., 2017; Manzocco et al., 2020).

1.2. Objectives

The objective of this study were:

1. To assess the effect of storage temperature on the micronutrient stability (vitamin C and iron) of fortified cookies
2. To assess the effect of storage temperature on the physicochemical properties of fortified cookies.
3. To assess the shelf life estimation of fortified cookies.

4. To analyze the proximate composition of the fortified cookies

1.3. Scope of the Research

The scope of the research mainly was focused on:

1. Conduct the predicted shelf life of fortified cookies using the Accelerated Shelf Life Test (ASLT) Arrhenius model.
2. Conduct the proximate analysis & physicochemical properties focusing on hardness, moisture content, and water activity.
3. Conduct the micronutrient stability focusing on vitamin C and iron and proximate analysis of fortified cookies.

1.4. Hypothesis

The hypothesis in this study were:

1. The **H_0 (null hypothesis)** is different storage temperatures will not affect the micronutrient stability of fortified cookies, while **H_1 (alternative hypothesis)** is different storage temperatures will affect the micronutrient stability of fortified cookies.
2. The **H_0 (null hypothesis)** is different storage temperatures will not affect the physicochemical properties, while **H_1 (alternative hypothesis)** is different storage temperatures will affect the physicochemical properties.
3. Fortified cookies will have a shorter shelf life at higher temperatures and a longer shelf life at lower temperatures.
4. The proximate composition of the fortified cookies will fulfill the requirement from Indonesian government.

1.5. Research Significance

This research could give depth insight about micronutrient stability, physicochemical properties, and shelf life estimation of fortified cookies. As well as the energy from cookies in comparison to pregnant women's requirements. Thus, this research would be beneficial for a future study on fortified cookies as a snack for pregnant women, that will be distributed throughout Indonesia.