CHAPTER I. INTRODUCTION

1.1 Background

Malnutrition is a condition where there is an imbalance in individual nutritional intake resulting from insufficient or excessive consumption of nutrients. Malnutrition consists of several forms, namely malnutrition (underweight, wasting, stunting, and micronutrient deficiencies including vitamin and mineral deficiencies) and excess nutrition. In 2020, on a global scale, approximately 149 million children under five were projected to experience stunted growth, indicating too short for their age. Additionally, an estimated 45 million children were deemed wasted, indicating they were too thin for their height, while 38.9 million were grappling with overweight or obesity. About 45% of child mortality cases in the under-five age group were attributed to undernutrition, with the majority of these incidents occurring in low- and middle-income nations. Simultaneously, in these very same countries, there was a concerning upward trend in childhood overweight and obesity rates (WHO, 2021). The prevalence of malnutrition in children under the age of five in developing countries is still worrying. Data from the Study on the Nutritional Status of Toddlers in Indonesia (SSGI) in 2022 reported that the percentage of stunting prevalence in Indonesia was still relatively high, around 21,6% but in Sumatera Barat the case of stunting is still high, around 25,2%. Based on (de Onis *et al.,* 2018) threshold value of 20%, it can be said that Indonesia especially Sumatera Barat is in high category. Malnutrition can affect cognitive abilities, metabolic disorders, learning disabilities, mental retardation, and decreased immune system, thereby increasing the risk of being easily infected with disease, and the risk of death (Woldehanna *et al.,* 2017;

Forgie *et al.,* 2020). As much as 50% of a child's cognitive potential has been formed at the age of 4 years and reaches 80% when he is 8 years of total intelligence that will be achieved at the age of 18 years (Papalia *et al.,* 2007). The prominent lasting consequences of early malnutrition are related to behaviour and cognition, resulting in diminished fine motor abilities, reduced IQ scores, and difficulties in maintaining attention (Galler and Robert Barrett, 2001). Structurally, malnutrition induces harm to tissues, growth retardation, dysregulated differentiation, reduction of synapses and synaptic neurotransmitters, delays myelination, and overall, diminishes the branching complexity of dendritic growth in the developing brain. This leads to an alteration in the typical timeline of brain maturation, subsequently disturbing the establishment of neural circuits (Udani, 1992). Reports have indicated enduring alterations in brain function that could be linked to persistent cognitive impairment resulting from malnutrition (Leenstra *et al.,* 2004). To comprehend the impact of malnutrition on brain development, initial experimental research focused on the consequences of inadequate diets on body weight and the brain (Winick, 1969). Additional studies delved into the influence of malnutrition on cognitive abilities (Tonkiss *et al.,* 1994, 1991, 1990) and its disruption of neurotransmitter systems (Alamy *et al.,* 2005), along with changes in protein phosphorylation and oxidative status within the brain (Bonatto *et al.,* 2005).

Chronic malnutrition significantly impacts brain growth and maturation. The developmental stages involved in this process are complex and multifaceted. These stages include the proliferation of neural cells, migration to specific locations, the establishment of necessary connections, the development of neurotransmitter

receptors, and the vital process of myelination, which is essential for effectively transmitting nerve messages. The precise coordination of neural cell assembly is susceptible to various environmental stressors, including the effects of malnutrition. Brain development continues after birth and is characterized by ongoing migration and cellular proliferation. Empirical observations indicate that insufficient protein intake in the diet results in a notable reduction in the thickness of specific brain regions, such as the visual cortex, parietal neocortex, dentate gyrus, CA3, and cerebellum (Ranade *et al.,* 2012). Cognitive impairments resulting from malnutrition become evident through challenges in memory retention, decreased intellectual processing speed, and particular learning difficulties encompassing reading, writing, or mathematical skills. Behavioral issues, including attention deficit hyperactivity disorder, problems with emotional regulation, and struggles in socialization, can also arise in affected children (El Hioui *et al.,* 2017).

Lima bean (*Phaseolus lunatus* L.) also known as Lima Bean (West Sumatra) has enormous potential to be a food product when viewed from a nutritional perspective and growth requirements. Lima Bean has the potential to be a good source of nutrition with a protein source of 14.24 -24.92% (Jayalaxmi *et al.,* 2016; Ibeabuchi *et al.,* 2019). This legume is abundant in complex carbohydrates, particularly starch and dietary fiber, alongside crucial B complex vitamins and essential minerals like zinc, iron, and calcium, as documented by Campos-Vega et al. (2010). Noteworthy is the prevalence of globulin and albumin proteins in Lima Beans, as emphasized by Agarwal (2017). In addition to its favorable macronutrient composition, Lima Beans are distinguished for their health-enhancing attributes,

largely due to their low glycemic index, which stems from the gradual release of carbohydrates into the bloodstream (Bello-Pérez *et al.,* 2007). Compounds found in Lima Beans are reported to have benefits as antioxidants and anti-cancer (Campos-Vega *et al.,* 2010; Alcázar-Valle *et al*., 2020). According to the findings of Tamayo *et al*. (2018), this bean demonstrates a comprehensive range of capabilities, including antimicrobial effects against both Gram-negative and Gram-positive bacteria and antioxidant and anti-inflammatory properties.

The high source of nutrients in Lima Beans has the potential to be a source of nutrition in treating malnutrition and overcoming accompanying diseases. Research that examines the effect of Lima Bean on malnutrition has not been reported so far. The purpose of this study was to see how the effect of Lima Bean on growth restoration and cognitive function improvement in malnourished rats.

1.2 Formulation of the Problem

The formulation of the problem in this study is:

1. Does giving Lima Bean flour to the malnourished rat group affect the growth morphometric as an indicator of growth recovery?
2. What is the effect of giving Lima Bean flour in improving cognitive function in the malnourished rat?
3. What is the effect of giving lima beans on the histopathology of malnourished rats brain?
4. Is there a relationship between brain histopathology and cognitive function in malnourished rats?

1.3 Research Purposes

The specific objective of this study was to prove that giving Lima Bean flour to malnourished rats:

1. To determine the effect of Lima Bean flour on growth morphometric features as an indicator of growth recovery in the malnourished rat group.
2. To determine the effect of Lima Bean in improving cognitive function of malnourished rats.
3. To determine the effect of giving lima beans flour on histopathology of malnourished rats brain.
4. To determine the relationship between brain histopathology and cognitive function in malnourished rats.

1.4 Benefits of Research

The fundamental contribution to the field of science from this research provides information and a comprehensive explanation of how nutritional recovery with Lima Beans *(Phaseolus lunatus)* positively impacts cognitive function and promotes growth restoration in malnourished animals.