CHAPTER I. INTRODUCTION

1.1 Background

Malnutrition is one of the global issues of concern. Malnutrition is triggered by malnutrition, micronutrient deficiencies, and body mass deficiencies, which can affect growth and development for children. Malnutrition generally occurs in low- and middle-income economies, especially in developing countries, such as Indonesia. The need for nutritious food sources that are not well met, access to food fulfillment with adequate nutritional quality is one of the initial causes of high stunting rates (Vassilakou, 2021).

According to the World Health Organization (WHO) in 2022 the number of stunting rates reached 22,3%. Among them 148,1 million children under the age of 5 have a height that is too short for their age, 45 million children have a weight that is too thin for their height (WHO, 2023). This is in line with what happened in Indonesia with the prevalence of stunting at 21,5% according to the Indonesian Nutrition Status Survey (IDS) in 2023. Stunting number decrease from 24,4% (2021) until 21,6% (2022) in Indonesia (Ministry of Health, 2024), but survey results the stunting rate has not changed significantly. Based on the mandate of the President of the Republic of Indonesia in 2024, the target of reducing the stunting rate is 14%. So to achieve this reduction, efforts need to be made to reduce the stunting rate, especially in West Sumatra Province with the condition of the stunting rate reaching 25,2% (TTPS, 2023).

Malnutrition can have long term effects on the body's physical condition, especially during growth and development. Nutrition plays an important role in bone

growth, which will affect bone composition. Severe energy and nutritional protein deficiencies and chronic malnutrition cause linear growth retardation (de Onis & Blossner, 2003). Energy for basal metabolism, physical activity and growth comes from macronutrients, namely protein, fat and carbohydrates. Micronutrients (vitamins and minerals) are also required for the body for organ and tissue formation. Unmet nutrition will affect poor absorption of bone-forming minerals, especially Ca and Zn (Prentice *et al*., 2006). Protein also plays an important role in the growth of bone skeleton shape and structure (Prentice *et al*., 2004).

The physiological effects that occur in the case of malnutrition animal models have an impact on osteoporosis with decreased bone mass, bone mineral density, and cortical bone strength. Several studies have shown that malnutrition causes a significant decrease in bone mineral density, an increase in bone resorption rate and a decrease in bone formation rate (Zipfel *et al*., 2001 ; Soyka *et al*., 1999 ; Soyka *et al*., 2002). Malnutrition and starvation have been shown to decrease bone growth and mineral density in animal models (Kueper *et al*., 2015).

Nutritional status is strongly influenced by systemic factors, including IGF-1 (Insulin-like Growth Factor 1) and leptin. IGF-1 has a very important role as a major mediator in growth hormone (GH), as well as functioning as a GH-independent growth factor. In addition, IGF-1 is a significant growth factor for chondrocytes and osteoblasts, which are key cells in the process of forming and maintaining bone tissue. IGF-1 concentrations in the body are highly responsive to various changes in nutritional status, including intake of amino acids and free fatty acids (Mosier & Jansons 1976; Hermanussen *et al*., 1996), Research shows that when nutrient intake is

inadequate, IGF-1 levels can decrease significantly resulting in cortical bone thinning (Yakar *et al*., 2002).

Micronutrients and macronutrients play an important role in the process of bone growth. Zinc deficiency causes inhibition of chondrocyte reproduction in the growth plate (Rossi *et al*., 2001). In addition, copper affects the thickness and hypetrophy of the growth plate, which affects bone metabolism (Kennedy *et al*., 2011). The fulfillment of micronutrient and macronutrient intake in the body can prevent the prevalence of stunting. One macronutrient that plays an important role in growth is protein. Therefore, protein malnutrition (Moraes, 2006) has a deleterious effect on growth plate morphology by reducing growth plate height and the number of chondrocytes. (Heinrichs *et al*., 1997; Farnum *et al*., 2003).

Lima beans (*Phaseolus lunatus* L.) or more commonly known as lima beans in West Sumatra, is one of the local food sources with enormous potential to substitute protein intake needs other than animal protein groups (Prasetya, 2020). Legumes are classified as an affordable source of protein with rich carbohydrates, dietary fiber, protein, fat, and minerals (Lin and Lai, 2006). Vegetable protein from the legume group can reduce nutritional deficiencies and can be an alternative choice for diets because it has twice as much protein content as cereals (Farinde *et al*., 2018). The protein content of legume grains ranges from 40g/100g much higher than cereals which are only 7-11,8g/100g with the same content as meat protein which is 18-25 g/100g (De Oliveira, 2006).

The content in lima beans plays an important role in the growth and development process, including lima beans containing 19,93-21,40% protein, 60,55-

74,62% carbohydrates, 0,99-1,21% fat, 3,46-3,61% ash content, and 4,20-5,50% fiber (Diniyah *et al*., 2015). The low fat content in paga nuts is because it has an unsaturated fat source (Diniyah *et al*., 2013). Previous research (Prasetya *et al*., 2022) showed that processing lima bean into flour dosage form caused an increase in protein content. The protein content of lima bean after being formed into a linear flour preparation is up to 33,74% (Nafi` *et al*., 2015). compared to the use of MOCAF flour only 1,00% (Subagio *et al*., 2008).

Lima beans have good nutritional content and are a good source of protein, amino acids (AA), minerals, dietary fiber, and B-complex vitamins (folate, B6, and niacin). Lima beans show high levels of calcium, iron, zinc, phosphorus and potassium. These mineral components are necessary for the body to aid muscle movement, maintain the nervous system, and keep bones and teeth strong. The high levels of phosphorus and potassium, 1181,7 and 4080 mg/100 g, make Lima beans an important food source component (Janet, 2023).

Apart from nuts, nutritional sources that are rich in protein come from fish, one of which is *Pangasius hypophthalmus* or better known as patin fish in Indonesia. Patin fishis one of the freshwater fish that is easy to breed in Indonesia (Sudirman *et al*., 2018). Patin fish is a source of protein, fat, vitamins, minerals, and a little unsaturated fat compared to livestock meat (Almunady *et al*., 2011). The protein content in patin fish ranges from 12,38-13,83% at a weight of 800-1000g (Sudirman *et al*., 2018). High quality protein content, balanced amino acids, high in omega-3 fatty acids, which are important in homeostatic tissue healing, hormone precursors and nitrogenous bases (Oluwaniyi *et al*., 2010; Wu, 2009).

Patin fish is a producer of long-chain ω-3 polyunsaturated fish fats, namely eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The intake of long-chain omega-3 polyunsaturated fatty acids prevents the development of many human diseases, especially cardiovascular diseases (Sidhu, 2003), arrhythmia, blood pressure, triglyceride concentration, platelet aggregation (Fung *et al*., 2010), and atherosclerosis, hypertension, hyperlipidemia, allergies, arthritis, autoimmune diseases, and even cancer (Calder, 2004 ; Mnari *et al*., 2007).

The potential of local foods rich in micronutrient and macronutrient intake is needed by the body especially in growth and development from childhood to adulthood. Lima beans and patin fish are sources of protein that are very instrumental in bone development and mineralization, thus playing an important role in growth performance. The purpose of this study was to see how the effect of Lima beans and Patin fish on bone morphometry and histology including growth plate thickness, condroblast and chondrocyte cell number, also total area matriks chondroid.

1.2 Research Problem

1. Does feeding lima bean and patin fish meal affect the growth morphometry of malnourished rats?
2. Does feeding lima bean and patin fish meal affect the growth plate thickness, condroblast and chondrocyte cell number of malnourished rats?
3. Does feeding lima bean and patin fish meal affect the total area chondroid matrix in growth plate of malnourished rats?

1.3 Research Purpose

1. To determine whether feeding lima bean and patin fish flour affects the growth morphometry of malnutrition rats.
2. To determine whether feeding lima bean and patin fish flour affects the growth plate thickness, condroblast and chondrocyte cell number of malnourished rats.
3. To determine whether feeding lima bean and patin fish flour has affect the total area chondroid matrix in growth plate of malnourished rats?

1.4 Research Benefits

This research is expected to make a basic contribution to the advancement of education and research on the effects of malnutrition recovery from lima beans (*Phaseolus lunatus* L.) and patin fish (*Pangasius hypophthalmus*) on the morphometric growth of malnourished animals and improvements in bone tissue.