



Potential of Nile Tilapia (*Oreochromis niloticus*) as an Alternative Complementary Food Ingredient for Stunting Children

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Abstract

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BACKGROUND: The result of the Basic Health Research 2018 stunting prevalence in Indonesia is 30.8%. One of the potential local foodstuffs in Indonesia is Nile tilapia (*Oreochromis niloticus*). Nile tilapia has a high nutrient content, especially protein, calcium, and monounsaturated fatty acids.

AIM: The objectives of the study were analyzed the nutrient and lead content in Nile tilapia.

METHODS: The study was a laboratory study using raw materials of Nile tilapia from Grobogan. Then analyzed the content of proximate, fatty acids, amino acids, and lead heavy metals. Statistic descriptive tests were used in this study.

RESULTS: The total nutrient content of 100 g Nile tilapia is 18.46 g protein and 74.38 g calcium. Total fatty acids of Nile tilapia 30.39% consisted of Palmitic acid 7.87%, stearic acid 4.30%, oleic acid 8.13%, and Linoleic Acid 3.67%. Total amino acids are 21.56%, consisted of arginine 1.88%, leucine 1.69%, lysine 1.84%, aspartic acid 2.16%, and glutamic acid 3.45%.

CONCLUSION: High nutrient content in Nile tilapia is proteins (18.46 g), calcium (74.38 g), oleic fatty acids (8.13%), palmitic (7.87%), linoleic (3.67%), and stearic acids (4.30%). The highest amino acids are aspartic acid (2.16%), glutamic acid (3.45%), lysine (1.84%), arginine (1.88%), and leucine (1.69%).

Introduction

Stunting is a condition of growth failure in children under 5 years due to chronic malnutrition in the first 1000 days of life, which is seen from the length or height below the standard for children his age [1]. More than half of stunted children (54%) in the world live in Asia and 40% live in Africa [2]. Indonesia is in second place after Timor Leste for the prevalence of stunting in Southeast Asia. Based on the 2018 Basic Health Research, the prevalence of stunting in Indonesia is 30.8% [3]. The prevalence has decreased from 37.2% in 2013, but this figure is still much higher than WHO recommendation, which is <20% [1], [3]. The prevalence of stunting in Indonesia shows that one of three children in Indonesia is stunted. One of the areas in Indonesia with a high prevalence of stunting is Grobogan Regency with prevalence of short and very short toddlers reached 36.76%.

Stunting has impact, both in short- and long-term. Short-term effects of stunting are cognitive development delays and low learning performance. Evidence shows that cognitive abilities are highly

depend on environment, parents, and nutritional status in toddler [4]. Meanwhile, the long-term impact of stunting is low work productivity and low wages, as well as an increased risk of obesity and non-communicable diseases [5], [6]. The increased risk of obesity in stunted children is related to lower resting energy expenditure than children who are not stunted. Stunting children have higher respiration quotient and carbohydrate oxidation, but lower fat oxidation than non-stunted children [7].

Stunting occurs during the first 1000 days of life, it happen during pregnancy until the child is 2 years old, during the transition from exclusive breastfeeding to complementary feeding (6–23 months). Children of this age are only able to eat small amounts of food because of their small stomach capacity, but their nutritional needs are quite high, so they need complementary foods with high energy density and high nutritional content to meet their growth and development needs [6]. Research shows that complementary foods have a significant relationship with the incidence of stunting. Complementary foods which contain diverse food materials and protein from various animal sources are associated with improvement in height [8].

Research in Africa shows that stunted children have low levels of essential amino acids such as tryptophan and lysine from their diet [9]. Research on children under five in Malawi found that nine essential amino acids in the blood serum of stunted children were very low which resulted in the repression of protein and fat synthesis by the mTORC1 gene which could inhibit cell growth. Research in Grobogan Regency explains that low protein and zinc intakes are positively related to stunting [10].

Research in West Java on 2018 showed that complementary food was dominated by a variety of food sources of carbohydrates and vegetable protein only [11]. This habit did not accordance with the WHO recommendation which state that toddlers should consume protein sources such as meat, chicken, or fish as often as possible [12]. Animal protein in addition to meeting the daily needs of protein also helps meet 29% of the daily needs of iron, calcium, and zinc in toddlers [13]. As a source of animal protein, fish contains essential amino acids such as lysine, methionine, cystine, threonine, and tryptophan. Fish are an excellent source of lysine. Fish has a high protein content (15–24%), all essential amino acids, high digestibility (95%), and omega-3 fatty acids which are beneficial for the health and growth of children.

Complementary food needs to meet the nutritional needs of infants and has been regulated by the government. Complementary food must contain a minimum of 400 kcal of energy with a protein content of 15–22 g and a fat content of 10–15 g where the linoleic acid content is at least 300 mg/100 kcal [11]. The WHO's global strategy in providing complementary feeding emphasizes the use of affordable local food. Considerations of food availability are considered more likely to result in long-term improvements in complementary feeding practices [14]. Indonesia, which is a maritime country that dominated by islands and sea, makes fish one of the abundant resources but its utilization is still not optimal. Education for eating fish in Lamongan Regency, Indonesia is known to be related to increasing maternal knowledge for stunting prevention [15]. The intervention of giving biscuits with the substitution of Snakehead fish flour with a protein content of 9.5 g/100 g of Snakehead fish showed an increase in nutritional status and serum albumin levels for undernourished toddlers aged 3–5 years. Research in Yogyakarta, Indonesia also shows that toddlers with low fish intake have a 6 times risk of stunting compared to toddlers with adequate fish intake [16].

One of the most popular fish in Indonesia is Nile tilapia. Nile tilapia (*Oreochromis niloticus*) is the main and superior commodity of fisheries industry in Indonesia and is spread throughout Indonesia. Indonesia is also the second ranked as Nile tilapia exporter after China. Nile tilapia has become a leading commodity because its production level continues to increase. Nile tilapia is also able to meet the needs of protein and omega

3, and the price is affordable [17]. The average protein content in fish is 18% which contains essential amino acids and has a good iron absorption rate. The protein content of Nile tilapia is the highest compared to carp and eel [18]. This makes Nile tilapia a potential food ingredient for complementary food.

The nutritional content of fish depends on the geographical conditions where the fish live. Based on research conducted on three different ecosystems, it shows that the level of pollution in water, chemical content in water, and oxygen content in water is related to the nutritional content contained in Nile tilapia meat. The study also showed that the protein content of Nile tilapia in Zimbabwe ranged from 13.86% to 17.2%, which means the protein content is equivalent to the protein content of marine fish and other freshwater fish [19]. Grobogan Regency is an area located between two mountains with the total economic structure dominated by agriculture, forestry, and fisheries, while the manufacturing and production industries only dominate 27% of the economic structure. This condition makes the waters in the Grobogan Regency area have a lower level of contamination compared to other big cities whose economic structure is dominated by the processing and construction industries. Based on this explanation, the researchers chose Nile tilapia from Grobogan Regency [20].

This study aims to analyze nutritional content (energy, protein, carbohydrates, leucine, lysine and phenylalanine, iron, calcium, zinc, and fatty acids) in Nile tilapia and shows the potential of Nile tilapia as a food source of protein that can play a role in preventing stunting. Nile tilapia from Grobogan Regency was chosen because of the low level of water pollution and Grobogan is one of the areas with high fish production. This research is a preliminary study that can be used as a basis for further research in the form of an intervention by giving complementary food Nile tilapia meat for stunting prevention.

Methods

This research was a laboratory research with a descriptive approach. Raw material that used in this research was Nile tilapia from cultivation in Grobogan Regency, Central Java, Indonesia. Nile tilapia is easily available and affordable source of protein and is widely cultivated in this region. Meat without bone and head was used to analyze the nutrient contain of Nile tilapia. Laboratory research was conducted at the Central Laboratory of Industrial Pollution Prevention Technology (BBTPPI) Semarang and Integrated Laboratory of the Bogor Agricultural Institute.

This study analyzed total calories, nutritional content (total calories, carbohydrates, fat, protein,

fiber, zinc, iron and calcium, amino acids, and fatty acids), and lead metal content per 100 g of Nile tilapia meat. Total calories were analyzed using the total calorie calculation method which was calculated using the total calorie approach in the following equation:

$$\text{Total calories} = (4 \times \text{protein content}) + (4 \times \text{carbohydrate content}) + (9 \times \text{fat content})$$

Carbohydrates were calculated using the carbohydrate-by-difference method with calculations based on water content, ash content, fat, protein, and fiber using the following equation [21]:

$$\% \text{ Carbohydrate content} = 100\% - (\text{water content} + \text{ash content} + \text{fat content} + \text{protein content})$$

Protein content was analyzed using the Kjeldahl method. Fresh Nile tilapia meat samples weighing 0.5 g were put into a Kjeldahl flask and added with 10 g of K_2SO_4 and 10 ml of concentrated H_2SO_4 . It was carried out on a heater in a fume hood using low heat. The temperature was raised when smoke appears and the heating process was terminated once the liquid becomes clear and colorless. After the Kjeldahl flask and its liquid cooled, 100 ml of distilled water and 45% NaOH solution were added. The Kjeldahl flask was mounted immediately on the distillation apparatus. The flask was heated until all of the ammonia had evaporated; the distillate was accommodated in an Erlenmeyer containing 25 ml of 0.1N HCl which had been given a few drops of 1% pp indicator. Distillation was ended after the distillate volume was 40 ml [22].

The protein content of the sample is calculated by the formula:

$$\% N = \frac{(x \text{ NaOH} \times 14.008 (\text{ml NaOH blanko} - \text{ml NaOH sampel}))}{(\text{g sampel} \times 10)}$$

$$\text{Protein content} = \%N \times \text{Correction factor} (6.38)$$

Fat content was analyzed using the Soxhlet method. The fat flask was dried in the oven and then weighed. A 2 g sample was wrapped in filter paper and put into a Soxhlet extraction apparatus. Petroleum ether was poured into a fat flask and extracted for 6 h. The liquid in the fat flask was distilled off and the solvent was collected. The fat flask contained with fat was evaporated in an oven at 105°C for 15–20 min and weighed until the weight was constant [22].

Fiber content and ash content were analyzed using the Gravimetric method. Gravimetric analysis was a quantitative analysis method based on a fixed weight (constant weight). Gravimetric analysis separated the analyzed element or compounds from a number of materials that being sampled. Gravimetric analyzed the process of the elements or groups of the sample into other compounds that were pure and stable which the fixed weight can be known. The weight of the element or group being analyzed was then calculated from the

formula of the compound and the atomic weight of its constituents. The purpose of gravimetric analysis was to produce a large amount of target compound precipitate that is easy to filter for further weighing. Gravimetric could be used to determine almost all inorganic and organic anions and cations [23].

Thermogravimetrically method was used to analyze the water content with the usual oven method which drying the material in an oven at a temperature of 105°C–110°C for 3 h or until the weight was constant. The difference in weight before and after drying was the amount of water that was evaporated. The weight loss due to the drying process was considered as the weight of the water content that contained in the material which evaporates during heating process [21].

Iron (Fe), zinc (Zn), calcium (Ca), and metal lead (Pb) were analyzed using atomic absorption spectroscopy. The measurement of Fe, Zn, and Ca metals refers to the SNI method 01-2896-1992. Samples were taken as much as 5 g and evaporated on a hot plate at a temperature of 100°C and put in an ashing furnace. The ashing furnace temperature was increased gradually from 100°C every 30 min until it reached 450°C and maintained for 18 hours. The sample that had undergone while the ashing process was then cooled at room temperature by adding 1 mL of HNO_3 (52% concentration) and evaporated on a hot plate at 100°C until dry. The dried material was putted back into the ashing furnace with the temperature being increased gradually from 100°C every 30 minutes to up to 450°C and maintained for 3 hours. The sample was cooled at room temperature then added 5 mL of HCl (18% concentration) and then 10 mL of HNO_3 was added. The sample was transferred to a 50 mL polypropylene volumetric flask and then HNO_3 was added until it reached the limit mark. The number of samples used by the examiner is 10 mL where Fe uses a resonance wave of 248.3 nm, calcium with a wavelength of 422.7 nm, while for Zn uses a wavelength of 214.9 nm and metallic lead (Pb) is measured at a wavelength of 217 nm using a spectrophotometer atomic absorption spectra arachidonic acid (AA) 240 variant [24].

Amino acids were analyzed using the high-performance liquid chromatography (HPLC) method. This method used the principle that amino acids from proteins are separated by hydrolysis with 6N HCl. The hydrolyzated was dissolved in sodium citrate buffer and each amino acid was separated using HPLC. Before the hydrolysis process, protein extraction was carried out using the Kjeldahl method [24].

Fatty acids were analyzed using gas chromatography with the AOAC method (2012). Before the hydrolysis and esterification processes, the fat sample was extracted using the Soxhlet method. After being esterified into fatty acid methyl ester, then analyzed using gas chromatography [24].

Results

Analysis of nutrient content of Nile tilapia

Analysis of the nutritional content of Nile tilapia was needed to be the basis for determining the right formulation to meet the needs of toddlers in the manufacture of complementary food. The followings were the results of the analysis of macro, micro, and lead metal contamination in Nile tilapia meat obtained from cultivation in the Grobogan area:

Table 1 shows that the total calorie in raw Nile tilapia is 1 kcal/1 g of fish meat. The total protein content is 18.46 g in 100 g of the sample. Based on this value, 73% of total calories come from protein and was the largest macronutrient in Nile tilapia. The highest micronutrient in Nile tilapia was calcium at 74.38 mg in 100 g, while iron and zinc levels were <1 mg in 100 g. The metal content of lead in 100 g of raw Nile tilapia meat from Grobogan Regency was 0.9 ppm.

Table 1: Nutrient content composition of Nile Tilapia in 100 g

| Parameter | Amount |
|---------------|----------|
| Total calorie | 100 kcal |
| Carbohydrates | 2.51 g |
| Protein | 18.46 g |
| Fat | 1.98 g |
| Ash | 1.60 g |
| Water | 75.44 g |
| Fiber | <0.010 g |
| Iron (Fe) | 0.61 mg |
| Calcium (Ca) | 74.38 mg |
| Seng (Zn) | 0.57 mg |
| Timbal (Pb) | 0.9 ppm |

Table 2 shows the total fatty acid (30.39%) content in Nile tilapia. Highest saturated fatty acid was palmitic acid at 7.87%, stearic acid at 4.30% of the total fatty acids. Monounsaturated fatty acids (MUFA), namely, oleic acid, accounted for 8.13% of the total fatty acids. Polyunsaturated fatty acids (PUFA), namely, Linoleic Acid, accounted for 3.67% of the total fatty acids.

Table 3 shows the results that the total amino acid in Nile tilapia was 21.56%. The essential amino acids in Nile tilapia were 1.88% arginine, 1.69% leucine, and 1.84% lysine of the total amino acids. Non-essential amino acids are aspartic acid 2.16%, glutamic acid 3.45%, glycine 1.64%, and alanine 1.37% of the total amino acids. The highest percentage of amino acids are glutamic acid, and aspartic acid, which are non essential amino acids.

Discussion

Nutritional content of Nile tilapia meat

Nile tilapia (*O. niloticus*) is a type of fish originating from the waters of the Nile River basin in Africa and was first imported to Indonesia in 1969 from

Table 2: Fat and fatty acid content Nile tilapia per 100 g

| Parameter | Mean* (%) |
|--|--------------|
| Fat content | 0.12 |
| Saturated fatty acid | |
| Lauric C12:0 | 0.16 ± 0.021 |
| Tridecanoic C13:0 | 0.02 ± 0.006 |
| Myristic C14:0 | 0.68 ± 0.025 |
| Palmitic C16:0 | 7.87 ± 0.261 |
| Hepatadecanoic C17:0 | 0.21 ± 0.012 |
| Stearic C18:0 | 4.30 ± 0.245 |
| Arachidic C20:0 | 0.20 ± 0.015 |
| Heneicosanoic C21:0 | 0.05 ± 0.006 |
| Behenic acid, C22:0 | 0.22 ± 0.015 |
| Pentadecanoic acid, C15:0 | 0.22 ± 0.012 |
| MUFA | |
| Myristoleic C14:1 | 0.13 ± 0.015 |
| Cis-10-Pentadecanoic C15:1 | 0.02 ± 0.000 |
| Cis-11-Eicosanoic, C20:1 | 0.33 ± 0.010 |
| Palmitoleat C16:1 | 0.86 ± 0.031 |
| Elaidic C18:1n9t | 0.07 ± 0.000 |
| Oleic C18:1n9c | 8.13 ± 0.321 |
| PUFA | |
| Linoleic acid C18:2n9t | 0.00 ± 0.000 |
| Linoleic C18:2n6c | 3.67 ± 0.301 |
| γ-Linolenic C18:3n6 | 0.15 ± 0.010 |
| Linoleic C18:3n3 | 0.24 ± 0.006 |
| Cis-11,14-Eicosadienoic C20:2 | 0.20 ± 0.010 |
| Cis-8,11,14-Eicosatrienoic C20:3n6 | 0.28 ± 0.015 |
| Erucic Acid Methyl Ester, C22:1n9 | 0.00 ± 0.000 |
| Cis-11, 14, 17-Eicosatrienoic Acid Methyl Ester, (C20:3n3) | 0.09 ± 0.010 |
| Arachidonic C20:4n6 | 0.97 ± 0.129 |
| Tricosanic C23:0 | 0.08 ± 0.000 |
| Cis-13-16-Docosadienoic C22:2 | 0.04 ± 0.000 |
| Lignoceric C24:0 | 0.22 ± 0.025 |
| Cis-5,8,11,14,17-Eicosapentanoic C20:5n3 | 0.05 ± 0.006 |
| Nervonic C24:1 | 0.14 ± 0.120 |
| Cis-4,7,10,13,16,19-Docosahexaenoic C22:6n3 | 0.62 ± 0.092 |
| Total fatty acids | 30.39 |

*Mean is obtained from the results of 3x measurement ± SD. MUFA: Mono unsaturated fatty acid, SD: Standard deviation, PUFA: Poly unsaturated fatty acid.

Taiwan. Nile tilapia is widely cultivated by large farmers in Indonesia because of the delicious taste of the meat, has not too many bones and has a high survival rate (up to 92%) [25]. Nile Tilapia is the main commodity with cultivation centers that have been established in Java, Sumatra, Kalimantan, Sulawesi, and Bali. Tilapia became the main commodity because its production continued to increase from year to year and contributed as much as 30.27% of the total production of finfish at the national level in 2015 [17].

Table 3: Amino acid content of Nile tilapia per 100 g

| Asam amino | Mean (%)* |
|----------------------------|---------------|
| Aspartic acid | 2.16 ± 0.035 |
| Threonine ^a | 0.93 ± 0.012 |
| Serine | 0.82 ± 0.006 |
| Glutamate | 3.45 ± 0.082 |
| Proline | 0.96 ± 0.115 |
| Glycine | 1.64 ± 0.240 |
| Alanine | 1.37 ± 0.049 |
| Cystine | 0.24 ± 0.025 |
| Valine ^a | 1.04 ± 0.025 |
| Methionine ^a | 0.58 ± 0.030 |
| Ileusine ^a | 0.97 ± 0.035 |
| Leusine ^a | 1.69 ± 0.066 |
| Tyrosine | 0.59 ± 0.045 |
| Phenylalanine ^a | 0.86 ± 0.023 |
| Histidine ^a | 0.55 ± 0.006 |
| Lysine ^a | 1.84 ± 0.012 |
| Arginine | 1.88 ± 0.067 |
| Total amino acids | 21.56 ± 0.035 |

*Mean was obtained from the results of 3x measurement ± SD. ^aEssential amino acids. SD: Standard deviation.

The total calorie in Nile tilapia meat weighing 100 g is 100 kcal, which indicates that the energy density of Nile tilapia meat is 1 kcal/g. Based on its energy density, foods are categorized into foods with low energy density (<1 kcal/g), medium (1–2.25 kcal/g), and high (>2.25 kcal/g) [26]. Based on these categories, Nile Tilapia meat is classified as a medium energy density food source. A high energy density value

indicates a high nutrient density. High energy density in complementary food is needed because the baby's stomach capacity is small but the nutritional needs are high [6]. The functional capacity of the baby's stomach is only 30 g/kg body weight. Foods with high energy density are needed so that babies are not full quickly and nutritional intake is met [27].

The protein content of Nile tilapia in this study was 18.78 g. This result is higher than the results of the protein content test of Nile tilapia in other studies, which is 17.12 g. Differences in protein content in fish can occur due to the availability of nutrients and the ability of fish to absorb important nutrients in fish habitats [19]. The protein content of Nile tilapia is also higher when compared to chicken egg white which in 100 g contains 10.82 g of protein [28]. Protein is needed to meet the adequacy of amino acids in the body. Essential amino acids that cannot be synthesized by body must be met through the intake of protein sources. The best source of protein that meets these needs is a source of animal protein, one example of which is Nile tilapia. Consumption of animal protein in toddlers aged 18-23 months is associated with a 4% reduction in the likelihood of stunting. This decrease was higher compared to nuts. Other studies also show that a 9% reduction in the likelihood of stunting is closely related to a high and varied intake of animal protein sources [29]. Consumption of animal protein sources in complementary food, especially meat, liver, and fish is associated with good growth and cognitive development in later life [30].

The percentage of total amino acids in Nile tilapia is 21.56%. Tilapia contains 8 of 9 essential amino acids (lysine, histidine, leucine, valine, threonine, phenylalanine, and threonine) and contains 2 of 3 conditionally essential amino acids (arginine and glycine). The highest percentage of essential amino acids was lysine (1.84%) and conditionally essential amino acids were arginine (1.88%). Research in Malawi shows that stunted children have low intake of amino acids such as lysine in their diet [31]. Evidence suggests that human growth is regulated by growth regulatory pathways, mTORCH and GCN2. Diets with low essential amino acids have the potential to repress protein and fat synthesis of mTORCH, GCN2, and inhibit growth. mTORCH and the availability of the amino acid leucine also regulate bone growth through the chordal plate [32]. Research in Malang also shows the same thing. Stunting toddlers have a lower intake of amino acids (lysine, histidine, and isoleucine) than children who are not stunted [32]. Essential amino acids cannot be synthesized by the body so they need to be met through diet. Lysine is one of the amino acids that play a role in the development of collagen. Lysine is a carnitine precursor which is required for structural modification of collagen [31]. The need for essential amino acids in children with low-income families and often experiencing various infectious diseases is often

not fulfilled. Infectious diseases and high metabolism in the body cause most of the essential amino acids to be prioritized for use in strengthening the immune system rather than for growth [33].

The calcium content in 100 g of Nile tilapia is 74.38 mg. The part of Nile tilapia used is the meat part. Calcium values may be higher if fish bones are also used because most of the calcium in fish accumulates in fish bones [34]. Calcium has a growth promoting factor which plays a very important role in the process of bone formation and growth [35]. Calcium deficiency of 50% of the normal value required in the body will affect the linear growth of the child. This relates to the important function of calcium in the process of mineralization and bone health, especially the formation and maintenance of bone structure and density [36]. Calcium needs in children are high so that low calcium intake can interfere with bone matrix mineralization due to low hydroxyapatite crystals (phosphate and calcium bonds) in the bones [37]. This was proven in a study in South Africa which showed that low calcium intake was associated with stunting in children under five [35]. Fish can be a source of micronutrients for families with middle to the lower economic levels because the price is quite affordable compared to other sources of animal protein. Fish consumed whole is a good source of calcium and has the same efficient absorption rate as skim milk [34]. This makes Nile Tilapia as one of the ingredients that can enrich minerals, especially calcium in complementary food through various processes to maintain nutritional content and make it easier to digest.

The total fatty acid content of Nile tilapia is 30.39%. The highest saturated fatty acid was palmitic acid at 7.87% of the total fatty acids and then stearic acid at 4.30% of the total fatty acids. MUFA, namely, oleic acid, accounted for 8.13% of the total fatty acids. PUFA, namely, linoleic acid, accounted for 3.67% of the total fatty acids. Oleic acid is the dominant fatty acid in freshwater fish. Freshwater fish contain higher C16 and C18 but lower C20 and C22 than seawater fish. This is influenced by differences in the food consumed by the fish [38]. In addition to oleic acid, Tilapia also contains linoleic acid, one of the essential omega-6 fatty acids for the body. Linoleic acid plays a role in growth because it is a substrate for eicosanoids such as prostaglandins that play a role in cell growth. Linoleic acid which is an essential fatty acid must be met through the diet [39].

Linoleic acid is an ingredient for the biosynthesis of AA which plays an important role in growth. In addition, various effects of deficiency of essential fatty acids (omega-3 and omega-6) can be met even with only omega-6 [40]. Research on children in Ghanaian showed that blood levels of long-chain omega-6 saturated fatty acids (n-6 LC-PUFA) were associated with stunting. An increase in the n-6 LC-PUFA score was associated with an increase in the TB/U score.

Intake of essential fatty acids is reflected in levels in the blood, so that adequate intake of essential fatty acids can affect fatty acid levels in the blood and reduce the incidence of stunting [41]. Nile tilapia contains linoleic acid and various PUFAs that play a role in growth. Nile tilapia is also a freshwater fish that is easily cultivated even in highland areas. Based on these reasons, Nile tilapia can be one of the potential food ingredients to meet the needs of fatty acids in complementary food for people from various groups and regions.

Based on this research, it was found that the heavy metal content of lead in Nile tilapia was 0.9 ppm. Maximum lead content limit in complementary food ready-to-consume package is 1.14 ppm [11]. The lead content of tilapia from Grobogan is still lower than the average concentration of lead in Nile tilapia meat in Semarang (2.35 ppm) [42]. The difference in lead concentrations in Nile tilapia meat in Semarang and in Grobogan was caused by the high lead contamination in waters in Semarang. This condition can occur because the number of manufacturing industries in Semarang City is the highest in Central Java. Lead is one of the products of manufacturing waste [43]. Lead is a toxic metal pollutant that can cause severe damage to the reproductive system, nerves, and inhibit development in children. Lead content is bioaccumulative in living tissues such as tilapia. The presence of lead in fish meat can come from residential and industrial wastes that are dumped into rivers and pollute the waters [44]. The maximum weight in consuming lead contaminated food every week is often called the maximum tolerable intake (MTI) which can be calculated using data on lead concentrations in fish meat. MTI is one of the mechanisms to reduce the effects of heavy metals on health [42]. Based on the calculated MTI in individuals weighing 10 kg, it is known that the maximum weight of Nile Tilapia consumed per week is 2.8 kg/week. In terms of price, Nile Tilapia is more affordable because the price is relatively cheap compared to other protein sources. Tilapia has a price of around IDR 25,000 – IDR 35,000 per kg. The price of Nile Tilapia is cheaper than the price of beef, which is around Rp. 120,000 – Rp. 150,000/kg.

The WHO global target in 2025 is to reduce the prevalence of stunting in children under five by 40%. Complementary feeding with good quality and quantity is one step to achieve this target. One way to improve the quality of complementary food and proven to be significantly correlated with growth is to add animal food sources to complementary food. Food sources with a combination of good nutrition and are local food ingredients are recommended to be used because they have been shown to improve the quality of complementary food [45]. Nile tilapia is a food that is easily available in Indonesia. Based on the results of this study, the nutritional content of Nile tilapia is good and complete so that Nile tilapia can be one of the potential food ingredients for the manufacture of complementary

food. Nile tilapia is also a cheaper source of protein than beef or chicken. This makes Nile tilapia in addition to having good and complete nutritional value to prevent stunting, Nile tilapia is also affordable for people with various economic backgrounds.

Conclusions

Nile tilapia has a calorie content of 1kcal/g with the highest content of macronutrients, namely protein (18.46%). The percentage of amino acids in Nile tilapia is 21.56% with the highest essential amino acid content, namely, lysine (1.84%) and contains eight of nine essential amino acids. Nile tilapia has a fairly high calcium content (74.58 mg/100 g) and a metallic lead content which is still below the ministry of health standard for ready-to-eat complementary food. Nile tilapia also contains 30.39% total fatty acids consisting of saturated fatty acids and unsaturated fatty acids (PUFA and MUFA). Nile tilapia which is widespread in Indonesia and its good nutritional content is one of the potential food ingredients for the manufacture of complementary food.

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