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FORMULATION OF TORO TUNA-BASED INSTANT PORRIDGE WITH ADDITION OF SEAWEED FLOUR FOR BABY COMPLEMENTARY FOOD

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Abstract

The high incidence of malnutrition among children under five in Indonesia underscores the critical need for timely and comprehensive interventions to mitigate its impact. One of the factors contributing to malnutrition in toddlers is a lack of balanced nutrition in complementary food (CF). Fishery commodities such as tuna and seaweed have great potential to be developed into instant complementary food porridge for complementary feeding because they contain amino acids and essential fatty acids that toddlers need for brain and eye development. This research aimed to determine the best formulation for instant MPASI porridge made from toro tuna and seaweed flour based on organoleptic assessment, fatty acid profile, and amino acid profile. The complementary food porridge with toro tuna and seaweed flour consists of four treatments, namely 94%:6%, 88%:12%, 82%:18%, and 76%:24%. The parameters analyzed included sensory tests (appearance, color, taste, and texture), fatty acid profile, and amino acid profile. The present study investigates the optimal formulation of instant complementary porridge (MPASI) for toddlers, emphasizing its significance for brain and eye development. Specifically, the research evaluates porridge made from toro tuna and seaweed flour through organoleptic assessment, fatty acid composition, and amino acid profile analysis. Four formulations were tested, comprising ratios of 94% tuna to 6% seaweed, 88% tuna to 12% seaweed, 82% tuna to 18% seaweed, and 76% tuna to 24% seaweed. The analysis focused on sensory attributes, including appearance, color, taste, and texture, alongside the nutritional profiles of fatty acids and amino acids. Based on the research results, it is known that the differences in the formula of tuna toro and seaweed flour influence the panelists' level of preference for appearance, smell, and taste parameters. Organoleptic evaluation selected the formula with a ratio of 82%:18% as the best. The dominant fatty acids include palmitic acid (SFA) at 33.68%, oleic acid (MUFA) at 45.95%, and linoleic acid (PUFA) at 1.34%. The dominant essential amino acid is leucine at 1.28%, and the dominant non-essential amino acid is glutamic acid at 1.37%.

Keywords: amino acid, fatty acid, glutamic acid, hedonic test, leucine

Formulasi Bubur Instan Berbasis Toro Tuna dengan Penambahan Tepung Rumput Laut Untuk Makanan Pendamping ASI

Abstrak

Kasus gizi buruk pada balita di Indonesia tergolong tinggi dan perlu segera ditangani dengan baik. Salah satu faktor terjadinya gizi buruk adalah kurangnya asupan makanan dengan gizi seimbang pada makanan pendamping ASI (MPASI). Ikan tuna dan rumput laut berpotensi besar untuk dikembangkan

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menjadi bubur MPASI instan karena mengandung asam amino dan asam lemak esensial yang dibutuhkan untuk perkembangan otak dan mata balita. Penelitian ini bertujuan menentukan formulasi terbaik bubur MPASI instan dari tepung ikan tuna toro dan rumput laut berdasarkan penilaian organoleptik, profil asam lemak dan asam amino. MPASI ikan tuna toro dan tepung rumput laut terdiri atas 4 perlakuan, yaitu 94%:6%, 88%:12%, 82%:18%, dan 76%:24%. Parameter yang dianalisis meliputi uji sensori (ketampakan, warna, rasa, dan tekstur), profil asam lemak dan asam amino. Perbedaan konsentrasi tepung ikan tuna toro dan rumput laut memberikan pengaruh terhadap tingkat kesukaan panelis pada parameter ketampakan, aroma, dan rasa. Formula dengan perbandingan 82%:18% terpilih sebagai formula terbaik berdasarkan penilaian organoleptik. Asam lemak yang dominan meliputi asam palmitat (SFA) sebesar 33,68%, asam oleat (MUFA) sebesar 45,95%, dan asam linoleat (PUFA) sebesar 1,34%. Asam amino esensial yang dominan adalah leusina sebesar 1,28% dan non esensial yang dominan adalah asam glutamat sebesar 1,37%. Penggunaan toro ikan tuna dan tepung rumput laut dapat diaplikasikan dalam pembuatan bubur MPASI instan.n

Kata kunci: asam amino, asam glutamat, asam lemak, leusina, uji hedonik

INTRODUCTION

Malnutrition is a persistent and significant problem in Indonesia, particularly among children under the age of five. According to national data from the 2018 Basic Health Research (Riskesdas) report, the prevalence of malnourished and undernourished toddlers, based on body weight for age (BB/U), is 3.9% and 13.8%, respectively. Several factors contribute to malnutrition among Indonesian toddlers, including inadequate nutritional intake during the first 1,000 days of life, from pregnancy to two years of age (Aprilia & Hati, 2016).

Inadequate nutritional intake in young children can contribute to the development of stunting or growth faltering. The effects of stunting are broad, encompassing both short- and long-term consequences. Several negative effects of stunting include increased morbidity and child mortality, a higher risk of infections and non-communicable diseases in adulthood, impaired learning development, and reduced productivity and economic capacity (Beal *et al*., 2017; Wicaksono & Harsanti, 2020). Therefore, adequate intake of breastfeeding, supplementary nutrition, and complementary foods is crucial. Both the Indonesian and global markets widely distribute processed complementary food products. However, Aprilia & Hati (2016) found that the most widely available complementary foods are enriched primarily with cereal-based plant proteins, including grains such as rice, wheat, maize, and millet. While these plant-based proteins provide essential nutrients, they often lack certain essential amino acids. In contrast, fish-derived amino acids, vitamins, and fatty acids are crucial for child development. Nurfaidah *et al*. (2024) have informed that complementary foods that incorporated carp flour and albumin contained essential and nonessential amino acids, including arginine (14.64%) and lysine (26.91%), and fatty acids, including linoleic acid.

Fishery commodities are a valuable food source, as fish protein is highly digestible by the human body (Aprilia & Hati, 2016). Meanwhile, Dogan & Ertan (2017) found that a balanced nutritional intake can be achieved through marine-based foods, as they contain essential amino acids, essential fatty acids (particularly omega-3), and vitamins. According to Andersen *et al*. (2018) and Mohanty *et al*. (2014), fishery products contain essential amino acids such as arginine, glutamate, tryptophan, and sulfur-containing functional groups, including methionine, cysteine, and taurine. This spectrum of amino acids can enhance children's immunity against diseases and improve the absorption of protein and calories, thereby reducing the risk of energy malnutrition. Additionally, fishery commodities are a primary source of healthy unsaturated fatty acids. Zhang *et al*. (2020) and Durmus (2018) found that different types of fish have healthy fatty acids, especially good for children's eye and brain growth, like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

One of the potential fisheries commodities that can be developed into instant complementary food porridge is toro tuna and seaweed. Toro is the fatty meat of tuna, which is in its belly (Oksuz, 2017). Nugroho *et al*. (2020) and Peng *et al*. (2013)

mentioned that the prominent amino acids in tuna are lysine, leucine, phenylalanine, and tyrosine. Meanwhile, DHA and MUFA account for most of the unsaturated fatty acids. According to the findings of Setha *et al*. (2024), providing processed tuna-based food for 36 days resulted in an increase in children's height and weight by 3.22 cm and 1.12 kg, respectively. This study indicates a significant difference between the conditions before and after the introduction of tuna-based complementary food.

People recognize seaweed as a food ingredient rich in antioxidant compounds, soluble dietary fiber, protein, minerals, vitamins, phytochemicals, and polyunsaturated fatty acids. Recent studies have shown that different types of seaweed, like red, brown, and green, may help with health and treating diseases, making them useful as alternative medicines. According to the Indonesian Ministry of Fisheries and Marine Affairs (KKP), seaweed and tuna production in 2020 reached approximately 9 million tonnes and 300 thousand tonnes, respectively. A significant portion of tuna production is allocated to the loin industry, which yields 39.7% of the product, while the remaining 60.3% consists of waste, including the unutilized toro part. This underutilized potential presents an opportunity for complementary food production to help reduce malnutrition. The manufacturing of complementary food requires an accurate formulation, as its determination is a crucial aspect of food product development (Widyantari, 2020; Vandevijvere & Vanderlee, 2019). This research aimed to determine the optimal formulation for complementary food porridge formulated with toro tuna and seaweed flour based on organoleptic evaluation, fatty acid, and amino acid profile.

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MATERIALS AND METHOD

Formulation of Infant Porridge Complementary Food

Toro of yellowfin tuna (*Thunnus albacares*) was prepared by removing the inedible parts that refer to (BSN, 2005). The remaining tuna flesh was then minced and weighed for use in the formulation of complementary infant porridge (MPASI). The initial stage of the formulation involved stir-frying the minced toro tuna with unsalted butter (Anchor), along with sliced shallots and garlic. The stir-fried mixture was subsequently combined with other primary ingredients, including white rice, commercial seaweed flour made from nori and wakame (Crystal of the Sea), and bone broth (babyplus.id). The composition of toro tuna and seaweed flour accounts for the variation in the formulation. The complementary food porridge with toro tuna and seaweed flour consists of four treatments, namely 94%:6%, 88%:12%, 82%:18%, and 76%:24%. The combined ingredients were then added with 170 mL of water and cooked using a slow cooker (Baby Safe) for 2 hours, following the porridge cooking method. The porridge was then cooled at room temperature until it reached ambient temperature, followed by drying at 70°C for 10 hours using a food dehydrator (LocknLock). The dried porridge was subsequently ground with a food grinder (Fomac) to produce granules. Table 1 presents the formulation details of the instant complementary food.

Hedonic Test

Anandito *et al.* (2016) conducted the organoleptic or hedonic test with 30 untrained panelists. The requirement for a panelist was a mother who had a baby aged between 6 and 24 months. The instant porridge was prepared by adding and stirring hot water at 80°C, using a porridge flour-to-water ratio of 1:4. The sensory evaluation assessed five parameters: appearance, color, odor, flavor, and texture. Mothers, acting as panelists, directly evaluated each assessment parameter. This was done because mothers are accustomed to tasting complementary foods (MPASI) preferred by their babies. A 7-point rating scale was employed, with the following criteria: 1 (strongly dislike), 2 (dislike), 3 (somewhat dislike), 4 (neutral), 5 (somewhat like), 6 (like), and 7 (strongly like).

Fatty Acid Analysis

Fatty acid analysis refers to Azka *et al.* (2015). Fatty acid analysis involved three steps: extracting the fatty acids, turning them

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Table 1 Complementary food porridge formulation from toro tuna and seaweed flour
Tabel 1 Formulasi bubur MPASI toro tuna dan tepung rumput laut

Ingredients (%)	Sample from toro tuna:seaweed flour treatments (%)			
	94:6	88:12	82:18	76:24
Toro tuna	19.06	17.87	16.68	15.49
Seaweed flour	1.19	2.38	3.57	4.76
White rice	47.66	47.66	47.66	47.66
Unsalted butter	16.68	16.68	16.68	16.68
Bone broth	15.41	15.41	15.41	15.41
Total	100	100	100	100

into methyl esters, and identifying them using gas chromatography (GC) with a Shimadzu GC 2010 Plus and SupelcoTM 37 Component FAME Mix. Fatty acid analysis was performed without replication. The first step was fatty acid extraction, in which fatty acid was extracted by Soxhlet methods, which subsequently obtained oil phase extract. Thereafter, 20–30 mg of oil was separated.

The second step was methyl ester formation (methylation). Fat or oil as much as 20–30 mg was weighed in NaOH 0.5 N in methanol and was heated in a water bath for 20 minutes, then 2 mL BF3 20 % was added for 20 minutes with subsequent cooling and addition of 2 mL saturated NaCl and 1 mL hexane with shaking until homogenous. The hexane layer was transferred with a pipette into 0.1 g Na_{2SO_4} anhydrate and incubated for 15 minutes. Then, liquid fraction was injected into GC.

Fatty acid identification, the final step, involved injecting the methyl ester into a gas chromatography (GC) instrument under the following conditions: The Supelco 37 fatty acid standard was used, along with a FAME mix component. The mobile phase was nitrogen gas with a flow rate of 20 mL/min, while the combustion gas was hydrogen with a flow rate of 30 mL/min. A Quadrex fused silica 007 cyanopropyl methyl siloxane capillary column, which is 60 mm long and has an inner diameter of 0.25 mm, was used to separate the components. The temperature was set at 125°C, increasing at a rate of 5°C per minute until reaching 225°C. The injector and detector temperatures were 220°C and 240°C, respectively.

Amino Acid Analysis

Amino acid analysis refers to Azka *et al.* (2015). Amino acid analysis was done using High Performance Liquid Chromatography (HPLC) (Shimadzu LC-10 AD, ODS Column) and included 4 steps: preparing the protein hydrolysate, drying it, changing it for analysis, and then injecting it for the amino acid analysis. Amino acid analysis was performed without replication. The first step was hydrolysate protein preparation. A 0.1 g sample was weighed and crushed, followed by the addition of 10 mL of 6 M HCl, then heated in an oven at 100°C for 24 hours to accelerate hydrolysis. The second step was sample drying, which aimed to remove and separate the solution from its solid componpart of the collected protein solution was combined with 30 µL of a drying solution made uphich consisted of methanol, picothiocyanate, and trimethylamine in a 4:4:3 ratio.

The third step was derivatization. The dried product was combined with 30 µL of a solution made of methanol, sodium acetate, and trimethylamine in a 3:3:4 mix. Derivatization was performed to enhance sample detection. Subsequent drying was carried out by adding 20 mL of 60% acetonitrile or 1 M NaOH, followed by 20 minutes of exposure. The derivatized product was then filtered, and 40 µL was injected into the HPLC for analysis. Amino acid concentration was determined using the chromatogram standard addition method, where a standard amino acid solution was treated similarly to the sample. The amino acid content was calculated using the following formula:

$$\text{Amino acid (\%)} = \frac{\text{sample area} \times C \times FP \times BM}{\text{standard area} \times \text{sample mass}}$$

Note:
C = amino acid standard concentration (μg/ mL)
FP = dilution factor
BM = molecular weight of each amino acid (g/mol)

Data Analysis

This study employed a Completely Randomized Design (CRD) with four treatment formulations for instant complementary food porridge. All obtained data were tabulated using Microsoft Excel 2013®. A descriptive analysis was conducted to examine the amino acid and fatty acid profiles of the complementary food porridge. Meanwhile, organoleptic data were analyzed using multivariate analysis. Both analyses were performed using MINITAB 16.

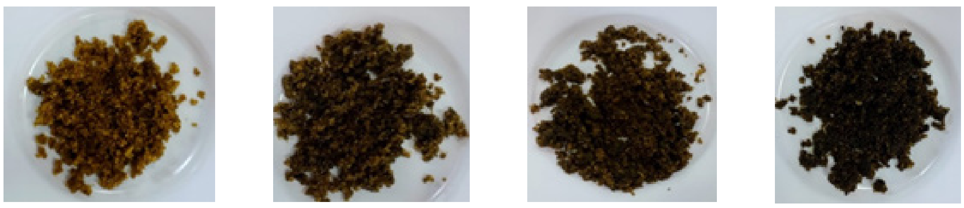
RESULTS AND DISCUSSION

Physical Appearance of Granule and Complementary Food Porridge

The manufacturing of toro tuna–seaweed flour instant complementary food porridge involved four different treatments, varying in the percentage of toro tuna and seaweed flour. These differences in formulation impacted the physical appearance of the granules, as shown in Figures 1 and 2.

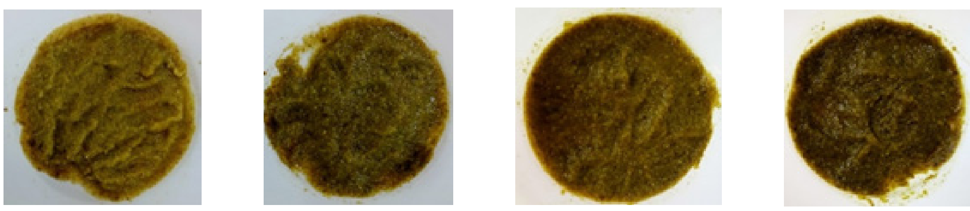
The complementary food porridge granules' color differences are due to formulation differences. The addition of seaweed flour caused the color to become progressively darker green. In product development, consumer acceptance is a crucial factor. Organoleptic evaluation, which involves assessing the product's appearance, color, odor, flavor, and texture, is commonly conducted to determine its sensory attributes. Table 2 presents the organoleptic test results.

Panelists' favorability ratings served as the basis for the organoleptic evaluation of the toro tuna and seaweed flour complementary food porridge. As shown in Table 2, differences in formulation influenced panelists' preferences for appearance, odor, and flavor ($p<0.05$), while texture was not significantly affected. The appearance parameter for the 94%:6% treatment showed a significant difference compared to the other three treatments. The odor parameter for the 94%:6% and 88%:12% treatments differed significantly from the other two treatments. The flavor parameter for the 94%:6% and 82%:18% treatments exhibited significant differences compared to the other two treatments. Additionally, the texture parameter for the 94%:6% and



94:6 88:12 82:18 76:24

Figure 1 Granule physical appearance of toro tuna and seaweed flour complementary food
Gambar 1 Tampilan fisik granula MPASI toro ikan tuna dan tepung rumput laut



94:6 88:12 82:18 76:24

Figure 2 Physical appearance of toro tuna and seaweed flour complementary food porridge
Gambar 2 Tampilan fisik bubur MPASI toro ikan tuna dan tepung rumput laut

Table 2 Average value of hedonic test for instant baby porridge of complementary food
Tabel 2 Nilai rata-rata uji hedonik bubur bayi MPASI instan

Parameters	Sample treatments (%)			
	94:6	88:12	82:18	76:24
Appearance	7.00±1.11^{a}	6.00±1.75^{b}	6.00±1.44^{b}	5.00±1.25^{c}
Odor	5.00±1.13^{a}	5.00±1.57^{a}	6.00±1.31^{b}	6.00±1.33^{b}
Flavor	6.00±1.17^{a}	5.00±1.44^{b}	7.00±1.18^{a}	6.00±1.07^{c}
Texture	6.00±1.25^{a}	6.00±1.31^{ab}	6.00±1.11^{a}	6.00±1.20^{b}

Different superscript notation in the same row indicated a significant difference at $p<0.05$

82%:18% treatments demonstrated significant differences when compared to the other two treatments.

The organoleptic test was conducted to determine the optimal formulation based on consumer preference. Based on the results, Formula 82%:18% was selected as the best complementary food formulation because it demonstrated an average organoleptic score of 6 and 7 for each observation parameter. A score of 6 indicates a favorable preference from the panelists, while a score of 7 indicates a strong preference.

According to the analysis results, the variation in toro tuna and seaweed flour content had a significant effect ($p<0.05$). The darker color observed in the formulations was attributed to the higher seaweed flour content, which originated from red and brown seaweed containing various pigments. De Fretes *et al.* (2012) found that red algae mainly contain pigments like chlorophyll a and d, zeaxanthin, lycopene, cryptoxanthin, α-carotene, β-carotene, lutein, and phycobilin. Similarly, Indrawati *et al.* (2015) reported the presence of fucoxanthin, chlorophyll c, and pheophytin c in brown algae. The combination of these pigments produces a greenish-yellow color in the flour, which in turn affects the color variation of the complementary food porridge. Meanwhile, the 76%:24% formulation exhibited a dark green color due to its higher seaweed flour content.

Odor is an important role parameter to prefer the food product due to people's habit of smelling odor before tasting. An alkali amino acid, proline, accounts for most of the fish flesh amino acids, which cause the fishy smell (Kusfriyadi & Nabilah, 2022). Similarly, fish flesh and seaweed flour have a slight fishy odor, which emerges as a new odor (Kesuma *et al.*, 2015). Hence, the addition of these materials affects the odor of complementary food. Higher fish content diminished the panelist's favorability of complementary food.

Five main flavors of food: sweet, sour, salty, bitter, and umami (Chan & Cheung, 2010). Meanwhile, the abundance of carbohydrates, minerals, and amino acids gives rise to the flavors of sweet, salty, and umami. In the formula 82%:18%, it was more acceptable by the panelist as the ratio between tuna toro and seaweed flour is similarly proportional. Furthermore, the content of toro tuna was influential in flavor; Hustiany (2016) stated that unsaturated fatty acids are prone to oxidation. The lipophilic nature of fat allows the dissolution of hydrophobic flavor compounds, such as esters, aldehydes, and ketones. The presence of fat helps retain these compounds for a longer duration, allowing the gradual release of aroma and taste during consumption. Furthermore, the decomposition of unsaturated fatty acids during the heating process contributes to the development of umami taste and a distinctive aroma. Manik *et al.* (2020) researched that higher tuna content leads to the savory flavor of biscuits due to its amino acid content. Aldehyde compound, which is synthesized from fat degradation, is influential in the flavor of fishing products (Mansur *et al.*, 2003).

The acceptance rate of food products is also determined by texture, as it influences the image. Setyaningsih *et al.* (2010) stated that the texture imaging is related to three elements: mechanic (stiff, chewy), geometric (sandy or crumbly), and mouthfeel (oily, watery). The complementary food porridge's hedonic test result yields 6 favorability points.

Fatty Acid Profile

Fatty acids are natural substances made up of a chain of 4 to 24 carbon atoms, with one carboxyl group at one end and a long chain of hydrogen and carbon atoms. The biological functions of fats include energy storage, structural components of cell membranes, and signal transduction. Although fatty acids can be synthesized through metabolism, certain essential fatty acids can only be obtained through dietary intake (Francavilla *et al*., 2013).

Fatty acids in food are categorized into three main groups: saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) (De Alencar *et al*., 2018). Fatty acid profile analysis is conducted to determine the types and concentrations of fatty acids present in a given food. Table 3 presents the fatty acid profile of the complementary food porridge.

According to the result of the fatty acid profile analysis, it was found that the formula 94%:6%, 88%:12%, and 82%:18% contained 5 types of saturated fatty acids (SFA): capric, lauric, myristic, palmitic, and stearic acid, and one monounsaturated fatty acid (MUFA) is oleic acid, as well as two polyunsaturated fatty acids (PUFA): linoleic and linolenic acid. Meanwhile, on the formula 76%:24%, only four types of SFA were detected, where capric acid is undetected, as well as one MUPA oleic acid and one PUFA linolenic acid. Oleic acid and palmitic acid were the first and second most abundant fatty acids, respectively. Hence, the percentage of toro, tuna, and seaweed flour affected the difference in fatty acid constituents. Nurfaidah *et al. (2024)* found that porridge made with carp flour and albumin has a lot of linoleic acid, which makes up 68.98% of all the fatty acids.

Palmitic acid is SFA, which accounts for most of the fatty acid in marine fish (Sahena *et al*., 2010; Elsdon, 2010). Yellowfin tuna contains a number of fatty acids, either SFA, MUFA, or PUFA. According to the research of Domingues *et al*. (2021), white flesh of tuna, which is harvested from three oceans—Pacific, Indian, and Atlantic—accounts palmitic acid as the most SFA by 20–30%, while oleic acid accounts for the most PUFA by 12–15%.

Table 3 Fatty acid profile of toro tuna and seaweed flour complementary food porridge
Tabel 3 Profil asam lemak bubur bayi MPASI toro tuna dan tepung rumput laut

Type of fatty acid (%)	Sample treatments (%)			
	94:6	88:12	82:18	76:24
Saturated Fatty Acid (SFA)				
Capric acid	0.09	2.87	1.68	-
Lauric acid	4.58	4.63	3.46	5.28
Myristic acid	11.66	11.85	10.61	9.85
Palmitic acid	31.58	30.76	33.68	27.93
Stearic acid	1.70	1.43	0.92	0.36
Total SFA	**49.61**	**51.54**	**50.32**	**43.42**
Monounsaturated Fatty Acid (MUFA)				
Oleic acid	41.29	39.76	45.95	34.36
Total MUFA	**41.29**	**39.76**	**45.95**	**34.36**
Polyunsaturated Fatty Acid (PUFA)				
Linoleic acid	1.84	1.12	1.34	1.58
Linolenic acid	0.10		0.28	-
Total PUFA	**1.94**	**1.40**	**1.62**	**1.58**

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Commercial seaweed flour consisted of a mix of red algae of *Porphyra* (nori) and brown algae *Undaria pinnatifida* (wakame). Both types of seaweed contain several fatty acids, either SFA, MUFA, or PUFA. Meanwhile, *Porphyra* seaweed contains myristic, palmitic, stearic, oleic, linoleic, and linolenic acid (Dawczynski *et al*., 2007; Arakaki *et al*., 2023). Also, *Undari pinnatifida* (wakame) contains similar fatty acids (Dawczynski *et al*., 2007). According to Dawczynski *et al.* (2007) research, *Porpyra* contains SFA by 43.78%, MUFA by 19.83%, and PUFA by 33.94%. Meanwhile, *U. pinnatifada* contains SFA 17.4%, MUFA 6.51%, and PUFA 73.79%. Palmitic acid accounts for most of the fatty acid in *Porphyra* by 37.1%, while stearidonic acid accounts for most of the fatty acid in *U. pinnatifida* by 25.8%.

Both the toro flesh of tuna fish and seaweed flour contribute the fatty acid for infant porridge. It is expected that the fatty acid intake from mother's milk complementary food is balanced with mother's milk. According to Delplanque *et al*. (2015) and He *et al*. (2016), mother's milk contains SFA between 34–47%, particularly palmitic acid by 17–25%. All four of the complementary food porridge contain SFA between 43–51%, with palmitic acid accounting for 27–33%.

Postpartum produced mother's milk within 15 days contains a number of MUFA by 44%, which is accounted mostly by oleic acid by 90% of total MUFA (Barreiro *et al*., 2018). All four complementary foods contained MUFA between 34 and 45% with oleic acid detected. Also, a number of PUFAs in mother's milk are found: arachidonic acid (AA) by 0.51%, docosahexaenoic acid (DHA) by 0.39%, linoleic acid (LA) by 14.6%, and linolenic acid (ALA) by 0.42% (Hernandez *et al*., 2019). Meanwhile, in complementary food porridge, LA and ALA were found between 1.1-1.8% and 0.1–0.2%, respectively.

Amino Acid Profile

At the time of infant growth, the amino acid intake from mother's milk and complementary food is needed to assist the brain and immunity development. Essential amino acids are not produced by the body; hence, they are only fulfilled from food intake. According to Semba *et al*. (2016), essential amino acid intake is crucial for various physiological roles such as protein-forming nutrition, hormone synthesis, and neurotransmitter function. Manufacturing complementary food porridge requires maintaining the amino acid content. Use of animal-source food such as fish is a method to fulfill the amino acid. In Table 4, the amino acid content of all four complementary food porridge is displayed.

Table 4 shows that all four formulations of complementary food porridge contained eight essential amino acids and seven non-essential amino acids. The most abundant essential amino acid was leucine, while the predominant non-essential amino acid was glutamic acid. Both amino acids were derived from the primary ingredients: yellowfin tuna toro and seaweed flour. Nurfaidah *et al.* (2024) found that porridge made with carp flour and albumin had the most essential and non-essential amino acids, with arginine making up 14.64% and lysine making up 26.91%.

Arbajayanti *et al*. (2021) reported that yellowfin tuna contains leucine amino acid by 17.96 mg/g and glutamic acid 32.96 mg/g. Glutamic acid is the most dominant non-essential amino acid in yellowfin tuna flesh (Peng *et al*., 2013). Dawczynski *et al*. (2007) also reported that seaweed of *Porphyra* sp. and *U. pinnatifida* contains several amino acids with glutamic acid and aspartic acid as the most prominent.

Leucine amino acid is required in the children's growth, particularly for the regulation of the formation and breaking of protein as well as an energy source for muscle (Grooper *et al*., 2018). In the children's growth, leucine and lysine amino acids enhance the work of growth hormone that affects the bone growth by regulating cell division and differentiation (Smith *et al*., 2005). Glutamic amino acid is widely found in various animal source foods, which naturally constitute its protein, such as beef, chicken, and marine organisms (Jacoeb *et al*., 2012). In addition, glutamic acid determines the flavor,

Table 4 Amino acid profile of toro tuna and seaweed flour complementary food porridge
Tabel 4 Profil asam amino bubur bayi MPASI toro tuna dan tepung rumput laut

Type of amino acid (%)	Sample treatments (%)			
	94:6	88:12	82:18	76:24
Tyrosine	0.50	0.46	0.47	0.51
Valine	0.86	0.80	0.84	0.87
Methionine	0.61	0.55	0.58	0.63
Isoleucine	0.81	0.72	0.77	0.85
Leucine	1.37	1.31	1.28	1.30
Phenylalanine	0.69	0.60	0.62	0.65
Lysine	1.18	1.20	1.12	1.19
Tronine	0.77	0.70	0.73	0.95
Tryptophane	-	-	-	-
Histidine	0.52	0.48	0.56	0.63
Arginine	0.62	0.65	0.59	0.69
Total essential amino acid (%)	7.93	7.47	7.56	8.27
Aspartic acid	1.34	1.30	1.37	1.52
Glutamic acid	1.85	1.79	1.37	2.11
Serine	0.60	0.55	0.62	0.72
Glycine	0.44	0.40	0.41	0.50
Alanine	0.54	0.51	0.58	0.62
Proline	0.33		0.28	0.33
Cysteine	0.29	0.31	0.38	0.42
Total non-essential amino acid (%)	5.39	5.22	5.01	6.22

which stimulates appetite in infants as well as influencing brain work by the gut– brain axis (Zai *et al*., 2009).

CONCLUSIONS

The selected complementary food porridge formulation was Formula 82%:18%, based on the results of the hedonic test assessment. The dominant fatty acids identified were palmitic acid (SFA), oleic acid (MUFA), and linoleic acid (PUFA). Additionally, leucine was the most abundant essential amino acid, while glutamic acid was the most dominant non-essential amino acid.

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