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Formulation of Ready-to-Use Fish Food Based on Mackerel (*Scomberomorus*) and Catfish (*Clarias gariepinus*)

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ABSTRACT

This study developed Ready-to-Use Fish Food (RUFF) as a high-energy, high-protein recovery food for children under five with severe acute malnutrition, using mackerel and catfish powders as animal protein sources. Four RUFF variants were formulated with skim milk powder, mackerel powder, catfish powder, and a mixture of both fish powders. Nutritional analysis included moisture, ash, protein, fat, carbohydrates, and energy content, which were compared to Codex Alimentarius (CXG 95-2022) standards. Protein ranged from 2.31 to 4.61 g/100 kcal, fat from 5.64 to 6.25 g/100 kcal, carbohydrates from 6.79 to 9.44 g/100 kcal, and energy from 524 to 550.49 kcal/100 g, meeting FAO/WHO criteria for therapeutic foods. The sensory acceptability was assessed using a hedonic test with toddlers aged 2 to 5 years using a Balanced Incomplete Block Design. Scores ranged from 1 (like), 2 (neutral), and 3 (dislike), analyzed by ANOVA and Tukey's test. The mixed fish powder variant had the least preference (mean score 2.08, neutral), while catfish, mackerel, and skim milk variants were liked (scores 1.23 to 1.83). Results confirm that these RUFF variants are nutritionally adequate and well accepted, supporting their use as an effective alternative to RUTF for malnourished toddlers.

1. INTRODUCTION

Indonesia faces a serious challenge known as the triple burden of malnutrition, which includes undernutrition, overnutrition, and micronutrient deficiencies. Acute malnutrition categorized as undernutrition includes wasting (UNICEF/WHO, 2017). Data from the Indonesian Nutritional Status Survey (SSGI) by the Ministry of Health of Indonesia in 2023 shows an increase in the prevalence of wasting by 0.6%, from 7.1% in 2021 to 7.7% in 2022. For comparison, the wasting prevalence in 2019 was 7.4%. This indicates that wasting remains a serious issue in Indonesia, as its prevalence is still far from the Sustainable Development Goals (SDGs) target of less than 5% wasting (Development Initiatives Poverty Research, 2020). The classification of wasting conditions is based on anthropometric measurements and clinical status, encompassing the categories of moderate acute malnutrition and severe acute malnutrition. Severe acute malnutrition is a major cause of immunodeficiency worldwide, particularly in newborns, children, adolescents, and the elderly, making these groups more vulnerable to infections (Black *et al*., 2013). Fish is a source of animal protein, essential fatty acids, vitamins, and minerals that are easily digested and abundantly available in Indonesia. However, fish consumption among toddlers is still low due to limited access, eating habits, and a lack of practical processed products suitable for early childhood needs. Fish contains a high protein content of around 43%, low saturated fatty acids, and high unsaturated fatty acids. Fatty acids are needed by toddlers as nutrients for brain development and to strengthen the immune system against diseases (Diana, 2013; Mervina *et al*., 2012).

Spanish mackerel and catfish are important and abundant sources of protein and nutrients in Indonesia, with annual production of approximately 165,957 tons and 656,684 tons, respectively (Jumsurizal *et al*., 2014). The high availability of Spanish mackerel indicates a significant potential marine resource that supports the sustainability of the fishing industry in Indonesian waters. In addition to Spanish mackerel, catfish also have a large availability in Indonesia, with production reaching 656,684 tons per year (BPS 2020). According to a study by Mervina *et al*., (2012), protein content in catfish ranges from 17.7% to 26.7%. Important minerals such as selenium (26% RDA), phosphorus (24% RDA), and potassium (19% RDA) are also found in this fish, supporting bone health, metabolism, and organ function (Astawan, 2008). These advantages make Spanish mackerel and catfish complete sources of nutrition and highly potential local food resources to address malnutrition in toddlers. One effort to improve the nutritional status of toddlers is through the provision of therapeutic nutritional foods such as Ready-to-Use Therapeutic Food (RUTF). RUTF is a lipid-based product enriched with nutrients designed to treat acute malnutrition in children aged 6–59 months. In the production of RUTF, about 50% of the protein comes from milk powder. Due to limited milk supply in Indonesia, UNICEF (2019) recommends using local ingredients like fish and legumes as substitutes for milk. One alternative product developed is Ready-to-Use Fish Food (RUFF), which is formulated as a therapeutic nutritional food with nutritional and energy values equivalent to milk-based RUTF. A similar product is Num'Trey, developed in Cambodia, which is a fish flour-based food used as a milk fortification alternative (Sigh *et al*., 2018). RUFF can be served in semi-solid forms such as paste or cream, as well as in solid forms like bars or biscuits. The development of RUFF must follow the Codex guidelines (CXG 95-2022) issued by FAO & WHO (2022). RUFF is developed as a ready-to-eat product that can be consumed immediately without cooking, making it practical and easy to use in various situations, especially to meet nutritional needs quickly and efficiently. This study aims to develop a Ready-to-Use Fish Food (RUFF) formulation that provides optimal nutritional value and ensures good organoleptic acceptance by the target users.

2. MATERIALS AND METHODS

2.1. Materials

The tools used in this research for producting RUFF consist of a digital food scale, a large mixing bowl or container merk lock and lock, oven (LabTach), kitchen blender (Philips), spluit filling, and 80-mesh sieve. For the proximate analysis, the instruments include an analytical balance merk Shimadzu, aluminum and porcelain crucibles, furnance (Ovan), oven (LabTech), desiccator, water bath (Ovan), Kjeldahl flask, digester (Buchi), glasswares (Iwaki).

The materials involved in RUFF production are handmade mackerel powder, handmade catfish powder, icing sugar merck Ratu bought from a baking supply store, coconut oil, peanut, and Isolate Soy Protein (ISP) bought from marketplace. The chemicals used for analyzing the RUFF were analytical grade from Merck comprised n-Hexane, sodium hydroxide 40%, boric acid 30%, sulfuric acid 98%, hydrocloric acid 0.13 N, methyl red 0.1 N, and methylene blue indicators, distilled water, and a selenium mixture.

2.2. Methods

2.2.1. Fish Powder Production (Mervina *et al.,* 2012; Rimbawan *et al.,* 2022)

The ingredients for produced catfish powder and mackerel powder were catfish and mackerel fillets. The fish fillets were steamed for 15 minutes and dried using an oven at 70 °C for 10 hours. After drying, the fish meat was homogenized using a blender at 18000 rpm and sieved using an 80-mesh sieve. The fish powder produced was then stored in an aluminum foil pouch and sealed airtight at room temperature.

2.2.2. RUFF Wafer Roll Product Manufacturing and Nutritional Content Analysis

The dry ingredients, consisting of fish powder, sugar, and cocoa powder, were homogenized using a blender for about 30 seconds at a speed of 18000 rpm. Then the mixture of dry ingredients was combined with peanut butter and vegetable oil, and homogenized for about 30 seconds until all the ingredients were dissolved in the oil. All the mixed ingredients were then added with a texturizer, mineral mix, and ISP (isolated soy protein) until a paste was formed (± 60 seconds). The RUFF paste was put into the wafer roll casing. The ratio of RUFF pastes to wafer roll was 1:4.

2.2.3. Proximate Analysis

Proximate analysis was conducted to determine the moisture, ash, fat, protein, and carbohydrate content in the samples. Moisture content was measured by drying the samples at 105°C until a constant weight was achieved, following AOAC (2005) standards. Ash content was determined by incinerating the samples in a furnace at 550°C for 6 hours until white ash remained, according to AOAC (2005). Fat content was extracted using the Soxhlet method with ether solvent for 6 hours, in accordance with AOAC (2005). Crude protein content was determined using the Kjeldahl method, which measures total nitrogen content and converts it to protein using a factor of 6.25. Carbohydrate content was calculated by difference, subtracting the sum of moisture, ash, fat, and protein from 100% (Tamimi, 2019).

2.2.4. Sensory Analysis

The hedonic ranking test was carried out by the protocol of the Research Ethics Commission Involving Human Subjects of Bogor Agricultural University Number 1130/IT3. KEPMSM-IPB/SK/2023. The sensory data collection method was carried out using the Home Use Test method and involved 70 panellists of toddlers aged 2–5 years accompanied by parents/guardians of toddlers. Toddlers who had allergies to fish, milk, nuts, and their processed foods were not included in this study. Each panellist was provided with two test samples with different formulas that have been determined based on the balance incomplete block design. The data collection was repeated in each formula 35 times. The attributes tested were the overall score and the rating scale used included 1 (like), 2 (neutral), and 3 (dislike) presented in the face symbol.

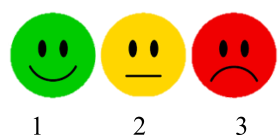

Figure 1. Symbol of the hedonic test score value of 1 (like); 2 (neutral); 3 (dislike)

2.2.5. Data Analysis

The research results were analyzed using a Completely Randomized Design (CRD) and processed with MiniTab21 software and Microsoft Excel. The standard deviation was calculated, and ANOVA test was performed at a significance level of α = 0.05. Tukey's post hoc test was used to compare significant differences.

3. RESULTS AND DISCUSSION

3.1. Nutritional Content of Fish Powder

Proximate analysis of mackerel powder and catfish powder showed significant differences in nutrient composition that affected the formulation of RUFF. The proximate test data of mackerel powder and catfish powder are presented in Table 1. The chemical composition of fish powder varies, influenced by the type and quality of raw materials, fish species, and processing methods (Shaviklo, 2015). The moisture and ash content of Spanish mackerel fish powder are 7.07% and 3.88%, respectively, while catfish powder has a moisture content of 10.01% and ash content of 2.80%. The differences in moisture and ash content between the two fish powders are caused by variations in their nutritional composition. A higher ash content in mackerel indicates a greater mineral content. Mineral content in RUFF mackerel

Table 1. Nutritional content of fish powder

Nutritional Content (% w/w)	Mackerel Powder	Catfish Powder
Moisture Content	7.07 ± 0.14^{a}	10.01 ± 0.14^{b}
Ash Content	3.88 ± 0.20^{b}	2.80 ± 0.52^{a}
Protein Content	76.24 ± 0.02^{b}	50.71 ± 1.65^{a}
Fat Content	12.16 ± 0.03^{a}	35.54 ± 2.23^{b}
Carbohydrate	0.65 ± 9.27^{a}	1.94 ± 0.14^{b}

Description: 1) The value shown is the average±standard deviation, n = 2; 2) Different lowercase letters indicate significant differences. ANOVA was followed by Tukey's Post Hoc test with a significance level of α = 0.05.

is quite rich, especially in calcium, phosphorus, potassium, magnesium, selenium, and other micronutrients that support bone health, the immune system, and general body function (Suad & Novalina, 2019). The protein content of mackerel powder is 76.24%, which is higher compared to the protein content of catfish powder, which is 50.71%. This makes mackerel powder source of high protein and superior essential amino acids. The high protein content reflects the superiority of mackerel as a nutrient-rich ingredient for RUFF. According to USDA (2018), complementary amino acid profiles are possessed by mackerel and catfish, by which a balanced supply of essential amino acids is provided. Lysine and leucine are found in high amounts in mackerel, while higher amounts of methionine, threonine, and valine are offered by catfish. This combination plays a role in effectively supporting protein synthesis, metabolic functions, growth, and nutritional recovery. The fat content in mackerel powder is 12.16%, while the fat content in catfish powder is 35.54%. The high fat content in catfish can be utilized to meet the high energy requirements in the RUFF formulation. This is because fats significantly support energy needs, as fats have a higher energy density compared to proteins and carbohydrates (FAO/WHO, 2018). To achieve balanced nutrition, the RUFF formulation must integrate these two ingredients. This combination is important so that protein can support growth while fat provides the necessary energy and carbohydrates in RUFF provide support metabolic balance, ensuring that growth and bodily functions operate optimally.

3.2. Formulation of Ready to Use Fish Food (RUFF)

The manufacture of RUFF products consists of the determination of specifications of final product and formulation. The specifications of the final product used refer to the Ready-to-Use Therapeutic Food (RUTF) products issued by FAO & WHO (2022). Recommended food ingredients use local ingredients, are high in nutrients, are affordable, and are acceptable (Novia *et al*., 2022). Animal protein sources in RUFF products are mackerel powder, catfish powder, and skim milk. According to data that has been reported by FAO/WHO (2018), as many as 42% of children under the age of 5 in the world experienced anaemia caused by iron deficiency. This formulation aims to provide food that is high in energy, protein, and micronutrients for the treatment of severe acute malnutrition in children. The selection of raw materials is conducted selectively, prioritizing local resources with optimal nutritional profiles, economical prices, and high community acceptance (Novia *et al*. 2022). The RUFF product not only functions as a dense source of nutrients capable of meeting daily caloric needs optimally but also provides essential amino acids important for tissue repair and enhancing children's immune systems during the recovery period. This aligns with the findings of Bhowmik *et al*. (2022), which emphasize that RUTF formulations must meet high energy and protein requirements to support children's optimal growth and development. Peanuts are one of the legume commodities that have a considerable fat content. Its largest components are composed of unsaturated fatty acids, especially oleic acid and linolenic acid, which have an important role for health because they can lower LDL-cholesterol levels in the blood (Trustinah & Kasno, 2012). The content of oleic acid and linolenic acid in peanuts from total fat is 70.8–85.4%. Meanwhile, the vegetable oil used in this study was coconut oil, and it was reported coconut oil had the main components lauric acid of 32.73% (Novilla *et al*., 2017). Lauric acid is known for its antimicrobial, anti-inflammatory, and antitumor (Ameena *et al*., 2024). Malnourished children face an increased risk of infection and a weakened immune system. The lauric acid content in RUFF can support growth recovery and reduce the inflammatory response in malnourished children (Sihombing *et al*., 2025). These two ingredients are needed in the manufacture of RUFF wafer roll products to increase their fat content, with an adequate fat content in RUFF, these benefits can be obtained, so RUFF not only provides energy but also supports overall health and growth recovery in children suffering from malnutrition. Isolate Soy Protein (ISP) is added as a high-quality plant protein source beneficial for children with lactose intolerance, providing essential amino acids and supporting tissue repair. Mineral-vitamin premix is also included to supply important micronutrients like iron, zinc, magnesium, and copper, addressing mineral deficiencies in severely malnourished children (Novilla *et al*., 2017). The RUFF paste formulation is presented in Table 2.

The formulation of RUFF paste products is carried out by determining four formulas, where each formula uses a different source of animal protein. This difference in formulation is carried out to find out which formulation has the best nutritional content and sensory attributes preferred by consumers under five. From all RUFF formulas, the amount of protein, fat, and carbohydrates will be calculated to be able to meet the standard nutrient composition according to the reference set by FAO & WHO (2022).

Table 2. Recipe for produce RUFF paste

Composition (g/100g)	RUFF skim milk	RUFF Mackerel	RUFF Catfish	RUFF mixed mackerel and catfish
Mackerel powder	0	20	0	10
Catfish powder	0	0	20	10
Skim milk	20	0	0	0
Refined sugar	18	18	18	18
Cocoa powder	5	5	5	5
Peanut	30	30	30	30
Vegetable oils	18	18	18	18
Texturizer	2	2	2	2
Isolate Soy Protein	5	5	5	5
Mineral-mix	2	2	2	2
Total			100	

3.3. RUFF Nutritional Content

The nutritional content analysed in RUFF wafer roll products includes water content, ash content, protein content, fat content, carbohydrates, and energy. The results of the analysis of the nutritional and energy content of RUFF wafer roll products meet the minimum standards of nutritional composition per 100 g of RUTF by the reference standards from FAO & WHO (2022). The results of the analysis of RUFF wafer roll are shown in Table 3. The results of the analysis of RUFF wafer roll products are shown in Table 3.

Table 3. Nutrient composition of RUFF wafer roll products

Nutrients (% w/w)	Wafer roll RUFF skim milk	Mackerel RUFF wafer roll	Wafer roll RUFF Catfish	RUFF wafer roll with mackerel and catfish mixture
Moisture Content	3.14±0.21^{a}	4.06±0.08^{b}	3.16±0.94^{a}	3.70±1.33^{a}
Ash Content	1.85±0.92^{a}	1.82±0.08^{a}	1.78±0.01^{a}	1.51±1.33^{b}
Protein Content	12.46±0.04^{a}	24.17±0.06^{b}	15.87± 0.02^{c}	20.92±0.04^{d}
Fat Content	31.70±0.00^{a}	29.54±0.01^{a}	34.42± 0.01^{a}	33.50±0.02^{a}
Carbohydrates Content	50.85±0.28^{a}	44.50±0.04^{b}	44.32± 0.09^{c}	37.11 0.25^{d}

Note: The values are average±standard deviations. Different superscripts mean significant difference based on Tukey's post hoc test α = 5%

The nutritional composition of RUFF wafer roll products demonstrates a well-balanced profile suitable for therapeutic food use, particularly in addressing malnutrition. The protein content in RUFF wafer rolls is quite high, ranging from 12.46% to 24.17%, which meets the essential protein requirement as a critical building nutrient for the recovery of malnourished children. Children with acute malnutrition have increased nutritional needs, especially for energy and protein, to support the recovery process. Accordingly, the World Health Organization (WHO) recommends providing approximately 150-220 kcal per kilogram of body weight per day, with protein intake ranging from 2 to 6 grams per kilogram of body weight per day, depending on the severity of malnutrition and the phase of recovery. This makes the nutrient profile of RUFF wafer rolls appropriate, as it supplies sufficient energy and protein density required for therapeutic nutrition, supporting effective rehabilitation of malnourished children. The fat content is also high, ranging between 29.54% and 34.42%, which is vital as a dense energy source for malnourished children because fat provides a large number of calories in a small volume and aids the absorption of fat-soluble vitamins. Additionally, the carbohydrate content is adequate to provide additional energy. The low moisture content and appropriate ash content indicate product stability and availability of essential minerals. The protein content in RUFF wafer rolls is quite high, ranging from 12.46% to 24.17%, meeting the essential protein requirement as a building nutrient critical for the recovery of malnourished children. Second, the fat content is also high, ranging between 29.54% and 34.42%, which is vital as a dense energy source for malnourished children because fat provides a large number of calories in a small volume and aids the absorption of fat-soluble vitamins. Carbohydrate content is adequate to provide additional energy. Third, the low moisture content and appropriate ash content indicate product stability and availability of essential minerals. Moisture content ranges from 3.14% to 4.06%, a low level that helps maintain product stability and shelf life by preventing microbial growth. Ash content, representing total minerals, is relatively low and consistent across variants, except for a slightly lower value (1.51%) in the mixed mackerel and catfish formula. According to FAO and WHO Standards, RUTF should contain approximately 10–15% protein, 35–45% fat, and 45–55% carbohydrates of total energy. The RUFF wafer rolls meet or exceed these standards, especially in protein and fat content, which are vital for therapeutic nutrition in malnourished children (Tamimi, 2019). Energy content calculated from macronutrients confirms this suitability, with the mackerel variant providing about 540 kcal per 100 grams, within the typical RUTF energy of 520–550 kcal/100grams.

3.4. Moisture Content

Moisture content is a fundamental parameter that directly impacts the quality, texture, safety, and shelf life of food products. For RUFF wafer rolls, analysis shows that all four formulas have moisture contents ranging from 3.14% to 4.06%. According to Manley (2000), the optimal moisture content for wafers to achieve a desirable crispy texture is between 2% and 5%. This means that the RUFF wafer rolls, with moisture content below 5%, are within the optimal range for crispness, ensuring a pleasant, crunchy texture. Maintaining low moisture levels are more susceptible to microbial safety. Foods with higher moisture levels are more susceptible to microbial growth, spoilage, and reduced shelf life. By keeping moisture content low, manufacturers can inhibit the growth of bacteria, molds, and yeasts, thereby extending the product's shelf life and ensuring safety during storage and distribution. Low moisture content eliminates the need to add water during manufacturing or consumption. RUFF are designed to be consumed directly without any need for mixing with water or cooking. This important in settings where access to clean water and cooking facilities is limited, reducing the risk of contamination and foodborne infections (Joint FAO/WHO, 2018). A significant difference in moisture content among the product formulas also indicates that base ingredients such as skim milk, mackerel, and catfish have different water-binding properties, which affect the final texture and stability of the product.

3.5. Ash Content

Ash content is an inorganic component of a substance and can be considered a component of food minerals. The higher the ash content in a food, the higher the total mineral content in that food (Mentari *et al*., 2022). Based on the results of the analysis, the four wafer roll formulas analyzed ranged from 1.51–1.85%. This value is assumed to be the total mineral content contained in the RUFF wafer roll products. Excessively high ash content in therapeutic food products may indicate an overabundance of minerals or harmful contaminants such as heavy metals, posing toxicity risks and affecting taste, which can reduce product acceptance by children. Conversely, too low ash content suggests a deficiency in essential minerals needed for the recovery of malnourished children. Therefore, ash content must be maintained within standards (typically not exceeding 3.5%) to ensure the safety, quality, and effectiveness of the product. However, the ash content does not determine the specific mineral content in RUFF wafer roll products. In RUFF wafer roll products that has the highest ash content is in skim milk formula, which is 1.85%. The findings align with the study conducted by Javed *et al*. (2021) which compared Ready-to-Use Therapeutic Food (RUTF) formulations based on milk, fish, peanuts, and soy protein isolate. Their results indicated that the highest ash content was found in the milk-based RUTF, measuring 5.9±0.27%. The insignificant difference in ash content among RUFF variants indicates that the mineral content of based ingredients such as skim milk, mackerel, and catfish is relatively similar. The inclusion of premixed vitamins and minerals in RUFF formulation is crucial to ensure the adequate intake of essential micronutrients such as vitamins A, D, E, iron, zinc, and iodine for supporting malnutrition therapy.

3.6. Protein Content

The results of the protein content analysis from this study are shown in Table 3 for RUFF wafer roll products made from milk (12.46%), RUFF wafer roll made from mackerel powder (20.08%), RUFF wafer roll made from catfish powder (15.87%), and RUFF wafer roll made from a mixture of mackerel and catfish powder (24.17%). The protein content of the RUFF wafer roll products meets the FAO & WHO (2022) standard of 13% to 16.5% per 100 g of RUTF. However, this standard is based on RUTF products containing 50% of protein from milk, while in this study, protein is derived from fish. Consequently, wafer rolls made from mackerel, catfish, or their combination have higher protein content than those made from skim milk, due to the naturally high protein level in fish powder. Besides fish powder, isolates soy protein (ISP) and peanut protein are commonly used in RUTF formulations. These plant-based proteins provide essential amino acids and enhance overall protein quality. Studies indicate that ISP has high biological value and good digestibility, whereas peanut protein is rich in essential amino acids but may have slightly lower digestibility than animal proteins. Combining these protein sources improves the amino acid profile and protein quality of RUTF, thereby increasing its effectiveness for malnutrition recovery. A significant difference is indicated by the presence of this variation, showing that the protein content of the products is significantly influenced by the differences in raw materials and formulation for each variant, rather than being caused solely by measurement variation. Therefore, it can be stated that the protein content in the final RUFF wafer roll products is truly affected by the raw material factors and composition of the formulation. Protein quality is critical, especially for malnourished toddlers, as their protein needs increase during the recovery phase to accelerate tissue growth and repair (Callaghan-Gillespie & Mui, 2018). Therefore, incorporating a balanced mix of high-quality proteins from fish, plant isolates, and milk can optimize the nutritional value and effectiveness of RUFF wafer rolls in therapeutic feeding programs.

3.7. Fat Content

Fat is a very important energy source for infants and toddlers. It has a significant impact on the energy density of food because fat has an energy density of 9 kcal/g, which is twice that of protein and carbohydrates, both of which have an energy density of 4 kcal/g. According to FAO & WHO (2022), fat consumed by children with malnutrition acts as a solvent for vitamins A, D, E, and K, and supports brain development, which plays a role in controlling, regulating, and integrating various bodily functions. Michaelsen *et al.* (2009) also support the view that food products with less than 22% of energy coming from fat can hinder the growth and development of children. In this study, the primary fat sources come from mackerel fish powder, catfish powder, peanut paste, and vegetable oil. In cases of malnourished children, fat is needed to support catch-up growth because it has a higher energy density compared to protein and carbohydrates (Joint FAO/WHO, 2018).

The results of the fat content analysis in RUFF pasta products showed that the four RUFF wafer roll formulas had fat content ranging from 29.54–34.42% of 100 g of RUTF. This value meets the minimum requirements set by FAO & WHO (2022), namely the recommended fat content of 26–37% of 100 g of RUTF. In fish powder, the highest fat content is in catfish whitch is 35.54±2.23 %. According to Mervina *et al.* (2012), Catfish flour has an unsaturated fat content such as linoleic acid 19.76% and palmitic acid 21.50% (Abdel-Mobdy *et al.*, 2021). Meanwhile, the content of unsaturated fatty acids in mackerel is palmitoleic fatty acid of 14.96% and oleic fatty acid of 5.92% (Pratama *et al.*, 2011). The statistical test results indicate that no significant differences are observed in the fat content among the four RUFF wafer roll variants. This is attributed to the balanced proportions of fat-containing raw materials such as mackerel powder, catfish powder, peanut paste, and vegetable oil used in the formulations, resulting in relatively homogeneous fat content. Consistent production and mixing processes have also contributed to maintaining stable fat levels across the variants.

3.8. Carbohydrate Content

Carbohydrates are considered the main nutrients providing energy and are influenced in sensory properties such as color, taste, and texture. In addition to serving as an energy source, carbohydrates are regarded as important for growth, body functions, and activity, especially in toddlers (Sharlin & Edelstein, 2014). The carbohydrate content in the four RUFF wafer roll formulations is ranged between 37.11% and 50.85%, with the majority being contributed by the wafer (approximately 82.37%). In RUTF products, the carbohydrate content is used to balance fat and protein content in order to achieve the target energy according to the standards. This high carbohydrate content is due to the wafers being mainly composed of wheat flour, which is rich in carbohydrates. Additionally, another source of carbohydrates is the icing sugar used in the formulation, which further increases the overall carbohydrate content of the product. In the context of Ready-to-Use Therapeutic Food (RUTF), carbohydrates play a crucial role as the main energy source. According to FAO/WHO (2022), RUTF typically contains carbohydrates accounting for about 45–55% of total energy. Carbohydrate content in RUFF must be maintained within an appropriate range because insufficient levels can result in inadequate energy and cause protein to be used for energy, hindering growth and recovery. Conversely, excessive carbohydrate content can lead to a reduction in the intake of essential protein and fat, as well as affect blood sugar levels, thereby disrupting nutritional balance (Bai *et al*., 2022). Other studies have also emphasized that a balanced carbohydrate content in RUTF formulations is essential to meet the energy needs of children suffering from malnutrition (Manary *et al*., 2016). The statistical test results show that significant differences are observed in carbohydrate content among the four RUFF wafer roll variants. These differences are mainly caused by variations in the natural carbohydrate content of raw materials such as fish powder, skim milk, and other additives, which affect the total carbohydrate content. Additionally, interactions between ingredients during mixing can alter carbohydrate availability and structure, while differences in moisture content or product humidity further impact the concentration of nutrients.

3.9. Total Energy RUFF

Energy is essential for children's growth, metabolism, and activity. Chronic insufficient energy intake in toddlers can impair brain development, structural growth, and cognitive function, ultimately leading to stunted growth and developmental delays (Sachdev & Kurpad, 2024). RUTF products must have high energy density to support severely malnourished children (FAO/WHO, 2022). Based on the analysis, all RUFF wafer roll formulas meet the Codex Alimentarius energy standard of 520–550 kcal/100 g. The energy content for each formula is presented in Table 4.

Table 4. Total energy products wafer roll RUFF

Nutrients	Wafer roll RUFF skim milk	Mackerel RUFF wafer roll	Wafer roll RUFF Catfish	RUFF wafer roll with mackerel and catfish mixture	Standard
Total Energy (kcal/100g)	538.58±0.10[a]	524.14±0.12[b]	550.49±0.02[c]	546.65±0.04[d]	520–550
Protein (g/100 kcal)	2.31±0.14 [a]	4.61±0.04 [b]	2.88 ±0.04 [c]	3.83±0.10 [d]	2.5–3.0
Fat (g/100 kcal)	5.89±0.10 [a]	5.64±0.02 [a]	6.25±0.09 [a]	6.13±0.18 [a]	5–7
Carbohydrates (g/100 kcal)	9.44±0.18 [a]	8.49±0.03 [b]	8.05±0.09 [c]	6.79±0.02 [d]	n/a

Standard from FAO/WHO 2022 – (Guidelines for ready-to-use therapeutic foods CXG95 – 2022)

Table 4 shows that the RUFF wafer roll products provide a high energy density, ranging from 524 to 550 kcal per 100 grams, which meets the Codex Alimentarius standards for therapeutic foods. The protein content varies between 2.31 and 4.61 grams per 100 kcal, with most variants meeting or exceeding the recommended range of 2.5 to 3.0 grams, essential for supporting growth and recovery. Fat content is well within the recommended 5 to 7 grams per 100 kcal, supplying a dense energy source and vital fatty acids. Carbohydrate amounts range from 6.79 to 9.44 grams per 100 kcal, contributing to balanced energy intake. Overall, the nutrient composition of these RUFF wafer roll products aligns closely with international standards, making them suitable as ready-to-use therapeutic foods for malnourished children. All RUFF formulas fall within or very close to the required range, ensuring that the RUFF products provide sufficient energy density for therapeutic feeding. Fat provides 45–60% of the total energy in RUTF, as recommended by Codex (FAO/WHO, 2022). The addition of vegetable oil is a common strategy to boost energy density without increasing volume, which is crucial for children with poor appetite. Carbohydrates and proteins are provided in proportions that support both energy needs and tissue repair. Meanwhile fat, had high energy density is essential for children with malnutrition who need to gain weight quickly and support catch-up growth. Most RUFF formulas meet or exceed protein standards, especially fish-based ones with naturally higher protein. All formulas have fat levels within the recommended range, ensuring high energy density. Carbohydrate levels align with typical RUTF, though no strict standard exists. The catfish RUFF formula is highlighted as the best match to RUTF standards for energy, protein, and fat.

3.10. RUFF Wafer Roll Preference

A preference test was conducted to determine the preference for the characteristics of RUFF products. The toddlers who became panellists were in good health and accompanied by guardians or parents of the toddlers, conducted a hedonic test using the home use test method. The toddler panellists consisted of 37 toddlers with female gender and 33 toddlers with male gender.

Testing conducted at home is more likely to have a higher preference score by panellists because respondents or panelist are more likely to conduct testing in relatively more comfortable circumstances or conditions (Boutrolle *et al*., 2005). The results of the hedonic test were analyzed using ANOVA variety analysis and Tukey's follow-up test on all sensory attributes of the four formulas, which had values ranging from 1.23 to 2.08, indicating that the panellists tended to be neutral towards the four formulas. The results of the hedonic test are presented in Table 5.

Table 5. The level of preference of panelists for RUFF wafer rolls

Formula	Hedonic rating test score [1,2]	Preferred level[3]
RUFF mixed mackerel and catfish	2.08±0.92[a]	Neutral
RUFF Catfish	1.83±0.92[a,b]	Liked
RUFF Mackerel	1.57±0.81[b,c]	Liked
RUFF skim milk	1.23±0.55[c]	Liked

Notes: [1)] The values are average ± standard deviations

[2)] Different letters followed standard sdeviation indicate significant difference based on Tukey's Post Hoc test at α = 5%.

[3)] The smallest level of liking indicates that the product is liked.

Based on Table 5 which shows the average preference value based on hedonic tests for various variants of RUFF wafer roll, it can be concluded that there is a significant difference in the level of preference between the products. Lower preference scores indicate that the product is preferred by panelists. The RUFF wafer roll product mixed with mackerel and catfish had the highest preference value of 2.08 in the neutral category, which means that this product is less preferred than other products. Meanwhile, three other products, namely RUFF wafer roll catfish, mackerel, and skimmed milk, have lower preference values ranging from 1.23 to 1.83, so all are favored. The most preferred product is the skimmed milk wafer roll with a value of 1.23. The results of the ANOVA test followed by the Tukey test prove that this difference is statistically significant, characterized by the presence of different lowercase letters in the average value of each product. Addition of a mixture of mackerel and catfish in the wafer roll makes the product less desirable, while the variant with skimmed milk is more acceptable to the panelists. This shows that the variation of the base material has a significant effect on the level of preference of the wafer roll product. RUFF wafer rolls made from skimmed milk are generally more liked than those containing fish such as mackerel or catfish. This preference is probably because dairy offers a gentler flavor and texture that children recognize, while fish-based options have a unique odor that some people might dislike. Consumption habits also play an important role, as children and consumers are generally more accustomed and comfortable with dairy-based nutritional products. This makes making skimmed milk-based RUFF wafer rolls more acceptable.

4. CONCLUSIONS AND SUGGESTIONS

The development of Ready-to-Use Fish Food (RUFF) products has been successfully carried out by replacing the animal protein source from milk with protein from mackerel fish powder and catfish powder. The RUFF products are formulated in four variants: skim milk-based, mackerel fish powder-based, catfish fish powder-based, and a mixture of mackerel and catfish fish powders. Nutritional analysis of the four RUFF wafer roll formulas showed that all nutritional parameters, including fat, protein, carbohydrate, and energy content, met the standards set by FAO & WHO (2022). Hedonic rating tests conducted on toddler panelists indicated that the RUFF formulas based on skim milk, mackerel fish powder, and catfish fish powder received good liking scores, whereas the formula using a mixture of mackerel and catfish fish powders received a more neutral taste rating.

This study highlights the potential to develop interventions using local food-based products, particularly fish, to improve the poor nutritional status of toddlera. It also emphasizes the need for further research to assess the safety of these foods for toddler consumption and to evaluate the effects of administering RUFF products to malnourished toddlers. To ensure adequate intake of essential micronutrients such as vitamins A, D, E, iron, zinc, and iodine which are critical for malnutrition therapy it is necessary to include a vitamin and mineral premix in the formulation of RUFF products.

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