Formulation of nutritious biscuits fortified with minced catfish and *Ulva* sp for malnourished children

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Abstract

Stunting is a critical problem that deserves attention and has become a global problem. The approach to reducing stunting is to provide nutritious supplementary food in the form of biscuits for children, especially those who are malnourished. The purpose of this study is to formulate nutritious biscuits enriched with minced catfish as a source of amino acids and *Ulva* sp as a source of dietary fiber. Design expert software (DX13) ® was used to analyze sensory data gathered from a hedonic scale assessment with 25 trained panelists to determine the best formulation for the fortified biscuit product. Taste and texture were among the sensory qualities that were assessed. In addition, physical aspects such as hardness and color (L, a, and b) are analyzed to determine the quality of the biscuit formula. The best formulas based on sensory evaluation and physical analysis undergo further analysis of their nutritional composition, including proximate analysis and amino acid profile.The best quality products found are biscuits fortified with a formula consisting of 33% wheat flour, 14% chopped catfish, and 1% *Ulva* flour.The state of the art of this research is the development of functional biscuits fortified with a combination of animal protein (catfish) and dietary fiber as well as antioxidants form *Ulva* sp., using an RSM-based formulation optimization approach to produce a highly nutritious product that is acceptable to children.

Keywords: *dietary,sensory, mixture design,seaweed*

Introduction

Malnutrition is a serious problem that deserves attention. Various forms of malnutrition have become global concerns. As many as 49.5 million children under five suffer from wasting (Golden *et al*., 2021; UNICEF *et al*., 2021). Acute malnutrition is a significant global public health issue that affects 49.5 million children yearly, over half of whom die as a result of it (Daures *et al*., 2020; UNICEF/WHO/World Bank, 2021). Stunting, caused by malnutrition, is indicated by a low height-for-age (HAZ) level. In contrast, wasting is marked by a low weight-for-height (WHZ) level. A low height-for-age (HAZ) level is indicative of stunting, which is brought on by malnutrition. On the other hand, a low weight-for-height (WHZ) level indicates wasting. The World Health Organization (WHO) and UNICEF define severe acute malnutrition (SAM) as meeting at least one of the following criteria: less than 115 mm in the mid-upper arm circumference, a low WHZ, or clinical indications of bilateral oedema (WHO, 2009). According to the World Health Organization's (WHO) child growth criteria, a child is considered stunted if their height for their age is fewer than two standard deviations below the median. Stunting occurs in children under five years old, which is defined as inadequate linear growth during a critical developmental phase (WHO, 2006). The effects of child stunting are both short-term and long-lasting, encompassing higher rates of illness and death, impaired development and learning ability, greater susceptibility to infections and noncommunicable diseases in adulthood, and diminished productivity and economic potential. The Global Nutrition Targets for 2025 have six targets, the main one being the decrease in stunting among children (WHO, 2012).

In Indonesia, the prevalence of stunting decreased from 27.67% in 2019 to 24.4% in 2021(Rahmi *et al*., 2022). In Indonesia, various factors contribute to stunting, including immediate causes like maternal nutrition, breastfeeding habits, complementary feeding practices, and infection exposure. Furthermore, underlying factors including healthcare, food systems, education, and the infrastructure and services related to water and sanitation all play important roles. (Beal *et al*., 2018). To improve nutritional status during adolescence and pregnancy, support appropriate gestational growth, and prevent child stunting, efforts should be made before conception and continue at least until the kid is 24 months old. (Dewey *et al*., 2021; Harper, 1981). Dietary guidelines implemented in some countries promote milk and other dairy foods, as well as foods that are high in protein and calcium for toddler growth and development to reduce the prevalence of stunting. (Ciudadanos *et al*., 2018; Plaza-Díaz *et al*., 2020; Slavin, 2012). A wide variety of healthy foods with different tastes, flavors, and textures as complementary foods should be gradually introduced to toddlers (Harris & Pomeranz, 2020).

Popular foods serve as effective carriers for nutrient incorporation, making them a focus for the growing and increasingly demanding market aimed at managing health disorders and preventing malnutrition. (Goubgou *et al*., 2021). As one of the most popular ready-to-eat foods, biscuits have significant nutritional potential and can be easily modified. Biscuits are also a favored snack among children (Cayres *et al*., 2021; Giuberti *et al*., 2021; Urganci & Isik, 2021). Biscuits offer a variety of ways to treat human nutrition-related illnesses. They are frequently consumed as appetizers or as a side dish. They are very well-liked because of their variety of forms, delicious tastes, extended shelf life, and convenience. (Agama-Acevedo *et al*., 2012; Goubgou *et al*., 2021; Manley, 2011). Studies on the nutritional composition of commercial biscuits highlight the importance of balancing macronutrients and minimizing unhealthy components like trans fats (Norhayati *et al*., 2015; Silveira *et al*., 2023).

Modified biscuits, by adding ingredients rich in amino acids and other nutrients, can help reduce malnutrition and stunting in children. Catfish (*Clarias* sp) which is rich in protein and contains all essential amino acids, includes 16 different types of amino acids (AA), divided into 2 semi-essential (SEAA) types, 7 non-essential (NEAA) types, and 7 essential (EAA) types. Six of these amino acids generate flavors (FAA). The most glycine was present at 14.15%, followed by proline, alanine, and phenylalanine (Zhang *et al*., 2022). Catfish meat contains 71.30% moisture, 19.03% protein, 8.10% lipids, and 1.5% ash. It is rich in calcium (304.82 mg/100 g), phosphorus (279.45 mg/100 g), iron (17.03 mg/100 g), and essential amino acids, particularly oleic acid (Abdel- Mobdy *et al*., 2021a). Other research was reported that Catfish extract contains 4.97% water, 8.91% ash, 29.87% fat, 48.85% protein, 7.40% carbohydrates, and 0.12% total polyphenols, with an antioxidant activity measured by an IC_{50} value of 4.9724%, highlighting its nutritional potential for improving stunted toddlers' diets (Sihombing *et al*., 2024).

The average production of catfish increased by 15.84% between 2015 - 2019. In the 2019 saw Indonesia produce 1.2 million tons of catfish, compared to a target of 1.7 tons.

It is anticipated that catfish production will rise by 100% by 2030 (Diatin *et al*., 2021; Henriksson *et al*., 2019). Another ingredient that could be added to the biscuits is *Ulva* sp., which contains a high nutrient composition, especially fiber and natural antioxidants. *Ulvans* from *Ulva lactuca* proved potent in antioxidant activity in vitro (Guidara *et al*., 2021). The dietary fiber content of *Ulva* is advantageous to children. The American Academy of Pediatrics recommends two formulas to determine the bare minimum of fiber consumed each day for children: one depending on the child's weight (0.5 grams of fiber each kilogram, up to 35 grams per day) and the other based on their age (age in years + 5 grams) (Salvatore *et al*., 2023). Unlike commercial biscuits that are generally low in protein and dietary fiber, and unlike previous studies on fish-based biscuits which focused on other fish species or single nutrient enhancement, this study introduces a novel formulation by combining catfish, as a rich source of essential amino acids, with *Ulva* sp., as a source of dietary fiber and antioxidants. This unique combination has not been previously explored, highlighting the gap in existing research and the potential of such a formulation to provide a more balanced and functional food product for improving children's nutrition.

The objective of this study is to develop a nutritious biscuit intended to prevent malnutrition in children by fortifying it with minced catfish and *Ulva* sp.

Material and Method

Material

Catfish (*Clarias* sp) is purchased from a local market, in West Java, Indonesia which is stored in a cooler box and transported to a laboratory. Ulva flour is obtained from suppliers in West Nusa Tenggara, Indonesia. The Ulva flour used was ready-to-use Ulva flour.The ingredients are wheat flour (Kunci Biru, Indonesia), cornstarch (Mama Suka, Indonesia), mung bean flour, milk powder (Dancow, Indonesia), eggs, refined sugar (Claris, Indonesia), coconut oil (Barco, Indonesia), margarine (Blue band, Indonesia), refined salt (Refina, Indonesia), maltodextrin, and sodium bicarbonate, and commercial biscuits as a comparison.

To optimize biscuit formulation, the experiment was set up to model and examine the impacts of four independent variables on response. With 18 sets and 3 independent elements, a mixed design technique is used to accomplish this. This is accomplished using the Stat-

Ease Design-Expert Software (Version 103 13.1.0.1, Stat-Ease, Inc., USA). Three separate ingredients affect the finished biscuit product: Ulva flour, minced catfish, and wheat flour.

Minced catfish processing

Catfish were cleaned, degutted beheaded, and then filleted. The fillets were washed twice using 0.3% (w/w) salt in cold water (at a temperature of 5-8 ºC) for 15 min and stirred. The ratio of water and fillets was 4:1. Then it was pressed at 1300 rpm for 5 minutes, then crushed with a meat cleaver (Panasonic MK-MG 1300, Japan). The minced meat was packaged and frozen.

Biscuit formulation

Sugar 15%, egg yolk 15%, and ammonium bicarbonate (0.5%) were mixed at high speed until the dough rises. Salt (0.2%), maltodextrin (0.3%), cornstarch (5%), mung bean flour (5%), milk (5%), butter (5%), coconut oil (2%), minced catfish (14%), Ulva flour (1%), and wheat flour (33%) were then added. The dough was mixed until homogen rolled to 5 mm thickness, cut into biscuits, and baked at 140 ºC for 25 minutes. The biscuits were stored in plastic jars at room temperature for further analysis.

Proximate analysis

The proximate analysis followed Indonesian National Standard (SNI) guidelines for moisture content. (BSN, 2006c), crude protein (BSN, 2006b), crude fat (BSN, 2006a), and ash content (BSN, 2010). Moisture content was measured by drying at 105 °C. Crude protein content was determined using the macro-Kjeldahl method.

Textural analysis

The texture of the samples was analyzed using a TA.XT Plus texture analyzer (Stable Micro Systems, Surrey, UK). The product sheets were divided into 30 mm by 30 mm squares. The spherical probe was attached to the load cell using a probe adaptor (AD/100) on the Heavy-Duty Platform (HDP/90) with a stainless steel spherical probe (P/5S). A 5-kilogram load cell and a 5 mm diameter cylindrical flat-faced probe 129 were utilized. Measurements were performed at a crosshead speed of 1 mm/s, with the probe positioned 20 mm from the surface, following. (Arimi *et al*., 2010).

Sensory analysis

A panel of 25 trained assessors conducted the sensory evaluation with a nine-point hedonic rating system (5 being neither like nor disliked, 6 being somewhat liked, 7 being highly liked, 8 being very much liked, and 9 being extremely liked) (Charutigon *et al*., 2008; Lawless & Heymann, 2010; Meilgaard, M., Civille, G.V., Carr, 2007; Sinurat *et al*., 2023) Before being placed on a tray and distributed to the panelists, each sample was given a random three-digit code and scrambled.

Colour analysis

A HunterLab LabScan XE Spectrophotometer (Hunter Associates Laboratory, Inc., USA) equipped with a D65 light source was used to measure the L*, a*, and b* values to assess the color of the samples. The sample preparation and measurement processes were carried out in compliance with the guidelines provided (del Olmo *et al*., 2018).

Amino Acid Analysis

Amino acid composition in the biscuit was analyzed using High-Performance Liquid Chromatography (HPLC) as outlined by (Wang *et al*., 2011). Amino acids were produced by hydrolyzing proteins, and HPLC was used to measure and identify the resulting compounds..

Statistical analysis

This research employed Response Surface Methodology (RSM) using Mixture Design - Design Expert 13 (MD-DX13) ®. A hedonic test with 25 trained panelists assessed product liking, with data analyzed using SPSS Statistic V22. All experimental data are presented as the mean values from three repetition along with their respective standard deviations.

Result and Discussion

Proximate composition of raw materials

The proximate composition and crude fiber content of the minced catfish and *Ulva* flour are tabulated in Table 1.

The minced catfish showed a high protein content (17.6±0.4%), in line with the reported results Ajibare *et al*. (2023) 17.45±1.7%, Shadyeva *et al*. (2019) 17.03±0.37. Slightly different results were reported by Sulieman *et al*. (2019) and Abdel-Mobdy *et al*. (2021a) the protein content of minced catfish of 18.18±0.20% and 19.03%, respectively. Catfish is categorized as a protein fish, containing 15-20% protein (Shadyeva *et al*., 2019). The fat content of catfish is low (3.64±0.06%) and It is indicated that catfish is classified as a medium-fat fish (fat content 2-6%) (Shadyeva *et al*., 2019).

The proximate composition of seaweed varies by species, environmental conditions, season, and geographical location. (Rohani-Ghadikolaei *et al*., 2012). In this study, the moisture content of *Ulva* was 12.45±1.27%, consistent with previous research of 0.95%-14.57% (Khairy & El-Shafay, 2013). *Ulva's* ash content was 36.32±0.62%, higher than reported in another study.(Abdel-Khaliq *et al*., 2014; Khairy & El-Shafay, 2013; Rasyid, 2017; Rohani-Ghadikolaei *et al*., 2012). The high ash content is linked to mineral absorption through the thallus surface (Santoso *et al*., 2024).

The protein content of *Ulva* in this study was 5.18±0.05%. This result was lower than the protein content reported by Abirami & Kowsalya (2011), 12.9%, (Tabarsa *et al*., 2012); 10.89%, (Khairy & El-Shafay, 2013) 16.78–17.88%, (Abdel-Khaliq *et al*., 2014) 17.6% and (Rasyid, 2017) 13.6%. The fat content studied in this study was 0.25±0.04%. This result is similar to that reported by (Rasyid, 2017), which is 0.19%, but lower than (Abirami & Kowsalya, 2011) 1.2%, and Abdel-Khaliq *et al*. (2014) 0.7%.

Table 1 The proximate composition and crude fiber of minced catfish and *Ulva* flour

No	Parameters	Minced catfish	*Ulva* flour
1	Water (%)	71.64±3.77	12.45±1.27
2	Ash (%)	0.74±0.39	36.32±0.62
3	Protein (%)	17.60±0.00	5.13±0.07
4	Fat (%)	3.64±1.42	1.27±1.44
5	Carbohydrate (%) (by different)	8.26±3.90	44.84±3.25
6	Crude fiber (%)	3.71±0.44	25.80±1.13

The content of Ulva's crude fiber in this study was 26.6±0.41%, this result was similar to (Rasyid, 2017) which was 28.4%. The high crude fiber content in *U. lactuca* suggests that it may serve as a promising alternative source of dietary fiber.

Formulation of fortified biscuits and response analysis

With the use of the DX13® program, the formula determination from the experimental design outcomes of Mixture Design-Design Expert (MD-DX) produced 18 formulas (run orders). Table 2. presents 18 biscuit formulations generated from the Mixture Design–Design Expert, with varying proportions of wheat flour, minced catfish, and Ulva sp. flour. The observed responses include sensory attributes (texture and taste), hardness, and color parameters (L, a, b*), which were analyzed to determine the optimal fortified biscuit formulation.

Sensory Properties of Nutritious Biscuits with Minced Catfish

Hedonistic sensory testing of the nutritious biscuits' texture and taste quality characteristics with minced meat refers to SNI 2346:2016 (BSN, 2015) for guidelines on using a 1-9 scale for sensory testing. Sensory reports with scores of three or higher were accepted, whereas those with values lower than three were discarded. Fifteen trained panelists conducted the sensory test.

a. Sensory test response for texture and taste

The polynomial equation for the sensory response of texture in fortified biscuits is the square model, with a p-value ($p<0.0001$) with a coefficient of determination ($R^2 = 0.8843$). Compared to the error of the value of p-value = $p>0.3056$ (insignificant).

The texture received a rating from panelists ranging from 3.7 to 4.5, which indicates that it is neutral to highly favored. Biscuits made with 36% wheat flour, 11.5% minced catfish, and 0.5% Ulva flour received the highest rating. Biscuits with formula 5 (Table 2) show the best value. Panelists found that this recipe produces biscuits with a texture that is easy to bite into and chew, resulting in the desired crunch. The amount of amylose in wheat flour has an impact on the taste of the food. The ratio of amylose and amylopectin affects the texture of biscuits (Harzau & Estiasih, 2013) In addition, the structure of starch gel, namely the content of amylose and amylopectin, affects the texture of the product including hardness, adhesion, durability, cohesion, and annoyance (Irani *et al*., 2019). According to Istinganah *et al*. (2017) the moisture content will also affect how soft or hard the texture of the biscuit product is. Figure 1 can give the conclusion that wheat flour tends to respond and contribute more to the texture of the biscuits.

A cubic model with a determination coefficient (R2=0.9799) and a p-value ($p<0.0001$) is the polynomial equation for sensory responses. The sensory reaction to the Lack of Fit was p-value = $p>0.1759$, indicating insignificance.

Table 2. Formulation Runs and Response Results of Minced Catfish and *Ulva* sp. Fortified Biscuits Based on Mixture Design

Run	Wheat flour	Minced Catfish	*Ulva* flour	Texture	Taste	Hardness	Color		
							L*	a*	b*
1	30.5	17.0	0.5	3.41	4.03	5622.47	65.79	7.39	20.31
2	36.0	11.5	0.5	4.33	3.83	3853.66	53.71	8.54	18.19
3	30.5	17.0	0.5	3.33	4.08	5605.04	65.04	8.90	19.58
4	32.3	15.2	0.5	3.72	4.00	5160.43	58.12	8.28	18.68
5	36.0	11.5	0.5	4.50	3.79	3812.72	53.07	5.65	17.12
6	34.5	12.8	0.8	4.13	4.00	3867.79	61.10	5.65	18.52
7	36.0	11.0	1.0	3.90	4.08	3736.16	56.47	5.06	20.31
8	33.0	14.0	1.0	4.12	4.10	4391.32	59.96	4.21	19.74
9	33.0	14.0	1.0	4.08	4.11	4205.97	56.52	5.87	18.35
10	36.0	11.0	1.0	4.18	4.04	3800.17	56.56	4.99	18.14
11	33.0	14.0	1.0	3.90	4.10	4032.52	54.33	6.41	18.31
12	31.5	15.4	1.1	3.83	4.05	4274.53	62.00	6.40	18.81
13	30.0	16.7	1.3	3.42	4.12	5566.63	63.78	6.78	18.44
14	30.0	16.7	1.3	3.47	4.15	5541.57	59.61	5.78	18.04
15	35.5	11.0	1.5	3.83	3.75	3493.06	57.07	4.14	19.56
16	31.8	14.7	1.5	4.00	3.80	4228.31	58.33	5.21	18.13
17	32.8	13.8	1.5	3.81	3.88	4229.25	58.41	5.53	17.97
18	33.7	12.8	1.5	4.19	3.84	4220.10	59.85	5.83	17.01

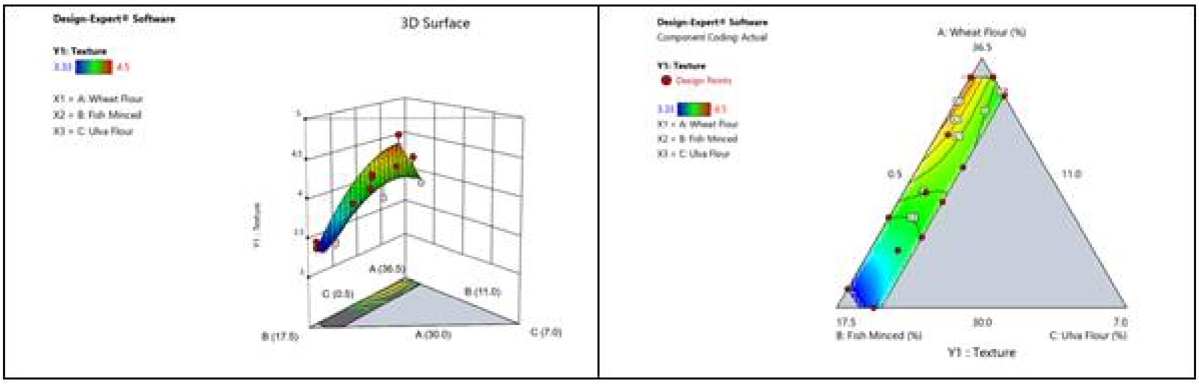

Figure 1. 3D graphic and contour of the textural response of biscuits fortified with minced catfish and *Ulva* flour.

The addition of wheat flour and Ulva flour will reduce the sweetness of the biscuits, thus affecting the panelists' assessment. According to Gracia *et al.* (2009), Adding water to minced fish will cause sugar to dissolve and decrease the amount of sweetness in the finished cake.

The taste was rated the best at 4.15 (very preferable) and the lowest rate at 3.75 (neutral) Panelists liked the biscuits which are mostly made from wheat flour and contain less *Ulva* flour and minced catfish. The highest sensory taste optimization points with a scale value of 4.15 (like) is indicated by the red area which is greatly influenced by the wheat flour variable. The presence of protein contained in wheat flour can cause a Maillard reaction in a food (Istinganah *et al.*, 2017). The Maillard reaction is a crucial chemical process in baking that occurs between proteins, particularly gluten, and reducing sugars, leading to the development of the characteristic flavor of baked goods like biscuits. The Maillard reaction is responsible for the desirable flavors and aromas in baked items, enhancing their overall appeal (Kerler *et al.*, 2010). Using minced catfish increased the protein content in the biscuits; however, during baking, the higher protein content promoted Maillard reactions, resulting in a more pronounced bitter taste and off-flavor due to peptide-derived compounds (Liu *et al.*, 2022). Fish rich in free amino acids and nucleotides, such as inosine 52 -monophosphate (IMP) and guanosine 52 -monophosphate (GMP) are known to enhance the umami taste, a savory flavor that is one of the five basic tastes. These compounds are crucial in creating the umami flavor profile, which is often associated with a pleasant and savory taste experience. The presence of these compounds in fish and other seafood can significantly influence their taste and culinary appeal (Lindemann *et al.*, 2002). Figure 2 can give the conclusion that wheat flour tends to respond and contribute more to the taste of biscuits. The addition of fish meat also contributes to the flavor, even though it is small.

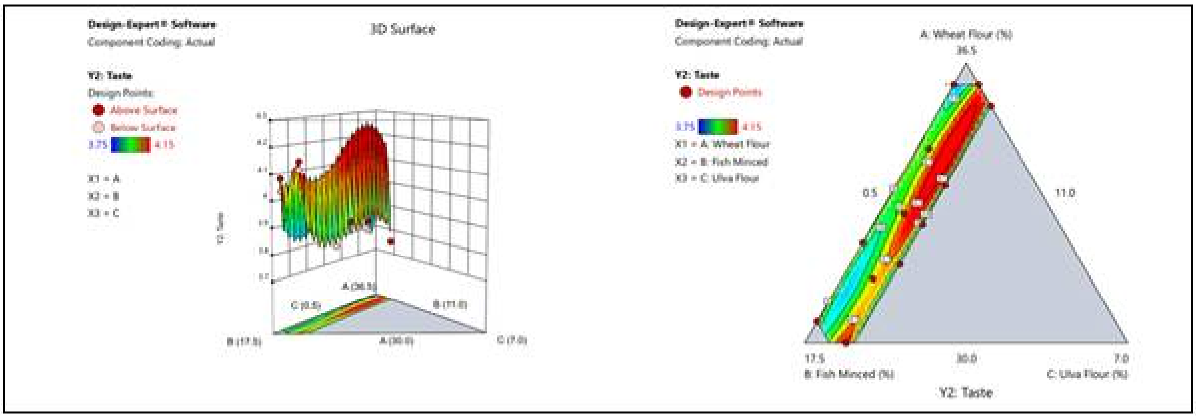

Figure 2. 3D graphic and *contour* biscuit taste response plots fortified with minced catfish and *Ulva* flour.

Physical Properties Hardness

The polynomial equation of hardness response is a cubic model with a p-value (p<0.0001). The value of the coefficient of determination (R^2 = 0.9923) shows that the Cubic model can explain the diversity of hardness of nutritious biscuits by 99.23%. The result of Lack of Fit obtained taste response is p value = p >0.9448 (not significant) which shows that Lack of Fit biscuit hardness is relatively insignificant to pure error.

Figure 3 illustrates how interactions between wheat flour, minced fish, and Ulva flour affect biscuit hardness. Wheat flour and minced fish significantly influence hardness, which results from gluten-fiber interactions. Dietary fiber increases water absorption and disrupts gluten development. (Najjar *et al.*, 2022). Thus, wheat flour and minced catfish are key contributors to biscuit hardness. The incorporation of *Ulva* flour in biscuit formulations increased product hardness. This effect is mainly attributed to the high dietary fiber and mineral content of *Ulva* flour, which interferes with gluten network formation and results in a denser and firmer texture after baking (Sadkey, 2023).

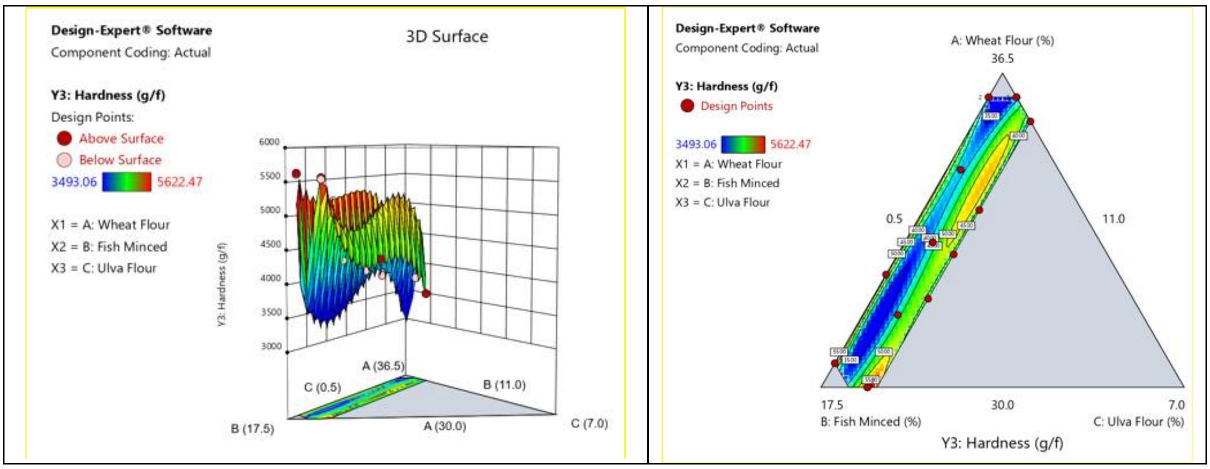

Figure 3. 3D graphic and contour of hardness response *plots* of biscuits fortified with minced catfish and *Ulva* flour.

Sensory test response for color

The color polynomial equation L* is a linear model with a determination coefficient value of R2 = 0.5656 and a p-value of p<0.0019. The result of the Lack of Fit obtained by the color response of L* is the value of p = p>0.2130 (insignificant).

The movement of L* color from the formulation interaction between wheat flour, minced catfish, and Ulva flour can be seen in Figure 4. The highest optimization points of L* color with a value of 65.79 is indicated by the red area which is greatly affected by the variable of chopped catfish. According to (Astiana *et al*., 2023) the appearance of the color of biscuits turning brown with the addition of surimi is due to the protein content in surimi which makes the biscuits quickly brown or brown on the surface of the biscuits.

The color polynomial equation a* is a p-valued linear model (p<0.0011) with a determination coefficient value (R^2 = 0.5967). The Lack of Fit result obtained by the color response* is a value of p = p>0.9175 (insignificant).

The interaction of color movement formulation between wheat flour, minced catfish, and Ulva flour can be seen in Figure 5. The conclusion is that the highest optimization point of color a* with a value of 8.9 is indicated by the red area that is heavily influenced by the minced catfish.

The color polynomial equation b* is a square model with a p-value (p<0.3397) with a coefficient of determination value (R^2 = 0.5833). The Lack of Fit result obtained by the L* color response is the value p = p>0.8652 (insignificant).

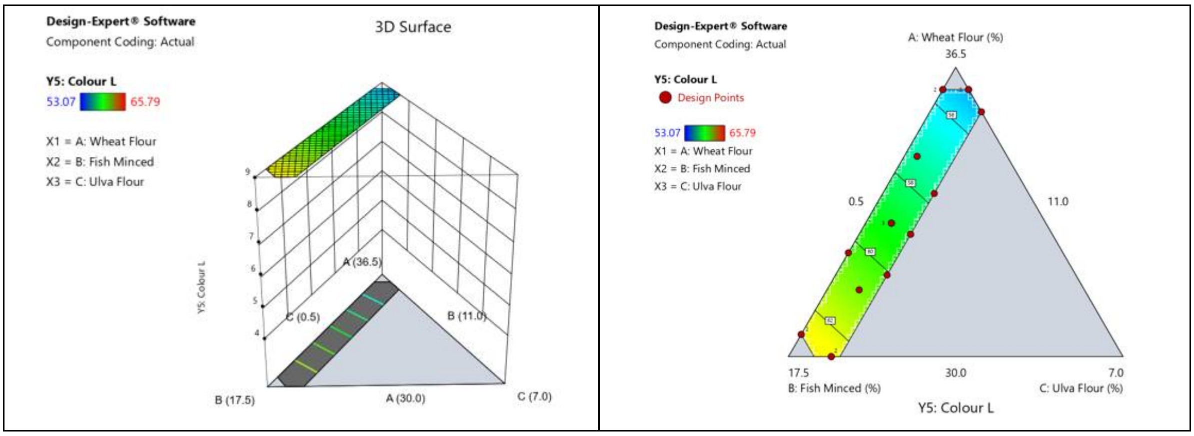

Figure 4. 3D graphic and contour response plot of Color L* of biscuits fortified with minced catfish and *Ulva* flour.

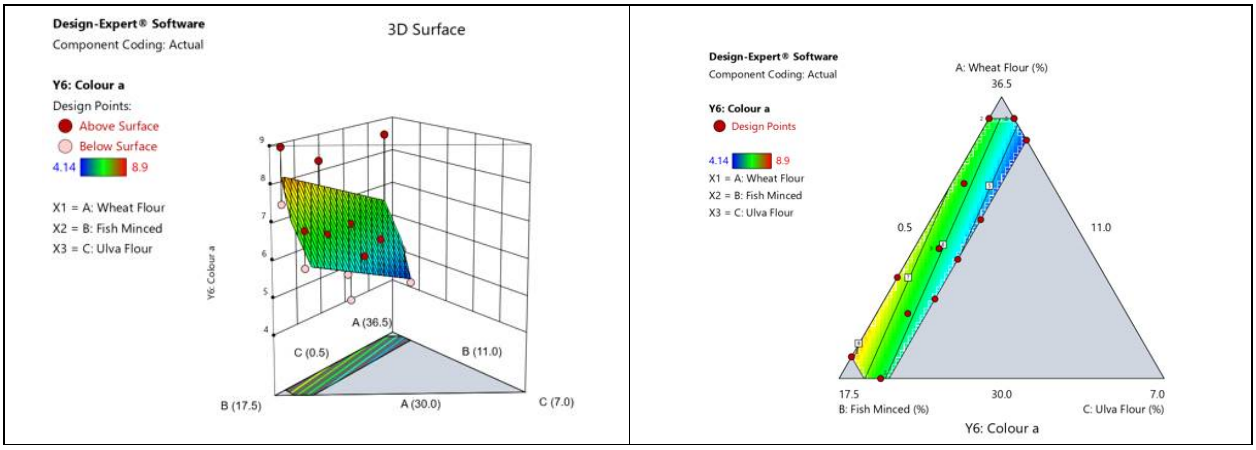

Figure 5. 3D graphic and contour of response plot color a* of biscuits fortified with minced catfish and *Ulva* flour.

The interaction of the b* color movement formulation between wheat flour, minced catfish, and *Ulva* flour can be seen in Figure 6. The conclusion is that the highest optimization points of color b* with a value of 20.11 are indicated by the red area that is greatly influenced by the minced catfish.

Comparison of Contribution to Nutrition Adequacy

The daily values for biscuits are presented in Table 3. Based on the Recommended Dietary Allowance (RDA) for children aged 4-6 years, the percent daily value is calculated(Indonesian Ministry of Health, 2019).

Table 3. Contribution to nutrition adequacy

Product		Energy (Kcal)	Protein (g)	Fat (g)	Carbohyd rate (g)	Dietary fiber (g)	Ca (mg)	Mg (mg)	P (mg)	Fe (mg)	Zinc (mg)	K (mg)
Fortified biscuits	Products contain	231.86	6.59	5.75	35.24	0.56	88.4	44.4	99.7	4.2	1.6	185.5
	RDA	1400	25	50	220	20	1000	95	500	10	5	2700
	% RDA	16.6	26.4	11.5	16.0	2.8	8.84	46.8	19.9	42	32	6.9
Commercial biscuits	Products contain	115.93	4.41	8.67	35.64	0.52	103.6	48.7	35.6	4.3	1.6	184.4
	RDA	1400	25	50	220	20	1000	95	500	10	5	2700
	% RDA	8.3	17.6	17.3	16.2	2.6	10.36	51.3	7.1	43	32	6.8
	FAO/WHO	1400	25	50	220	20	1000	95	500	10	5	2700

Note: Serving size: 50 g

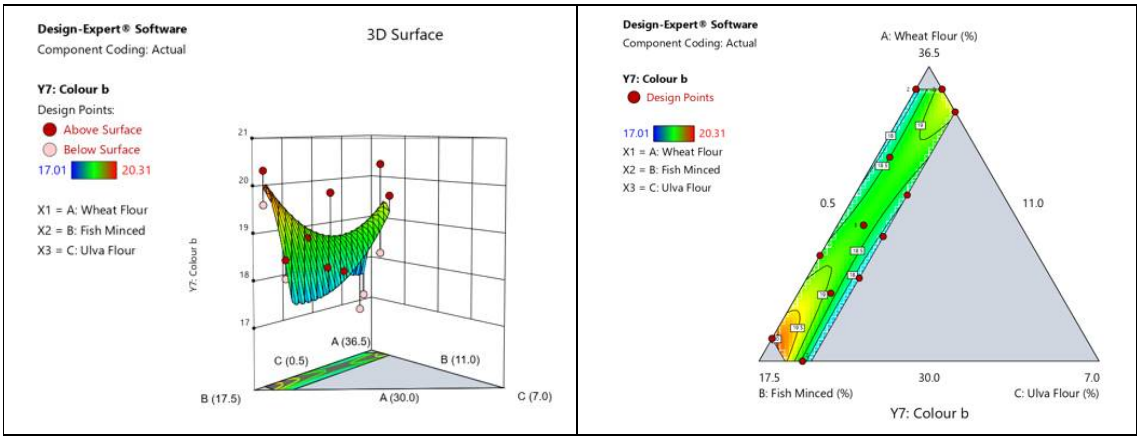

Figure 6. 3D graphic and contour of response plot color b* of biscuits fortified with minced catfish and *Ulva* flour.

The daily value for the biscuits is presented in Table 3. Percent daily values are based on the Recommended Dietary Allowance/ RDA of children aged 4-6 years (Indonesian Ministry of Health, 2019). Fortified biscuits provided higher protein, phosphorus, iron, and zinc contents due to the addition of minced catfish and *Ulva* flour, whereas commercial biscuits contained higher fat levels, largely from wheat flour, sugar, and margarine. These nutritional differences highlight the potential role of fortified biscuits in addressing children's nutritional problems, particularly protein, iron, and zinc deficiencies that are closely related to growth and development. The contribution per serving of biscuits was assessed by analyzing their energy and nutrient content and comparing these results to the RDA) (Dewi *et al*., 2020). The recommended daily allowance for energy (16.6%) and protein (26.4%) was greater in the fortified biscuit compared to commercial biscuits (energy 8.3% and protein 17.6%). On the other hand, the percentages of the RDA for carbohydrate and dietary fiber were similar in both fortified (carbohydrate 16.0% and dietary fiber 2.8%) and commercial biscuits (carbohydrate 16.2% and dietary fiber 2.6%). The commercial biscuits had a higher percentage of the %RDA only for fat (17.6%) compared to the fortified biscuits (11.5%).

The % RDA for protein of fortified biscuits was higher than commercial biscuits. Fortifying biscuits with catfish significantly increased their protein content. The lower %RDA for the fat of fortified biscuits than that of commercial biscuits. According to the results reported by Klerks *et al.* (2023), the fat content in biscuits varied significantly ($P < 0.05$) due to different recipes used by the manufacturers, which affected the amount of fat included in the biscuit formulations. Rutkowska *et al* (2012) reported that the fat content of various biscuit products ranged from 2.2% to 22.8%. The % RDA for dietary fiber of both fortified and commercial biscuits was no different. The result was due to the addition of *Ulva* sp. in the formula (1%) being too little to increase the dietary fiber content in the fortified biscuits. According to Klerks *et al*. (2023), the dietary fiber content in biscuits, including those for babies, children, and adults, tends to be low, in the range of 3.0-3.1%.

In terms of mineral adequacy, the fortified biscuits have a higher % RDA of phosphorus (19.9%) compared to commercial biscuits (7.1%), but a lower % RDA of magnesium, with 46.8% compared to 51.3%. The % RDA of calcium, iron, zinc, and potassium in fortified and commercial biscuits was not different. According to the % RDA, both types of biscuits have a high content of magnesium, zinc, and iron.

Amino acids profiles

The quality of protein content in biscuits can be evaluated by their amino acid composition. The amino acid profiles of fortified and commercial biscuits are shown in Table 4.

Table 4. Amino acids profile of fortified and commercial biscuits (mg/g DW)

No	Constituents	Fortified biscuits	Commercial biscuits	FAO/WHO
	Essential amino acids (EAAs)			
1	Histidine	51	22	18
2	Leucine	79	60	66
3	Lysine	28	48	57
4	Methionine	10	15	25
5	Phenylalanine	61	33	63
6	Threonine	34	31	34
7	Valine	50	37	35
8	Isoleucine	41	34	28
9	Tryptophan	12	11	11
	Total	**366**	**295**	**337**
	Non-essential amino acids (NEAAs)			
1	Cystine	15	6	25
2	Arginine	143	48	-
3	Aspartic acid	42	63	-
4	Glutamic acid	418	149	-
5	Serine	54	34	-
6	Glycine	40	28	-
7	Tyrosine	27	21	63
8	Alanine	35	36	-
9	Proline	12.7	36	-
	Total	**786**	**421**	**88**

Amino acid profiles showed that both fortified biscuits and commercial biscuits contain nine categories of amino acids: nine essential and nine non-essential. Compared to commercial biscuits, fortified biscuits contain higher levels of both essential and non-essential amino acids. Compared to the necessary amino acids in commercial biscuits, which are 295 mg g-1, the amount of essential amino acids in the fortified biscuits is higher at 366 mg g-1. Non-essential amino acid content in fortified biscuits was also higher at 786 mg g^{-1} compared to that in commercial biscuits (421 mg g^{-1}). The amount of essential and non-essential amino acids in the biscuits rose dramatically with the addition of minced catfish, which added 24% and 87% of amino acids, respectively. All essential amino acids in fortified biscuits were higher than those in commercial biscuits, except for lysine and methionine. Similar results were observed in the non-essential amino acid content, where most were higher in fortified biscuits, except for aspartic acid and proline.

Table 4 shows that in fortified biscuits, non-essential amino acids are dominated by leucine (79 mg/g), while essential amino acids are dominated by glutamic acid at 418 mg/g. According to Dang *et al*. (2019) and Zhao *et al*. (2003) contributes to umami flavor, affecting the savory taste in the resulting fish biscuits. The components of the sweet taste include glycine, alanine, serine, and threonine, while the components of the bitter taste include phenylalanine, histidine, arginine, leucine, valine, methionine, and isoleucine (Ma *et al*., 2017).Fortified biscuits showed higher levels of essential amino acids such as histidine (51 mg/g, more than double that of commercial biscuits at 22 mg/g and exceeding the FAO/WHO requirement of 18 mg/g), leucine (79 mg/g, higher than 60 mg/g in commercial biscuits and meeting the FAO/WHO standard of 66 mg/g), and valine (50 mg/g, compared to 37 mg/g in commercial biscuits and above the FAO/WHO standard of 35 mg/g), with glutamic acid (418 mg/g vs. 149 mg/g in commercial biscuits) being the most dominant non-essential amino acid, indicating a better amino acid profile although lysine (28 mg/g, lower than 48 mg/g in commercial biscuits and below the FAO/WHO requirement of 57 mg/g) remained inadequate.

Fatty acids profile

The fatty acid profile of fortified and commercial biscuits is shown in Table 5.

Table 5. Fatty acids profile of fortified and commercial biscuits (mg/g DW)

Constituents	Fortified Biscuits	Commercial Biscuits	Standar FAO/WHO
Caprylic acid C8:0	0.50	1.29	
Capric acid C10:0	0.80	0.99	
Lauric acid C12:0	3.00	9.41	
Myristic acid C14:0	8.00	3.97	
Palmitic acid C16:0	22.83	14.54	
Stearic acid C18:0	0.80	2.39	
Arachidic acid C20:0	25.00	0.09	
Saturated Fatty Acids (SFAs)	**60.93**	**32.68**	**<10%**
Palmitoleic acid C16:1	0.80	0.41	
Oleic acid C18: 1	23.58	15.51	
Monounsaturated Fatty Acids (MUFAs)	**24.38**	**15.92**	**15-20%**
Linoleic acid C18: 2	7.48	5.79	
Linolenic acid C18: 3	1.80	0.18	
Polyunsaturated Fatty Acids (PUFAs)	**9.28**	**5.97**	**6-11%**
Total Fatty Acids	**94.59**	**54.57**	

Fortified biscuits had a higher content both saturated (SFA) and unsaturated fatty acids (UFA), compared to commercial biscuits. The SFA content of fortified biscuits was dominated by palmitic and arachidic acid. The high content of arachidic acid and palmitic acid in the fortified biscuits is due to the addition of egg (12.5%) and minced catfish (14%) in the formulation. Many studies reported that catfish contain high levels of palmitic acid, with concentrations ranging from 20.62 to 30.74% (Abdel- Mobdy *et al*., 2021b). Palmitic oil is a vital element in membrane structure, secretory, and transport of lipids. It plays a key role in protein palmitoylation and the function of signaling molecules in children (Innis, 2016). Early nutrition is a crucial factor in determining the composition of the gut microbiota, which can impact metabolic and immune system development both in the short term and long term. Increased Lactobacillus and Bifidobacterium colonization of the infant's intestines may be facilitated by palmitic acid (Yaron *et al*., 2013). A diet rich in 16:0 fatty acids promotes enhanced cell proliferation and decreases apoptosis, which improves the growth and adaptability of the ileum and jejunum in bowel syndrome (Sukhotnik *et al*., 2011).

Fortified biscuits also have higher levels of unsaturated fatty acids (UFA), including oleic acid (23.58%) and linoleic acid (7.48%), compared to commercial biscuits. The high content of both fatty acids is due to the addition of minced catfish in the fortified biscuits. According to Abdel- Mobdy *et al*. (2021a), the composition of oleic acid and linoleic acid in catfish is 36.35% and 19.76%, respectively. Linoleic acid is crucial for maintaining “metabolic integrity.” It serves as a precursor to arachidonic acid (ARA), which is vital for the normal growth and development of the brain. In term infants, insufficient levels of linoleic acid have been linked to poor growth and potential skin health problems. (González *et al*., 2020). Oleic acid has been shown to produce positive anti-inflammatory properties in autoimmune disorders, provide advantages in preventing breast cancer, and strengthen immune system performance. (Sales-Campos *et al*., 2013).

The higher and more complete total fatty acid content and profile of saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acids in the fortified biscuits, particularly marked by a tenfold higher level of linolenic acid (Omega-3), is directly influenced by the use of fish meatwhich is rich in complex lipidsin the product’s formulation (Garg *et al*., 2006).

Conclusion

This study successfully achieved its objective to develop a nutritious biscuit for preventing malnutrition in children through fortification with minced catfish and *Ulva* sp. The optimal formulation, containing 33% wheat flour, 14% minced catfish, and 1% *Ulva* sp. flour, yielded a product with significantly enhanced nutritional profile compared to commercial biscuits. The fortified biscuits contained 15.06% protein—more than double the commercial variant (7.14%)—and exhibited substantially higher phosphorus content (296.48 mg/100 g). The essential amino acid profile was notably improved, with levels of leucine, valine, and isoleucine exceeding the FAO/WHO reference pattern, although lysine content remained slightly below the standard. Furthermore, the total fatty acid content was higher (94.59 mg/g), dominated by beneficial unsaturated fats like oleic acid and linoleic acid. Critically, this nutritional enhancement was achieved without compromising sensory acceptability, as the product received favorable scores for taste, color, texture, and hardness in evaluations. Therefore, the developed fortified biscuit demonstrates strong potential as an effective functional food to address protein and micronutrient deficiencies, thereby supporting efforts to combat malnutrition and stunting among Indonesian children.

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References

Abdel- Mobdy, H. E., Abdel-Aal, H. A., Souzan, S. L., & Nassar, A. G. 2021a. Nutritional Value of African Catfish (Clarias gariepinus) Meat. *Asian Journal of Applied Chemistry Research, April 2021*, 31–39. https://doi.org/10.9734/ajacr/2021/v8i230190

Abdel- Mobdy, H. E., Abdel-Aal, H. A., Souzan, S. L., & Nassar, A. G. 2021b. Nutritional Value of African Catfish (Clarias gariepinus) Meat. *Asian Journal of Applied Chemistry Research*, *8*(2), 31–39. https://doi.org/10.9734/ajacr/2021/v8i230190

Abdel-Khaliq, A., Hassan, H., & Rateb, M. 2014. Antimicrobial Activity of Three Ulva Species Collected from Some Egyptian. *Biology, Environmental Science, Medicine*.

Abirami, R. G., & Kowsalya, S. 2011. Nutrient and nutraceutical potentials of seaweed biomass Ulva lactuca and Kappaphycus alvarezii. *Agricultural Science and Technology*, *5*(1), 1–7.

Agama-Acevedo, E., Islas-Hernández, J. J., Pacheco-Vargas, G., Osorio-Díaz, P., & Bello-Pérez, L. A. 2012. Starch digestibility and glycemic index of cookies partially substituted with unripe banana flour. *Lwt*, *46*(1), 177–182. https://doi.org/10.1016/j.lwt.2011.10.010

Ajibare, A. O., Ayeku, P. O., & Udoh, F. E. 2023. Proximate Composition and Sensory Evaluation of Catfish (Clarias gariepinus) Smoked with Different Materials. *Aquatic Food Studies*, *3*(2). https://doi.org/10.4194/afs193

Arimi, J. M., Duggan, E., O’Sullivan, M., Lyng, J. G., & O’Riordan, E. D. 2010. Effect of water activity on the crispiness of a biscuit (Crackerbread): Mechanical and acoustic evaluation. *Food Research International*, *Volume 43*(6), 1650–1655. https://doi.org/10.1016/j.foodres.2010.05.004

Astiana, I., Lahay, A. F., Utari, S. P. S. D., Farida, I., Samanta, P. N., Budiadnyani, I. G. A., & Febrianti, D. 2023. Organoleptic and nutritional characterization of fish biscuits with fortification of surimi powder from purple-spotted bigeye fish (Priacanthus tayenus). *Jurnal Pengolahan Hasil Perikanan Indonesia*, *26*(1), 107–116. https://doi.org/10.17844/jphpi.v26i1.44286

Beal, T., Tumilowicz, A., Sutrisna, A., Izwardy, D., & Neufeld, L. M. 2018. A review of child stunting determinants in Indonesia. *Maternal and Child Nutrition*, *14*(4), 1–10. https://doi.org/10.1111/mcn.12617

BSN. 2006a. Cara uji kimia - Bagian 3: Penentuan kadar lemak total pada produk perikanan. *Badan Standardisasi Nasional*, 16.

BSN. 2006b. Cara uji kimia - Bagian 4: Penentuan kadar protein dengan metode total nitrogen pada produk perikanan. *Standar Nasional Indonesia*, 1–16.

BSN. 2006c. Penentuan Kadar Air Pada Produk Perikanan. *Badan Nasional Standardisasi*.

BSN. 2010. Cara uji kimia - bagian 1: penentuan kadar abu dan abu tidak larut asam pada produk perikanan. *Jakarta (ID): BSN 2010*, 2–8.

BSN. 2015. *SNI 2346:2016 - Pengujian Sensori Produk Perikanan*.

Cayres, C. A., Ascheri, J. L. R., & Couto, M. A. P. G. 2021. Evaluation of nutritional characteristics and consumers' acceptance of gluten-free sweet biscuits made from rice-based pregelatinized composite flours containing orange pomace and soy protein isolate. *SN Applied Sciences*, *3*(2), 1–13. https://doi.org/10.1007/s42452-021-04209-z

Charutigon, C., Jitpupakdree, J., Namsree, P., & Rungsardthong, V. 2008. Effects of processing conditions and the use of modified starch and monoglyceride on some properties of extruded rice vermicelli. *Lwt*, *41*(4), 642–651. https://doi.org/10.1016/j.lwt.2007.04.009

Ciudadanos, C., Atención, P., Colectivos, P. Y., Hernández, A. G., Victoria, E. M. De, Rodrigo, C. P., Vasco, P., & Ehu, U. P. V. 2018. *Guia Senc*.

Cohen, S. A., & Wandelen, C. van. 1997. Amino acid analysis of unusual and complex samples based on 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate derivatization. *Techniques in Protein Chemistry*, *8*, 185–196.

Dang, V. D., Cohanim, A. B., Fontana, S., Privman, E., & Wang, J. 2019. Has gene expression neofunctionalization in the fire ant antennae contributed to queen discrimination behavior? *Ecology and Evolution*, *9*(22), 12754–12766. https://doi.org/10.1002/ece3.5748

Daures, M., Phelan, K., Issoufou, M., Kouanda, S., Sawadogo, O., Issaley, K., Cazes, C., Séri, B., Ouaro, B., Akpakpo, B., Mendiboure, V., Shepherd, S., & Becquet, R. 2020. New approach to simplifying and optimising acute malnutrition treatment in children aged 6-59 months: The OptiMA single-arm proof-of-concept trial in Burkina Faso. *British Journal of Nutrition*, *123*(7), 756–767. https://doi.org/10.1017/S0007114519003258

del Olmo, A., Picon, A., & Nuñez, M. 2018. Cheese supplementation with five species of edible seaweeds: Effect on microbiota, antioxidant activity, colour, texture and sensory characteristics. *International Dairy Journal*, *84*, 36–45. https://doi.org/10.1016/j.idairyj.2018.04.004

Dewey, K. G., Pannucci, T. R., Casavale, K. O., Davis, T. A., Donovan, S. M., Kleinman, R. E., Taveras, E. M., Bailey, R. L., Novotny, R., Schneeman, B. O., Stang, J., de Jesus, J., & Stoody, E. E. 2021. Development of food pattern recommendations for infants and toddlers 6–24 months of age to support the dietary guidelines for Americans, 2020–2025. *Journal of Nutrition*, *151*(10), 3113–3124. https://doi.org/10.1093/jn/nxab201

Diatin, I., Shafruddin, D., Hude, N., Sholihah, M., & Mutsmir, I. 2021. Production performance and financial feasibility analysis of farming catfish (Clarias gariepinus) utilizing water exchange system, aquaponic, and biofloc technology. *Journal of the Saudi Society of Agricultural Sciences*, *20*(5), 344–351. https://doi.org/10.1016/j.jssas.2021.04.001

Garg, M. L., Wood, L. G., Singh, H., & Moughan, P. J. 2006. Means of delivering recommended levels of long chain n-3 polyunsaturated fatty acids in human diets. *Journal of Food Science*, *71*(5). https://doi.org/10.1111/j.1750-3841.2006.00033.x

Giuberti, G., Bresciani, A., Cervini, M., Frustace, A., & Marti, A. 2021. Moringa oleifera L. leaf powder as ingredient in gluten-free biscuits: nutritional and physicochemical characteristics. *European Food Research and Technology*, *247*(3), 687–694. https://doi.org/10.1007/s00217-020-03656-z

Golden, C. D., Koehn, J. Z., Shepon, A., Passarelli, S., Free, C. M., Viana, D. F., Matthey, H., Eurich, J. G., Gephart, J. A., Fluet-Chouinard, E., Nyboer, E. A., Lynch, A. J., Kjellevold, M., Bromage, S., Charlebois, P., Barange, M., Vannuccini, S., Cao, L., Kleisner, K. M., … Thilsted, S. H. 2021. Aquatic foods to nourish nations. *Nature*, *598*(7880), 315–320. https://doi.org/10.1038/s41586-021-03917-1

González, N., Calderón, J., Rúbies, A., Bosch, J., Timoner, I., Castell, V., Marquès, M., Nadal, M., & Domingo, J. L. 2020. Dietary exposure to total and inorganic arsenic via rice and rice-based products consumption. *Food and Chemical Toxicology*, *141*(May), 111420. https://doi.org/10.1016/j.fct.2020.111420

Goubgou, M., Songré-Ouattara, L. T., Bationo, F., Lingani-Sawadogo, H., Traoré, Y., & Savadogo, A. 2021. Biscuits: a systematic review and meta-analysis of improving the nutritional quality and health benefits. *Food Production, Processing and Nutrition*, *3*(1). https://doi.org/10.1186/s43014-021-00071-z

Gracia, C., Haryanto, B., & Sugiyono. 2009. Study on Corn Biscuit Formulation to Subtitute of wheat Flour. *Jurnal Teknologi Dan Industri Pangan*, *20*(1), 32–40.

Guidara, M., Yaich, H., Amor, I. Ben, Fakhfakh, J., Gargouri, J., Lassoued, S., Blecker, C., Richel, A., Attia, H., & Garna, H. 2021. Effect of extraction procedures on the chemical structure, antitumor and anticoagulant properties of ulvan from Ulva lactuca of Tunisia coast. *Carbohydrate Polymers*, *253*(August 2020), 117283. https://doi.org/10.1016/j.carbpol.2020.117283

Harper, A. E. 1981. Dietary guidelines for Americans. *The American Journal of Clinical Nutrition*, *34*(1), 121–123. https://doi.org/10.1093/ajcn/34.1.121

Harris, J. L., & Pomeranz, J. L. 2020. Infant formula and toddler milk marketing: Opportunities to address harmful practices and improve young children's diets. *Nutrition Reviews*, *78*(10), 866–883. https://doi.org/10.1093/nutrit/nuz095

Harzau, H., & Estiasih, T. 2013. Karakteristik Cookies Umbi Inferior Uwi Putih (Kajian Proporsi Tepung Uwi: Pati Jagung dan Penambahan Margarin). *Jurnal Pangan Dan Agroindustri*, *1*(1), 138–147.

Henriksson, P. J. G., Banks, L. K., Suri, S. K., Pratiwi, T. Y., Fatan, N. A., & Troell, M. 2019. Indonesian aquaculture futures-identifying interventions for reducing environmental impacts. *Environmental Research Letters*, *14*(12). https://doi.org/10.1088/1748-9326/ab4b79

Innis, S. M. 2016. Palmitic Acid in Early Human Development. *Critical Reviews in Food Science and Nutrition*, *56*(12). https://doi.org/10.1080/10408398.2015.1018045

Irani, M., Razavi, S. M. A., Abdel-Aal, E. S. M., Hucl, P., & Patterson, C. A. 2019. Viscoelastic and textural properties of canary seed starch gels in comparison with wheat starch gel. *International Journal of Biological Macromolecules*, *124*, 270–281. https://doi.org/10.1016/j.ijbiomac.2018.11.216

Istinganah, M., Rauf, R., & Widyaningsih, E. N. 2017. Tingkat Kekerasan dan Daya Terima Biskuit dari Campuran Tepung Jagung dan Tepung Terigu dengan Volume Air yang

Proporsional. *Jurnal Kesehatan*, *10*(2), 83. https://doi.org/10.23917/jurkes.v10i2.5537

Kemenkes. 2019. *Permenkes No 28*. *Tentang Angka Kecukupan Gizi*.

Kerler, J., Winkel, C., Davidek, T., & Blank, I. 2010. Basic Chemistry and Process Conditions for Reaction Flavours with Particular Focus on Maillard-Type Reactions. In *Food Flavour Technology: Second Edition*. https://doi.org/10.1002/9781444317770.ch3

Khairy, H. M., & El-Shafay, S. M. 2013. Seasonal variations in the biochemical composition of some common seaweed species from the coast of Abu Qir Bay, Alexandria, Egypt. *Oceanologia*, *55*(2), 435–452. https://doi.org/10.5697/oc.55-2.435

Klerks, M., Román, S., & Sánchez-Siles, L. 2023. Baby, children, and adult biscuits. Differences in nutritional quality and naturalness. *Food Science and Nutrition*, *11*(12), 7946–7956. https://doi.org/10.1002/fsn3.3711

Lawless, H. T., & Heymann, H. 2010. *Similarity, Equivalence Testing, and Discrimination Theory*. 101–123. https://doi.org/10.1007/978-1-4419-6488-5_5

Lindemann, B., Ogiwara, Y., & Ninomiya, Y. 2002. The discovery of umami [2]. *Chemical Senses*, *27*(9), 843–844. https://doi.org/10.1093/chemse/27.9.843

Liu, S., Ma, G., Zhang, T., Wang, L., Pei, H., Li, X., & Gao, L. 2022. Insights into flavor and key influencing factors of Maillard reaction products: A recent update. *Frontiers in Nutrition*, *9*, 1–18.

Ma, C., Wang, Y., Gu, D., Nan, J., Chen, S., & Li, H. 2017. Overexpression of S-adenosyl-L-methionine synthetase 2 from sugar beet M14 increased arabidopsis tolerance to salt and oxidative stress. *International Journal of Molecular Sciences*, *18*(4). https://doi.org/10.3390/ijms18040847

Manley, D. 2011. *Manley's technology of biscuits, crackers and cookies: Fourth edition*.

Meilgaard, M., Civille, G.V., Carr, B. T. 2007. *The Spectrum Descriptive Analysis Method. Sensory Evaluation Techniques*. 2376–2377.

Najjar, Z., Alkaabi, M., Alketbi, K., Stathopoulos, C., & Ranasinghe, M. 2022. Physical Chemical and Textural Characteristics and Sensory Evaluation of Cookies Formulated with Date Seed Powder. *Foods*, *11*(3), 1–13. https://doi.org/10.3390/foods11030305

Norhayati, M. K., Mohd Fairulnizal, M. N., Zaiton, A., Wan Syuriahti, W. Z., Rusidah, S., Aswir, A. R., Ang, J. L., Mohd Naeem, M. N., Suraiami, M., Mohd Azerulazree, J., & Vimala, B. 2015. Nutritional composition of selected commercial biscuits in Malaysia. *Sains Malaysiana*, *44*(4), 581–591. https://doi.org/10.17576/jsm-2015-4404-13

Plaza-Díaz, J., Molina-Montes, E., Soto-Méndez, M. J., Madrigal, C., Hernández-Ruiz, Á., Valero, T., Villoslada, F. L., Leis, R., de Victoria, E. M., Moreno, J. M., Ortega, R. M., Ruiz-López, M. D., Varela-Moreiras, G., & Gil, Á. 2020. Clustering of dietary patterns and lifestyles among spanish children in the esnupi study. *Nutrients*, *12*(9), 1–25. https://doi.org/10.3390/nu12092536

Rahmi FJ, Huljannah, N., & Rochmah, T. N. 2022. Stunting Prevention Program in Indonesia: A Systematic Review. *Media Gizi Indonesia*, *17*(3), 281–292. https://doi.org/10.20473/mgi.v17i3.281-292

Rasyid, A. 2017. Evaluation of nutritional composition of the dried seaweed Ulva lactuca from Pameungpeuk waters, Indonesia. *Tropical Life Sciences Research*, *28*(2), 119–125. https://doi.org/10.21315/tlsr2017.28.2.9

Rohani-Ghadikolaei, K., Abdulalian, E., & Ng, W. K. 2012. Evaluation of the proximate, fatty acid and mineral composition of representative green, brown and red seaweeds from the Persian Gulf of Iran as potential food and feed resources. *Journal of Food Science and Technology*, *49*(6), 774–780. https://doi.org/10.1007/s13197-010-0220-0

Rutkowska, J., Adamska, A., Sinkiewicz, I., & Bia³ek, M. 2012. Composition of fatty acids in selected sorts of biscuits, offered for children. *Acta Alimentaria*, *41*(4), 433–442. https://doi.org/10.1556/AAlim.41.2012.4.5

Sadkey, A. A. 2023. Effect of partial replacement of wheat flour by different sources on the quality parameters of dough and hard sweet biscuits. *Al-Azhar Journal of Agricultural Research*, *48*(1), 1–11. https://doi.org/10.21608/ajar.2023.316052

Sales-Campos, H., Reis de Souza, P., Crema Peghini, B., Santana da Silva, J., & Ribeiro Cardoso, C. 2013. An Overview of the Modulatory Effects of Oleic Acid in Health and Disease. *Mini-Reviews in Medicinal Chemistry*, *13*(2), 201–210. https://doi.org/10.2174/1389557511313020003

Salvatore, S., Battigaglia, M. S., Murone, E., Dozio, E., Pensabene, L., & Agosti, M. 2023. Dietary Fibers in Healthy Children and in Pediatric Gastrointestinal Disorders: A Practical Guide. *Nutrients*, *15*(9), 1–17. https://doi.org/10.3390/nu15092208

Santoso, J., Priasmoro, G. P., Uju, U., Subaryono, S., & Sumandiarsa, I. K. 2024. The Effect of Alkali Pretreatment and Different Parts of Sargassum polycystum Thallus on Alginic Acid Attributes. *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, *19*(1), 31–43. https://doi.org/10.15578/squalen.829

Shadyeva, L., Romanova, E., Romanov, V., Spirina, E., Lyubomirova, V., Shlenkina, T., & Fatkudinova, Y. 2019. Forecast of the nutritional value of catfish (Clarias gariepinus) in the spawning period. *IOP Conference Series: Earth and Environmental Science*, *403*(1). https://doi.org/10.1088/1755-1315/403/1/012218

Sihombing, F., Rumaseuw, E. S., & Raniadita, M. A. 2024. Analysis of the Nutritional Content of Catfish Extract as a Reliable Food Ingredient to Improve the Nutrition of Stunted Toddlers. *Jurnal Biologi Tropis*, *24*(3), 216–222. https://doi.org/10.29303/jbt.v24i3.7335

Silveira, J. T., De Moura, F. A., & Dornelles Gasperin, P. 2023. Qualidade nutricional de biscoitos disponíveis à venda em supermercados. *DEMETRA: Alimentação, Nutrição & Saúde*, *18*, e67477. https://doi.org/10.12957/demetra.2023.67477

Sinurat, E., Sihono, S., Fateha, F., Supriyanto, A., Suryaningrum, T. D., Nurhayati, N., Fransiska, D., Utomo, B. S. B., Sedayu, B. B., & Waryanto, W. 2023. Proximate composition , sensory evaluation , physical properties , mineral content and amino acid profile of nori-like product from Ulva lactuca and Gracilaria. *Research Square*, 1–28. https://www.researchsquare.com/article/rs-3451985/v1

Slavin, J. 2012. Dietary guidelines: Are we on the right path? *Nutrition Today*, *47*(5), 245–251. https://doi.org/10.1097/NT.0b013e31826c50af

Sukhotnik, I., Shamir, R., Bashenko, Y., Mogilner, J. G., Chemodanov, E., Shaoul, R., Coran, A. G., & Shehadeh, N. 2011. Effect of oral insulin on diabetes-induced intestinal mucosal growth in rats. *Digestive Diseases and Sciences*, *56*(9), 2566–2574. https://doi.org/10.1007/s10620-011-1654-6

Sulieman, A. A., Zhu, K. X., Peng, W., Hassan, H. A., Obadi, M., Siddeeg, A., & Zhou, H. M. 2019. Rheological and quality characteristics of composite gluten-free dough and biscuits supplemented with fermented and unfermented Agaricus bisporus polysaccharide flour. *Food Chemistry*, *271*(January 2018), 193–203. https://doi.org/10.1016/j.foodchem.2018.07.189

Tabarsa, M., Rezaei, M., Ramezanpour, Z., & Waaland, J. R. 2012. Chemical compositions of the marine algae Gracilaria salicornia (Rhodophyta) and Ulva lactuca (Chlorophyta) as a potential food source. *Journal of Science of Food and Agriculture*, *92*, 2500–2506.

UNICEF/WHO/WORLD BANK. 2021. Levels and trends in child malnutrition UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates Key findings of the 2021 edition. *World Health Organization*, 1–32. https://www.who.int/publications/i/item/9789240025257

UNICEF, WHO, & WORLD BANK. 2021. Levels and trends in child malnutrition; UNICEF/WHO/World Bank Group-Joint child malnutrition estimstes 2021 edition. *World Health Organization*, 1–32. https://data.unicef.org/resources/jme-report-2021/

Urganci, U., & Isik, F. 2021. Quality Characteristics of Biscuits Fortified with Pomegranate Peel. *Akademik Gida*, *19*(1), 10–20. https://doi.org/10.24323/akademik-gida.927462

Wang, Y., Shen, K., Li, P., Zhou, J., & Yan, C. 2011. Simultaneous determination of 20 underivatized amino acids by high performance liquid chromatography-evaporative light-scattering detection. *Chinese Journal of Chromatography (Se Pu)*, *29*(9), 908–911. https://doi.org/10.3724/SP.J.1123.2011.00908

WHO. 2006. WHO Child Growth Standards. *Developmental Medicine & Child Neurology*, *51*(12), 1002–1002. https://doi.org/10.1111/j.1469-8749.2009.03503.x

WHO. 2009. *Child Growth Standards And The Identification of Severe Acute Malnutrition in Infants and Children. In A Joint Statement by The World Health Organization And The United Nations Children's Fund. WHO: Geneva, Switzerland.*

WHO. 2012. Sixty-Fifth World Health Assembly. *World Health Organization*, *May*, 148. http://www.who.int/nutrition/topics/WHA65.6_resolution_en.pdf?ua=1

Yaron, S., Shachar, D., Abramas, L., Riskin, A., Bader, D., Litmanovitz, I., Cohen, F. B.-Y. T., Levi, L., Lifshitz, Y., Shamir, R., & Shaoul, R. 2013. Effect of High â-Palmitate Content in Infant Formula on the Intestinal Microbiota of Term Infants. *Journal of Pediatric Gastroenterology and Nutrition*, *56*(4), 376–381.

Zhang, X., Zheng, W., Zhang, H., Chai, Y., & Ruan, G. 2022. Comparison of Muscle Quality of the Yellow Catfish Cultured in In-Pond Raceway Systems and Traditional Ponds. *Water (Switzerland)*, *14*(8), 1–11. https://doi.org/10.3390/w14081223

Zhao, G. Q., Zhang, Y., Hoon, M. A., Chandrashekar, J., Erlenbach, I., Ryba, N. J. P., & Zuker, C. S. 2003. The Receptors for Mammalian Sweet and Umami Taste University of California at San Diego. *Cell*, *115*, 255–266.