January – March, 2026
Original Article
DOI: http://dx.doi.org/10.30867/action.v11i1.2871

Pages: 84 – 96

AcTion:
Aceh Nutrition Journal
p-issn 2527-3310; e-issn 2548-5741

Potential of lindur flour (*Bruguiera gymnorrhiza*) for gluten-free cookies (Kulinur) as an alternative snack for children with autism spectrum disorder

Potensi tepung lindur (Bruguiera gymnorrhiza) untuk kue kering bebas gluten (Kulinur) sebagai camilan alternatif untuk anak dengan gangguan spektrum autisme

Hidayatusy Syukrina Puteri[1*], Adhi Nurhartanto[2], Yunita Dinda Dewi[3]

[1] Nutrition Study Program, Faculty of Health, Mitra Indonesia University, Bandar Lampung, Indonesia.
E-mail: syukrinaputeri@umitra.ac.id.
[2] Nutrition Study Program, Faculty of Health, Mitra Indonesia University, Bandar Lampung, Indonesia.
E-mail: nurhartanto@umitra.ac.id.
[3] Nutrition Study Program, Faculty of Health, Mitra Indonesia University, Bandar Lampung, Indonesia.
E-mail: yunitadindadewi@gmail.com

***Correspondence Author:**
Nutrition Study Program, Faculty of Health, Mitra Indonesia University, Bandar Lampung, Indonesia.
E-mail: syukrinaputeri@umitra.ac.id

Article History:
Received: September 09, 2025; Revised: October 22, 2025; Accepted: October 29, 2025; Published: March 04, 2026.

Publisher:
Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

Abstract

Autism Spectrum Disorder (ASD) affects about 2.4 million individuals in Indonesia, with 500 new cases annually. Children with ASD often experience gluten and casein intolerance, leading to a restricted diet and inadequate protein and carbohydrate intakes. Lindur flour (*Bruguiera gymnorrhiza*), containing 2.57–2.68% protein and 80–82% carbohydrates, may serve as a local gluten-free substitute for wheat flour. This quasi-experimental study used a Completely Randomized Design (CRD) with five formulations (F0–F4) combining lindur and modified cassava (mocaf) flours. Proximate composition, gluten content (ELISA), and sensory attributes were analyzed in duplicate and evaluated using one-way ANOVA ($p<0.05$) and the Kruskal–Wallis test. Increasing the substitution of lindur significantly affected the moisture, ash, protein, fat, crude fiber, and carbohydrate contents. The 100% lindur formulation (F4) exhibited the highest protein (11.54%) and fiber (7.82%) contents, whereas all products were gluten-free (<3 ppm). Sensory evaluation indicated that formulations with 25–50% lindur flour (F1–F2) achieved the highest acceptability in terms of taste, texture, and overall preferences. This study is the first to utilize lindur flour in gluten-free cookie development for children with ASD, demonstrating its potential as a nutritious, locally sourced ingredient for functional food innovation in gluten-free diets.

Keywords: Functional Food, Lindur Flour, Gluten-Free, Autism, Cookies.

Abstrak

Prevalensi Autism Spectrum Disorder (ASD) di Indonesia sekitar 2,4 juta individu dengan 500 kasus baru setiap tahun. Anak dengan ASD sering mengalami intoleransi terhadap gluten dan kasein, sehingga membutuhkan diet bebas gluten dan kasein yang berisiko menurunkan asupan protein dan karbohidrat. Tepung lindur (Bruguiera gymnorrhiza), yang mengandung 2,57–2,68% protein dan 80–82% karbohidrat, berpotensi menjadi pengganti tepung terigu bebas gluten dari sumber lokal. Penelitian ini menggunakan desain kuasi-eksperimental dengan Rancangan Acak Lengkap (RAL) pada lima formulasi (F0–F4) yang memadukan tepung lindur dan mocaf (modified cassava flour). Analisis dilakukan secara duplo mencakup uji proksimat, kadar gluten (ELISA), dan uji organoleptik, dengan analisis statistik menggunakan ANOVA satu arah ($p<0,05$) dan Kruskal–Wallis. Substitusi tepung lindur berpengaruh signifikan terhadap kadar air, abu, protein, lemak, serat kasar, dan karbohidrat. Formulasi F4 (100% lindur) memiliki kadar protein tertinggi (11,54%) dan serat kasar (7,82%), sementara seluruh produk terbukti bebas gluten (<3 ppm). Formulasi F1–F2 (25–50% lindur) paling disukai berdasarkan rasa, tekstur, dan penerimaan keseluruhan. Studi ini merupakan eksplorasi pertama penggunaan tepung lindur dalam kue kering bebas gluten untuk anak ASD dan menunjukkan potensi pengembangannya sebagai pangan fungsional lokal bergizi.

Kata Kunci: Pangan Fungsional, Tepung Lindur, Bebas Gluten, Autisme, Kue Kering

Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder that appears in children before the age of three years and is characterized by difficulties in forming social relationships and developing normal communication skills (Dewi & Morawati, 2024). Studies have shown that the urine of individuals with ASD contains abnormal levels of gluten and casein (González-Domenech et al., 2022). These substances can act as allergens that trigger allergic reactions, leading to decreased cortisol and metabolic hormone levels and increased progesterone and adrenaline levels (Cahya & Berawi, 2016). Such changes may affect the functions of the central nervous system and the brain (Chaudhry et al., 2023), therefore children with ASD are recommended to follow a gluten-free and casein-free diet to reduce the impact of these allergens.

In Indonesia, the prevalence of ASD is estimated to reach 2.4 million people, with approximately 500 new cases annually since 2010 (Ramadhanty et al., 2024). One common health problem among individuals with ASD is nutritional imbalance (Atmika & Karina, 2020). The implementation of gluten- and casein-free diets may result in inadequate nutrient intake. Studies indicate that most individuals with ASD (65.6%) consume insufficient carbohydrates and protein, while 40.6% consume an excessive amount of fat. Consequently, many experience obesity (40.6%), overnutrition (12.5%), and undernutrition (9.4%) (Sopiandi, 2017).

Preschool children tend to prefer processed foods that are visually appealing and flavorful. Gluten is generally found in wheat, flour, cornstarch, oats, and barley, whereas while casein originates from dairy products (Cahya & Berawi, 2016). This condition limits children with ASD from consuming common market foods that usually contain carbohydrates and proteins. Families with sufficient economic resources may fulfill their protein needs through animal sources, although excessive consumption can increase the risk of obesity. In contrast, families with limited resources face difficulties in meeting carbohydrate and protein requirements, highlighting the need for affordable alternatives. One possible innovation is the use of lindur flour, which is naturally low in gluten, as a substitute for wheat flour, combined with chicken eggs as a gluten- and casein-free protein source (Viorafanti Olivia et al., 2025).

Indonesia has the world's largest mangrove forests and extensive coastlines (Karim et al., 2023). One abundant mangrove species is *Bruguiera gymnorrhiza* (lindur). However, its utilization as a food source remains limited, as rice continues to dominate as the primary staple food (Wibowo & Untari, 2023). Coastal communities in Lampung, particularly on Pahawang Island, have processed lindur into do using lindur flour. However, this product has a relatively short shelf life (Meidasari et al., 2023). Previous studies have shown that lindur flour has potential as a raw material for gluten-free bakery products, chips, dodol, and mixed rice or corn products (Amin et al., 2019; Meidasari et al., 2023). Cookies are a practical snack option that is durable and widely favored by children because of their crispy texture and sweet flavor. Conventional cookies are typically made with wheat flour, which contains gluten (Relita et al., 2024), making them unsafe for individuals with gluten allergy, celiac disease, or gluten intolerance, including children with ASD (Cahya & Berawi, 2016). Lindur flour can be used as an alternative ingredient in biscuits because of its low gluten content (Amin et al., 2019). However, to date, no study has systematically evaluated the application of lindur flour in cookie formulations that are both sensory acceptable and tailored to meet the nutritional and dietary needs of children with ASD.

Lindur flour contains approximately 2.57–2.68% protein and 80–82% carbohydrate (Rosulva et al., 2021). For comparison, mocaf flour contains 2.17% protein (Gaol et al., 2022) and approximately around 39.63% carbohydrates in a 70% mixture (Zaki et al., 2024). These values suggest that lindur flour has a greater potential as a safe carbohydrate and protein source in the diet of individuals with ASD.

Based on this rationale, the present study is the first to combine lindur flour (Bruguiera gymnorrhiza) and mocaf to formulate gluten-free cookies (Kulinur) designed for children with Autism Spectrum Disorder (ASD). Specifically, this study aimed to determine the macronutrient composition and gluten content of lindur flour, develop gluten- and casein-free cookie formulations using lindur and mocaf flours, and evaluate the physical and sensory characteristics of the resulting cookies.

This study hypothesized that combining lindur and mocaf flours would produce gluten-free cookies with favorable physicochemical and sensory properties while meeting the nutritional requirements suitable for ASD-specific dietary needs.

Methods

This study employed a quasi-experimental design using a Completely Randomized Design (CRD) with the substitution of lindur flour and modified cassava flour (mocaf) as the primary variables. The formulation process was adapted from a previous study that developed cookies using sago flour. In this study, cookies were formulated using lindur flour and mocaf as the main ingredients, with a total weight of 100 g per sample. Five formulation treatments were prepared to evaluate the effects of different ratios of lindur flour to mocaf: F0 (0:100), F1 (25:75), F2 (50:50), F3 (75:25), and F4 (100:0) (Table 1). All formulations were subjected to proximate analysis, organoleptic evaluation, and gluten testing, each conducted in duplicate (duplo) to ensure data reliability.

Proximate analysis of the products included the determination of moisture and ash content by the gravimetric method, protein content by the Kjeldahl method, fat content by Soxhlet extraction, carbohydrate content by difference, and crude fiber content using chemical reagents such as sulfuric acid (H_2SO_4) and sodium hydroxide (NaOH).

The gluten profile was analyzed using the Enzyme-Linked Immunosorbent Assay (ELISA) technique, which enables the precise quantification of gluten content in both raw ingredients and processed food matrices. The SENSISpec INgezim Gluten R5 ELISA kit was used for this purpose, providing quantitative measurements with a limit of detection (LOD) of 3 ppm (mg/kg).

Table 1. Formulation of Kulinur Cookies (100 g)

Ingredients	Formulation				
	F0	F1	F2	F3	F4
Lindur Flour(g)	0	25	50	75	100
Mocaf Flour (g)	100	75	50	25	0
Cornstarch (g)	25	25	25	25	25
Coconut milk powder (g)	10	10	10	10	10
Egg white (g)	45	45	45	45	45
Raw cane	45	45	45	45	45
sugar (g)	60	60	60	60	60
Coconut Oil (g)	1	1	1	1	1
Salt (tsp)	2	2	2	2	2
Vanilla paste (tsp)	2	2	2	2	2

g = Gram, tsp = Teaspoon

The main raw materials were sourced from local Indonesian products, including lindur flour, mocaf flour, cornstarch, coconut milk powder, coconut oil, cane sugar, vanilla paste, eggs, salt, and almonds, all purchased from markets in Bandar Lampung. The equipment used included mixing bowls, whisks, spoons, sieves, baking paper, spatulas, baking trays, and an oven. The figures of the ingredients and tools are presented in Figure 1.

The preparation of Kulinur cookies involved five formulations, focusing on the proportions of lindur and mocaf flour. The ratios included 100 g mocaf only, 25 g lindur with 75 g mocaf, 50 g lindur with 50 g mocaf, 75 g lindur with 25 g mocaf, and 100 g lindur without mocaf. The proportions of other ingredients followed standard cookie recipes to ensure acceptable product quality. The step-by-step cookie preparation process is shown in Figure 2.

The organoleptic evaluation of Kulinur cookies was conducted at the Nutrition Laboratory, Universitas Mitra Indonesia. A hedonic sensory test was conducted with 30 semi-trained panelists, consisting of nutrition students who had completed at least six semesters or had taken the Food Processing and Preservation course. Each panelist evaluated the cookies based on color, taste, aroma, texture, and overall acceptability. Sensory assessment was performed using a five-point hedonic scale, where 1 = strongly like, 2 = like, 3 = neutral, 4 = dislike, and 5 = strongly dislike. All samples were presented under uniform testing conditions and coded with random five-digit numbers to minimize the bias. Panelists were provided with water between samples to cleanse their palates

The study was approved by the Ethics Committee of Universitas Mitra Indonesia on July 21, 2025 (approval no. S.25/2025/fkes10/2025). The study was conducted from July to August 2025 at Universitas Mitra Indonesia, POLINELA, and MBRIO Food Laboratory, West Java. Data processing included cleaning, editing, coding, and entry, followed by analysis using Microsoft Excel 2010 and SPSS version 16.0 for Windows. Proximate and organoleptic data were analyzed using one-way ANOVA ($p<0.05$), while gluten content was analyzed using the Kruskal–Wallis test ($p<0.05$). When significant differences were detected, post-hoc comparisons were conducted using Duncan's multiple range test for parametric data and Dunn's test for non-parametric data.

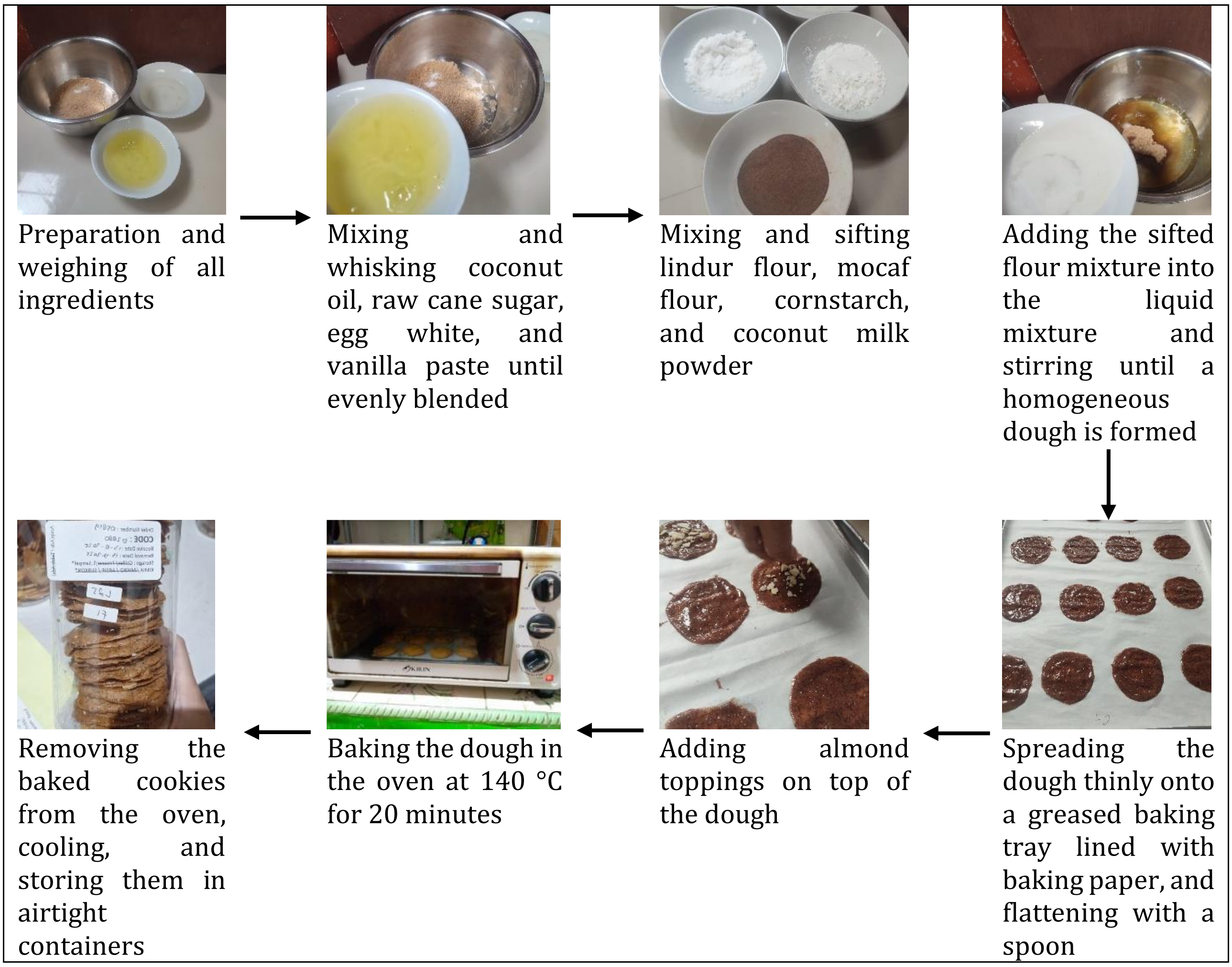

Figure 2. Preparation process of Kulinur cookies

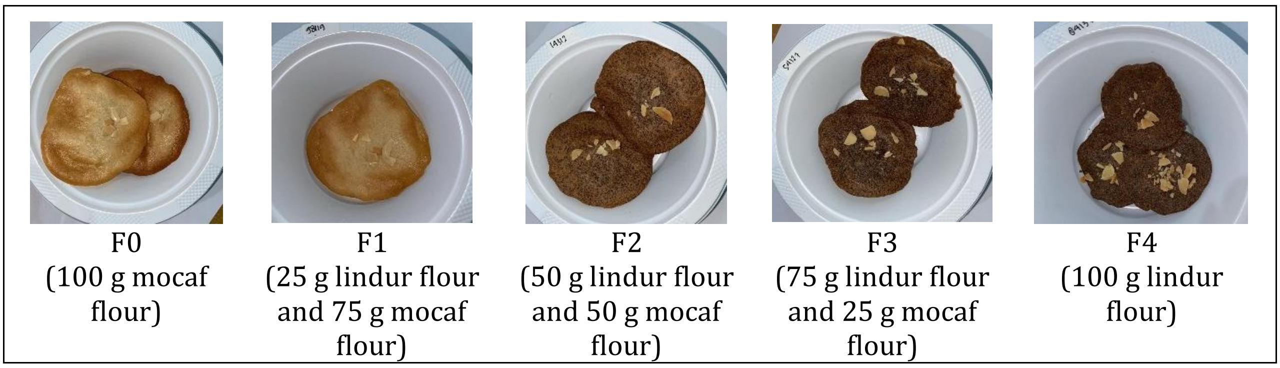

Figure 3. Formulation results of F0, F1, F2, F3, and F4 Kulinur cookies

Result and Discussion

Nutritional Content of Kulinur

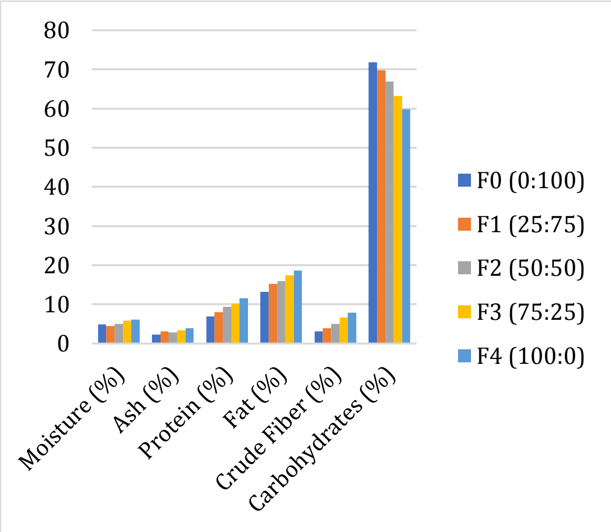

Figure 4. Proximate Composition of Kulinur Cookies

Bivariate analysis of proximate test results was conducted to determine differences in nutrient values such as moisture, ash, protein, fat, crude fiber, and carbohydrates across the different formulations. Bivariate analysis of the proximate data was performed using one-way ANOVA. The results of the proximate analysis of Kulinur are presented in Table 2.

Table 2. Proximate composition of Kulinur cookies

Variables (Lindur Flour: Mocaf Flour)	Mean± SD	p-value
Moisture (%)		
F0 (0:100)	4.83±0.15	
F1 (25:75)	4.45±0.06	
F2 (50:50)	5.05±0.02	0.000
F3 (75:25)	5.82±0.10	
F4 (100:0)	6.14±0.00	
Ash (%)		
F0 (0:100)	2.34±0.00	
F1 (25:75)	3.12±0.01	
F2 (50:50)	2.85±0.03	0.000
F3 (75:25)	3.39±0.09	
F4 (100:0)	3.92±0.10	
Protein (%)		
F0 (0:100)	6.93±0.08	
F1 (25:75)	7.98±0.01	
F2 (50:50)	9.33±0.06	0.000
F3 (75:25)	10.20±0.08	
F4 (100:0)	11.54±0.02	
Fat (%)		
F0 (0:100)	14.15±0.16	0.000
F1 (25:75)	15.21±0.09	
F2 (50:50)	15.90±0.08	
F3 (75:25)	17.40±0.24	
F4 (100:0)	18.60±0.10	
Crude Fiber (%)		
F0 (0:100)	3.12±0.07	
F1 (25:75)	3.90±0.04	
F2 (50:50)	5.06±0.08	0.000
F3 (75:25)	6.69±0.04	
F4 (100:0)	7.82±0.10	
Carbohydrates (%)		
F0 (0:100)	71.76±0.23	
F1 (25:75)	69.75±0.02	
F2 (50:50)	66.87±0.03	0.000
F3 (75:25)	63.20±0.17	
F4 (100:0)	59.80±0.22	

*One-Way ANOVA *significant (p<0,05)*

Moisture Content

Moisture analysis was performed to determine the water content of Kulinur cookies with different concentrations of lindur flour. The maximum moisture content limit for biscuit/cookie products set by the Indonesian National Standard (SNI) 2973:2011 is 5% (w/w). The analysis results in Table 2 show that the lowest moisture content was observed in F1 (4.45%). The highest moisture content was in formula F4 (6.14%) with raw material of 100 g of lindur flour without any mixture of MOCaf flour. Therefore, based on the standard, the formulas that met the requirements were F0 and F1, respectively. Based on analysis of variance using one-way ANOVA, it was obtained ($p < 0.001$), indicating significant differences in the moisture content of Kulinur products, although the formulas were different.

The results of the proximate analysis showed that the higher the proportion of lindur flour, the higher the moisture content in the product. The increase in moisture content in Kulinur products occurred because lindur flour has a fairly high water absorption capacity, which ranges from 125%–145% (Husain et al., 2023). Therefore, in product F4 with 100 g of raw material, approximately 125–145 ml of water was required to make the dough elastic. Another factor that affected the moisture content was the temperature and time during processing. In this study, the baking temperature and time were approximately 140 °C for 20 min. According to Afifah (2022) the ideal baking temperature and time to reduce the moisture content of biscuit/cookie products is approximately around 150 °C with a time of 20 minutes (Afifah et al., 2022).

Ash Content

Ash content refers to the inorganic or mineral components of food. In general, food is composed of water, organic components (such as carbohydrates, proteins, and fats), and inorganic components in the form of minerals known as ash content. Determination of total ash content has several purposes, including assessing the quality of processing, identifying the types of ingredients used, and estimating the nutritional value of a food product, particularly related to its mineral content (Mongdong et al., 2023).

The analysis results presented in Table 2 show that the difference in formulations between lindur and MOCAF flours had a significant effect on ash content ($p < 0.001$). The ash content in the control product (F0) was 2.34%, which was relatively lower than that of all tested formulas. Along with the increase in the proportion of in the formulations, the ash content of the product also increased. This increase was most evident in Kulinur cookies with formulation F4, which had the highest ash content (3.92 %). This finding indicates that the addition of lindur flour contributed to the increase in mineral content, as reflected in the ash value of the product. Based on the theory found in previous studies, the higher the detected ash value, the greater the mineral content of the food (Ahmed et al., 2022).

When compared with the quality requirements based on the Indonesian National Standard (SNI) 2971-2011, which sets the maximum limit of ash content in biscuits at 2%, it can be seen that all formulations of Kulinur cookies did not meet the standard. This was because the average ash content values obtained, both in the control product and in all formulations with the addition of lindur flour, were above the specified threshold. This indicates that the use of lindur flour, although positively contributing to the increase in mineral content of the product, also resulted in an increase in ash content that exceeded the biscuit quality standard according to SNI (Pebrina et al., 2021).

Protein is an essential nutrient that not only functions as an energy source, but also plays an important role in the growth and development of the body (Mongdong et al., 2023). According to the Indonesian National Standard (SNI) 2971-2011, the minimum protein content required in biscuit products is 5%. The results of the study, shown in Table 2, indicate that formulation F4 with the addition of 100 g of lindur flour had the highest protein content of 11.54%, while formulation F0 using 100 g of mocaf flour showed the lowest protein content of 6.93%. The protein content of the product was determined by the contribution of protein from all the ingredients used in the formulation. In this study, egg white was added up to 45 g in each formulation and served as the main protein source. However, the differences in protein content among the formulations were also influenced by the protein composition of the raw flour. Lindur flour has a higher protein content than mocaf flour, thereby increasing the total protein content in the product.

This finding is consistent with the results of Afifah et al. (2022), who reported that the addition of 15 g of lindur flour to sagon cake produced a protein content of 6.98%. This shows that the use of lindur flour can increase the protein content of processed food products, thus potentially improving their nutritional value, particularly in cookies based on local flours (Afifah et al., 2022).

Fat

Based on the results of the analysis of variance using one-way ANOVA, the obtained p value was < 0.001, which shows that there were significant differences in the fat content of Kulinur products using different formulations. The proximate analysis results showed that the fat content in Kulinur cookies ranged from 14.15% (F0) to 18.60% (F4). This pattern shows a tendency for increasing fat content with an increase in the proportion of lindur flour in the formulation.

This is consistent with the report by Moreine (2017), who which stated that lindur fruit starch flour has a relatively high fat content of 3.9%. The results of this study are also consistent with findings reporting that the addition of lindur flour to basreng products increased the fat content up to 11.63% (Zhenilla et al., 2024).

In addition to lindur flour, the increase in the fat content of a product can also be influenced by additional ingrediened. According to Raudah & Arif (2025), ingredients such as eggs, chocolate, and margarine play an important role in increasing the fat content of food products. In this study, the additional ingredients that became the main sources of fat were coconut oil, coconut milk powder, and egg white. Virgin Coconut Oil (VCO) is known to have a free fatty acid content of 0.18% (Ayu et al., 2023).

Crude Fiber

Based on the results of one-way ANOVA on the crude fiber content of Kulinur cookies, a p-value of < 0.001 was obtained, which shows that the difference in the ratio of lindur flour and mocaf flour had a significant effect on fiber content. The results of the proximate analysis (Table 2) show that the crude fiber content in Kulinur cookies ranged from 3.12% (F0) to 7.82% (F4). This indicates that the addition of lindur flour tends to increase the crude fiber content of the product.

Lindur flour is reported to have a fairly high crude fiber content, ranging from 11.43% to 14.35% (Nurafifah et al., 2024), whereas mocaf flour contains approximately 6% crude fiber about 6% (Rizky Fitriyanti et al., 2025). The difference in fiber content explains the contribution of lindur flour to the increase in crude fiber content in the Kulinur cookie formulations. From a functional food perspective, this increase in crude fiber has the potential to improve the health value of the product, particularly in relation to the role of fiber in digestive health and the prevention of metabolic diseases. In addition, the increase in crude fiber content was related to a change in product color. Crude fiber generally consists of components that are insoluble in water, such as lignin and pentose, which can affect the color intensity of processed foods. According to previous studies,researchers it is stated that the higher the fiber content, the darker the product color product color tends to be darker (Yulia Lestari & Susmayu Saputri, 2023). This phenomenon was also confirmed in this study, as shown in Figure 2, where the addition of lindur flour produced Kulinur cookies with a darker color than the control product.

Carbohydrates

Carbohydrates are the main energy source for the Indonesian people contributing approximately with a contribution of about 60–70% of total daily energy (Sumartini et al., 2021). In this study, the carbohydrate content was determined using the following athe by a different method: namely by reducing the number 100 with the percentage of other components (moisture, ash, fat, and protein). Analysis of variance (Table 2) showed significant differences among the formulas (p <0.001). The carbohydrate content of Kulinur products varied, with the highest content in F0 (100% mocaf) at 71.76% and the lowest in F4 (lindur flour) at 59.80%. The decrease in carbohydrate content was influenced by the characteristics of the raw materials, where mocaf flour had a higher carbohydrate content (81.96%) compared to lindur flour from mangrove fruit of the bakau type (Bruguiera gymnorrhiza) at 78.85% (Kristanti & Setiaboma, 2022; Pentury, 2016).

Total Gluten Content of Kulinur

Gluten is the main protein in wheat flour consisting of gliadin (20–25%) and glutenin (35–40%) (Masrikhiyah, 2021). Gluten determines the physical characteristics of food products, especially dough elasticity and final texture. However, in the process of making cookies, the presence of gluten is not the main factor; so therefore, wheat flour can be replaced with other raw materials that have low gluten or gluten-free content (Punfujinda et al., 2025). The analysis results of gluten content of the Kulinur cookies is shown in Table 3.

Table 3. Total Gluten Content of Kulinur Cookies

Gluten Content (%) (Lindur Flour: Mocaf Flour Ratio)	Mean ± SD (mg/kg)	Gluten (ppm)	p-value
F0 (0 : 100)	-4.26 ± 0.031	ND (LOD 3)	
F1 (25 : 75)	-4,70 ± 0.094	ND (LOD 3)	
F2 (50:50)	-5,19 ± 0.094	ND (LOD 3)	0.317
F3 (75 : 25)	-4,15 ± 0.126	ND (LOD 3)	
F4 (100 : 0)	-4,19 ± 0.063	ND (LOD 3)	

ND = Not Detected ; LOD = Limit of Detection

*Kruskal Wallis *significant (p<0,05)*

Table 3 presents the results of the gluten content analysis of various Kulinur cookie formulations with different proportions of lindur and mocaf flours. The average results of gluten content analysis ranged from (−5.19% = F2) to (-4.15% = F3). Based on the analysis of variance with the Kruskal–Wallis test, there was no significant difference in gluten content in each Kulinur cookie product (p>0.05). Based on testing using the Enzyme-Linked Immunosorbent Assay (ELISA) method, all formulations showed negative results, indicating that the gluten content was below the detection limit of the kit (3ppm)(Yu et al., 2021).

According to the International Food Standard for Special Dietary Use for Individuals with Gluten Intolerance, a product can be categorized as gluten-free if its gluten content does not exceed 20 mg/kg (20 ppm). Based on this reference, all Kulinur cookie products produced in this study can be classified as gluten-free products.

The results of this study strengthen the evidence that lindur flour, which belongs to the mangrove group, is gluten-free. This finding is consistent with the study of Manik (2023) who reported that mangrove flour of the api-api type (*Avicennia marina*) was gluten-free (Manik et al., 2023). Biologically, this can be explained by the fact that mangroves do not belong to cereal groups (such as wheat, barley, and rye), which naturally contain glutenin and gliadin proteins as the main components of gluten. In addition, mocaf flour has long been known as a gluten-free food ingredient. Several studies have proven this, including a study by one of which by Masrikhiyah (2021) who reported that mocaf flour does not contain gluten and that there (Masrikhiyah, 2021). Thus, both lindur and mocaf flours have great potential as alternative raw materials for the development of gluten-free products.

Hedonic Evaluation

Acceptance Test/Preference Test is a sensory evaluation method aimed at measuring the subjective responses of panelists to a product. In this test, panelists are asked to state their level of liking or disliking for various product attributes without comparing them to a certain standard. Because it is very personal, panelists who showed extreme reactions (very like or very dislike) were excluded from the assessment. The hedonic test focused on measuring the level of panelists' preference for Kulinur cookies based on sensory characteristics, such as taste, aroma, texture, appearance, and overall impression.

Table 4. Hedonic evaluation of Kulinur cookies

Variables	Average Panelist Preference Hedonic Evaluation of Kulinur Formula (Lindur Flour: Mocaf Flour)					p-value
	F0 (0:100)	F1 (25:75)	F2 (50:50)	F3 (75:25)	F4 (0:100)	
Color	2.22±1.24	1.91±0.95	2.04±1.22	2.26±1.32	2.52±1.44	0.420
Aroma	1.43±0.73	1.57±0.79	2.26±1.05	2.30±1.29	2.57±1.38	0.000
Taste	1.30±0.63	1.74±0.81	2.09±0.95	2.78±1.24	3.04±1.64	0.000
Texture	1.87±1.09	1.87±0.97	2.00±1.09	2.57±1.31	2.48±1.41	0.000
Overall	1.52±0.85	1.78±0.74	1.91±0.99	2.57±1.08	2.61±1.44	0.000

*One Way ANOVA *significant (p<0,05)*

Color

Color is the first evaluation indicator for Kulinur products because it can be directly observed. Attractive color can increase the interest of panelists or consumers in trying Kulinur products. Based on the results of the ANOVA test, the value of p was 0.420 (p>0.05), indicating that there was no significant difference in the color of any of the products. However, formulation F1 received the highest mean preference score (1.91, "strongly like"), while the other formulations obtained average scores ranging from 2.04 (F2) to 2.52 (F4), categorized as "like."

In this study, the Kulinur cookie formulation F4 was made from 100% lindur flour without a mixture of mocaf flour. This formulation produced the darkest brown color compared to the others. While formulation F1 consisted of 25% mocaf flour and 75% lindur flour, so the color produced was lighter that to the other formulas. Figure 3 shows that the more lindur flour was used, the darker and more attractive the color of the cookies produced.

The color change in these cookies was influenced by the physical characteristics of the lindur mangrove flour, which has a natural brownish colo;, thus, the higher the concentration the lindur mangrove flour, the crispier the product became and the more crispy and had a brownish color (Nurafifah et al., 2024) . In addition, the color of Kulinur products was influenced by the Maillard reaction that occurred during the cooking process. The Maillard reaction can increase brightness intensity, caramel aroma, and taste, and may also contribute to the change in of brown color (Relita et al., 2024).

Aroma

The aroma of food products is influenced by several factors, including raw materials and processing temperature. In this study, the main raw material used was the lindur fruit flour. Lindur fruit is known to have a distinctive sap aroma owing to the presence of tannins, flavonoids, and steroids (Purwoko et al., 2025). In addition, Hamzah (2022) reported that lindur flour has a characteristic rancid aroma (Hamzah et al., 2022).

The results of the analysis of variance (ANOVA) showed a p-value of 0.000 ($p<0.05$), indicating significant differences in the aroma of each sample. Further analysis using Duncan's test revealed that formulation F4 (2.57 ± 1.38; "like") was the most distinct, suggesting that the panelists preferred the cookies made with 100 g of Lindur flour without MoCAf addition. The results of this study were able to overcome the distinctive aroma of lindur flour that was previously less preferred by consumers. In addition to the distinctive aroma of lindur flour, the aroma of Kulinur cookies was influenced by other ingredients, such as raw cane sugar. Previous studies have explained that cooking raprocess at a temperature of 120–140 °C on raw cane sugar activates volatile content and retronasal aroma profile when consumed (Asikin et al., 2024).

Taste

Taste is the main factor that determines consumer preference and decisions regarding food. Flavor is influenced by ingredient components, processing, and other factors such as chemical compounds, temperature, concentration, and interaction among flavor components (Purwoko, 2025). As shown in Table 4, the value of p was 0.000 ($p<0.05$), indicating significant differences in the taste of each sample. Further analysis using Duncan's test revealed that formulation F2 (1.74 ± 0.81; "strongly like") was significantly preferred by panelists, while formulation F4 obtained a mean score of 3.04 ± 1.64 ("neutral").

The taste variable in this study was influenced by the tannin content of the lindur flour. Tannin are is an astringent compounds that produce a bitter taste and are; characterized by the presence of polyphenol groups that interact with proteins through binding and precipitation mechanisms (Raudah & Arif, 2025). The results of this study are consistent with previous reports stating that cookies with higher concentrations of lindur flour were less preferred (Simamora et al., 2024).

The sensory evaluation results indicated that formulation F2, which contained a balanced ratio of lindur and mocaf flours, achieved the highest preference score for taste. This formulation is recommended for industrial-scale production because its favorable flavor profile and consumer acceptability. For large-scale processing, maintaining a lindur-to-mocaf ratio of approximately 50–75% to 25–50% is suggested to preserve the distinctive flavor while minimizing the bitterness caused by tannins. The addition of natural sweeteners, such as raw cane sugar or palm sugar, along with mild flavor enhancers, such asvanilla or cinnamon extract, may further improve sensory appeal.

Texture

Texture is an important factor in the evaluation of a food product, which is determined by physical properties such as size, shape, and amount, as well as its components, and can be perceived through the sense of touch or taste. Texture is also an indicator of food quality, which is generally recognized during chewing (Esalson, 2025). The table shows the value of p = 0.000 ($p>0.05$), indicating significant differences in the texture of each sample. Further analysis using Duncan's test revealed that formulation F1 (1.87 ± 0.97; "strongly like") received the highest preference score among the panelists.

The findings demonstrated that the addition of 25% *lindur* flour produced a crispier texture than the control formulation (F0). This result is consistent with the study of Rahmaningsih (2016), who stated that substituting wheat flour with lindur flour at concentrations above 50% increased the acceptance level of panelists toward biscuits. This phenomenon was caused by the physical characteristics of lindur flour, which has a larger particle size than wheat flour, thereby affecting the final product texture (Rahmaningsih et al., 2016). In addition, the crispy texture of Kulinur cookies was influenced by the characteristics of the lindur fruit flour, which has a relatively high carbohydrate content, thereby playing a role as a filler in the dough and improving its texture. The high carbohydrate content was related to starch, particularly amylopectin. The dominant amylopectin content can reduce starch solubility thereby absorbing limited amounts of water (Zhenilla et al., 2024).

From a texture perspective, formulation F1, containing 25% lindur flour, is recommended for industrial-scale production due to its desirable crispness and high panelist acceptance. Maintaining a powder-to-base flour ratio of approximately 25:75 ensured a balanced texture without excessive hardness.

Overall Acceptance

The quality of food products is influenced by the type and proportion of the ingredients used. Overall evaluation is a summary of all sensory attributes assessed by the panelists, therefore it can represent the level of panelists' acceptance of the products (Simamora et al., 2024). The results of the analysis of variance on the overall hedonic scores showed that the combination of lindur and mocaf flours had a significant effect ($p = 0.000$; $p < 0.05$). Further analysis using Duncan's test revealed that formulations F1 (1.78 ± 0.74) and F2 (1.91 ± 0.99) received the highest preference scores, categorized as (strongly like). Overall, the panelists preferred Kulinur cookies made with 25–50% *Lindur* flour. The balanced formulation observed in F1 and F2 contributed significantly to the final product quality, while the use of complementary ingredients and appropriate processing techniques helped to compensate for the inherent limitations of *lindur* flour.

The sensory analysis results suggest that formulations F1 and F2 possess the most balanced combination of visual appeal, aroma, flavor, and texture, making them suitable candidates for large-scale production. Formulation F1 (25% *lindur* flour) yielded a pleasant appearance and crispy structure, whereas F2 (50% *lindur* flour) had a well-rounded flavor profile appreciated by the panelists. These formulations demonstrate that partial substitution with *lindur* flour can enhance the product functionality without compromising the sensory quality. For industrial optimization, maintaining *the proportion of lindur flour* within the 25–50% range, alongside precise control of ingredient blending and baking conditions (160–170 °C for 20–25 min), is recommended. Incorporating natural flavor enhancers and finely processed *lindur* flour may further improve product uniformity, aroma integration, and textural stability, supporting the commercial feasibility of *Kulinur cookies* as a nutritious and marketable functional food product.

Limitations of the Study

This study had several limitations. Nutritional analysis only focused on macronutrients (protein, fat, carbohydrates, and crude fiber) without assessing micronutrient content, which is also important for individuals with ASD. In addition, this study did not evaluate the shelf life of the product, even though durability is an important factor in the development of alternative food products. The study was also limited to the laboratory scale; therefore, the potential for industrial-scale production has not yet been described.

Conclusion

The findings indicate that *lindur* flour shows strong potential as a functional raw material for developing gluten-free cookies with improved nutritional composition compared to mocaf, particularly in terms of protein, fat, and crude fiber contents. All Kulinur formulations met the criteria for gluten-free products (<20 ppm), demonstrating their feasibility for further product development targeting gluten-restricted consumers in Brazil. Sensory evaluations revealed that formulations F1 and F2 (containing 25–50% *lindur* flour) were most preferred by the panelists, especially regarding aroma, taste, and overall acceptability. These results suggest that *lindur*-based Kulinur cookies could serve as a promising prototype for future optimization and industrial-scale production of gluten-free products. Further research focusing on formulation refinement, consumer acceptance testing, and shelf-life stability is recommended to support product commercialization and enhance the utilization of mangrove-derived local food resources is recommended.

Acknowledgments

The authors would like to thank the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) for the Beginner Lecturer Research Grant (PDP), which provided funding support for this study. Appreciation is also extended to Universitas Mitra Indonesia, which served as the venue and facilitator in the implementation of this research so that it could run well.

References

Afifah, D. N., Ningrum, Y. P. A., Syahidah, T., Nuryanto, N., Ayustaningwarno, F., & Sugianto, D. N. (2022). Nutrient content, organoleptic quality, and shelf life of sagon substitute from lindur (Bruguiera gymnorrhiza L.) and soybean flour (Glycine max L.), as an alternative emergency food. *Frontiers in Nutrition*, *9*. https://doi.org/10.3389/fnut.2022.878539

Ahmed, I., Jan, K., Fatma, S., & Dawood, M. A. O. (2022). Muscle proximate composition of various food fish species and their nutritional significance: A review. In *Journal of Animal Physiology and Animal Nutrition* (Vol. 106, Issue 3, pp. 690–719). John Wiley and Sons Inc. https://doi.org/10.1111/jpn.13711

Amin, M. N. G., Hasan, M. N., Zakariya, Pralebda, S. A., Pramono, H., Saputra, E., Subekti, S., & Alamsjah, M. A. (2019). Texture profile of the bread produced from composite flour Bruguiera gymnorrhiza flour (BGF) and wheat flour. *IOP Conference Series: Earth and Environmental Science*, *236*(1). https://doi.org/10.1088/1755-1315/236/1/012109

Asikin, Y., Nakaza, Y., Oe, M., Kaneda, H., Maeda, G., Takara, K., & Wada, K. (2024). Volatile component composition, retronasal aroma release profile, and sensory characteristics of non-centrifugal cane sugar obtained at different evaporation temperatures. *Applied Sciences (Switzerland)*, *14*(24). https://doi.org/10.3390/app142411617

Atmika, C., & Karina, I. A. (2020). Hubungan penerapan diet gluten free casein free dengan perkembangan motorik dan status gizi anak autis di pusat layanan autis kota Denpasar. (Skripsi Sarjana, Poltekkes Denpasar. https://repository.poltekkes-denpasar.ac.id/3989/

Ayu, G., Lestari, D., & Cahyadi, K. D. (2023). *Analisis mutu minyak kelapa (VCO) yang diperoleh dari buah kelapa (Cocos nucifera L.)*. Prosiding Simposium Kesehatan Nasional,2(1). https://doi.org/10.52073/simkesnas.v2i1.71

Cahya P., F., & Berawi, K. N. (2016). Terapi diet bebas gluten dan bebas casein pada Autism Spectrum Disorder (ASD). *Majority*, 5(1), 38-42. https://adoc.pub/terapi-diet-bebas-gluten-dan-bebas-casein-pada-autism-spectr.html

Chaudhry, T. S., Senapati, S. G., Gadam, S., Mannam, H. P. S. S., Voruganti, H. V., Abbasi, Z., Abhinav, T., Challa, A. B., Pallipamu, N., Bheemisetty, N., & Arunachalam, S. P. (2023). The impact of microbiota on the gut–brain axis: examining the complex interplay and implications. In *Journal of Clinical Medicine* (Vol. 12, Issue 16). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/jcm12165231

Dewi, S., & Morawati, S. (2024). Gangguan Autis pada Anak. Scientific Journal(SCIENA), 3(6), 418–431. https://doi.org/https://doi.org/10.56260/sciena.v3i6.177

Gaol, M., Dauly, A., Ridwanto, & Rahayu Yayuk. (2022). Uji kadar protein pada optimasi pembuatan tepung mocaf dari ubi kayu variates roti dan kuning dengan fermentasi lactobacillus casei. *Journal Pusat Pendidikan Rakyat*, *2*(4), 51–60. https://doi.org/10.32696/fjfsk.v2i2.1884

González-Domenech, P. J., Diaz-Atienza, F., Gutiérrez-Rojas, L., Fernández-Soto, M. L., & González-Domenech, C. M. (2022). A narrative review about autism spectrum disorders and exclusion of gluten and casein from the diet. In *Nutrients* (Vol. 14, Issue 9). MDPI. https://doi.org/10.3390/nu14091797

Hamzah, Y. S., & Fadilla Ratnawaty. (2022). Analisis kandungan tepung buah mangrove jenis lindur (bruigiera sp) sebagai alternatif bahan pangan lokal. *Jurnal*

Pendidikan Tambusai, *6*(2). https://doi.org/10.31004/jptam.v7i2.6693

Husain, F., Naiu, A. S., & Dali, F. A. (2023). Pengaruh substitusi tepung buah lindur (Bruguiera gymnorhizza) terhadap karakteristik mutu kue kolombengi. *Jurnal Ilmiah Perikanan Dan Kelautan*, *11*. https://doi.org/10.37905/nj.v11i5.23936

Karim, N., Makbul Syamsuri, A., & Toding, E. (2023). Studi perencanaan bangunan pelindung pantai di Sausapor Kab Tambrauw. *Jurnal Teknik Sipil MACCA*, *8*(1), 37–48. https://doi.org/10.33096/fw6chm58

Kristanti, D., & Setiaboma, W. (2022). Physicochemical and functional properties of composite flours based on mocaf and tempeh flour for making cookies. *IIUM Engineering Journal*, *23*(2), 20–31. https://doi.org/10.31436/iiumej.v23i2.2234

Manik, G. O., Tri, W., & Agustini, R. (2023). Characteristics of baked anchovy brownies (stolephorus spp.) Using api-api mangrove flour (avicennia marina) and mocaf flour. *Jurnal Ilmu Dan Teknologi Perikanan*, *5*(2). https://doi.org/10.14710/jitpi.2023.10679

Masrikhiyah, R. (2021). Retensi kadar gluten cookies substitusi tepung mocaf (Modified Cassava Flour). *Jurnal Ilmu Pangan Dan Hasil Pertanian*, *5*(1), 20–25. https://doi.org/10.26877/jiphp.v5i1.8485

Meidasari, E., Hairudin, Cn, Y., Brajanoto, D., & Bisnis, F. (2023). Pemasaran dodol mangrove melalui digital marketing di desa wisata Pulau Pahawang implementation of pregnancy exercise with gym ball in Padang Pelawi Village, Sukaraja District. *Insan Mandiri: Jurnal Pengabdian Masyarakat*, *3*(1). https://ejournal.stikestrimandirisakti.ac.id/index.php/insanmandiri

Mongdong, P. I. T., Mokosuli, Y. S., & Ogi, N. L. I. M. (2023). The nutritional content found in rhizophora mangrove fruits in Sondaken Village, Tatapaan Subdistrict, South Minahasa. *Jurnal Pembelajaran Dan Biologi Nukleus*, *9*(3), 514–521. https://doi.org/10.36987/jpbn.v9i3.4468

Moreine B. S., Mardiono Jacoeb, A., & Nurhayati, T. (2017). Karakteristik pati dari buah lindur dan aplikasinya sebagai edible film. *JPHPI*, *20*(3), 446–453. https://journal.ipb.ac.id/index.php/jphpi/article/download/19764/13648/0

Nurafifah, D. A., Sumardianto, & Anggo, A. D. (2024). Analisis kadar tanin dengan perbedaan sumber adsorben pada perebusan terhadap tepung mangrove dari buah lindur (Bruguiera Gymnorrhiza). *Jurnal Ilmu Dan Teknologi Perikanan*, *6*(1), 1–8. https://doi.org/10.14710/baf.%25v.%25i.%25Y.144-157

Pebrina, S. M., Wahyuni, S., & Endang Susilowati, P. (2021). Karakteristik fisik biskuit formulasi tepung wikau maombo dengan tepung spirulina plantesis. *Jurnal Sains Dan Teknologi Pangan*, *6*(1). http://dx.doi.org/10.33772/jstp.v6i1.16635

Pentury, M. H. (2016). Analysis of physical and chemical of starch lindur (Bruguiera Gymnorrhiza), pedada (Sonneratia Casiolaris) and api-api (Avicennia Marina). *Journal of Environment and Ecology*, *7*(2), 42. https://doi.org/10.5296/jee.v7i2.10610

Punfujinda, C., Pattarathitiwat, P., Chombhuphan, R., Songnearm, S., Tula, P., Sakkaekaew, K., Anunvrapong, A., Boukaew, S., & Chumkaew, K. (2025). Physical and chemical properties of gluten-free biscuits incorporated with purple sweet potato flour. *International Journal of Food Science*, *2025*(1). https://doi.org/10.1155/ijfo/9955286

Purwoko, A., Julianti, E., Sari, R. K., Widyastuti, D. E., & Sitorus, A. K. (2025). Prospect of processing lindur fruit (Bruguiera sexangula) biscuits as a culinary product to support the development of mangrove-based nature tourism. *Food Research*, *9*(2), 241–251. https://doi.org/10.26656/fr.2017.9(2).110

Rahmaningsih, A., Surti, T., & Anggo Apri Dwi. (2016). Pengaruh Penambahan Tepung Buah Lindur terhadap Kualitas Biskuit Ikan Lele. *Jurnal Pengembangan & Biotek*, *5*(3). https://ejournal3.undip.ac.id/index.php/jpbhp/article/view/16016

Ramadhanty, C., Simanungkalit, S. F., Octaria, Y. C.,

& Maryusman, T. (2024). Faktor yang berhubuungan dengan status gizi anak dengan Autism Spectrum Disorder di sekolah khusus wilayah JABODETABEK. *Amerta Nutrition*, *8*(2), 206–213. https://doi.org/10.20473/amnt.v8i2.2024.206-213

Raudah, N., & Arif, S. A. (2025). Product development of yellow pumpkin (cucurbita moschata) brownies with the natural sweetener substitution of stevia leaves (stevia rebaudiana) as a functional food. *Amerta Nutrition*, *9*(2), 186–198. https://doi.org/10.20473/amnt.v9i2.2025.186-198

Relita, A., Simamora, M. B., Suroso, E., Rina, O., Hidayati, S., & Silaturahmi. (2024). Sensory and chemical charateristics of cookies based on mangrove type flour (Bruguiera gymnorrizha). *Jurnal Agroindustri Berkelanjutan*, *3*(2). https://doi.org/10.23960/jab.v3i2.9931

Rizky, F. A., Pratiwi, A., Sunarto, S., & Salma Luqyana, N. (2025). Analisis zat gizi dan karakteristik sensoris pukis substitusi tepung mocaf dengan penambahan tepung daun kelor. *Jurnal Kesehatan*, *13*(1), 38–46. https://doi.org/10.25047/j-kes.v13i1.562

Simamora, A. R. M. B., Suroso, E., Rina, O., Hidayati, S., & Silaturahmi, W. (2024). Karakteristik sensori dan kimia cookies berbasis tepung mangrove jenis lindur (bruguiera gymnorrizha) sensory and chemical charateristics of cookies based on mangrove type flour (bruguiera gymnorrizha). *Jurnal Agroindustri Berkelanjutan*, *3*(2), 223–230. https://doi.org/10.23960/jab.v3i2.9931

Sopiandi, R. (2017). Maternal nutrition knowledge, food pattern, dietary intake and nutritional status of children with Autism Spectrum Disorder (ASD). *ARGIPA*, *2*(2), 45–53. https://journal.uhamka.ac.id/index.php/argipa/article/view/2335

Sumartini, S., Harahap, K. S., & Mujiyanti, A. (2021). Brownies from mangrove fruit flour: the use of variation of flours as an alternative to high food nutrition. *Indonesian Food and Nutrition Progress*, *17*(1), 16. https://doi.org/10.22146/ifnp.55188

Viorafanti, O. M., Crosita, Y. O., Malkan Bakhrul Ilmi, I., & Nasrullah, N. (2025). Mocaf flour, moringa flour, and mackerel flour food bars as an emergency food source for neurodivergent/autistic children during a natural disaster. *BIO Web of Conferences*, *153*. https://doi.org/10.1051/bioconf/202515303007

Wibowo, T. D., & Untari, D. S. (2023). Potensi Buah Mangrove dan Ikan Tembakul Sebagai Bahan Alternatif Pembuatan Kaki Naga Ikan. *Jurnal Ilmu Perikanan Dan Kelautan*, *5*(1), 30–45. http://dx.doi.org/10.36526/jl.v5i1.2408

Yu, J. M., Lee, J. H., Park, J. D., Choi, Y. S., Sung, J. M., & Jang, H. W. (2021). Analyzing gluten content in various food products using different types of elisa test kits. *Foods*, *10*(1). https://doi.org/10.3390/foods10010108

Yulia L., R., & Susmayu Saputri, D. (2023). Pengaruh penambahan tepung kulit pisang kepok (musa paradisiacal l) terhadap kadar air, kadar serat kasar dan sifat organoleptik brownies kukus tepung mocaf (Cassava Flour). *Food and Agro-Industry Journal*, *4*(2), 1–8. https://doi.org/10.36761/fagi.v4i2.3550

Zaki, M., Devi, M., & Hidayati, L. (2024). Penggunaan tepung mocaf (modified cassava flour) dengan persentase berbeda mempengaruhi kualitas bolu kukus. *Journal of Food Technology and Agroindustry*, *6*. https://doi.org/10.24929/jfta.v6i1.3363

Zhenilla, M. B., Dewi Masithah, E., & Nirmala, D. (2024). The effect of adding lindur flour (bruguiera gymnorrhiza) on chemical characteristic and acceptability of patin (pangasius sp.) basreng. *Journal of Marine and Coastal Science*, *13*(2), 68–77. https://doi.org/10.20473/jmcs.v13i2.51323