The potential of composite flour (sago and fish) as a source of raw materials for frozen food processing

Sumarto Sumarto[1]*, *Suparmi* Suparmi[1], *Andarini* Diharmi, *Rahman* Karnila[1] and *Taufik* Hidayat[2]

[1]Department of Fisheries Product Technology, Fisheries and Marine Science Faculty, Universitas Riau, Pekanbaru, Riau, Indonesia.
[2]Research Center of Agroindustry, National Research, and Innovation Agency, Laptiab Building 614 Puspiptek Serpong, Banten Indonesia

Abstract. A mixture of sago flour and fish flour (*Ilisha elongata*) can be used as a composite flour source of raw material for food processing production of functional value. The research aimed to determine the characteristics of composite flour from sago and bang fish flour with concentration. The experimental research method processed composite flour from sago flour and fish flour with varying additions of fish flour 1%, 5%, and 10% of the total sago flour. The composite flour was subjected to a gelatinization process, a cooking method that involves heating the flour in water to form a gel to obtain its characteristics. The result showed that the processing of composite flour with fish flour affects the moisture content, protein, fat, ash, carbohydrates, mineral content, and profile of the number of essential and non-essential amino acids of composite flour. The best concentration of composite flour was 10%, with a high protein of 6.39 and calcium of 2869 mg/kg. Methionine and glutamate Methionine and glutamate are the highest amino acids, and the degree of gelatinization is 93.95%. Composite flour, with a concentration of 10%, has much potential for applied frozen food products (nuggets and fish balls).

1 Introduction

Indonesia is an archipelagic country that has enormous potential for marine biodiversity. Riau Province has great potential for marine fisheries, especially in capture fisheries, based on 2019 data reaching 119.274 tons [1]. In the Riau Province area, there is the Meranti Islands Regency, which is a coastal area with a relatively large potential for capturing fisheries resources; based on 2017-2019 data, there was an increase (2017 by 1545 tons; 2018 by 1986 tons; 2019 reaching 2696 tons) [1]. Other potentials in the Meranti Islands Regency have very large sago potential in Riau Province and nationally [2].

Meranti Islands Regency had a sago potential in 2019 of 243.71 thousand tons [2] and

* Corresponding author: sumarto@lecturer.unri.ac.id

high marine fisheries potential, one of which is big fish. Biang fish has the potential to be developed into value-added products. Innovation is needed to obtain products with added value based on the potential of sago and biang fish because processing into fishmeal has high nutrition with a protein content of 68%, a calcium content of 364 mg, and phosphorus of 258 mg. This is very important or good for growth [3]. Biang fish flour has the benefit of healthy digestion and cell growth. In addition, Sago flour has the advantage of controlling cholesterol, healthy digestion, maintaining bone and joint health, and increasing body fitness.

Fish *Ilisha elongata is* very popular in Riau Province. Moreover, according to [4], Biang fish has a high protein content. However, the problem faced at this time is that fish commodity fishery products are still limited to fresh consumption as a side dish. The processed product is only salted fish; even though the production of prickly fish is relatively high, the prickly fish has a lot of spines, so the consumption level is relatively small even though this fish has a delicious taste and is tasty and is rich in calcium and phosphorus. The potential for fisheries and sago has not been maximally developed into competitive superior products in the era of food product globalization. Some research results related to sago flour include its use in products that require good stickiness. This is because sago has a sticky texture. After all, it is dominated by amylopectin. Sago flour has a high carbohydrate and low glycemic content but does not contain additional nutrients such as protein, ash, and fat. Therefore, blending with the source fish flour requires adding ingredients from other flours with good protein content. Thus, flour products from sago and biang fish must be developed. Fish flour in Indonesia is still imported, but the food industry needs it. In addition [5,6], it is easier to diversify with other additives with flour products.

According to [7], The problem with sago is that some products, such as sago noodles, have a very low protein value (0.7%), and sago crackers, 0.3% protein; therefore, fish protein needs to be added for noodle products, crackers, and biscuits. In general, it is necessary to increase the added value of fish and sago products, which can be done by processing composite flour to become food products with functional value. This study aims to determine the characteristics of composite flour (sago and fish) by adding different formulations of fish flour.

2 Method

2.1 Materials and Equipment

Research materials included 50 kg of fresh Biang fish (*I. elongata*) weighing between 77 and 95 g, ice cubes, sago flour from a small group processing sago meranti, and consumables (tissue, soap, hand sanitizer) that were obtained from fishermen in the Selatpanjang Waters, Meranti Islands Regency, Riau Province. The equipment used in the form of a styrofoam cork container, ruler, paperboard, freezer capacity of 200 L (Sharp), pressure cooker, grinding machine, drying oven, flouring machine, 100 mesh sieve, transparent glass bottle packaging, and tools that support in analysis (ash, moisture, fat, protein, carbohydrates, mineral content, and amino acid analysis).

2.2 Research method

This research conducted an experimental design by processing composite flour (sago and fish flour) by adding different fish flours: 0% (control), 1%, 5%, and 10%. Observation and analysis of composite flour included ash, moisture, fat, protein, and carbohydrate content, the mineral content of calcium (Ca), Phosphorus (P), Magnesium (Mg), Iodine (I), Magnesium, Zn, and Fe, as well as total amino acid.

The research procedure was carried out in stages, namely:

a) Processing of fish flour (*I. elongata*) is carried out by the wedding and flouring process of prickly fish by separating the meat and spines/bones from fish waste (head, gills, entrails, and scales) [4]. The fish was cooked in a pressure cooker system for 60 minutes and ground until smooth. The crushed meat is dried in an oven at a temperature of 40-45ºC for 36 hours; then, the fish meat is ground to a fine powder with a size of 100 mesh. The process of making Biang fish flour can be seen in Figure 1.

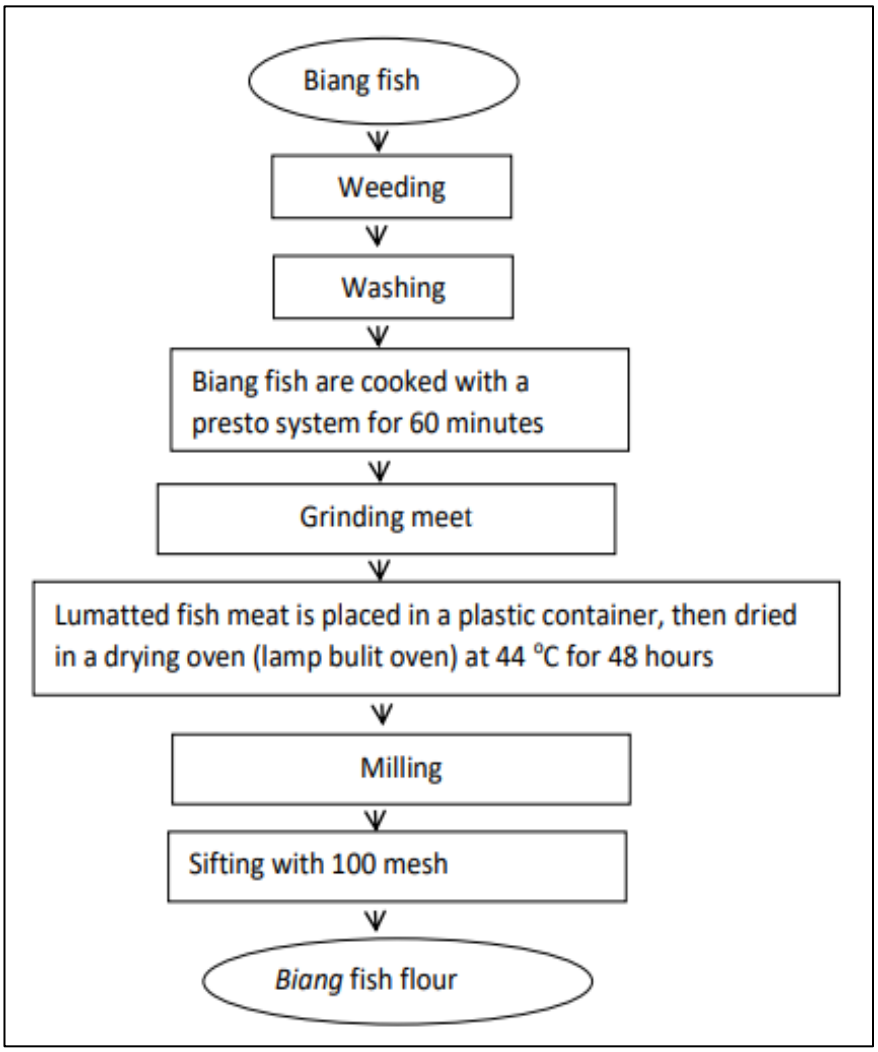

Fig. 1. Flow chart making *Biang* fish flour

b) The sago composite flour with *I. elongata* fish flour is processed through gelatinization. The gelatinization process of sago flour and the fish flour was done by wetting the flour until moist, then heating and drying (roasted) for 5 minutes. The sago and fish composite flour were sifted again (100 mesh) [3].

c)

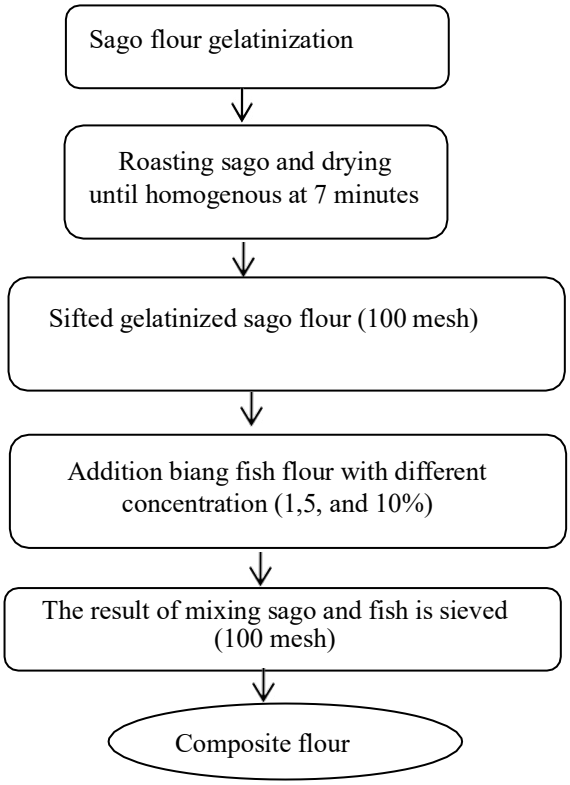

Fig. 2. Making Composite Flour

2.2 Parameters Analysis

Parameter analysis of sago and fish composite flour processing used the moisture content, protein, fat, ash, carbohydrate, and mineral and amino acid profile (HPLC).

2.3.1 Proximate [7]

Proximate analysis includes moisture, ash, protein, fat, and carbohydrate content.

2.3.2 Minerals [7]

The minerals analyzed are calcium, phosphorus, iodine, magnesium, zinc, and Fe minerals.

The principle of total mineral testing is to determine the metal absorption value using the Atomic Absorption Spectrophotometer (AAS) method, or it can be said to dissolve the minerals in the sample into an acidic solvent, which is then calculated the mineral content contained. The sample was weighed in a porcelain cup as much as 2 g, then kiln for 4 hours at a temperature of 550oC, then 10 mL of concentrated HNO_3 solvent was added, then heated on a hotplate until boiling for 10 minutes, then 50 mL of distilled water was added in a measuring flask, then filtered using Whatman filter paper which was collected in a 50 mL measuring flask. Each mineral's standard stock solution is diluted with distilled water until the concentration is within the desired metal concentration range. The standard solution, blank, and sample are flowed into the Pectin Elmer Analyst 3110 Atomic Absorption Spectrophotometer (SSA) with the wavelength of each type of mineral. The absorption or peak height of the standard, blank, and sample is measured using the appropriate wavelength and parameters for each mineral.

2.3.3 Amino acids [7]

Using the HPLC brand Varian 940-LC, the amino acid analysis is carried out in four stages: the protein hydrolyzate stage, the drying phase, the derivatization phase, and the injection phase (amino acid analysis). The first stage involved homogenizing a sample (0.1 g), adding 5 mL of 6N HCl, heating the mixture to 1000 C for 24 hours, and filtering the result to form a protein hydrolyzate. The samples that had been filtered and thirty milliliters of a solution containing methanol, sodium acetate, and triethylamine (2:2:1) were dried in the second phase until the solvent had evaporated entirely. Phase three involved derivatization. After combining methanol, Picoltiocianat (PITC), and triethylamine (TEA) in a 3:3:1 ratio, 10 mL of 1 M sodium acetate buffer plus was added, and the mixture was let to settle for 20 minutes to create a 30 mL derivatization solution. The derivatization procedure was completed to identify the compounds in the sample for the detector.

Injecting the stock solution into the HPLC of the standard solution and combining it with the standard solution and borate buffer (1:1) constituted the last step. In less than 30 minutes, 5 mL of the solution was put into the HPLC. The identical procedures were performed on a sample by combining the stock solutions and borate buffer 1:1.To find every amino acid, the mixture was put into the HPLC. Calculating the material's amino acid content involves dividing the broad and weight standard sample area by the sample's area multiplied by 100% and the molecular weight of each amino acid, dilution factor, and concentration of standard amino acids (mg/mL). The P1 Cotag column was utilized in HPLC, with acetonitrile and phosphate buffers employed in the motion phase. The wavelength was 272 nm, and the flow rate was 0.5 mL/min.

2.3.4 Degree gelatinization (modification [8])

A modified approach was utilized to analyze the degree of gelatinization. Fifty milliliters of KOH 0.15 M were used to dissolve 0.04 grams of material, then mixed for 15 minutes. Next, the Whatman 42 filter paper was used to filter the mixture. 9 mL of 0.017 M HCl is used to neutralize 1 mL of the filter. Following that, 0.1 mL of iodine solution (1 g iodine and 4 g KI in 100 mL of water) was added to the solution to neutralize it and create a colored complex with 2.3.4 degree gelatinization (modification [8]). A modified version was used to analyze the level of gelatinization. Fifty milliliters of KOH 0.15 M were used to dissolve 0.04 grams of material, then mixed for 15 minutes. Next, the Whatman 42 filter paper was used to filter the mixture. 9 mL of 0.017 M HCl is used to neutralize 1 mL of the filter. Subsequently, 0.1 mL of iodine solution (1 g iodine and 4 g KI in 100 mL of water) was added to the solution to neutralize it and create a colorful complex.

2.4 Data Analysis

SPSS was used for Windows software version 17, and a one-way analysis of variance (ANOVA) was used to analyze the data (SPSS Inc, Chicago, IL, 2008). The impact of the composite flour content was the therapy that was applied. At a 95% significance level ($P<0.05$), the difference between the treatments was ascertained using the Least Significant Difference test.

3 Result and Discussion

3.1 Proximate composition

Table 1 displays the detailed research findings on the proximate nutritional makeup of sago flour, fish flour, and composite flour (a blend of sago and fish). Table 1 displays the variations and changes in the nutritional makeup of sago flour, fish flour, and composite flour (a blend of sago and fish after gelatinization). 9.62% moisture, 0.25% protein, 0.21% fat, 0.27% ash, and 89.65% carbs are found in sago flour (by difference). Table 1 shows that the fish flour has 7.88% moisture, 71.87% protein, 5.96% fat, 12.97% ash, and 1.33% carbs. Figure 3 shows the look of sago flour, composite flour, and biang fish flour.

Table 1. Proximate composition content of sago, fish, and composite flour

Parameter (%)	Sago flour		Composite flour (sago dan *I. elongata*)		
		Fish flour	1%	5%	10%
Moisture	9.62±0.2	7.88±0.50	9.57±0.4^{c}	9.62±0.1^{b}	9.20±0.2^{a}
Protein	0.25±0.1	71.87±0.7	3.58±0.1^{a}	5.07±0.3^{b}	6.39±0.3^{c}
Fat	0.41±0.3	5.96±0.40	0.24±0.2^{a}	0.32±0.4^{b}	0.42±0.4^{b}
Ash	0.27±0.3	12.97±0.3	0.34±0.4^{a}	0.48±0.3^{b}	0.76±0.1^{d}
Carbohydrate	89.45±0.4	1.33±0.3	86.27±0.1^{c}	84.51±0.3^{b}	83.23±0.2^{a}

The same letter in the table row shows no significant difference ($P<0.05$)

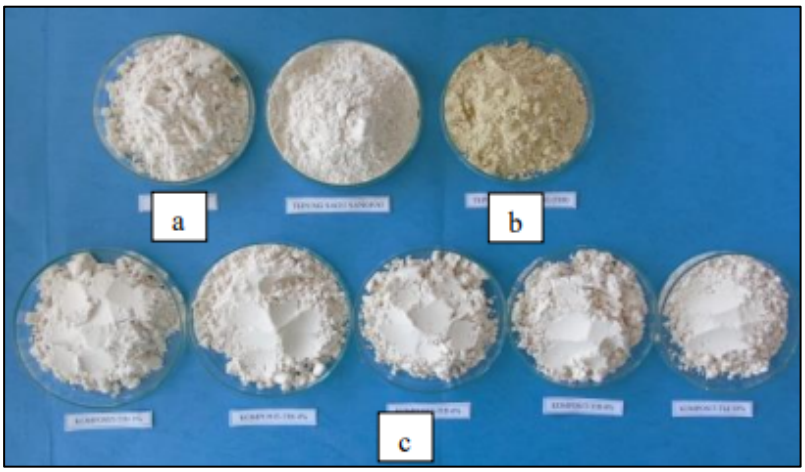

Fig. 3. Appearance a) sago flour, b) Biang fish flour, c) Composite flour

The moisture level of the composite flour, which is a blend of fish and sago, changed during the manufacturing process. A more significant proportion denotes decreased moisture

and carbohydrate contents, according to the findings of manufacturing composite flour with lead fish flour added [9]. The more significant percentage of fish flour in composite flour raises the nutrient content of the ash, lipid, and protein components [10].

Fish flour composite flour with a percentage of 1%, 5%, and 10% has 9.20–9.57% moisture, 3.58–6.39% protein, 0.24–0.42% fat, 0.34-0 0.76% ash, and 83.23–86.27 percent carbs. Because sago flour is hygroscopic, using more fish flour during the composite flour manufacturing process lowers the finished product's moisture content. According to [11], the use of sago flour, which is hygroscopic, will cause the water absorption capacity to be high because of the amylose content in sago flour. So, the addition of fish flour will result in a decrease in the moisture content of the sago composite flour product [12]. The content of protein, fat, ash, and carbohydrates in the composite flour had a significant effect (p<0.05) from the addition of lead fish flour to sago flour [13]. According to [14] and [15], bonefish flour can add high protein content.

3.2 Minerals

The mineral composition of calcium ranges from 1901-2869 mg/kg, phosphorus 60-160 mg/kg, iodine 182.14-285.67 mg/kg, magnesium 28,42063.05 mg/kg, zinc 3.83-18.36 mg /kg, and iron minerals 7.26-9.58 mg/kg (Table 2).

Table 2. The composition of minerals from sago, fish, and composite (fish and sago) flour

Mineral content (mg/kg)	Sago flour	Fish flour	Composite flour (sago dan fish)		
			1%	5%	10%
Ca	1131±0.1	8398±0.1	1901±0.3^{c}	2460±0.5^{ab}	2869±0.4^{a}
P	111,14±0.2	169±0.3	60±0.4^{c}	98±0.3^{b}	160±0.2^{a}
Iodine	118±0.12	189.44±0.2	182.14±0.2^{c}	165.52±0.4^{bc}	285.67±0.3^{a}
Mg	20,4±0.15	141.32±0.45	28.42±^{c}	44.18±0.21^{b}	63.05±^{a}
Zn	154±0.4	152.07±0.1	3.83±0.14^{c}	4.51±0.12^{bc}	18.36±0.2^{a}
Fe	29±0.2	15.76±0.1	7.26±0.25^{c}	6.65±0.09^{b}	9.58±0.1^{a}

Letter: Different letters in the same column indicate significant (P<0.05)

Table 2 illustrates the variations and alterations in the mineral content of fish flour, composite flour (a combination), and roasted sago flour (the product of the gelatinization process). Minerals found in roasted sago flour include low iron (Fe) of 29 mg/kg and high calcium (Ca). In addition, Fish flour contains minerals high in calcium (Ca) and low in iron (Fe). The results of mineral measurements of sago flour and fish decreased in Zn and Fe values compared to composite flour. However, the higher the composite concentration, the higher the Zn and Fe values. This also occurs in other mineral components. According to [16-17]. The biang fish flour composite with sago flour can increase the mineral content. The mineral content in fish is more than calcium. Likewise, sago flour is also high in calcium, so using composite flour increases the calcium content [18].

The mineral composition of composite flour, which is a blend of fish and sago, changed during the manufacturing process. The higher the proportion in each treatment of the final composite flour that arises from the manufacturing process when lead fish flour is added, the higher the mineral content overall [19-21]. Moreover, according to [22-23], fish can be added to high macro and micro minerals values. This is due to the relatively high mineral content of *I. elongata* fish flour, thus affecting the processing of the resulting composite flour [23-24].

3.3 Amino Acids

The study results showed that the number of amino acids in the Biang fish reaches 91.93% of the 15 types of amino acids identified using the HPLC method [24] (Table 3). The content of essential amino acids in prickly fish flour reaches 45.89%, and non-essential amino acids at 46.04%. The manufacture of composite flour (sago and fish starter) with variations in the concentration of fish flour that was carried out (1%, 5%, and 10%) gave changes to the amino acid composition of the composite flour, significantly an increase in the pattern of the number of essential amino acids in the composite flour is from 1.06% to 4.80% essential amino acids [25-26].

The highest amino acids in fish flour and composite flour are methionine and glutamic acid. Methionine is very important for the body as an anti-inflammatory and prevents poisoning [26-28]. Glutamic acid functions to give flavor to food and is also very good in health metabolism [29]. The influence of the main fish dominated the increase in amino acids in composite flour. The higher the concentration of compost, the higher the amino acid concentration. The composition of biang fish flour dominates for the increase in amino acids. According to [23], biang fish has a high amino acid content in glutamic acid, which functions for human taste and health.

Table 3. Amino acid profile of composite flour Biang and fish flour (*Ilisha elongata*)

Amino acids (%)	**1%**	**5%**	**10%**	**Fish flour**
Material protein content	**1.58%**	**2.99%**	**4.39%**	**71.86%**
1. Threonine*	0.07±0.1^{a}	0.20±0.45^{bc}	0.36±0.3^{d}	3.69±0.2
2. Methione*	0.29±0.23^{a}	0.52±0.2^{bc}	1.19±0.3^{d}	11.25±0.1
3. Ileusine*	0.07±0.5^{a}	0.20±0.1^{bc}	0.37±0.2^{d}	4.16±0.2
4. Valine*	0.10±0.1^{a}	0.26±0.3^{bc}	0.45±0.2^{d}	4.46±0.2
5. Leucine*	0.12±0.1^{a}	0.35±0.4^{bc}	0.63±0.1^{d}	7.36±0.3
6. Lysine*	0.18±0,1^{a}	0.48±0.1^{bc}	0.80±0.5^{d}	8.39±0.2
7. Phenylalanine*	0.5±0.3^{a}	0.14±0.3^{bc}	0.42±0.2^{d}	4.33±0.55
8. Histidine*	0.18±0.2^{a}	0.48±0.2^{bc}	0.58±0.4^{d}	2.25±0.3
9. Aspartic acid	0.15±0.2^{a}	0.42±0.5^{bc}	0.74±0.5^{d}	8.82±0.3
10. Glutamate	0.28±0.4^{a}	0.76±0.2^{bc}	1.34±0.3^{d}	15.56±0.4
11. Serine	0.06±0.3^{a}	0.17±0.3^{bc}	0.30±0.2^{d}	3.07±0.13
12. Glycine	0.08±0.2^{a}	0.22±0.1^{bc}	0.38±0.4^{d}	4.48±0.23
13. Alanine	0.10±0.2^{a}	0.27±0.5^{bc}	0.47±0.6^{d}	5.34±0.3
14. Tyrosine	0.02±0.3^{a}	0.07±0.5^{bc}	0.17±0.3^{d}	3.35±0.4
15. Arginine	0.16±0.3^{a}	0.47±0.2^{bc}	0.77±0.3^{d}	5.41±0.2
Total amino acids (%)	1.91±0.3^{a}	5.01±0.4^{bc}	8.98±0.2^{d}	91.93±0.3
Essential amino acids (%)	1.06±0.2^{a}	2.63±0.3^{bc}	4.80±0.1^{d}	45,89±0.5
Non-essential acids (%)	0.85±0.3^{a}	2.38±0.25^{bc}	4.18±0.3^{d}	46,04±0.4

*essential amino acids

Note: Different letters in the same column indicate significant ($P<0.05$)

3.4 Degree of Gelatinization

When a combination of fish flour was added to sago flour, the degree of gelatinization of the composite flour material also dropped. Once the roasted sago flour underwent gelatinization, the gelatinization level reached 94.65%. Subsequently, the gelatinization level declined as the lead fish flour's composition increased, ultimately reaching 93.95%. The purpose of gelatinization on composite sago flour is to facilitate the process of further food processing

designation. The gelatinization process of flour begins at 60°C. This research indicates that the melting process of sago flour and composite flour begins at 93°C and above. According to [30] and [31], gelatinization is a process when starch granules are heated with sufficient water so that starch granules expand and produce a thick liquid to provide the desired product quality. In addition, according to [32-34]. The study revealed that the flour higher in starch content took the lowest temperature for gelatinization, whereas sago flour took less time for gelatinization due to the higher content.

4 Conclusion

The processing of sago composite flour and *Ilisha elongata* fish flour affects the moisture content, protein, fat, ash, carbohydrates, mineral content, and profile of the number of essential and non-essential amino acids of composite flour. The best concentration of composite flour was 10%, with a high protein of 6.39 and calcium of 2869 mg/kg. Methionine and glutamate Methionine and glutamate are the highest amino acids, and the degree of gelatinization is 93.95%. Composite flour, with a concentration of 10%, has the potential to be used in frozen food products (nuggets and fish balls).

Acknowledgments

The Ministry of Research and Technology and Higher Education, Republic of Indonesia, and the Director General of Higher Education are thanked by the authors for providing money under the Applied Research Green Program 2024. The research was carried out under project No. 20706/UN19.5.1.3/AL.04/2024 (derived contract) and 083/E5/PG.02.00.PL/2024 (master contract).

References

1. [CAS] Central Agency of Statistics of Riau Province, Riau Province in Figures. Central agency of statistics of riau province, Pekanbaru. (2020) https://riau.bps.go.id/id/publication/2020/04/27/a7d70bfbb3ce90b6b6a640d6/provinsi-riau-dalam-angka-2020.html
2. [CAS] Central Agency of Statistics of Meranti Islands Regency. Regional statistics of meranti islands regency, Selatpanjang. (2020). https://merantikab.bps.go.id/id/publication/2020/04/27/c210086073c8572a100be874/kabupaten-kepulauan-meranti-dalam-angka-2020.html
3. S. Sumarto, D Desmelati, R Karnila, D Dahlia, S. Suparmi, B Hasan, Characteristics of composite flour (biang fish *ilisha elongata* and sago) for the development of good nutritional food products. IOP Conf. Ser.: Earth Environ. Sci. **934**, 012088 (2021). http://doi:10.1088/1755-1315/934/1/012088.
4. A. Azka., P.W. Ratrinia, N.E, KS, Hasibuan, Please. The effect of different salt concentrations on the proximate composition of dried salted fish (*ilisha elongata*). J. Aurelia. **1**, 1 (2019). http://doi:10.15578/aj.v1i1.8378.
5. C.K. Chin., N. Huda, T.A. Yang, Incorporation of surimi powder in wet yellow noodles and its effects on the physicochemical and sensory properties. J. Int. Food Research. **19**, 2 (2012). http://www.ifrj.upm.edu.my/19%20(02)%202012/(50)IFRJ-2012%20Nurul.pdf

6. P. Santana, N. Huda, T.A. Yang, Technology for production of surimi powder and potential of applications: A review. J. Int. Food Research. **19**, 4 (2012). Journal homepage: http://www.ifrj.upm.edu.my.
7. [AOAC] Association of Official Analytical Chemists, Official method of analysis of the association of official analytical of chemists. (Published by The Association of Analytical Chemists, Inc. Arlington, Virginia, USA, 2005). file:///C:/Users/ACER/Downloads/-AOAC-2005.pdf.
8. T. Baks, I.S. Ngene, J. Soest, A. Janssen, R.M. Boom, Comparison of methods to determine the gelatinization degree for both high and low starch concentrations. J. Carbohydrate Polymer. **67**, (2007). https://doi.org/10.1016/j.carbpol.2006.06.016
9. A. Abdullah, N. Nurjanah, T. Hidayat, Y. Yusefi, Amino acid and fatty acid profiles of cockles (*Anadara antiquata*). J. Ind of Fish Product Processing. **16**, 2 (2015). https://www.researchgate.net/publication/274065689.
10. S. Suparmi, D. Dewita, D. Desmelati, T. Hidayat, Study the making of hydrolyzate protein powder of reborn shrimp as a food nutrition enhancement ingredient. J. Pharmaconogsy. **13**, 5 (2021). http://dx.doi.org/10.5530/pj.2021.13.151
11. T. Hidayat, P. Suptijah, N. Nurjanah, Characterization of lindur fruit flour (*Bruguiera gymnorrhiza*) as analogous rice with the addition of sago and chitosan. J. Ind of Fish Prod. Processing. **16**, 3 (2013). https://www.researchgate.net/publication/274065676.
12. H. Abdalla, Wang Yu, M.Y.E. Jack, A.A.M. Noer, Effect of soybean flour supplementation and cooking on proximate composition, minerals and sensory evaluation of corn flour. J. Egyp. and Nutr. **39**, 2 (2024). https://ejn.journals.ekb.eg/.
13. S. Suparmi, S. Sumarto, U. Afriana, T. Hidayat, Utilization of *biang* fish flour (*ilisha elongata*) as an enrichment material for sago noodles nutrient value. J. Int. of Biomaterials. **22**, (2022). https://doi.org/10.1155%2F2022%2F8746296.
14. A.N. Asikin, I. Kusmumaningrum, T. Hidayat, Effect of knife-fish bone powder addition on characteristics of starch and seaweed krupuk as calcium and crude fiber sources. J. Current Research in Nut. and Food Sci. **7**, 2 (2019). http://dx.doi.org/10.12944/CRNFSJ.7.2.27.
15. A.O. Ashogbon, E.T. Akintayo. Recent trend in the physical and chemical modification of starches from different botanical sources: A review. Starch. **66**, (2014). http://dx.doi.org/10.1002/star.201300106.
16. N. Nurjanah, T. Nurhayati, T. Hidayat, M. Ameliawati. Profile of macro-micro mineral and carotenoids in pomacea canaliculata. *Current Research in Nutrition and Food Sci*. **7**, 1 (2019). http://dx.doi.org/10.12944/CRNFSJ.7.1.29.
17. P. Kumar, R. Annathai, J. Shakila, S.A. Shanmugam, The proximate and major mineral composition of 23 medium-sized marine fin fishes landed in the Thoothukudi Coast of India. J. Nutrition Food Sci. **2**, 4 (2014). http://doi:10.4172/2155-9600.1000259.
18. N. Nurjanah, S.H. Suseno, T. Hidayat, Y. Ekawati, P. Paramudhita, A. Arifianto. Change the Composition chemical of skipjack tuna due to the frying process. J. Int. Food Research. **22**, 5 (2015). http://www.ifrj.upm.edu.my.
19. M.S. Rohaya, M.Y. Maskat, A.G. Ma'aruf. Rheological properties of different degrees of pregelatinized rice flour batter. J. Sains Malaysiana. **42**, 12 (2013). https://www.researchgate.net/publication/287572394_Rheological_Properties_of_Different_Degree_of_Pregelatinized_Rice_Flour_Batter.
20. N. Nurjanah, R. Suwandi, E.N. Aisyah, T. Hidayat, Changes in mineral content and vitamin A of cobia (*Rachycentron canadum*) due to the steaming process. IOP Conf.

Ser.: Earth Environ. Sci, **1137**, 1 (2023). http://doi.10.1088/1755-1315/1137/1/012032.

21. D. Dewita, D. Desmelati, S.W. Sidauruk, T. Hidayat, Isolation and characterization of snakehead fish meal extract with fresh, boiled, and steamed treatments and its potential for health drinks and immunomodulators. J. Pharmacognosy. **14**, 5 (2022). http://dx.doi.org/10.5530/pj.2022.14.131.
22. O.C. Oginni, O.P. Sobukola, F.O. Henshaw, W.A.O. Afolabi, Effect of starch gelatinization and vacuum frying conditions on structure development and associated quality attributes of cassava-gluten based snack. J. Food Structure. **3**, (2015). http://dx.doi.org/10.1016/j.foostr.2014.12.001.
23. S. Sumarto, S. Suparmi, A. Hidayati, Utilization of biang fish (*ilisha elongata*) as raw material for flavoring powder. IOP Conf. Ser.: Earth Environ. Sci. **1118**, (2022). http://10.1088/1755-1315/1118/1/012033.
24. N. Setyawan, C. Clarissa, E.A. Purwani, A. Budiyanto, Moisture sorption isotherm characteristic of composite flour (cassava, rice, sorghum, and sago) at various fitting models. IOP Conf.: Earth Environ.Sci. **1024**, (2022). http://dx.doi.org/10.1088/1755-1315/1024/1/012053.
25. A. Ratnaduhita, A.M.P. Nuhriawangsa, L.R. Kartikasari, Physico-chemical Properties of gathot (fermented cassava) flour applied on edible film.IOP Conf. Ser.: Earth Environ. Sci. **888,** 012035 (2021). http://dx.doi.org/10.1088/1755-1315/888/1/012035. https://doi.org/10.26656/fr.2017.4(6).419
26. M. Hasmadi, M. Noorfarahzilah, H. Noraidah, M.K. Zainol, M.H.A. Jahurul, Functional Properties of Composite Flour: a review. J. Food Research. **4**, 6 (2020). https://doi.org/10.26656/fr.2017.4(6).419.
27. S. Sumardiono, K. Budiyono, I.A.P Heny, P.P. Fawzia, C. Heri, Influence of composite flour constituents and extrusion temperature in the production of analog rice. J. Food Sci and Nutr. 4386-4394. (2021). https://doi.org/10.1002%2Ffsn3.2411.
28. A.A. Adebowale, S.T. Kareem, O.P. Sobukola, M.A. Adebisi, A.O. Obadina, M.O. Kajihausa, O.E. Adegunwa, L.O. Sanni, T. Keith, Mineral and antinutrient content of high-quality cassava-tigernut composite flour extruded snack. J. Food Proc and Pres. **41**, 5 (2016). https://doi.org/10.1111/jfpp.13125.
29. G.S. Rombe, M.M. Tahirand, A.B Tawali, Physicochemical characteristics of pempek premix flour made from mackerel fish (*Scomberomorus commersoni*) surimi powder. IOP Conference Series: Earth and Env. Sci. **564** (2020). https://doi.org/10.1088/1755-1315/564/1/012042.
30. X. Wang, L. Cheng, Z. Gu, Y.Li.Z. Hing, L. Caiming, X. Ban, Effects of different gelatinization degrees of potato flour on gluten network integrity and dough stickiness. LWT. **153**,112577 (2021). http://dx.doi.org/10.1016/j.lwt.2021.112577.
31. S. Chandra, S. Singh, D. Kumari, Evaluation of functional properties of composite flours and sensory attributes of composite flour biscuits. J. Food Sci .Technol. **52**, 6 (2015). https://doi.org/10.1007/s13197-014-1427-2.
32. N. Zainol, S. Subramanian, A.S. Adnan, A.A.M. Zulkifli, N.R.W. Kassim, A.A. Kamarudin, The potential source for composite flours as food ingredients is from locally grown crops. J. Food Research. **4**, 2 (2020). https://doi.org/10.26656/fr.2017.4(S2).S11.
33. J. Ma Z. Fangyuan, X. Wang, X Li, L. Liu, X. Hu, Effect of kansui addition on dough rheology and quality characteristics of chickpea-wheat composite flour-based noodles and underlying mechanisms. J. Food Chem. **298**, 125081 (2019).

https://doi.org/10.1016/j.foodchem.2019.125081.

34. M.G. Ewunetu, A.Y. Atnafu, W. Fikadu. Nutritional enhancement of bread produced from wheat, banana, and carrot composite flour. J. Food Quality. **2023**, 1917972 (2023). https://doi.org/10.1155/2023/1917972.