Potential of Modified Flour Derived from The Bamboo Shoot and Swamp Tuber Origin from South Kalimantan as Environmentally Friendly Food

E Setiawati, S Hamdi, S Hidayati, D M Amaliyah, Miyono, R Salim, B T Cahyana

Institute of Research and Standardization of Industry, Ministry of Industry, Jl. Panglima Batur Barat No.2, Banjarbaru South Kalimantan, Indonesia

E-mail: evy.kemenperin@gmail.com

Abstract. To reduce dependence on wheat flour, it is necessary to find substitutes for flour from local food. As local food, bamboo shoots (betung) and swamp tubers (alabio and nagara) have the potential to be processed into flour even though they have relatively low characteristics. To improve the flour characteristics, it can be made by modifying the flour biologically. The purpose of this study was to investigate modified fibre-rich flour derived from bamboo shoot and swamp tuber through fermentation and to formulate the flours as functional food. This modification was preferred because it did not need chemical agents that may be harmful for environmental. The modified flour was prepared by both spontaneously and non-spontaneously fermentation, using mocaf starter. Alabio tuber (Dioscorea alata L.), nagara tuber (Ipomoea batatas L.), bamboo shoots betung (Dendrocalamus asper) were fermented for 24, 48, and 72 hours. After fermentation, the modified flours were formulated based on a certain combination to meet the nutritional adequacy rate. The best results of alabio, nagara and betung flour were 72 hours spontaneous fermentation, 48 hours spontaneous fermentation, and 72 hours starter fermentation, respectively. The best-modified flour formulation was obtained in the combination of nagara tuber flour: bamboo shoots in 90:10.

1. Introduction

Local foods in the South Kalimantan have the potential to be processed in the context of food diversification such as bamboo shoots and swamp tubers. In South Kalimantan, bamboo shoots are commonly used as vegetables [1]. Bamboo shoots contain protein, carbohydrates, fat and high fiber [2]. In addition, bamboo shoots contain vitamins, minerals and 12 essential amino acids that are needed by the body [3]. Consuming bamboo shoots regularly is a preventive measure to prevent various types of diseases including cardiovascular diseases, cancer, and diabetes [4]. Bamboo shoots have the potential to be processed into various kinds of food and flour [5], even though they have relatively low carbohydrate content but high in fiber. In this study, the Betung bamboo shoots (Dendrocalamus asper) were used because they were considered as the most delicious compared to other types of bamboo shoots [6].

South Kalimantan is rich in types of swampy tubers such as alabio tubers (Dioscorea alata L.) and nagara tubers (Ipomoea batatas L.). Every 100 grams of alabio flour contains 112 calories, 8.9 grams of protein, 1.4 grams of fat, 56 grams of carbohydrates, 30 SI of vitamin A, 0.04 milligrams of vitamin B,
9 milligrams of vitamin C, 39 milligrams of Ca, 62 milligrams of phosphor, 0.9 milligrams of iron, and 15 grams of water [7]. Alabio tubers have functional properties on metabolism in the body. Nagara tuber (Ipomoea batatas L), which is a giant sweet potato typical of South Kalimantan and has 4-7 kilograms weight. These two tubers can be used as medicine because they contain prebiotics [8]. Prebiotic is very important because it can feed the microbes in the intestines so that digestion will be healthy.

Based on the data above, the utilization of bamboo shoots and swamp tubers into modified flour has very good prospects and is worthy of research and development in order to support the flour industry and food security through food diversification in Indonesia. The flour modification process can be carried out in several ways including through fermentation [9], acid hydrolysis [10,11], H2O2 oxidation [12], or its combination [13]. Biological modification through fermentation is preferred because it does not need chemical agents that be harmful for health. Modified flour can be carried out through fermentation [14] for certain purposes such as preserving food and providing added value / nutritional value to food which can increase food quality [15]. Yuliana et al. [16] had reported that the fermented flour had better properties than non-fermented cassava flour due to improvement in the physicochemical properties of cassava flour. The modified fermented flour has better properties than nonfermented flour and can be used to support food diversification. This research was aimed to investigate modified fibre-rich flour derived from bamboo shoot and swamp tuber through fermentation and to formulate the flours as functional food.

2. Materials and methods

2.1. Materials

Research materials included alabio tubers (Dioscorea alata L.), tuber nagara (Ipomea batatas), bamboo shoots (Dendrocalamus asper), mocaf starter, sodium hydroxide, Whatman 45 filter paper, sulfuric acid, nitric acid, ethanol, petroleum benzene, distilled water. Research equipment included equipment for proximate standard testing such as UV Vis spectrophotometer, atomic absorption spectrophotometer (AAS), fermentation tubs, ovens, furnace, fume hood, milling, glassware, and kjehdahl distillation.

2.2. Methods

First treatment was Spontaneous Fermentation (SF), which fermentation took place without addition of a starter for 24 (SF1), 48 (SF2), and 72 (SF3) hours at room temperature. Second by using mocaf fermentation starter. Mocaf fermentation was also carried out at room temperature for 24 (NSF1), 48 (NSF2), and 72 (NSF3) hours. Then flours were washed and dried in the sun. After that the flours were ground into flour on each fermentation time parameter. The flours were tested based on proximate content, amylose-amyllopectin content, starch content, dietary fiber and viscosity. Flours which have the best characteristics were selected for formulation as a raw material for functional food. The formulation was showed in the table 1. The proximate content of raw materials was showed in table 2. All statistical analysis was performed using SPSS 16.

| Table 1. Functional food formulations in 100 gr. | Flours |
|---------------------------------------------|-------|
| Formulation                  | Wheat | Alabio (A) | Nagara (N) | Betung (R) |
| B1 (A: R)                  | 0     | 90         | 0          | 10        |
| B2 (A: N: R)               | 0     | 70         | 20         | 10        |
| B3 (A: N: R)               | 0     | 45         | 45         | 10        |
| B4 (A: N: R)               | 0     | 20         | 70         | 10        |
| B5 (N: R)                  | 0     | 0          | 90         | 10        |
| B6 (blank)                 | 100   | 0          | 0          | 0         |
Table 2. Proximate content of raw materials

| Parameter       | Unit | Alabio | Nagara | Betung |
|-----------------|------|--------|--------|--------|
| Moisture        | %    | 72.66  | 68.83  | 94.08  |
| Ash             | %    | 1.19   | 1.22   | 0.22   |
| Protein         | %    | 1.83   | 6.09   | 7.06   |
| Fat content     | %    | 0.07   | 0.10   | 0.14   |
| Carbohydrate    | %    | 8.45   | 2.27   | 1.57   |

3. Results and discussion

3.1. Modified flours

Moisture content is an important characteristic of food, because water can affect the appearance, texture and taste of food [17]. The moisture content of the modified flour from spontaneous and non-spontaneous fermentation on alabio tubers; nagara tubers; and betung shoots were ranged from 8.05 - 10.64%; 3.96 - 9.89%; and 5.61 - 8.97%, respectively (figure 1). Based on analysis of variance, the type of raw materials and fermentation and their interaction had a significant effect on the moisture content of modified flour ($\alpha = 0.05$). The results indicated that the longer the fermentation time (using starter), the moisture content tended to decrease. The moisture content in flour can be affected by the fermentation process, where the fermented flour had a lower moisture content than flour without the fermentation process. It was because the fermentation process could degrade starch by microorganisms and caused a decrease in the water retaining material. The longer the fermentation time, the greater the enzyme activity to degrade the starch so that the more bounding water could release, as a result the texture of the flour becomes soft and porous [18]. However, the moisture content in the spontaneous fermentation tended to increase with the length of time, but it was still fulfilled the requirement (maximum 12%).

The ash content is a component non-volatile, mineral element as the residue left after it is burned, and persists during the combustion [19]. The ash content of modified flour from spontaneous and non-spontaneous fermentation for alabio tuber; nagara tuber; and betung shoot were ranged from 0.823 - 2.37%; 0.79 - 1.31%; and 1.331 - 6.17%, respectively (figure 2). The types of raw materials were significantly different from the ash content of modified flour. However, the treatment of 24 hours of spontaneous fermentation was equal to 48 hours. 72 hours of spontaneous fermentation was equal to 24 hours and 48 hours non spontaneous fermentation, while 72 non spontaneous fermentation was different from the others. The ash content of modified flours was still fulfilled the requirement (maximum 10%). Generally, the ash content decreased with increasing fermentation time. It was because organic compounds were formed due to the activity of lactic acid bacteria from the mocaf starter. Dewi and Mustika [20] explained that the increase in organic compound during the fermentation will decrease the percentage of inorganic material due to the increasing period of the fermentation (ash content).

![Figure 1. Moisture content of modified flours.](image-url)
Proteins are macro molecules composed of amino acids that are bounded to each other in peptide bonds. Amino acids consist of the elements carbon, hydrogen, oxygen and nitrogen [21]. Protein also contributes to the physical properties of food due to its ability to stabilize, foam, emulsify, and gel stability. The protein content of modified flour can be seen in figure 3. The protein content of modified flour from spontaneous and non-spontaneous fermentation of alabio tuber, nagara tuber, and betung shoot were ranged from 11.73 - 11.99%, 13.58 - 15.89%, and 12.89 - 13.43%, respectively. The protein content of modified flour in all fermentation was increased with the fermentation time. This increase in protein content was due to the increase in protein synthesis fermentation. Besides, the loss of dry matter during the fermentation process could also increase the proteins. This was in line with Dewi and Mustika [20] who stated that fermentation could increase the nutrients in the food through biosynthesis of proteins, essential amino acids, and vitamins. In addition, during the fermentation, the protein was also able to satisfy the condition of microorganism cells that grow during fermentation so that it could increase the protein content of the flour [18].

Figure 4 showed that the fat content of modified flours from spontaneous and non-spontaneous fermentation of alabio tuber, nagara tuber, and betung shoot were ranged from 0.13 - 0.17%, 0.69 - 0.81%, and 0.32 - 0.51%, respectively. The trend showed that the fat content was increased as fermentation time. The longer the fermentation time, the higher the fat content. The water weight of the ingredients would decrease, so that the concentration of other components would increase. The raw material had a significant effect on the fat content of modified flour, while the fermentation and its interactions did not had a significant effect (α = 0.05).
Figure 5 showed the trend of carbohydrate in modified flour. The longer the fermentation, the higher the carbohydrate. From the figure 5, it could be seen that alabio had the highest carbohydrate. It was because alabio tubers had the highest carbohydrate. Carbohydrates in flour consisted of carbohydrates in the form of simple sugars, pentose, dextrins, cellulose, and starch. Starch was a component main carbohydrate which was very important in determining the quality requirements of modified flour. Raw materials, fermentation time, and their interactions significantly influenced the carbohydrate content of modified flour ($\alpha = 0.05$). The types of raw materials and fermentation type were significantly different in treatments. Treatment of 24 hours-spontaneous and non-spontaneous fermentation were same, whereas 48 hours spontaneous and non-spontaneous fermentation were same, and 72 hours spontaneous fermentation was same with 72 hours non spontaneous fermentation.

The best results were obtained for 72 hours-spontaneous fermentation of alabio tubers, 48 hours-spontaneous fermentation of nagara tubers, and 72 hours-non spontaneous fermentation of betung shoots. 72 days-spontaneous fermented alabio tuber flour and 72 days-non spontaneous fermented flour of betung shoots were rich in carbohydrates, following by protein. On the other hand, the 48 hours-spontaneous fermented nagara flour was rich in protein, following by carbohydrates.

### 3.2. Formulation of modified flours

In general, all parameters had met the quality requirements of Indonesian National Standard SNI 01-4469-1998, except pH of B4 and B5, but they were still considered feasible because they were suitable for wheat flour. Proximate content of B1, B2, B3, B4 and B5 were shown in table 3. Same as the blank, B4 and B5 were rich in carbohydrates. The fat content of B5 was higher than B1, B2, B3, and B4, but low in protein, which was 8.50%. B5 was suitable for making biscuits because the modified flour contained 7-9% protein. The modifications led to the formation of a stickier and harder dough [22], so it was suited to make crispy and crumbly cakes.
Table 3. Quality of modified flour formulation.

| Parameters       | Unit | Formulation of modified flours |
|------------------|------|---------------------------------|
| Carbohydrate     | %    | B1     | B2    | B3     | B4     | B5     | B6     |
| Fat              | %    | 0.27   | 0.30  | 0.24   | 0.68   | 0.86   | 0.97   |
| Protein          | %    | 12.18  | 13.29 | 12.92  | 10.50  | 8.50   | 16.17  |
| Moisture         | %    | 9.23   | 8.41  | 8.68   | 7.70   | 8.22   | 7.33   |
| Ash              | %    | 2.20   | 1.89  | 1.98   | 1.96   | 1.82   | 0.58   |
| Amilose          | %    | 34.04  | 30.47 | 25.59  | 23.07  | 19.90  | 30.05  |
| Amilopectin      | %    | 47.19  | 39.96 | 62.36  | 9.29   | 12.15  | 9.57   |
| Starch           | %    | 25.89  | 29.99 | 25.06  | 34.63  | 33.50  | 40.52  |
| Dietary Fiber    | %    | 51.90  | 48.20 | 36.60  | 20.40  | 18.30  | 4.20   |
| Viscosity 2 % ctp|       | 1.00   | 1.00  | 2.00   | 1.00   | 1.00   | 1.20   |

Table 3 showed that the carbohydrate content of B4 and B5 was quite high, even exceeded the carbohydrates of wheat flour (B6). The carbohydrate content of the five formulation was (18.77-67.95)%. The more the amount of starch, the higher the carbohydrate content. The fat content of the five formulas was (0.24–0.86)%. Fat content increased with increasing starch content. Low fat content could lead to a longer shelf life of flour. Flour could avoid oxidation reactions, thus avoiding rancidity. The protein content of the five formulas was ranged from (8.50–13.29)%. The protein content tended to decrease with increasing levels of nagara modified flour. The moisture content of the five formulation was ranged from 7.70-9.23% and met the quality standard requirements of flour for cakes, for maximum of 15%. The ash content of the five formulation was ranged from (1.82–2.19)%. Ash content was an indicator of the presence of minerals in flour. The presence of ash content can be used as indicator the amount of minerals contained in a food ingredient. Ash is an inorganic substance left over from the combustion of an organic material.

The higher the proportion of amylose causes the the low viscosity of the flour. Based on table 3, there was a decrease in amylose content and an increase in viscosity along with the increase in the composition of the nagara modified flour. Starch with high amylose content would cause the layer (film) to become dense due to the stronger chain-to-chain interaction of polymer molecules, so that the hydrophilic nature of the layer (film) decreased because it contained few hydroxyl groups [23]. Amylose levels were grouped into 3, consisted of low amylose group (10-20)%; moderate (20-25)% and high (> 25%) [24]. Based on that level, the B1 - B3 modified flour was included in the high amylose group, while B4 was classified as the medium amylose group and B5 was classified as low amylose content. Flour with high amylose content was believed to produce high amount of resistant starch in baking and food processing. Whereas, the low amylose contents was related to higher starch swelling properties with better quality of noodle [25].

Amylopectin plays a role in trapping water which affects the viscosity to be higher. Amylopectin is a starch constituent composed of α-glucose monomers which are bound to 1,4-glycosidic bonds by forming branches (every 20 glucose chains) with 1,6-glycosidic bonds [26]. The existence of a branch chain causes amylopectin has amorphous properties so that it is more tenuous and water is easier to enter [27], so that the viscosity increases.

The formulation of B5 modified flour (nagara: betung shoot = 90:10) was suitable as raw material of biscuit making. The protein content of modified flour B5 was 8.50%, this was in accordance with the literature which stated that flour with a protein content of 7-9% was suitable for biscuits [28,29]. While
the protein of B4 modified flour (alabio: nagara:betung shoots = 20:70:10) was 10.50% and suitable for use as a coating flour for fried products).

4. Conclusion
The best results were obtained for 72 hours-spontaneous fermentation of alabio tubers, 48 hours-spontaneous fermentation of nagara tubers, and 72 hours-non spontaneous fermentation of betung shoots. The formulation of B5 modified flour (nagara: betung shoot = 90:10) was suitable as raw material of biscuit making, while the B4 modified flour (alabio: nagara:betung shoots = 20:70:10) was suitable for use as a coating flour for fried products.

Acknowledgments
The authors would like to thank the Ministry of Industry and the Ministry of Research and Technology for funding research in the incentive program of Researcher and Engineer Capacity Building. The authors also thank all parties involved.

References
[1] Chotimah H E N, Kresnanita S and Miranda Y 2013 Ethnobotanical study and nutrient content of local vegetables consumed in Central Kalimantan, Indonesia Biodiversitas 14 106–111
[2] Wan Rosli W I and Habibah B 2021 The effect of bamboo shoot (Gigantochloa albociliata) addition on the physical properties and sensorial acceptability of beef patty Food Res. 5 114–123
[3] Nongdam P and Tikendra L 2014 The nutritional facts of bamboo shoots and their usage as important traditional foods of Northeast India Int. Sch. Res. Not. 679073 1–17
[4] Santosh O, Bajwa H K, Bisht M S, and Nirmala C 2018 Freeze-dried bamboo shoot powder for food fortification: enrichment of nutritional content and organoleptic qualities of fortified biscuits MOJ Food Process. Technol. 6 342–348
[5] Giri P 2019 Effect of bamboo shoot powder incorporation on biscuit quality (Nepal: Tribhuvan University)
[6] Singh S R, Dalal S, Singh R, Dhawan A K, and Kalia R K 2012 Micropropagation of Dendrocalamus asper J. Plant Biochem. Biotechnol. 21 220–228
[7] Hassan Z H 2014 Aneka tepung berbasis bahan baku lokal sebagai sumber pangan fungsional dalam upaya meningkatkan nilai tambah produk pangan lokal Pangan 23 93–107
[8] Barus W L, Bachruddin Z, Hanim C, and Yusiati L M 2021 Effect of yellow sweet potato extract (Ipomoea batatas L.) as a prebiotic source for the kinetics of fermentation and the production of lactic acid by Lactobacillus paracasei in IOP Conference Series: Earth and Environmental Science 686 012047
[9] Nurani D, Sukotjo S and Nuralasari I 2013 Optimasi proses produksi tepung talas (Colocasia esculenta L. Schott) termodifikasi secara fermentasi J. IPTEK 8 65–71
[10] Rahmawati W, Kusumastuti Y and Aryanti N 2012 Karakterisasi pati talas (Colocasia esculenta L.) sebagai alternatif sumber pati industri di Indonesia J. Teknol. Kim. dan Ind. 1 347–351
[11] Sumardiono S, Jos B, Firmansyah D, Hidayatunajah R and Pudijasihutri I 2018 Modification of cassava starch using lactic acid hydrolysis in the rotary-UV dryer to improve physiochemical properties MATEC Web Conf. 156
[12] Ariyanti D, Budiyati C S and Kumoro A C 2014 Modifikasi tepung umbi talas Bogor (Colocasia Esculentum (L) Schott) dengan teknik oksidasi sebagai bahan pangan pengganti tepung terigu Reaktor 15 1–9
[13] Sumardiono S, Pudijasihutri I, Budiyono, Hartanto H and Sophiana I C 2017 Combination process method of lactic acid hydrolysis and hydrogen peroxide oxidation for cassava starch modification AIP Conf. Proc. 1840
[14] Seveline S, Heldyana R and Kurniawati S 2020 The use of three species of lactic acid bacteria in the mocaf (modified cassava flour) production,” Ind. J. Teknol. dan Manaj. Agroindustri 9 163–172

[15] Hasan M N, Sultan M Z and Mar-E-Um M 2014 Significance of fermented food in nutrition and food science J. Sci. Res. 6 373–386

[16] Yuliana N, Nurdjannah S, Setyani S and Novianti D 2017 Improving properties of sweet potato composite flour: Influence of lactic fermentation in AIP Conference Proceedings 1854

[17] Ashari D, SWahyuni S, Faradilla R H F and Oleo U H 2018 Review : Pengaruh proses modifikasi terhadap karakteristik tepung J. Sains dan Teknol. Pangan 3 1736–1744

[18] Iswari K, Astuti H F and Srimaryati 2010 Pengaruh lama fermentasi terhadap mutu tepung cassava termodifikasi Fak. Teknol. Pertan. Univ. Andalas 1250–1257

[19] Basiak E, Lenart A andDebeaufort F 2017 Effect of starch type on the physico-chemical properties of edible films,” Int. J. Biol. Macromol. 98 348–356

[20] Juliano B O 1971 A simplified assay for millied-rice amylose Cereal Foods World 16 334–360

[21] Van Hung P, Maeda T and Morita N 2006 Waxy and high-amylose wheat starches and flours- characteristics, functionality and application Trends Food Sci. Technol. 17 448–456

[22] Berg J M, Tymoczko J L and Stryer L 2002 Complex carbohydrates are formed by linkage of monosaccharides (New York: W.H. Freeman)