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Revealing Glycemic Index Properties of Flakes from Composite Flour (Mangrove Fruit: Porang and Mocaf Flour)

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Abstract—**Foods with a low glycemic index are a good choice for diabetics, including flakes created from mangrove fruit flour (pedada and lindur), porang as well as mocaf flour. These products contain dietary fiber and bioactive compounds and are thus suitable for low-glycemic functional foods. Therefore, this study aims to determine the glycemic index of various flour mixtures' flakes products, using a one-factor completely randomized design. Therefore, ten formulations were created with mangrove fruit flour: porang or mocaf flour ratio of (0:100, 10:90, and 20:80). The yields were then analyzed for proximate and organoleptic characteristics, while the glycemic index was measured in vivo with 22 subjects. Subsequently, blood samples were collected from the fingers of the subjects, followed by the assessment and comparison of blood glucose with a pure glucose curve to obtain the glycemic index. Furthermore, the glycemic load was calculated by multiplying the value derived with available carbohydrates. This study showed that the flakes produced from the combination of PFF and LFF with mocaf flour indicated lower GI values compared to the control (100% mocaf flour), namely at 40.96–48.27 with GL 9.83–11.96. The best treatments were obtained in flake product $P_{20}R_{80}$, characterized by the lowest glycemic index and glycemic load of 34.42 and 8.36, respectively. Meanwhile, the highest values were obtained in MFF_0M_{100}, at 51.02 and 12.72, correspondingly. The results indicate the inclusion of these flake products in the low glycemic index category.**

Keywords—**Flakes; glycemic index; mangrove fruit flour; mocaf; porang.**

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I. INTRODUCTION

Flakes cereals are a ready-to-eat food generally consumed with milk. Cereal flakes are the most popular breakfast choice of ready-to-eat products [1]. These products are created from whole corn kernels, and innovations in the processing aspects are required to increase nutritional value. Starches and flour from rice, maize, and potatoes with low micronutrients, protein, dietary fiber content, and high glycemic index tend to be used to make good products [2]. Besides, mangrove fruit flours (MFFs), including the pedada fruit flour (PFF) and lindur fruit flour (LFF) varieties are made from fruits of the mangrove species pedada (*Sonneratia caseolaris*) and lindur (*Bruguiera gymnorrhiza*). Previous studies on both flour types have shown possible application as substitutes in biscuit products, with anti-diabetic and anti-cholesterol properties [3], [4]. However, flakes have the advantage of being light, popular and widely consumed by the public. Products of flakes may be labeled with a nutrition claim and may be included in functional foods [5]. This product variety has been developed in many countries as a valuable trade commodity since the 20th century.

The glycemic index (GI) value is a measure used to classify food based on the intrinsic effect on blood glucose levels. This parameter is influenced by several factors, including processing, starch content, dietary fiber, fat, protein, and anti-nutrients [6]. Furthermore, the determination of GI in cereal flakes products requires knowledge of the starch content and the total sugar. These data are then used to evaluate the amount of available carbohydrate, and is subsequently converted into total glucose content. Moreover, the GI value obtained is also applied in the calculation of glycemic load. This is estimated as a number indicating the carbohydrate content in one portion of food due to carbohydrate consumptions [7]. The present paper is a continuation of previous studies, featuring an immense focus on the additions to MFFs, capable of reducing the GI values.

Porang tuber (*Amorphophalls anchophyllus*) is a member of the taro family (*Araceae*), *indigenious* to only tropical and sub-tropical regions. These plants have not been widely cultivated in Indonesia and only grow wild in the forest, riverbanks, and mountain slopes. In addition, there is also minimal utilization in food and non-food industries. The Porang tuber is known to contain glucomannans, including water-soluble polysaccharides with the capacity to cause a feeling of fullness after consumption. Porang flour is made into glucomannan flour for health benefits [8]. Moreover, glucomannan administration instigates the reduction of blood glucose levels in people with diabetes mellitus. Glucomannan increases prandial ghrelin reduction when given before glucose load and inhibits the increase in ghrelin [9]. Diabetics need low GI carbohydrates [10]. Hence, porang flake cereal products are expected to demonstrate these properties.

Mocaf is a form of cassava (*Manihot esculenta*) flour, modified through a process of fermentation, drying, crushing and sifting, leading to the loss of characteristic aroma and taste [11]. This variety is more soluble in water, easier to expand after heat exposure, and also has properties similar to wheat flour. Cassava starch and polyaniline molecules can interact in the composite material to form hydrogen bonds between the hydroxyl (OH) groups of glucose units [12]. The soluble dietary fiber content is estimated to be higher than cassava flour, and the calcium content is greater than the value reported in rice or wheat. Besides, the protein content is similar to wheat type II (i.e., medium protein content), and digestibility is relatively higher than cassava tapioca flour.

Therefore, this study is designed to determine the GI and glycemic load (GL) of flakes cereal products from MFFs treated with mocaf and porang flour. The GI is then tested using normal human subjects. This approach allows for collecting direct evidence on the effect of the flake products on human blood glucose.

II. Material and Method

The research was conducted at the Food Processing Technology Laboratory, Food Analysis, Food Technology Study Program, University of Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, East Java.

The materials used include the two types of mangrove fruit (pedada, and lindur), obtained from Sawohan village, Sidoarjo. Meanwhile, porang tubers and cassava were respectively procured from the Madiun and the traditional market of Rungkut Surabaya. Therefore, additional ingredients in the form of skim milk, salt, sugar, margarine, egg yolk, sugar syrup, SSL (Sodium Stearoyl Lactylate) and sodium bicarbonate were obtained from the Cakeshop in Wiguna Rungkut, Surabaya.

The materials for analysis include petroleum ether, selenium, sulphuric acid, NaOH, boric acid, methyl red indicators, hydrochloric acid, aluminum foil, sodium phosphate buffer, thermal enzyme, pepsin, pancreatin (pancreatic acid), ethanol, and acetone.

The research tools used include a set of flour and flake-making tools, cabinet dryers, ovens, and other glassware. Furthermore, Glucometer One Touch Select Simple, lancet needle, One Touch strip, weight scale, and sphygmomanometer were used for analysis.

This study consisted of three stages, including (1) the creation of mangrove fruit flour (pedada and lindur), porang flour and mocaf, (2) production of ten flake formulation, with a mangrove flour and porang flour to mocaf ratio of 0: 100, 10:90 and 20:80 (see Table 1), (3) This involves determining the respective glycemic index. This study was approved by ethics commission no. 237/EC/KEPK/UNUSA/2019

A. Flour Making

Mangrove flour was collected and randomly selected from various parts of the fruit, brought into the laboratory, and freeze-dried. After that, the fruit is peeled, and processed into a blender pulp with distilled water (1: 3). The pulp is sieved for sowing and dried in a drying cabinet for 15-18 hours at a temperature of 50-60^{0}C. After that, it is grounded to 80 mesh. Subsequently, each yield was analyzed for starch content before the flaking procedure.

B. Flakes Formulation

The flakes cereal-making process was performed by mixing sugar, egg yolk, margarine, and glucose syrup with a mixer at high speed. This was followed by adding skim milk, SSL, and 0.5 g sodium bicarbonate. Therefore, mangrove fruit flour (pedada and lindur) was added alongside porang or mocaf, in a ratio of 0: 100; 10:90 and 20:80 (Table 1), and further mixed to attain a homogeneous smooth mixture. The dough was flattened to ± 1mm and cut to size 1.5x1.5 cm, before roasting in an oven at 160 ºC for 10 minutes. Subsequently, the flake products were subjected to proximate analysis, to evaluate the starch and total sugar content.

TABLE I
FLAKES FORMULATION

Flake Formulation		
Code	**Flour**	**Ratio (%**
MFF_0M_{100}	Pedada : Mocaf	0 : 100
MFF_0R_{100}	Lindur : Porang	0 : 100
$P_{10}M_{90}$	Pedada : Mocaf	10 : 90
$P_{20}M_{80}$	Pedada : Mocaf	20 : 80
$P_{10}R_{90}$	Pedada : Porang	10 :90
$P_{20}R_{80}$	Pedada : Porang	20 : 80
$L_{10}M_{90}$	Lindur : Mocaf	10 : 90
$L_{20}M_{80}$	Lindur : Mocaf	20 : 80
$L_{10}R_{90}$	Lindur : Porang	10 : 90
$L_{20}R_{80}$	Lindur : Porang	20 : 80

Note: MFF= Mangrove Fruit Flour (Pedada or Lindur); L = Lindur; P = Pedada; R = Porang; M = Mocaf

C. Proximate Analysis

The moisture content was determined according to AOAC [13]. This required drying the samples in an air oven at 101^{0}C for about 10 hours to attain constant weights before cooling in a desiccator. Furthermore, the sample was reweighed, and the moisture was determined by estimating the difference between fresh and dry weights. Ash content was determined by heating the samples in a muffle furnace at 550^{0}C for several hours. Therefore, the percentage value was calculated by subtracting the ash weight from the initial.

Crude protein was analyzed using the Kjeldahl method. This involved treating the samples with the three essential steps of digestion, distillation, and titration, using a conversion factor of 6.25 to convert total nitrogen to crude protein. The percentage value was then calculated. Therefore, subtracting the sum of fat, protein, ash, and moisture content from 100 yielded the total carbohydrate content. Crude fat was determined by weighing 5.0 g of each sample wrapped in a filter paper and placed in a Soxhlet apparatus, using petroleum ether. This process was performed for 4 hours, and the extracted remnant materials after solvent evaporation were weighed to determine the fat content [14].

D. Determination of Glycemic Index and Glycemic Load

The glycemic index (GI) value was determined using blood samples of subjects, including exclusively University of Pembangunan Nasional "Veteran" students. A total of 30 prospective candidates were initially screened, and only 22 were selected. These were subsequently divided into 11 groups, comprising one control (pure glucose), and then treated with flakes product, with each comprising two individuals. The measurement of GI values was initiated by subjecting each respondent to fasting at night (except water) for ±10 hours (starting at 22:00 a.m.–8:00 a.m.). Therefore the test food was consumed in the form of flakes cereal in the morning, and about 20 µL blood samples were collected after 30 minutes, through the fingers. This sampling process was performed every 30 minutes for 2 hours, and the blood glucose levels were determined using the One Touch Select Simple Glucometer. The result shown by the test equipment is graphed with the X-axis representing time (in minutes), and the Y-axis denotes the blood glucose level (mg/dL). Furthermore, the area under the curve was calculated, and the value obtained was compared with standard food (pure glucose) [15]. Subsequently, glycemic index and glycemic load (GL) were calculated.

E. Sensory Evaluation

The sensory evaluation used hedonic scale scoring, with 25 male and female panellists selected from Food Technology Department, University of Pembangunan Nasional "Veteran" Jawa Timur, Indonesia. These professionals were asked to evaluate the flake product, in terms of color, taste, aroma, and crispness, with a scale scoring 1-5. The rate of 5 denoted favored, while 1 for disfavoured

F. Data Analysis

The glycemic index and glycemic load data were analyzed using one-way ANOVA. Therefore, comparisons between treatments were performed using the Duncan post hoc test, at a significance level of 5 %, using Minitab V 17 software. The sensory evaluation data were evaluated using Frietman test.

G. Research Flowchart

In making it easier to know the data collection process, you can see the research flowchart in Figure 1.

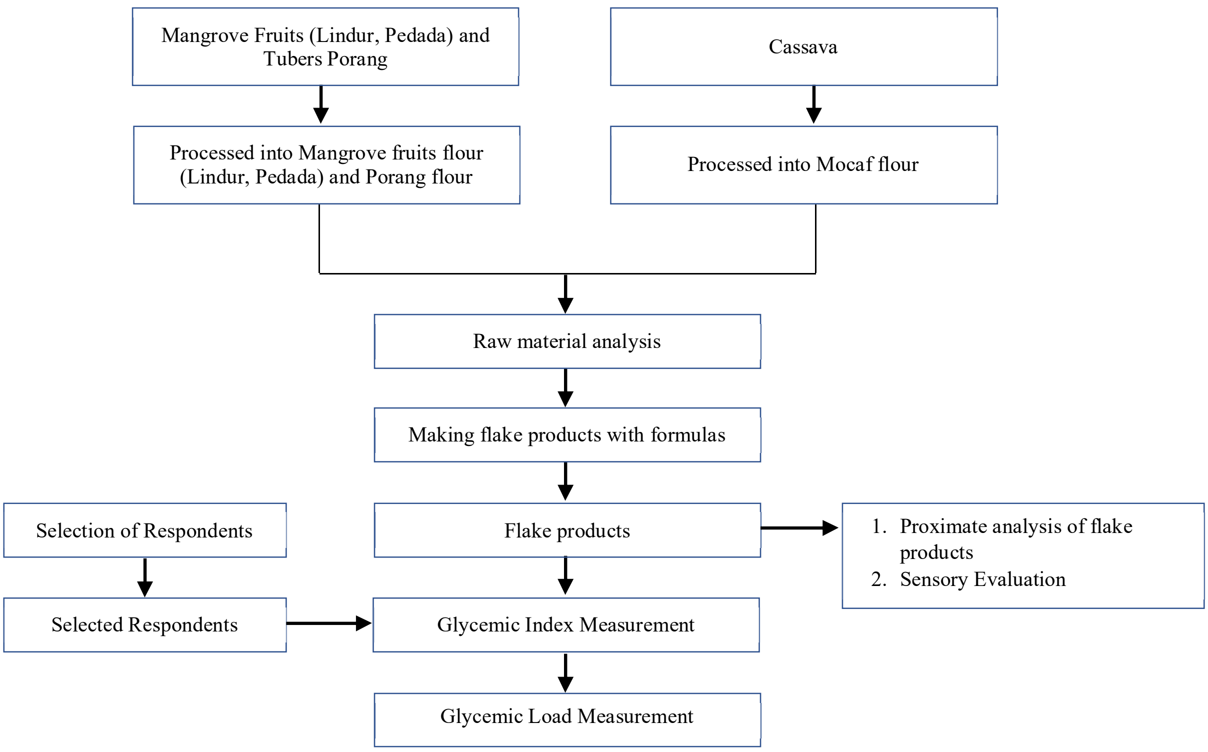

Fig. 1 Research Flowchart

III. Result and Discussion

A. Chemical Composition of Flours

The chemical composition of flours used determines the quality of the flake produced. Therefore, this raw material was analyzed for moisture, ash, fat, protein, carbohydrate, starch, amylose, and dietary fiber content. The results are shown in Table 2. The moisture content of all flour (6.09% - 11.41%) was good and in accordance with the SNI quality standard for flour (13.00%) (SNI, 2011). The ash content analysis results were quite diverse, ranging from 0.61% - 7.05%, with pedada fruit flour (PFF) measuring 7.05%. The present value Current 4.65-5.65% for Lindur and 4.10-4.17% for Pedada. In addition, 0.61% was estimated in mocaf flour, indicating a value lower than the SNI 7622-2011 provisions of 1.50%. Meanwhile, 4.51% determined in porang. The differences in results are instigated by variations in the location of raw material acquisition. This consequently influences the overall nutritional and ash content, and also affects dough stability. Moreover, high ash content was implicated in the dark coloration observed in the product, and vice versa.

TABLE II

CHEMICAL COMPOSITION OF FLOURS

Parameter	Pedada Fruit Flour (PFF)	Lindur Fuit Flour (LFF)	Mocaf Flour	Porang Flour
Moiusture	9.39	11.41	7.32	6.09
Ash	7.05	2.44	0.61	4.51
Fat	0.28	2.39	1.82	0.27
Protein	4.19	5.29	1.29	3.22
Carbohydrate	79.09	78.47	88.96	85.92
Dietary Fiber	4.56	3.52	0.56	4.82
Starch	0.00	67.46	85.26	81.40
Amylose	19.31	16.16	16.61	17.17

The fat content derived in this study was 0.28% for PFF, 2.39% for lindur fruit flour (LFF), 1.82% for mocaf flour, and 0.27% for porang flour. These analysis values are not significantly different from the outcome at 0.36%, 0.89%, 0.40%, and 0.60% [6], respectively. In addition, variations reported are possibly caused by differences in cassava types used as raw material. Also, the composition is influenced by variety, age of harvest, climate, treatment, and soil fertility. In addition, distinct processing into mocaf influences the end product obtained.

The flour protein content ranged from 1.29 - 4.19%, indicating a variation, where lindur flour was 3.31%. Moreover, it showed a value of 1.20% in mocaf flour, while reported 2.35% in porang, and 3.57% in PFF [16]. These differences result from the blanching process in processing PFF, implicated in protein level reduction. The finding is supported by Abraha *et al.* [17] where a total nutrient loss comprising 40% minerals and vitamins, 35% sugar, as well as 20% protein was estimated. The drying process also instigates protein denaturation due to interrupted non-covalent interactions in the natural structure.

The dietary fiber assessed in PFF was 4.46, which was similar to the values obtained in porang flour, at 4.82, while mocaf generated the lowest levels. In addition, the starch content of all samples was high, except for PFF, estimated to contain no starch, as well as amylose.

B. Proximate of flakes product

Table 3 shows the flakes product proximate analysis.

TABLE III

PROXIMATE ANALYSIS OF FLAKES PRODUCT

Code Formulation	Mouisture	Ash	Protein	Fat	Carbohydrate by different
	(%)				
MFF_0M_{100}	4.14^{a}	2.16^{de}	3.81^{e}	6.63^{ab}	83.63^{bc}
MFF_0R_{100}	3.67^{bc}	2.99^{ab}	4.41^{ab}	6.08^{d}	83.52^{a}
$P_{10}M_{90}$	3.96^{ab}	2.40^{d}	3.10^{c}	7.13^{ab}	81.59^{f}
$P_{20}M_{80}$	3.78^{bc}	2.85^{bc}	4.14^{bc}	7.63^{ab}	80.04^{i}
$P_{10}R_{90}$	3.60^{cd}	3.46^{ab}	4.50^{ab}	6.25^{cd}	83.13^{a}
$P_{20}R_{80}$	3.17^{g}	3.68^{a}	4.63^{ab}	6.49^{bc}	81.01^{cd}
$L_{10}M_{90}$	3.99^{bc}	2.22^{de}	3.91^{d}	7.38^{ab}	82.59^{h}
$L_{20}M_{80}$	3.88^{bc}	2.42^{bc}	4.36^{bc}	7.87^{a}	81.80^{e}
$L_{10}R_{90}$	3.55^{de}	3.04^{ab}	4.92^{ab}	6.60^{bc}	82.61^{cd}
$L_{20}R_{80}$	3.40^{f}	3.21^{ab}	5.58^{a}	7.08^{ab}	81.55^{g}

There was a decline in the product moisture content, which was congruent with the increasing proportion of MFF (PFF and LFF), either combined with mocaf or porang. This is influenced by the materials' starch and dietary fiber content, characterized by binding and ensuring higher water composition. The starch nature easily attaches and releases water [18]. Conversely, an increase in flake products' ash content is observed at a sequentially higher proportion of MFF (PFF and LFF). This is due to the initially high ash content in MFF raw materials, assumed to affect the final product. In addition, a similar trend was observed with protein flake levels, and the outcome was not in accordance with SNI standard number 01-4270-1996 (minimum 5%), except for flakes with the $L_{20}R_{80}$ formula.

The low protein percentage is also affected by roasting, carried out in the flakes creation process. This was due to heat's ability to allow unstable hydrophobic interactions between hydrogen bonds and non-polar components. Therefore, the kinetic energy is increased, causing the movement or fast vibration of protein building blocks, consequently damaging molecular bonds and the entire structure. In addition, protein content possibly decreases due to heating, soaking, pH, and chemicals [19].

An increase in MFF and a decline in mocaf and porang flour led to elevated flakes fat levels due to the relatively higher MFF content. Furthermore, all four parameters impact on carbohydrate content, and the value recorded was in accordance with SNI standard number 01-4270-1996.

C. Glycemic Index and Glycemic Load

The selected research subjects comprise 7 men and 14 women with good health status, no history of diabetes, and are not currently on treatment, or under the influence of drugs and alcohol [6]. Table 4 shows the subjects' criteria.

The food provided to the subjects was equivalent to 50 g carbohydrate, calculated from the total glucose and starch content of the flake's cereal product. Hence, it is possible to provide the equivalent amount of test food, and Table 5 shows the estimated total injected by subjects. The carbohydrate content of products generated using each formula was determined by difference, which the starch composition was used to calculate the glycemic load.

TABLE IV

CRITERIA OF RESPONDENTS

No.	Criteria Subjects	Range (units)
1	Age	20-23 years
2	Body weight	40-80 kg
3	Height	1.50-1.84 cm
4	Body mass index (BMI)	16.87-28.69 kg/m^2
5	Blood pressure	100/77-140/100 mmHg
6	Fasting blood glucose	77-100 mh/dL

Based on Table 5, the total glucose ranged from 26.94 %–30.71 %, while pure glucose was 94.53 %. In addition, the available carbohydrate was respectively in the span of 90.17 to 112.63 g, while the overall amount of test food varied between 43.79–54.34 g.

TABLE V

TOTAL GLUCOSE, AVAILABEL CARBOHYDRATE AND TOTAL FOOD TEST FOR FLAKES PRODUCTS AND STANDARD FOOD (PURE GLUCOSE)

Code Formulation	Total glucose (%)	Available Carbohydrate (gram)	Food Test (gram)
Glucose	94.53	94.53	52.89
MFF_0M_{100}	30.19	112.63	44.39
MFF_0R_{100}	30.71	96.01	52.08
$P_{10}M_{90}$	30.07	108.74	45.98
$P_{20}M_{80}$	29.38	104.54	47.83
$P_{10}R_{90}$	30.17	92.75	53.91
$P_{20}R_{80}$	29.91	90.17	55.45
$L_{10}M_{90}$	29.09	114.18	43.79
$L_{20}M_{80}$	26.94	110.11	45.41
$L_{10}R_{90}$	29.91	94.67	52.82
$L_{20}R_{80}$	28.34	92.01	54.34

Table 6 shows the average blood glucose level and responses measured from 22 subjects after the consumption of flakes and the test food.

TABLE VI

BLOOD GLUCOSE RESPONSE FOR FLAKES PRODUCT TREATMENT (MG/DL)

Code Formulation	0	30	60	90	120
	minutes				
Glucose	96.0	172.5	153.5	132.5	121.0
MFF_0M_{100}	95.0	135.0	127.5	110.0	106.5
MFF_0R_{100}	95.0	127.5	119.5	114.0	107.5
$P_{10}M_{90}$	95.0	132.5	121.5	115.0	103.5
$P_{20}M_{80}$	97.0	121.5	121.0	116.5	110.0
$P_{10}R_{90}$	95.0	115.0	108.0	100.5	92.5
$P_{20}R_{80}$	90.5	124.0	114.0	109.5	102.0
$L_{10}M_{90}$	93.5	125.5	118.5	107.5	100.0
$L_{20}M_{80}$	97.5	132.5	120.0	113.5	106.5
$L_{10}R_{90}$	97.0	120.5	116.5	115.0	107.5
$L_{20}R_{80}$	98.0	130.5	123.5	111.5	101.5

Table 6 shows higher response to the increased blood glucose from pure glucose, compared to the flakes cereal product. However, there was better control with MFF_0M_{100} and MFF_0R_{100} compared to other treatments (Fig. 2). Glucose levels increase at 30 minutes and consequently decrease at the 60th to 120 minutes. The decline from 30 to 120 minutes for $P_{10}M_{90}$ was by 29.00 mg / dL (132.5-103.5 mg / dL) or 21.88%, 11.50 mg / dL (121.5-110.0 mg / dL) or 9.46% for $P_{20}M_{80}$, while $P_{10}R_{90}$ and $P_{20}R_{80}$ had similar outcome at 19.56% and 17.74%, respectively. Moreover, the $L_{10}M_{90}$; $L_{20}M_{80}$; $L_{10}R_{90}$; and $L_{20}R_{80}$ formulas decreased by 20.31%; 19.62%; 10.78% and 22.22%, correspondingly. These results are relatively lower than the values reported in flakes control products (MFF_0M_{100} and MFF_0R_{100}), and the yield from PFF combined with mocaf and Porang are generally lower than LFF. In addition, glycemic index is estimated by calculating the area under the curve of each flakes product. Table 7 shows the outcome for the controls and flakes with substitutions of porang and mocaf flour.

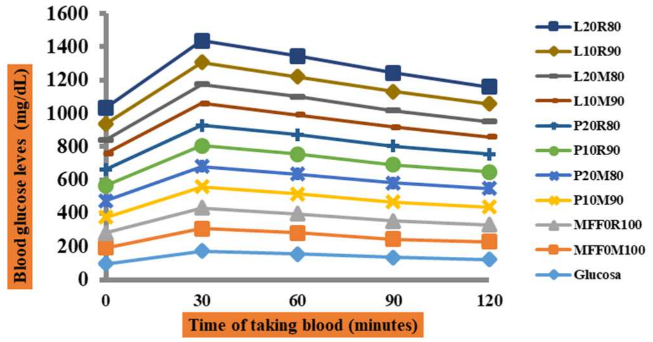

Fig. 2 Curve blood glucose response for flakes product

Table 7 shows the lower glycemic index in flakes formulation of pedada and lindur flour mixed with mocaf flour ($P_{10}M_{90}$; $P_{20}M_{80}$; $L_{10}M_{90}$ and $L_{20}M_{80}$) compared to MFF_0M_{100} (control). Similarly, the formulation with porang flour ($P_{10}R_{90}$; $P_{20}R_{80}$; $L_{10}R_{90}$ and $L_{20}R_{80}$) demonstrated lower result than the MFF_0R_{100} control. This trend is possibly due to the total dietary fiber content, and the analysis results showed values of 66.50 %; 55.20 %; 64.82 % and 3.56 % respectively in pedada, lindur, porang, and mocaf flour. Therefore, the resulting products are estimated to demonstrate low GI.

TABLE VII

GLYCEMIC INDEX AND GLYCEMIC LOAD OF FLAKES PRODUCT FROM MANGROVE FRUIT FLOUR WITH MOCAF FLOUR AND PORANG

Formulation	Starch (%)	Glycemic index (GI)	Glycemic load (GL)
MFF_0M_{100}	74.94	51.02	12.72
MFF_0R_{100}	59.37	44.84	11.27
$P_{10}M_{90}$	71.52	44.78	10.96
$P_{20}M_{80}$	68.33	40.96	9.83
$P_{10}R_{90}$	56.89	40.61	10.12
$P_{20}R_{80}$	54.78	34.42	8.36
$L_{10}M_{90}$	77.35	48.27	11.96
$L_{20}M_{80}$	75.60	46.77	11.47
$L_{10}R_{90}$	58.87	42.77	10.59
$L_{20}R_{80}$	57.88	40.11	9.81

The dietary fiber ability to slow food rate in the digestive tract, and also inhibit enzyme activity. These activities lead to slower digestive processing, and consequently lower glucose response. Affiliated the hypoglycemic effect of dietary fiber with slow gastric emptying, alongside glucose diffusion and absorption, thus instigating lower blood glucose elevations [20]. Another factor influencing the product GI is the starch content (Table 7). In addition, formulations of pedada flour or lindur fruit flour substituted with mocaf flour, including $P_{10}M_{90}$, $P_{20}M_{80}$, $L_{10}M_{90}$, and $L_{20}M_{80}$, comprise relatively higher starch content of 71.52; 68.33; 77.35 and 75.60 compared to porang, encompassing $P_{10}R_{90}$, $P_{20}R_{80}$, $L_{10}R_{90}$ and

$L_{20}R_{80}$, at 56.89; 54.78; 58.87 and 57.88%. This flake cereal product composition affects the GI value, especially the amylose content, where analysis result showed a respective value of 16.16%, 16.61% and 15.17% for lindur, mocaf, and porang flours, while the pedada variety has 0%. The high amylose content in slower digestion is implied because the glucose polymer features a non-branching structure (more crystalline with extensive hydrogen bonds). In addition, the hydrogen bonds observed are relatively stronger than amylopectin, leading to greater difficulties in hydrolysis by digestive enzymes. The non-branching characteristics ensure stronger bonds and difficulties in the gelatinization process, consequently causing digestion challenges. Gelatinization is an important property of starch for biomedical applications [21]. However, the ease of bonding and crystallization is responsible for the effortless retrogradation, which is difficult to digest. The GI values are possibly divided into three categories, including low (<55); moderate (55–70); high (> 70) [22].

The proximate flakes cereal results show a fat and protein content range of 6.08–7.86% and 3.41–5.62%, respectively. These parameters are estimated to influence GI value. the proportions of ingredients in the formula are adjusted to allow for a higher fiber and protein content. Consumption of low GI foods supports the body's cells to utilize insulin more effectively [23]. High fat and protein contents are implicated in lower glycemic index value, compared to similar foods with lower percentage. The high-fat level slows down the gastric emptying time, and consequently the digestive rate in the small intestine. Meanwhile, elevated protein content stimulates insulin secretion; thus blood sugar is controlled to not be excessive. High-fiber foods have the least impact on trefoil insulin absorption and result in decreased plasma glucose levels [24]. The glycemic load of the product determined from the calculated glycemic index is multiplied by the carbohydrate content per serving. Therefore, the derived value is used to assess the impact of carbohydrate consumption, and Table 5 shows the analysis result. The formulations with pedada: porang flour proportion of 20:80 had the lowest value compared others. Hence, the product is recommended for consumption by diabetics and for dietary purposes, due to the low IG and GL values. The glycemic load successively decreases at lower carbohydrate levels [25]. Therefore, the result is included in the low category at <11, where medium is in the range of 11–19, and high at >20 [26]. The high propensity for foods with glycemic index and lower glycemic load slowly triggers a rise in blood glucose levels and generates lower peak responses. The lower the glycemic index, the better the material [27]. This phenomenon reduces the risk of hyperglycemia, as the ingredients hinder glucose absorption.

D. Sensory Evaluation

Sensory evaluation through hedonic scale scoring indicates the preference level for product color, flavor, aroma and crispness. Therefore, the final results are indicated by the total rank. Table 8 shows the highest total rank in flakes formulation comprising a mixture of lindur and mocaf flour ($L_{10}M_{90}$) after MFF_0M_{100} (control). Conversely, the lowest was observed in the combination of pedada and porang flour ($P_{20}R_{80}$).

TABLE VIII
TOTAL RANK VALUE OF FLAKES PRODUCT

Formulation	Color	Taste	Aroma	Crispness
MFF_0M_{100}	243	241	217	196
MFF_0R_{100}	143	106	111	131
$P_{10}M_{90}$	189	188	196	191
$P_{20}M_{80}$	179	127	201	167
$P_{10}R_{90}$	109	115	136	142
$P_{20}R_{80}$	96	74	122	79
$L_{10}M_{90}$	212	217	195	209
$L_{20}M_{80}$	190	236	197	190
$L_{10}R_{90}$	116	135	119	137
$L_{20}R_{80}$	77	158	133	156

The addition of mocaf to both pedada and lindur flour samples generated a preferred product compared to the substitutions with porang. This is due to the high tendency of brown pigmentation after heating, therefore yielding flakes with less-favored colors. Regard the taste, formulations with lindur and mocaf were preferred to the mixture of pedada flour and mocaf, estimated to have high acid content. The porang flour was generally responsible for the disfavoured. This is also observed in terms of crispness, where the formulation mixture of lindur and mocaf was of greater preference. In addition, the manifestation results from the amylose content, as higher values facilitate the production of harder flakes

IV. CONCLUSIONS

Based on the results and discussion, flakes produced from a combination of pedada and lindur fruit flours with mocaf flour demonstrated GI values lower than the control (100% mocaf flour), at 40.96–48.27 with GL of 9.83–11.96. A similar outcome was observed in mixtures with porang flour, at 34.42–42.77, and 8.36–10.59, respectively.

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