FTIR (Fourier Transform Infra Red) profile of banana corm flour, nutritional value and sensory properties of resulting brownies

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Abstract. There is a need for continuous development in the aspect of local food resource utility, especially for rarely used foodstuffs. These include banana corm, with a propensity for processing into flour. The objectives of this study, therefore, were to determine the FTIR profile of banana corm flour and effect of steamed brownies formulated from banana corm and wheat flour, based on the nutritional and sensory properties. Furthermore, Completely Randomized Design with five treatments were adopted during the experiment, including the comparison of banana corm flour:wheat flour at ratio (50:50), (60:40), (70:30), (80:20) and (90:10)%. These individual treatments were replicated three times, and the data obtained were analyzed with ANOVA. Subsequently, samples with significant effect were further evaluated with the Least Significant Difference test at α=0.05. The FTIR results showed a chemical profile containing phenols, alkanes, alkenes and nitro compounds in banana corm flour, while wheat in contrast showed significantly different moisture, ash, fat, protein, carbohydrate, fiber content, and energy. In addition, the sensory test results indicate the ratio (90:10)% as the panelist’s favored steamed brownies.

1. Introduction
The banana plant (Musa paradisiaca val) is a popular fruit crop widely spread through the tropics, including in Indonesia [1], and grow more profusely in tropical rain forest areas. Furthermore, the fruit possess flesh rich in starch capable of transformation into sugars during the ripening process, and is also a good source of resistant starch. These specimen are also rich in carbohydrates, dietary fibres, certain vitamins, as well as minerals. The high nutrient content prompt the recommendation as a nutritious food for people of all ages, including babies, and as diet food for adults, although limited consumption is a necessity for patients with diabetes and kidney problems [2,3].

The banana sap has astringent chemical qualities, frequently used in traditional medicine to treat a wide variety of ailments, including leprosy, hysteria, fever, digestive disorders, hemorrhage, epilepsy, hemorrhoids, and insect bites. In addition, the roots and seeds have been adopted in the management of digestive disorders, while the peel and pulp scientifically demonstrate both antifungal and antibiotic components. These structures also contain the neurotransmitters norepinephrine, serotonin and dopamine[4].

The native banana pseudo-stem flour (NBPF) and tender core of pseudo-stem flour (TCBPF) were previously evaluated for chemical and functional properties. The results show relatively higher polyphenols, flavonoids, total dietary fibre, insoluble dietary fibre, lignin, hemicellulose, and cellulose content, alongside greater antioxidant, and free-radical scavenging capacity in NBPF [5]. Furthermore, the plant rhizome is considered a rich source of numerous polyphenolic compounds with antioxidant activities [6].

In terms of utility, people only tend to use banana fruit, leaves, and heart, while other underexploited parts include the corm, which is very easily accessible. Therefore, innovation is needed to increase the intrinsic value, including as processed flour. Furthermore, the banana corm occurs in the form of a stem tuber below the soil surface, and is rarely applied for human consumption. This raw material is possibly used as a substitute for wheat flour in noodles, cakes, and cookies processing, and further increases the usability [7].
The flour obtained from numerous banana variety (kepok, raja, mahuli, susu, ambon) have the following characteristics: water content (1.09-1.41%), ash content (0.47-0.67%), 10.20-12.56% yield, water absorption of 166-260%, and crude fiber (19.11-29.62%). Particularly, an absorption capacity of 210% was recorded in kepok bananas species, where the corm is harvested before fruit development, 233% in the presence of fruits, and 254% after harvest [8].

Brownies are a type of cake with dark brown coloration and a slightly harder texture, compared to the normal forms. The ingredients use consist of wheat flour, margarine, eggs, sugar, as well as cocoa (cocoa powder and cooking chocolate), and have become a favorite food for most Indonesians. Furthermore, the products are usually cooked by baking or steaming. Hence, it is necessary to perform substantial research to determine the FTIR profile of banana corm flour, and also to evaluate the effect of novelty steamed brownie formulations prepared subsequently, in contrast with wheat flour, on the nutrition and sensory properties.

2. Materials and methods

2.1. Materials

The materials used in this study include banana corms from the farmers' gardens at Bengkuring village, medium protein flour, sugar, eggs, baking powder, margarine, cocoa powder, powdered milk, clean water (Sempaja cake shop), as well as chemicals for analysis.

The equipment used in this study include scales, spoons, steamer, mixer, baking sheet, knife, 80 mesh sieve, slicer, baking sheet, basin, blender, stove, analytical scale, desiccator, porcelain dish, ashing furnace, soxhlet, erlenmeyer, stopwatch and glass ware.

2.2. Design

This research was compiled using Completely Randomized Design with five treatments, including the comparison of banana corm flour:wheat flour (50:50), (60:40), (70:30), (80:20) and (90:10)%.

Furthermore, each treatment was replicated three times.

2.3. Preparation of banana corm flour and steamed brownies

The banana corm flour production process involves some stages, encompassing peeling, washing and cutting the corm. This is followed by draining and drying in the oven for 18 hours at 60°C to achieve dryness. Subsequently, the samples were ground and sieved with an 80 mesh to obtain the flour, and the chemical profile was then analyzed through FTIR. The steamed brownies formulation process requires evenly shaking 187 g of chicken eggs, 230 g of sugar, 45 g of cocoa powder, 1 g of baking powder, 1 g of salt, and 100 g of powdered milk in a bowl with a mixer to achieve a homogenous dough. Therefore, Kepok banana corm and wheat flour were added according to the treatment requirement, while continuously beating with a mixer. Subsequently, the melted margarine was added and stirred again to attain complete blending before the dough is poured into a pan greased with butter. This unit is then placed into an oven set at a temperature of 100°C for ± 30 minutes. Furthermore, the nutritional and sensory values were analyzed, and the following analytical method were used to measure the observed parameters:

2.4. Nutrient analytical testing

These include analysis of water, ash, fat (Soxhlet method), protein (Kjeldahl method) and carbohydrate content by difference, as well as the evaluation for total energy [9].

2.5. Chemical profile analysis with FTIR

Thermo Nicolet IS 10 FTIR test (Beam splitter: KBr / Ge mid-infrared, Detector Type: Deuterated TriGlycine Sulfate (DTGS), Accessories: Smart ATR Diamond. The FTIR spectra was recorded on a Nicolet iS10 FT-IR spectrometer equipped with crystal cell diamonds to assess the attenuated total reflection (ATR) operation [10].
2.6. Sensory test
The sensory properties were evaluated based on hedonic preference and hedonic quality testing, using 5 scales of 20 panelists. The score attributed to color, aroma, texture, and taste preference were between 1 and 5, indicating strongly dislike, dislike, somewhat like, like, and very much like.

Moreover, hedonic quality was evaluated at 1-5 colors (very not brown, not brown, slightly brown, brown, very brown), while aroma was assessed with 1-5 (for very chocolate scented, chocolate scented, somewhat chocolate, banana corm flour, very banana corm flour). In addition, texture and taste were also rated 1-5 at (very soft, soft, slightly soft, slightly hard, hard) and (very chocolate taste, chocolate taste, rather chocolate taste, taste of banana corm flour, very taste of banana corm flour), respectively.

2.7. Data analyses
The data obtained were then analyzed with ANOVA, and treatments with significant effects were then continued with the Least Significant Difference test at $\alpha=0.05$.

3. Result and discussion

3.1. FTIR (Fourier Transform Infra Red) profile of banana corm
Figure 2 shows the chemical profile analysis results for banana corm flour. The FTIR data demonstrate the presence of 2 most obvious peaks from IR 4000 to 2500 spectrum at 3297.68 (O-H bonds) for phenolic compounds and 2912.95 (strong C-H bonds) for alkanes. The range between the region 2500 to 2000 is not distinct, while there is one at position 1629.56 (C = C bond) from 2000 to 1500, identified as an alkene compound.

![Figure 1. FTIR profile banana corm flour.](image)

The two IR spectrum ranges from 1.500 to 400, included 1322.93 (NO$_2$ bond) designating a nitro compound, and 995.09 as the highest peak. Furthermore, a comparison with the data from [11] was made, where strong C-H bond indicating an alkene compound was determined at position 995.56 [10,12]. The phenolic compounds are considered an important component in plant based food quality. These constituents are responsible for the colour of banana corm flour, serve as substrates for enzymatic browning, and are also involved in flavour properties.

3.2. Nutrient value
Table 1 shows the ANOVA test results indicating the significant effect of banana corm on nutritional value in contrast with wheat flour.
3.2.1. Water. The further test results with LSD at the α 5% level denotes a significantly different water content between banana corm and wheat flour across all treatments. In addition, the moisture content of steamed brownies ranged from 24.70% to 31.20%, and is in accordance with SNI 01-3840-1995, where values less than 40% is recommended [13]. The water content recorded increased at higher banana corm flour ratios, in contrast with wheat.

3.2.2. Ash. The results of further tests with LSD at α 5% level showed a significantly different ash content across all treatments. Furthermore, the values recorded in the steamed brownies ranged from 3.47% to 8.03%, and is not in accordance with the SNI 01-3840-1995 quality requirements < 3%. The dried flour sample contains 60 mg calcium, 2 mg iron and 150 mg phosphorus per 100 g [14]. Moreover, there was a decline in the ash content of steamed brownies at higher banana corm flour to wheat flour ratio.

3.2.3. Protein. The LSD test result showed the protein levels in P1 and P2 treatments, where some showed no significant difference while others demonstrated a positive outcome. This constituent ranged from 17.22% to 20.30% in steamed brownies, although higher values were affiliated with the eggs added at each treatment, at 187g. Furthermore, lower protein content was recorded in treatments with additional banana corm flour, due to the higher protein content of 8.9g per 100 ingredients observed in wheat flour [15], compared to the dried test specimen at 3.45 g per 100g [14].

3.2.4. Fat. The results of further tests with LSD at α 5% showed a significantly different fat content between all treatments. Furthermore, there was a simultaneous decline in value with increasing banana corm flour ratio, compared to wheat. This parameter ranged from 10.11% to 16.23% in steamed brownies, and 20.29% was recorded for those prepared without kepok banana corm flour, while the baked variety were [16]. The outcome was attributed to a fat content of 1.3 g per 100 ingredients in wheat flour [15], compared to the total absence in banana corm flour [14].

3.2.5. Carbohydrate. The LSD test result showed the presence of both significant and insignificant differences between the carbohydrate content in P2 and P3 treatments. In addition, the values recorded in steamed brownies ranged from 31.0% to 38.0%, which is lower than the baked variety. This outcome is possibly attributed to the discrepancies in the production process, as other research showed a 63.30% higher value compared to the steamed brownies[16]. The content in wheat and dry banana flour were 77.3 g and 66.20 g per 100 g of ingredients, respectively [15]. Moreover, most of the banana corm flour components comprise 80% polysaccharides [14]. Figure 1 shows the FTIR results indicating phenol and C-H as the main carbohydrate constituents. However, flavonoids were mainly identified in the form of glycoside, and was linked with glucose, rhamnose, galactose and xylose as the main sugars [17;18].

| Parameter       | Treatment |
|-----------------|-----------|
|                 | P0        | P1        | P2        | P3        | P4        |
| Water (%)       | 24.7e     | 25.66d    | 26.94c    | 30.55b    | 31.20a    |
| Ash (%)         | 8.03a     | 7.72b     | 6.04c     | 5.12d     | 3.47e     |
| Protein (%)     | 20.30a    | 18.30b    | 18.04b    | 16.18c    | 17.22d    |
| Fat (%)         | 16.23a    | 15.12b    | 13.90c    | 13.15d    | 10.11e    |
| Carbohydrates (%)| 31.01d   | 33.20c    | 35.08b    | 35.00b    | 38.00a    |
| Fiber (%)       | 14.43e    | 17.24d    | 19.54c    | 21.72b    | 25.18a    |
| Energy (cal)    | 350.23a   | 342.08b   | 337.58c   | 323.07b   | 311.87e   |

Note: Numbers followed by a similar letter on the same line indicate no significant difference (p <0.05).
3.2.6. Fiber. The results of further tests with LSD at α 5% showed a significantly different fiber content between all treatments. Furthermore, the value recorded in steamed brownies ranged from 14.43% to 25.18%, where samples with higher kepok banana corn flour compositions demonstrated greater percentage in the resulting steamed and also in the baked brownies (13.68%) [16]. However, the fiber content was more significant in the steamed variety, while 1.61% was reported in the samples baked without banana corn flour [16]. Figure 1 shows the FTIR results indicating the presence of free phenolic compounds or the bounded forms, encompassing those mainly attached to arabinosyl chains of cell wall arabinoxylans [17;18]. Moreover, the total fiber content identified in banana corn flour was 29.62% [8].

3.2.7. Energy. The total energy in steamed brownies ranged from between 311.87, to 350.23 cal/100g. This parameter was lower in steamed brownies compared to 417.20 cal/100g recorded in the baked variety [16]. Therefore, variations in production processes are estimated to influence the total energy value, although the calories in dried banana corn was 245 calories per 100g [14]. The outcome in the steamed variety tend to decrease at higher banana corn to wheat flour ratio.

3.3. Sensory Properties

Table 2. Sensory Properties.

| Sensory properties | Treatment | P0          | P1          | P2          | P3          | P4          |
|--------------------|-----------|-------------|-------------|-------------|-------------|-------------|
|                    |           | P0          | P1          | P2          | P3          | P4          |
| Hedonic            | color     | 2.29±1,34   | 2.84±1,75   | 3.32±1,48   | 3.12±1,20   | 3.21±1,31   |
|                    | aroma     | 2.52±1,30   | 2.52±1,44   | 3.54±3,00   | 3.44±3,12   | 2.49±3,45   |
|                    | texture   | 2.96±1,13   | 2.87±1,29   | 3.01±1,38   | 2.72±1,02   | 2.84±1,20   |
|                    | taste     | 2.29±1,34 a | 2.84±1,75 b | 3.32±1,48 b | 3.12±1,20 b | 3.21±1,31 b |
| Hedonic            | color     | 3.19±1,39   | 3.28±1,50   | 3.29±1,09   | 3.44±1,12   | 3.60±1,19   |
|                    | aroma     | 2.29±1,34 a | 2.84±1,75 b | 3.00±1,28 b | 3.12±1,20 b | 3.45±1,14 b |
|                    | texture   | 2.45±1,21 b | 2.48±1,66 b | 2.45±0,92 b | 2.13±1,02 b | 1.96±1,47 a |
|                    | taste     | 3.19±1,39   | 3.28±1,50   | 3.29±1,09   | 3.44±1,12   | 3.60±1,19   |

Note: Numbers followed by similar letters on the same line indicate no significant difference (p <0.05).

3.3.1. Color. Based on the ANOVA test results, the comparison of banana corn and wheat flour had no significant effect on the steamed brownies produced. The hedonic preference value obtained for color ranged from 2.29% (somewhat like) to 3.21% (like), while the quality was between 3.19% (brown) and 3.60% (brown). Moreover, the steamed brownies were influenced by the addition of cocoa powder, and the kepok banana corn flour had no effect. However, the phenol component observed from the FTIR test results attributed the brown coloration to corn oxidation.

3.3.2. Aroma. The hedonic test results for the aroma sensory attributes of steamed brownies ranged from 2.49% (rather like) to 3.54 (somewhat like). Meanwhile, the hedonic quality was between 2.29% (slightly bananas corn flour) and 3.45% (somewhat chocolate). This indicates the propensity for formulations with higher banana corn flour to produce more flavor. The aroma formation process is possibly attributed to the phenol, alkane, alkene and nitrous components, as indicated by the FTIR test results shown in Figure 1.

3.3.3. Texture. The hedonic value for texture ranged from 2.72% (rather like) to 3.01% (like), while the quality obtained was between 1.96% (soft) and 2.48% (soft). In addition, brownies produced with higher banana corn flour proportion tend to demonstrate less dense properties. This was due to the high water
absorption characteristics, while the greater fiber content as shown in Table 1 is responsible for the less soft texture.

3.3.4. Taste. The taste hedonic value was in the range of 2.29% (somewhat like) to 3.32% (like), while the quality obtained varied between 3.19% (rather chocolate taste) and 3.60% (rather chocolate taste). Furthermore, additional banana corm flour instigates a decline in the chocolate flavor of brownie produced. The phenolic compounds present possibly contributes directly to desirable and undesirable food aromas and tastes.

4. Conclusion
The FTIR results showed the chemical profiles of banana corm flour, comprising phenols, alkanes, alkenes and nitro compounds. Furthermore, the comparison between banana corm flour and wheat flour significantly affected the nutritional value. However, the recorded results fulfilled the SNI requirements, except for higher ash content. The samples with 90:10 were considered the most favored by panelists in the resulting steamed brownie.

5. References
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