Chemical Compositions of Banana Peels (*Musa sapientum*) Fruits cultivated in Malaysia using proximate analysis

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Abstract

*Global fruit consumption has a remarkable increase worldwide because of disease prevention and health benefits due to the presence of nutrients and other bioactive compounds needed by the human in healthy life. Fruits processing waste are highly perishable and seasonal and are a problem to pollution monitoring agencies. In some fruits, peels represent almost 30% of the total weight. This study aims to investigate the chemical composition of banana (*Musa sapientum*) peels.*

Peels of banana were removed and analyzed for their nutrients and anti-nutrients contents. The results showed that water content, crude protein contents, crude lipid contents, crude fiber, total ash contents and carbohydrate in banana peels were 50.5, 5.3, 1.6, 19.2, 8.8 and 14.6% respectively. The results indicate that if the peels are properly exploited and processed, they could be good ingredients and cheap source of carbohydrates for culture media.

Keywords: Banana, peels, *Musa sapientum*, proximate analysis.

Introduction

Global fruit production and consumption have experienced a remarkable increase worldwide because of taste and health benefits due to the presence of nutrients such as minerals, vitamins, fiber and other bioactive compounds needed by the human body for a healthy life[1-3]. However, the increase in consumption of these fruits indicates an increase in the volume of waste generated, especially peels and seeds. Food waste is the major problem worldwide; therefore, the study of peel and seed of fruits can reveal important natural sources of nutrients and country economic indexes[4].

Banana, the largest herbaceous plant in the world, is among the ten most important crops, which is the fourth largest producer in the world at over 7 million tones, produced by conventional cultivation systems[5]. Approx. 90 million tonnes of banana fruit are produced, mainly in tropical areas such as Africa (13%), South and Central America (28%) and South Eastern Asia (47%).

However, 40% of this production is wastes, mainly peels[6]. Peel is a waste material of various fruit and vegetables. Therefore, it is possible to obtain banana peel sufficiently and application depends on its chemical compositions. In addition, peels and seeds can present higher nutrient contents[7]. According to Morais et al[8] and Moo-Huchin et al,[9] peels are highly perishable, mainly due to the large amount of water in their composition. Moreover, they have a wide range of vitamins and minerals present in both pulps and peels[10].

The objective of research was to determine the nutritional composition of banana fruit peels with the aim of exploiting the potential value of these peels. The following parameters were evaluated: chemical composition (Water content, ash, crude protein, total lipids and crude fiber). Hence in this study, the feasibility of using locally available and economical agro-waste substrates as growth medium for microorganisms was investigated. The proximate composition of the agro-waste was determined prior to fermentation. Furthermore, the fermentation parameters such as biomass yield and viable count were determined.

Material and Methods

Preparation of Banana Peels powder: Banana (*Musa sapientum*) fruit peels were washed and allowed to dry at room temperature. The yield was recorded and fresh peels were dried at 50°C, then ground to obtain a fine powder[11].

Proximate analyses: The proximate analysis was carried out using the method described by Speight[12]. The parameters determined were: water content, crude protein, crude fat, crude fiber, total ash, nitrogen-free extract (carbohydrate) and gross energy.

i) Water content determination: 2.0 grams of fresh samples were placed in a pre-dried and weighed crucible. Oven combustion (Binder GmbH, Germany) was used to dry the samples at a temperature of 105 °C until a constant weight was obtained. After removing the samples from the oven, they were allowed to cool for 60 min in a desiccator and then re-weighed. The water content of each variety was calculated as loss in weight of the original sample and expressed as percentage. The water content was determined according to the equation below:

$$\text{Water content (\%)} = \frac{W_1 - (W_2 - W_0)}{W_1} \text{ x } 100\% \qquad (1)$$

where W_0 = container constant weight; W_1 = fresh sample weight and W_2 = container and dry sample weight.

ii) Crude protein determination: Kjeldahl analysis was used to determine the crude protein content by using a Kjeltec analyzer which measures the total nitrogen content in the sample. This is then converted to crude protein by using the factor 6.25 based on the assumption that the average of protein contains about 16% nitrogen. The principle of this analytical technique is similar to the conventional micro-Kjeldahl method and can be divided into three stages: i) digestion, ii) distillation and iii) titration. The protein content (%) of the samples was calculated by using the following equation:

$$\text{Nitrogen in sample (\%)} = \frac{W_2 \text{ x Normality of acid x } 14}{W_1} \text{ x } 100\% \quad (2)$$

where W_1 = Sample weight measured by milligram and W_2= volume of HCl.

A conversion factor of 6.25 was used to convert total nitrogen to protein for all the waste substrates using the following equation:

$$\text{Crude protein (\%)} = \text{Nitrogen (\%) x } 6.25 \quad (3)$$

iii) Crude lipid determination: Exhaustive Soxhlet extraction was used to determine the crude lipid by petroleum ether on a Soxhlet extraction system 2055 (FOSS Tecator, Sweden). A total amount of 1.0 g of the sample was put into pre-weighed thimbles and covered with a wad of cotton. A Soxhlet extraction cup was weighed and 100 mL of petroleum ether was added to each sample. This process started in the controller unit and consisted of the following steps: boiling for 20 min, rinsing for 35 min, recovery for 10 min and finally drying for 5.0 min. After the extraction, the solvent was evaporated. The extraction cup was removed and placed in an oven for drying at 105°C. The extraction cup was removed from the oven after 60 min and allowed to cool in desiccators. The lipid was measured by re-weighing the extraction cup and the crude lipid content was determined by using the following formula:

$$\text{Crude lipid (\%)} = \frac{W_3 - W_1}{W_2} \text{ x}100\ \% \quad (4)$$

where W_1= container weight; W_2= sample weight and W_3= lipid and container weight

iv) Total ash determination: The ash content is defined as the inorganic residue that remained after the organic matter was burnt away. The porcelain crucible was dried in the oven at 105°C for 60 min and then weighed after being cooled in the desiccator. As much as 1.0 g of the sample was weighed and placed overnight in a muffle furnace (Carbolite, UK) which was set at 550°C. After ashing, the sample was removed from the furnace. The crucible was cooled in a dessicator and then re-weighed. The total ash content was calculated using the following equation:

$$\text{Ash (\%)} = \frac{W_2 - W_0}{W_1} \text{ x } 100\ \% \quad (5)$$

where W_0= crucible weight; W_1 = sample weight and W_2 = crucible and ash sample weight.

v) Crude fiber determination: Crude fibers defined as the indigestible carbohydrate portion of feed consist principally of cellulose, hemicelluloses and lignin. It can be defined as the loss on ignition of the remaining dried residues after the consecutive digestion of feed sample with dilute acid and alkali under specific conditions (Weende method)[13]. Triplicate fat-free dried samples of 1.0 g were weighed in a clean pre-weighed filter crucible. The crucible, together with the sample, was transferred to the hot-extraction unit and the sample was left to digest for 30 min with 150 mL of the solution containing 12.5% sulfuric acid and 0.25 mL of octanol. The condenser was switched off after 30 min and allowed to cool.

The acid solution was filtered and washed with hot distilled water by suction. Then, the sample was digested for 30 min with 150 mL alkali solution (12.5% sodium hydroxide) and 0.25 mL of octanol to dissolve alkali-soluble matter from the sample. The porcelain crucibles together with final residue were dried at 105°C in an oven for 60 min, cooled in a dessicator and then weighed. The ashing of the residue was ignited in a pre-heated muffle furnace (Carbolite, UK) at 550°C for 180 min. The flask was again cooled and the final weight of the crucible, together with the ash, was recorded and the weight difference was recorded.

The percent of crude fiber content was calculated using the following equation:

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \text{ X } 100\ \% \quad (6)$$

where W_1= sample weight; W_2= crucible with residue weight and W_3 = empty crucible with ash residue weight.

vi) Nitrogen-free extract (carbohydrate) determination: Nitrogen-free extract (carbohydrate) was determined according to the equation below:

$$\text{NFE \%} = [100 - (\text{WC \%} + \text{CP \%} + \text{CL \%} + \text{CF \%} + \text{ash \%}) \quad (7)$$

where NFE = nitrogen-free extract; WC = water content; CP: crude protein; CL = crude lipid and CF = crude fiber.

vii) Gross energy determination: Gross or total energy content of agro-waste material can be obtained by summation of the known energy values contributed by the crude protein, crude fat and carbohydrate fractions of the sample using the Atwater's conversion factors. Gross energy of the samples was calculated from data obtained on proximate analysis and the calories percent in the selected

samples were calculated by multiplying the percentage of crude protein and carbohydrate with 4.0 and crude fat with 9.0. The values were then converted to calories per 100 gm of the sample.

Preparation of Banana agro-wastes as growth substrates: The Banana skin was treated using the method of Danyluk et al[14] with modification. Banana skin was washed with distilled water to remove dirt particles before sliced and blended (Khind, Malaysia) with distilled water at a ratio of 1:1 (w/w). The mixture was filtered twice using a muslin cloth and centrifuged at 8000 RPM for 15 min. The pH of supernatant was adjusted to 6.0 ± 0.1 using 1.0 M hydrochloric acid and sterilized at 121°C for 15 min.

Bacterial cultures: *Staphylococcus aureus* and *Escherichia coli* were selected to examine their ability to grow in banana peels (*Musa sapientum)* substrate.

Screening of agro-wastes as growth substrate: 1.0 mL of 24-hr culture of *S. aureus* and *E. coli* (1.0 %v/v) was transferred into Erlenmeyer flask containing 100 mL of sterile liquid medium of banana agro-waste. The bacteria were cultivated at 37°C for 30 hr. Samples were collected at 0, 6, 12, 18, 24 and 30 hr, for biomass and viable count determination as growth indicator.

Determination of biomass: Biomass accumulation was determined gravimetrically as described by Nigam[15]. One milliliter culture broth was centrifuged (Kubota 3500, Japan) at 10000 RPM for 10 min. The supernatant was discarded and the cells were washed with sterile phosphate buffer (pH 7.2) for 1.0 min. The cells were again centrifuged at 10000 RPM for 10 min. The washed cells were dried at 105°C to a constant weight.

Determination of viable count: Appropriate tenfold dilution of the samples was prepared in phosphate buffer solution. The viable counts (log_{10} CFU/mL) were determined at 0, 6, 12, 18 and 24 hrs by pour plate technique. The plates were subsequently incubated at 37°C for 24 hrs. After incubation, the single colonies were counted and the number of viable cells determined[16].

Statistical analysis: Results were reported as mean ± standard deviation (SD). Data were analysed by one-way analysis of variance (ANOVA). The Tukey test, at p = 0.05, was used to assess significant differences between means of samples.

Results and Discussion

Proximate analysis: Proximate analysis gives the nutritional value of banana peels agro-wastes used in this study was presented in table 1.

Proximate analysis gives valuable information of the nutritional composition and helps to access the quality of the sample. It provides information on moisture, protein, lipid, ash, fiber and carbohydrate content[17]. Studies have shown that fruit wastes (peels and seeds) contain among other vital nutrients an appreciable quantity of carbohydrate, proteins fats, fibers and phytochemicals[18].

The mean value of water content was 50.5 ± 2.7, water content which plays a significant role in determining the shelf-life of the product[19], water content is dependent on genetic makeup of varieties and agronomic as well as climatic conditions[20]. According to Hausmann et al[21] products with lower water content, generally, are less subject to degradation by microorganisms and chemical changes. The high moisture peel contents observed suggest that the peels requiring carbohydrate are the chief source of energy to the body; they are constituent of compound lipid, conjugated protein and glycosaminoglycans (GAGs) which form ground substance of mesenchymal tissues[22].

Ash is the inorganic residue remaining after water and organic matter has been removed by heating[17]. It is important to note that the ash composition is the number of mineral elements in food[23]. Protein provides amino acids which are the substrates required for the support of body protein synthesis and maintenances of cell and organ protein content. Thus, it furnishes amino acid the building block of all protein[21]. It is important to remark here that fruit values of crude protein are low because the fruits in general are not potential sources of proteins[24].

The finding in this research was in line with the reported result of Romelle et al[11] who reported that these peels are sources of nutrients (lipids, proteins, minerals etc.) The lipids content found in banana peel were similar to that found by Morais et al[25] but lower than found by Munguti et al[26]. This might be due either to the differences in varieties or to geographical factors. The ash content of banana peels was 8.8 ± 0.54%. Similar observations were made by Emaga et al[7] who reported that the ash content in different banana peels varied from 6.4 to 12.8%. It is clear that banana peels agro-wastes, could be used as substrate for bacterial growth. The values calculated in this study indicate that banana peel has energy value in the range of other fruit by-products such as citrus peels[27] oranges peels[28] and cassava peels[29].

It is important to highlight that neither freeze drying nor oven drying methodologies decreased the nutrient amount (ash, crude protein, total lipids and crude fiber)[25].

Determination of biomass and viable growth: The bacteria culture grew well in banana agro-waste medium. Fig. 1-2 shows the viable count and biomass of *S. aureus* and *E. coli*. The viable counts ranged between 7.94 log10 CFU/mL to 7.96 log10 CFU/mL. The maximum viable count was obtained at 18 hr after incubation, but the number of cells slightly decreased at 24 hr with no significant difference. At 30 hr of cultivation the number of cells dramatically decreased with significant difference (dead phase). On the other hand, the biomass increased dramatically from zero to 36 hr.

It was noted that higher viable count could be associated with higher biomass and production of higher amount of cells[30,31]. The use of waste could reduce the total bacterial production cost[32]. In addition, the use of agro-wastes could also reduce the pollution to environment. The findings in this study suggested that agro-waste substrate especially banana skin has the potential to be used as growth substrate for production of bacteria.

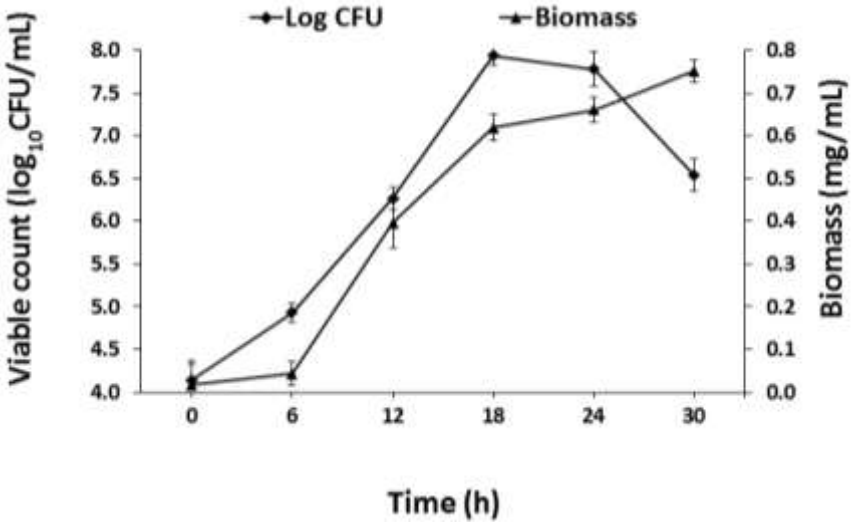

Figure 1: Viable count and the yield of biomass versus incubation time of *S. aureus.* Mean ± SD, n=3.

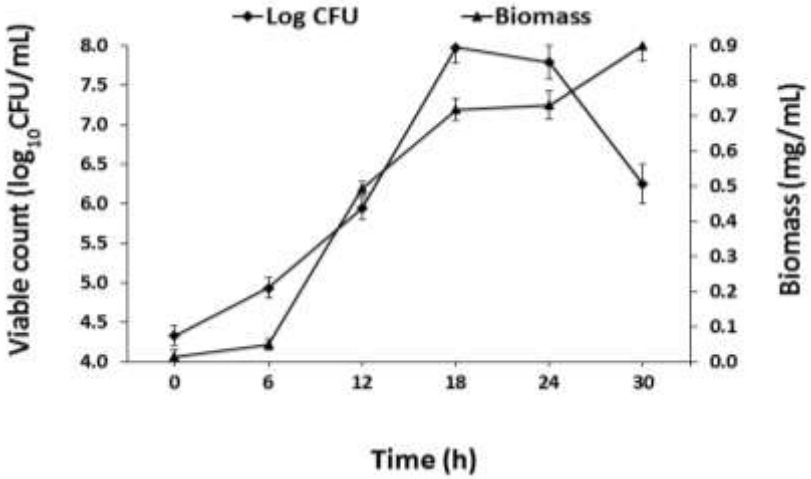

Figure 2: Viable count and the yield of biomass versus incubation time of *E. coli.* Mean ± SD, n=3.

Table 1
Proximate analysis of nutritional contents in banana peels agro-waste. Mean ± SD, n = 3.

Proximate analysis	Wet sample (%)
Water content	50.5 ± 2.7
Protein	5.3± 0.02
Lipid	1.6 ± 0.14
Fibre	19.2 ±0.54
Ash	8.8 ±0.54
Dry matter	49.5
NFE	14.6
Gross energy (kcal)	94.0

Conclusion

Proximate analysis gives a good idea of the nutritional value of agro-waste used in this study. By replacing the conventional synthetic media with cheaper alternative agricultural substrates, it will save the production cost. The results of nutritional analysis suggest that banana waste for growing microorganisms could be the cheapest and valuable bio-resource. This technology will guide to green environment.

Acknowledgement

The present study was financially supported by the Universiti Sains Malaysia (USM) Grant Number (1001 /PFARMASI/843084).

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