Evaluation of Resistant Starch Quality from Different Types of Banana in Batter Coating Formulation to Reduce Oil Absorption in Fried Food

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Abstract: Fried food is convenient for many people due to its pleasant texture and taste. On the other hand, it comes with the risk of high oil absorption which might lead to certain health problems. Resistant starch (RS) has been known to have a functionality of reducing oil absorption. Three different types of banana: Kepok (\textit{Musa paradisiaca} formatypica), Raja Bulu (\textit{Musa paradisiaca} L.) and Ambon (\textit{Musa paradisiaca} L. var sapientum) were evaluated on its performance when utilized as source of resistant starch especially on their application in reducing oil absorption in fried food. Tempeh was used as the food model. Banana starch (RS2) was isolated through water alkaline extraction process, continued with modification process through three repeated cycles of autoclaving-cooling process to obtain the RS3. RS3 was added into the batter coating formulation at three substitution ratios (10%, 30% and 50%) and then used to coat tempeh before frying. Evaluation of resistant starch in batter and battered product was conducted on the following parameters: fat content, water retention capacity (WRC), coating pick up and sensory analysis. The result of this study revealed that Raja Bulu showed the most effective result on reducing oil absorption in the food tested. In the three bananas used, the ratio of 50% performed best in coating pick up (highest), WRC (highest) and fat content (lowest) parameters, but not significantly different with the 30% ratio. In terms of sensory acceptance, using Raja Bulu as the selected banana type, 30% of substitution ratio was significantly more preferable by the panelists in crispness, oiliness, and overall acceptance attributes compared to control and other substitution ratios.

Keywords: \textit{Musa paradisiaca} formatypica, \textit{Musa paradisiaca} L., \textit{Musa paradisiaca} L. var sapientum, resistant starch, oil absorption

1. Introduction

Fried foods have been commonly consumed by people around the world, especially in Indonesia. Their pleasant taste and texture are among the reasons of why they are convenient to consume. However, high fat content in the product remains its major disadvantage, particularly for those who concern more about health issue. An excessive fat intake by consuming fried product can lead to cardiovascular, cancer or obesity. Thus, providing a healthier battered coating that contributes to reduce oil absorption in fried food is quite a necessity (Sanz et al., 2007; Sajilata, 2006).

Resistant starch has been known for its functionality to reduce oil absorption (Fiszman and Salvador, 2003). Moreover, resistant starch offers bland flavor, low water-holding capacity (Homayouni et al., 2013), providing crispiness and texture improvement in the final product (Sajilata et al., 2006). As its mentioned benefit and functionality, RS is deemed potential to be applied in batter formulation to reduce oil absorption in fried food.

Unripe banana has been known as potential source of resistant starch type 2 (RS2) which has higher resistant starch content (56.3%-63.7%) compared to cassava (9.69±1.28%), taro (51.9±0.9%) and sweet potato (13.5%-25.3%) (Moongngarm, 2013; Vatanasuchart et al., 2009; Ngoc et al., 2017).
However, RS2 has limitation in terms of stability in high temperature, while resistant starch type 3 is found to be more heat-stable (Homayouni et al., 2013). Modification of RS2 can be done to generate the more heat-stable RS3.

Kepok (Musa paradisiaca formatypica), Raja Bulu (Musa paradisiaca L.) and Ambon (Musa paradisiaca L. var sapientum) are found to have high RS content respectively, 27.70%, 30.66% and 29.37% compared to Nangka (26.28%) and Muli banana (26.42%) (Musita, 2009). Kepok, Ambon and Raja banana are the banana types which mostly produced in Java (Ministry of Agriculture, 2016). Currently, the white kepok banana is still underutilized and consumed mostly as feed for birds. Moreover, Ambon and Raja banana have high productivity but the demand for their consumption is still lower than other varieties of banana (Statistics of Food Consumption 2015, 2015). With the available potential and low consumption, Kepok, Ambon and Raja Bulu banana were used in this study.

This study aims to evaluate the effect of different banana types (Kepok, Ambon and Raja Bulu) on the effectiveness in reducing oil absorption while maintaining sensory properties of product. Concentration of RS from different banana types in batter coating will also be observed for its effect on oil absorption.

2. Materials and Methods

2.1. Materials

Materials used in this research were unripe Kepok banana, Raja Bulu banana, Ambon banana, wheat flour (Segitiga Biru, Indonesia), banana starch, glutamate (Ajinomoto, Indonesia), salt (Dolphin, Indonesia) and baking powder (Koepoe Koepoe, Indonesia). Unripe Kepok, Ambon and Raja Bulu banana were purchased from local supplier in Tangerang. The selected banana had the characteristic of green color and hard. The chemicals used were the following: sodium hydroxide (NaOH) (Merck, Germany), hexane (Merck, Germany), and distilled water.

2.2. Methods

This study consisted of four main stages which were extraction of banana starch (RS2), modification of banana starch into resistant starch type 3 (RS3), application of RS2 and RS3 in batter coating formulation, and analysis of batter and battered fried food quality.

2.2.1. Extraction of banana starch (RS2)

RS2 extraction method were carried out following a previous research by Zhang et al. (2014) and Vatanauschart et al. (2012), using water alkaline method.

2.2.2. Modification of banana starch (RS2) into RS3 through Autoclaving-Cooling Cycles

Starch was mixed with distilled water in Erlenmeyer with a ratio of 1:5. The starch solution was then heated at 80°C for 5 minutes with constant stirring. The suspension was then put into autoclave at 121°C for 15 minutes and cooled down at room temperature until it reached 40°C. It was then put into the chiller and left for 24 hours. The cycle of autoclaving-cooling was repeated for another 2 more times. After that, the gel-like suspension was heated in the oven at 40°C for 1.5 days to dry and milled to fine starch particles.

2.2.3. Formulation of batter coating

Ingredients of batter are presented in Table 1. Batter was prepared by mixing all ingredients with water with the ratio of 1.0: 1.5. Next, tempeh was cut into the size of 4 cm x 3 cm x 1 cm. Then, the batter coating with control and three different formulations for each banana were applied to tempeh. The battered tempeh was then deep fried in cooking oil at approximately 130 ± 5°C for 5 minutes until the golden-brown color of fried battered tempeh was reached.
Table 1: Amount of ingredients from different batter formulation*

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Wheat Flour</th>
<th>Resistant Starch</th>
<th>Glutamate</th>
<th>Salt</th>
<th>Baking Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>92.8</td>
<td>0</td>
<td>0.6</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>10% RS</td>
<td>82.8</td>
<td>10</td>
<td>0.6</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>30% RS</td>
<td>62.8</td>
<td>30</td>
<td>0.6</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>50% RS</td>
<td>42.8</td>
<td>50</td>
<td>0.6</td>
<td>3.5</td>
<td>3.1</td>
</tr>
</tbody>
</table>

*Referred to Sanz et al. (2007).

2.2.4. Analysis of batter and battered fried food quality

2.2.4.1. Fat Content (SNI 01-2891-1992)

Fat content analysis was done gravimetrically using soxhlet method, referring to SNI 01-2891-1992.

2.2.4.2. Coating Pick Up

Coating pick up is the total batter that remains stick onto the product after frying process. The percentage of coating pick up was taken in triplicate. The percentage of coating pick up was calculated according to the formula as follow:

\[
\text{Coating pick up} (%) = \frac{B}{B+C} \times 100\%
\]  

Where:

- \( B \) = weight of batter coating of tempeh after final frying (g)
- \( C \) = weight of tempeh excluding batter coating after final frying (g)

2.2.4.3. Water Retention Capacity (WRC) (Sanz et al., 2007)

As much as 30 g of batter were weighed and placed in 50 mL centrifuge tube and it was centrifuged at 11,000 rpm for 10 minutes at 15°C. After the centrifugation process, the supernatant was carefully removed and weighed. The data was taken in triplicate. The percentage of water retention capacity was calculated according to the formula as follow:

\[
\text{Water retention capacity} (%) = 100\% - \text{water released} \% \\
\text{water released} (%) = \frac{B}{A} \times 100\%
\]  

Where:

- \( A \) = batter weight (g)
- \( B \) = supernatant weight (g)

2.2.5. Sensory Analysis

Sensory analysis of battered fried product (tempeh) was conducted to 30 untrained panelists. Hedonic scoring test was used for the sensory evaluation to know the preference and acceptability of sensory attributes of the product according to sensory attributes which are appearance, color, crispiness, flavor, oiliness and overall acceptability. In this sensory analysis, battered fried tempeh that have been coated with different batter formulation of RS from Raja Bulu banana as the chosen banana type were used as the sample.
2.2.6. **Statistical Analysis**

The experimental data result were analyzed statistically by one way analysis of variance (ANOVA) using Microsoft Excel and statistical significance in the difference among the values was evaluated by Tukey Post-Hoc Test at a confidence level interval of \( p \leq 0.05 \). The sensory analysis data result were analysed statistically using Friedman’s Test and if there is a significant difference between each sample, Post Hoc analysis using Wilcoxon’s Test were carried out.

3. **Results and Discussion**

3.1. **Fat Content**

Fat content is an important parameter to study the effect of resistant starch incorporation in batter formulation to reduce oil absorption in the final product (fried tempeh). Table 2 presented fat content of battered fried tempeh incorporated with RS3 from Kepok, Raja Bulu, and Ambon Banana at three different substitution ratios.

As seen on the table, battered tempeh with RS3 incorporation resulted in the lower fat content compared to control with no RS3. The data also showed a trend of a decreasing fat content when higher concentration of RS3 was added into the batter. However, it was observed that the fat content at 30% is not significantly different with that at 50% ratio. Raja Bulu banana, at all RS substitution ratios, has been shown to give the lowest fat content, compared to the other banana types.

Resistant starch is known to have a film forming ability, especially contributed by the amylose portion of starch which can form a gel and coat the food. This film can act as a protective barrier which prevents the excessive oil absorption in food (Altunakar, Sahin and Sumnu, 2004).

**Table 2:** Fat Content of Battered Tempeh at Different Substitution Ratios

<table>
<thead>
<tr>
<th>Ratio of RS3</th>
<th>Kepok RS3</th>
<th>Raja Bulu RS3</th>
<th>Ambon RS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>43.55 ± 0.25</td>
<td>43.55 ± 0.25</td>
<td>43.55 ± 0.25</td>
</tr>
<tr>
<td>10%</td>
<td>38.78 ± 0.87</td>
<td>34.12 ± 0.97</td>
<td>37.17 ± 0.87</td>
</tr>
<tr>
<td>30%</td>
<td>25.23 ± 0.35</td>
<td>23.55 ± 0.86</td>
<td>30.68 ± 0.81</td>
</tr>
<tr>
<td>50%</td>
<td>24.22 ± 0.33</td>
<td>21.37 ± 0.77</td>
<td>28.00 ± 0.90</td>
</tr>
</tbody>
</table>

*different code in same columns indicate the difference among samples

3.2. **Coating Pick Up**

Coating pick up indicates the amount of batter that still adhering to the tempeh after battering. Stated by Altunakar et al., (2006) and Sahin et al., (2005), coating pick up influences the amount of oil absorbed by coated products during deep-fat frying.

Viscosity of batter is positively correlated with the quantity of coating pickup (Dogan et al., 2005; Chen et al., 2008; Altunakar et al., 2006). According to Sanz et al., (2007), batter with high viscosity resulting in high coating pick up, whereas low viscosity batter have less coating pick up value. Coating pick up of batter at three different RS substitution ratio with different banana types is presented on Table 3.

**Table 3:** Coating Pick Up of Formulated Batter at Different Substitution Ratios.

<table>
<thead>
<tr>
<th>Ratio of RS3</th>
<th>Kepok RS3</th>
<th>Raja Bulu RS3</th>
<th>Ambon RS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>40.10 ± 0.49</td>
<td>40.10 ± 0.49</td>
<td>40.10 ± 0.49</td>
</tr>
<tr>
<td>10%</td>
<td>45.28 ± 0.65</td>
<td>42.34 ± 1.72</td>
<td>44.32 ± 0.31</td>
</tr>
<tr>
<td>30%</td>
<td>49.96 ± 0.94</td>
<td>47.85 ± 1.08</td>
<td>49.89 ± 0.61</td>
</tr>
</tbody>
</table>
It is shown on the Table 3 that coating pick up presented an increasing trend in a higher RS3 concentration up to 30% ratio. However, at 50% ratio the value decreased but not statistically significant compared to 30% ratio.

### 3.3. Water Retention Capacity (WRC)

Water retention capacity (WRC) were analyzed in order to identify the ability of the batter to retain water. WRC and fat content have opposite correlation. Increasing in WRC will decreasing fat content. Increasing in WRC will diminish water loss during frying and thus reduce the interchange with oil (Gamble et al., 1987).

This theory also supported by studies done by Sanz et al., (2007). They stated that addition of RS3 in batter formulation will decrease the fat content and increase in the moisture content in the batter crust during deep-fat frying which relate to the increase of WRC with RS. This theory was also proven in this study, as presented in Table 4.

**Table 4: Water Retention Capacity of Batter at different Substitution Ratio**

<table>
<thead>
<tr>
<th>Ratio of RS3</th>
<th>Kepok RS3</th>
<th>Raja Bulu RS3</th>
<th>Ambon RS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>56.74 ± 0.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>56.74 ± 0.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>56.74 ± 0.06&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>10%</td>
<td>58.70 ± 0.09&lt;sup&gt;c&lt;/sup&gt;</td>
<td>60.20 ± 0.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>60.45 ± 0.18&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>30%</td>
<td>68.40 ± 0.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>68.38 ± 0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>72.59 ± 0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>50%</td>
<td>95.52 ± 0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>78.28 ± 0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.22 ± 0.21&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*different code in same columns indicate the difference among samples

The higher substitution ratio of RS has led to a higher WRC value, which is in line with the decreasing trend of fat content, as explained by the abovementioned theory.

### 3.4. Sensory Evaluation

Based on fat content result which showed that Raja Bulu resulted in the lowest fat content, supported with the fact that Raja Bulu provides higher yield of starch (the data is not available in this paper), therefore Raja Bulu is selected to be evaluated further through sensory test. Result of the sensory evaluation at different substitution ratios is displayed on Table 5.

**Table 5: Result of sensory evaluation of tempeh with Raja Bulu RS3 at different substitution ratios.**

<table>
<thead>
<tr>
<th>Batter Type</th>
<th>Appearance</th>
<th>Color</th>
<th>Crispness</th>
<th>Oiliness</th>
<th>Flavor</th>
<th>Overall Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7.23 ± 1.28&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.97 ± 1.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.16 ± 1.55&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.52 ± 1.71&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>7.03 ± 0.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.74 ± 1.06&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>10%</td>
<td>7.55 ± 1.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.35 ± 1.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.71 ± 1.27&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.97 ± 1.54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.00 ± 1.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.10 ± 0.98&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>30%</td>
<td>7.58 ± 0.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.65 ± 0.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.26 ± 1.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.55 ± 1.55&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.35 ± 0.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.58 ± 0.85&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>50%</td>
<td>7.52 ± 1.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.71 ± 0.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.97 ± 1.14&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.23 ± 1.26&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.29 ± 0.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.35 ± 0.88&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
*different code in same columns indicate the difference among samples

As shown in the table, panelists gave highest score for sample with 30% substitution ratio for appearance, crispness, oiliness, flavor, and overall acceptance. The score is statistically higher compared to control which means that RS addition has resulted in better sensory acceptance.

4. Conclusion

This study revealed that resistant starch type 3 (RS3) from banana starch had successfully lowered the oil absorption of fried product, with tempeh as food model used. Raja Bulu was found to generate the lowest oil absorption in fried food, based on the fat content analysis, compared to Kepok and Ambon types. The higher concentration of RS generally resulted in the lower fat content, but not significantly different in 30% and 50%. The addition of RS has the positive effect on the sensory acceptance of product, where the 30% was given the significantly higher score by the panelists on crispness, oiliness, and overall acceptance attributes, compared to control and other substitution ratios.

References


Ministry of Agriculture. 2016. Horticultural commodity outlook (Banana). Jakarta: Center for Agricultural Data and Information System


