The Effect of Banana Kepok Substitution on Soybean Tempe as a Food Rich in Carbohydrates and Protein

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Abstract. Tempe is a fermented food product made from soybeans. It is a traditional Indonesian food. To make tempe, soybeans are soaked, dehulled, and partially cooked. Afterward, a specific type of mold called Rhizopus oligosporus is added to the soybeans. Kepok bananas are a type of food that high in carbohydrates. This research aimed to determine the effect of kepok bananas on tempe's carbohydrate and protein content. This research used a Completely Randomized Design (CRD) method with 4 treatments and three replications. A0: No Banana Kepok Substitution; A1: 80% Soybeans and 20% Banana Kepok; A2: 60% Soybeans and 40% Banana Kepok; A3: 40% Soybeans and 60%. Banana Kepok The parameters observed were proximate analysis (water, carbohydrate, protein and fat content) as well as organoleptic tests. The data analysis technique used is Variance Analysis and Duncan test. The results of the study showed that Kepok bananas had a real influence on the carbohydrate and protein content of tempe. The carbohydrate value of tempe with the substitution of kepok banana ranges from 4.81% -13.93%. The protein content value of tempe with the substitution of kapok banana ranges between 11.48% - 18.98%.

1 Introduction

Tempe is a native food from Indonesia, which is one of the important foods. Tempe is generally made from soybeans, without grinding, cooking, mixing with a tempe starter (*Rhizopus oligosporus* or *Rhizopus oryzae culture*) and incubating for a day or 2. The white mycelium from *Rhizopus* forms the soybeans into a dense shape that is easy to cut. In Indonesia, tempe is traditionally made from soybeans, but in Western countries, you can find tempe made from vegetables, grains and other beans.

Fermentation is a processing method through a process that utilizes the decomposition of compounds from complex protein ingredients. Tempe fermentation is a two-stage fermentation, namely fermentation by bacterial activity which takes place during the soybean soaking process, and fermentation by mold which takes place after inoculation with the mold. The composition and growth of tempe microflora during fermentation are

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very interesting to observe because it turns out that not only R. oligosporus plays a role. Studied in depth the microbial ecology during the soaking of soybeans for making tempe, found that bacteria are the microflora that always grow significantly during tempe making and have an important role.

Banana is a cultivated plant that has the potential to be developed massively as an alternative food ingredient to replace staple foods. This is the opinion of [1] who stated that bananas are a type of plant in Indonesia that has great potential to be developed and utilized by the community because it has high economic value. Apart from being consumed, Kepok bananas also have quite high economic value so many people use them as agricultural products that can be traded. However, until now they don't know much about the nutritional content of the Kepok banana itself. This is due to the lack of information and studies conducted regarding the nutritional content of Kepok bananas, especially their carbohydrate content.

The carbohydrates found in bananas are also the result of photosynthesis which are transported from the leaves to the banana fruit. [2] stated that the largest carbohydrate component in bananas is starch. Protein is one of the important human needs in maintaining body stability. Protein can be used as an energy source that is equivalent to carbohydrates because it produces 4 kcal/g protein. One source of protein in food is tempe. Tempe is the result of the fermentation of yellow soybeans by the mould Rhizopus oligosporus. Tempe contains various nutrients needed by the body such as protein, fat, carbohydrates, minerals and isoflavones. Several studies show that tempe's nutrients are easier for the body to digest, absorb and utilize. This is because the mould that grows on soybeans hydrolyzes complex compounds into simple compounds that are easily digested by humans.

Banana kepok are a good source of carbohydrates. Carbohydrates are one of the important nutrients needed by *Rhizopus* fungus to grow and produce the enzymes needed for tempe fermentation. Kapok bananas can provide a sufficient source of energy for the growth of the fungus. Kapok bananas contain various nutrients such as vitamins, minerals, fiber and protein. Thus, the addition of banana kepok can increase the nutritional content of the tempe. Bananas kepok also provide a good texture to tempe. When fermented, banana kapok gives tempe a denser and chewier texture. This can improve the consistency and deliciousness of the tempe. Kapok bananas provide a natural sweet taste to tempe. This can add an interesting dimension of flavor to tempe, especially if it is eaten straight away without cooking it first.

2 Research methods

2.1 Research materials and tools

The ingredients used in this research were soybeans, kapok bananas, and yeast. The tools used in this research were basins, pans, spoons, cheese graters, plastic, candles, toothpicks, and scales.

2.2 Research design

This research used a completely randomized design with 4 treatments and 3 replications.
A0: 100% Soybeans and 0% Banana Kepok
A1: 80% Soybeans and 20% Banana Kepok
A2: 60% Soybeans and 40% Banana Kepok
A3: 40% Soybeans and 60% Banana Kepok

$$Yij = \mu + \tau i + \beta j + \varepsilon ij \quad (1)$$

Information Yij observation on treatment -i and group j, μ general average, τi effect of treatment-I, βj effect of group j, εij random effect on treatment -i and group –j.

The results of the analysis will be calculated statistically using Analysis of Variance (ANOVA). If there is a real or very real difference in treatment, it will be continued with the DUNCAN test at the 5% level.

2.3 Research implementation

Here are the general steps for making tempe: Necessary materials: Whole soybeans 100 grams, 80 grams, 60 grams and 40 grams; Tempe yeast (usually about 1/4 tablespoon); Kepok bananas, 20 grams, 40 grams and 60 grams; Plastic wrap or banana leaves.

The working procedures of this research are : **Soy Preparation:** Soak the soybeans in water for 12-18 hours. This helps loosen the skin and makes the peeling process easier. After soaking, rub the soybeans gently to remove the skin.Wash the soybeans thoroughly with running water to remove loose skins and other dirt. **Sorting Process:** Once the soybeans are clean, sort the soybeans to make sure none of them are germinated, black, or damaged. Discard unfit soybeans. **Boiling Soybeans:** Boil the soybeans in clean water for about 10-15 minutes or until boiling. Make sure the soybeans are completely cooked. Then drain the soybeans and soak them in a container with clean water for 3 hours. Then cook again for about 5-10 minutes, then drain the soybeans again and cool until dry. **Tempe Yeast Mixing:** Mix the prepared tempe yeast into the cooled soybeans. Make sure the soybeans are mixed well with the yeast then add the grated kepok banana and stir until evenly mixed.**Packaging:** Prepare a clean container for making tempe, you can use plastic leaves. Put the soybean and yeast mixture into the container and smooth the surface. **Packaging and Fermentation:** Cover the surface of the soybeans with a plastic cover or banana leaf. Let the soybeans ferment for 24-48 hours. Place the container in a warm, dark place. The ideal temperature for tempe fermentation is around 30-32°C. **Tempe Inspection:** After fermentation, check the container to ensure that the tempe has fermented properly. Usually, tempe will be solid and white with a distinctive aroma. When the tempe is done, you can store it in the refrigerator to slow down the fermentation process further. That's how to make tempe in general. It is important to remember that factors such as temperature and cleanliness are very important in the tempe making process to produce a quality product that is safe to consume.

2.4 Research parameter

2.4.1 Organoleptic test

The organoleptic test was carried out using a preference (hedonic) test for the aroma, colour and taste of tempeh with the substitution of kapok banana which was carried out by 30 panellists. The hedonic scale has a value between 1-5 where 1: don't like it very much, 2: don't like it, 3: like it a bit, 4: like it, 5: like it a lot [3].

2.4.2 Water content

The procedure for testing the water content of the contents is as follows: The empty cup is placed in the oven for at least 2 hours, then transferred to the desiccator for 30 minutes until it reaches room temperature, and weighed (A). Next, ± 2 g of the ground sample is placed into the cup (B) and weighed again. Subsequently, the plate filled with the sample is placed

in the oven for 12 hours at a temperature of 100°C to 105°C. Following this, the plate is moved into a desiccator for approximately 30 minutes and then weighed (C) using tong [4].

$$\%\ kadar\ air\ \frac{(B-C)}{(B-A)}\ X\ 100\ \% \qquad (2)$$

Information A the weight of the empty cup, expressed in g, B weight of empty cup + initial sample, expressed in g, C weight of empty cup + dry sample in g

2.4.3 Measurement of carbohydrate levels

The procedure for carbohydrate analysis involves the following steps: First, a standard glucose solution is prepared with concentrations ranging from 0 to 90 ppm. Subsequently, 1 ml of each solution is taken and combined with 1 ml of 5% phenol solution, followed by agitation. Then, 5 ml of concentrated sulfuric acid solution is rapidly added, and the mixture is immersed in water before being allowed to stand for 10 minutes. Absorbance is measured at a wavelength of 490 nm, and a standard curve is constructed. This process is repeated by substituting the standard glucose solution with the sample to be analyzed. The treatment is conducted twice. Additionally, the same procedure is replicated for mango seed flour after sulfurization. The carbohydrate content is quantified as a percentage of glucose (%), calculated using the formula: (G/W) x 100, where G represents the concentration of glucose (in grams) and W represents the weight of the sample (in grams).

2.4.4 Fat content analysis

The fat content was analyzed using the Soxhlet Extraction method as follows: The pumpkin was dried in an oven suitable for the Soxhlet extraction apparatus. Subsequently, it was cooled in a desiccator and weighed. 2 grams of gadung mango seed flour without sulfurization were weighed, then wrapped in cotton and filter paper. The sample was inserted into the Soxhlet extraction apparatus, with the condenser installed above it and the flask positioned below. Sufficient n-hexane solvent was added to the flask. The reflux process was conducted until the solvent returned to the flask and the solution became clear. The flask was heated until the solvent boiled and evaporated into the sample wrapped in filter paper, subsequently condensing back into the flask

The solvent level in the flask decreased as the extraction proceeded. The flask containing the extracted fat was heated in an oven at 105°C, then cooled in a desiccator and weighed until a constant weight was achieved. This procedure was repeated twice, and the treatment was replicated for gadung mango seed flour with sulfurization [5]. The fat content was calculated using the following formula:

$$Kadar\ lemak\ (\%)\ \frac{Berat\ labu\ akhir\text{-}Berat\ labu\ awal\ x\ 100\%}{Berat\ sampel\ kering} \qquad (3)$$

2.4.5 Protein content analysis

Protein levels were analyzed using the micro-Kjeldahl method as follows: 0.5 grams of Gadung mango seed flour without sulfurization were weighed and placed in a digestion tube. A mixture of 1 gram of (K2SO4 and HgO) and 10 mL of concentrated H2SO4 solution was added. All ingredients in the digestion tube were heated until boiling, ensuring dissolution and clarity of the liquid. Heating was then stopped, allowing the mixture to cool. The

distillation process was carried out, followed by titration of the distillate. Titration was ceased upon the distillate turning red. A blank solution was prepared by substituting the sample with distilled water. Digestion, distillation, and titration were performed on the sample was calculated using the following formula:

$$\textit{Percentage of N content } ((ts\text{-}tb) x \text{ N HCI } x \text{ 14.008 } x \text{ 100 \% })/(\text{mg Sample}) \quad (4)$$

% Protein Content = % N x 6.25 where ts: Sample titration volume and tb: Blank titration volume [6].

3 Results and discussion

3.1 Water content

The results of the analysis of variance showed that the water content values in tempeh with the substitution of kapok banana were not significantly different for all treatments (A0, A1, A2 and A3). The results of the variance analysis of the water content values can be seen in the table below.

Table 1. Results of water content analysis of tempe with banana kapok substitute.

Sample	Average	Standar Deviation
A0	62,28[a]	0.85610
A1	63,27[a]	0.47159
A2	62,96[a]	0.43247
A3	67,28[a]	5.59590

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

Water as a result of metabolism greatly influences other components including the growth of mold as a microorganism that plays a role in tempeh fermentation. Based on table 1. The water content value of tempeh with kapok banana substitution ranges from 62.28% -67.28%. The lowest percentage of water content value was in treatment A0 with a value of 62.28%, while the highest percentage of water content was in treatment A3 67.28%. The water content of tempeh is influenced by the concentration of kapok bananas. Kapok bananas can increase the water content of the tempeh produced because Kepok bananas contain more water than soybeans. According to data from which states that raw Kepok bananas contain 71.9 grams per 100 grams of banana, while the water contained in soybeans is 20 grams per 100 grams of soybeans.

3.2 Carbohydrate levels

The results of the analysis of variance showed that the carbohydrate content values in tempeh with the substitution of kepok banana were very significantly different for all treatments (A0, A1, A2 and A3). The results of the variance analysis of carbohydrate content values can be seen in the table below.

Table 2. Results of analysis of tempeh carbohydrate content with banana kepok substitution.

Sample	Average	Standar Deviation
A0	4,81[a]	0.10817
A1	7,09[b]	0.20984

A2	10,25[c]	0.94002
A3	13,93[d]	0.78704

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

Carbohydrates are the main source of calories and several groups of carbohydrates produce fibre which is useful for digestion, and has an important role in determining the characteristics of food ingredients such as taste, colour, texture and others. Apart from acting as the main energy source, carbohydrates also play a role in preventing excessive breakdown of body protein, and loss of minerals and helping in the metabolism of fats and minerals.

Based on Table 2 the carbohydrate value of tempeh with the substitution of kepok banana ranges from 4.81% -13.93%. The lowest percentage of carbohydrate content values was in treatment A0, while the highest percentage was in treatment A3 (13,93[d])

It can be seen that the higher the concentration of kapok banana added, the higher the carbohydrate content produced. Referring to [7], raw Kepok bananas contain 26.3 grams/100 grams of carbohydrates.

3.3 Fat level

The results of the analysis of variance showed that the fat content values in tempeh with the substitution of kapok banana were very significantly different. The treatment of A0 is very different from A1, A2 and A3.The treatment ofA1 is very different from A0, A2 and A3. The treatment of A2 is very different from A0, A1 and A3. The treatment of A3 is very different from A0, A1 and A2. The results of the variance analysis of the fat content values can be seen in the table below.

Table 3. Results of analysis of tempeh fat content with substitution of banana kapok.

Sample	Average	Standar Deviation
A0	10,47[a]	0.22008
A1	9,70[b]	0.62172
A2	8,17[c]	0.10017
A3	7,02[d]	0.09539

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

Fat is a source of energy for the body which can provide greater energy value than carbohydrates, namely 9 kcal per gram. Fats are obtained from animal and vegetable foods, including cooking oil, butter and margarine. Fat functions as a source of flavour and provides a soft texture to the product.

Based on Table 3,the fat content value of tempeh with the substitution of kepok banana ranges from 7.02% -10.47%. The lowest percentage of fat content values was in treatment A3, while the highest fat content values were in treatment A0.

It can be seen that the fat content of tempeh substitute for kepok banana decreases as the concentration of kepok banana increases. This is because the fat content in Kepok bananas is low, while soybeans contain higher fat. Referring to [8] states that raw Kepok bananas contain as much fat as 0.5 grams per 100 grams, while the fat content in soybeans is 15.6 grams per 100 grams.

3.4 Protein content

The results of the analysis of variance showed that the fat content values in tempeh with the substitution of kapok banana were very significantly different. The treatment of A0 is very different from A1, A2 and A3. The treatment of A1 is very different from A0, A2 and A3. The treatment of A2 is very different from A0, A1 and A3. The treatment of A3 is very different from A0, A1 and A2. The results of the variance analysis of the fat content values can be seen in the table below.

Table 4. Results of analysis of tempeh protein content with banana kapok substitution.

Sample	Average	Standar Deviation
A0	18,98[a]	0.43662
A1	16,57[b]	0.11590
A2	15,55[c]	0.35921
A3	11,48[d]	0.15044

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

Based on tempeh quality requirements according to SNI 01-3144-2009, the protein content parameter in tempeh is a minimum of 16%. From the treatment, those that meet tempeh quality standards are the A0 and A1 treatments. The protein content in food varies, both in quantity and type. Animal foods, legumes and cereals generally contain high levels of protein. Protein is the main source of nutrition, protein also provides important functional properties in forming the characteristics of food ingredients [8].

Based on Table 4, the protein content value of tempeh with the substitution of kapok banana ranges between 11.48% - 18.98%. The highest percentage of protein content values was in treatment A0 (18,98[a]), while the lowest percentage of protein content values was in treatment A3 (11,48[d]).

The effect of tempeh concentration on protein content is that the more soybean concentration is used, the more tempeh protein content increases. Meanwhile, the more concentration of Kepok bananas is used, the protein content will decrease. This happens because the protein content in soybeans is greater than the protein content in Kepok bananas. According to [8], raw Kepok bananas contain 0.8 grams per 100 grams of banana, while soybeans contain 30.2 grams per 100 grams of soybeans.

3.5 Organoleptic test

3.5.1 Colour

The results of the analysis of variance showed that the organoleptic test results for the colour of tempeh with the substitute kepok banana were significantly different. The treatment of A0 is significantly different from A1, A2 and A3. The treatment of A1 is significantly different from A0, A1 A2 and A3. The treatment of A2 is significantly different from A0, A1 and A3. The treatment of A3 is significantly different from A0, A1 and A2. The results of the colour variance analysis can be seen in the table below.

Table 5. Organoleptic test results for color in tempeh substituted with banana kapok.

Sample	Average
A0	4,35[a]
A1	3,33[b]
A2	3,02[b]

A3	3,11[b]

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

The results showed that on average the panelists liked the color of tempeh with the substitution of kepok banana in treatment A0. The tempeh produced is white. The formation of this white colour is influenced by the fact that the mycelial strands in tempeh are so dense that they appear white. During the fermentation process, beans will experience physical changes such as an increase in the number of mold mycelia covering the beans. This mycelia is white and becomes flatter and more compact over time so that it binds one nut to another into a single unit called mycelia. Good tempeh has a compact shape that is bound by mycelia so that it looks white and when sliced the soybeans look yellow [8].

3.5.2 Flavour

The results of the analysis of variance showed that the organoleptic test results for the taste of tempeh with the substitution of kepok banana were significantly different. The treatment of A0 is significantly different from A1, A2 and A3. The treatment of A1 is significantly different from A0, A1 A2 and A3. The treatment of A2 is significantly different from A0, A1 and A3. The treatment of A3 is significantly different from A0, A1 and A2. The results of the colour variance analysis can be seen in the table below.

Table 6. Organoleptic test results on the taste of tempe with banana kepok substitution.

Sample	Average
A0	4,17[a]
A1	3,46[b]
A2	3,52[b]
A3	3,57[b]

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

In this study, panellists liked the taste of treatment A0. The distinctive taste of tempeh is caused by the degradation of the components in tempeh during the fermentation process. Factors that influence taste are chemical compounds, temperature, concentration and interactions with other taste components. The sensitivity of the papilla in tasting can be influenced by several factors, including age, spicy eating habits and food temperatures that are too cold or hot [9].

3.5.3 Texture

The results of the analysis of variance showed that the organoleptic test results for the texture of tempeh with the substitute kepok banana were significantly different. The treatment of A0 is significantly different from A1, A2 and A3. Treatment A1 is not significantly different from A2 but is significantly different from A0 and A3. Treatment A2 is not significantly different from but is significantly different from A0 and A3. The treatment of A3 is significantly different from A0, A1 and A2. The results of the colour variance analysis can be seen in the table below.

Table 7. Organoleptic test results on the texture of tempe with banana kepok substitution.

Sample	Average
A0	4,06[a]
A1	3,46[b]

A2	3,40[b]
A3	3,06[c]

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

The results of research on tempeh with the substitution of kepok banana showed that on average the panelists liked the texture of the A0 treatment. The texture of tempeh is influenced by the number of mould mycelia during fermentation. The mould mycelia are able to penetrate the surface of the soybeans so they can use the nutrients in the soybean seeds so that the nutritional value of tempeh is better than soybeans. Another physical change is an increase in the number of mould mycelia that cover the soybeans one by one to become one unit [10].

3.5.4 Aroma

The results of the analysis of variance showed that the organoleptic test results for the aroma of tempeh with the substitution of kapok banana were very significantly different. The treatment of A0 is significantly different from A1, A2 and A3. Treatment A1 is not significantly different from A0, A1 A2 and A3. Treatment A2 is not significantly different from A3 but is significantly different from A0 and A1. The treatment of A3 is not significantly different from A2 but is significantly different from A0 and A1. The results of the colour variance analysis can be seen in the table below.

Table 8. Organoleptic test results on the aroma of tempe with banana kepok substitution.

Sample	Average
A0	4,20[a]
A1	3,44[b]
A2	3,11[c]
A3	2,93[c]

Note: The same letter notation indicates there is no difference in treatment based on the DUNCAN advanced test at 5% level

This research shows that on average the panelists liked tempeh in treatment A0. The aroma of tempeh comes from the aroma of mould mycelia mixed with the delicious aroma of free amino acids and the aroma produced by the breakdown of fat. The longer the fermentation takes, the soft aroma turns sharp due to the release of ammonia [13].

4 Conclusion

The conclusion obtained in this research is that the addition of kapok banana substitutes in making tempeh has a very real influence on the carbohydrate and protein content. In the organoleptic test, panellists preferred tempeh without the addition of kapok banana substitute.

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