Quality Study of Sweet Corn Extract Yoghurt (*Zea mays saccharata sturt*) with Red Bean Extract (*Phaseolus vulgaris*) Substitution

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Abstract. Sweet corn yoghurt with red bean substitution is a functional food product made from plant-based ingredients. In addition to containing probiotics, this yogurt also contains other nutrients that have health benefits for the body, such as fighting cancer cells, maintaining the digestive system, and strengthening the body's immune system. This study aims to determine the effect of the red bean substitution ratio on chemical properties (lactic acid, protein, fat, ash, acidity), physical properties (viscosity), and hedonic aroma, color, texture, and taste. This study is an experimental study with a Completely Randomized Design (CRD) with different substitution ratio variations, namely 10%, 20%, and 30%. The data that had been obtained was then analyzed statistically with the one-way ANOVA test and continued with the DMRT test. The results showed that 30% substitution resulted in the highest content of lactic acid (2.070%), protein (4,360%), fat (1.743%), ash (0,573%), and pH (4,06). It was concluded that the yoghurt substituted with 30% red beans produced a product that had better quality than the other two formulations because it had the highest nutritional content compared to the others.

Keywords: yoghurt, sweet corn, red beans, functional food, fermentation of lactic acid bacteria

1. Introduction

The immune system, according to [1], is the body's defense reaction to avoid infection from toxins' effects and other virulent factors that are antigenic. One of the critical things that must be done is to consume nutritious foods that can strengthen the body's immune system. According to [2], lactobacilli present in probiotic foods can stimulate macrophage activity against antigens that enter the body. Probiotics are live microorganisms (lactic acid bacteria, or LAB), which, when consumed in certain amounts, can have a positive effect on body health. One of the most well-known probiotics is yogurt. According to [3], probiotics such as *Lactobacillus spp*. and several other bacteria can be immunostimulants that function to stimulate the immune system. According to [4], the benefits of probiotics in yogurt, in addition to fighting cancer cells, can also reduce cholesterol levels..

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Yoghurt is a dairy product that contains probiotics due to the addition of lactic acid bacteria (LAB) such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus* then through a fermentation process. According to [5] fermentation in yoghurt production involves *Lactobacillus bulgaricus* and *Streptococcus thermophilus* which utilize each other's metabolic products to produce lactic acid. Both bacteria utilize the free amino acids present in milk/cider for bacterial growth and carry out their activities in producing lactic acid.

Yogurt is generally made from fresh cow's milk. However, knowledge has also improved; yoghurt can be made from vegetable juices such as nuts, cereals, and tubers. According to [6], although vegetable juices do not contain lactose as in cow's milk, they contain other carbohydrates that can be used by LAB as an energy source. According to [7], red beans contain oligosaccharides of glucose in the form of raffinose and stakiose. Oligosaccharides have the potential to be prebiotics, namely food components that can stimulate the activity and growth of probiotics. In addition, other components used to make yogurt, such as sweet corn, contain high levels of glucose from the fructose and sucrose groups; the glucose content can also be utilized by the bacteria *Lactobacillus bulgaricus* and *Streptococcus thermophilus* to produce lactic acid [8]. This content is expected to be used as a carbon source for lactic acid bacteria to produce the lactic acid contained in yogurt.

Corn is a food that is well known in Indonesia, it occupies the second position after rice as a staple food source of carbohydrates. Sweet corn is one of the types favored by the public because of its better texture and taste than ordinary varieties of corn [9]. In addition, sweet corn also does not contain fiber that is not too tough so it has a more comfortable texture when chewed. This causes sweet corn to be superior to ordinary corn [10]. According to [11] sweet corn per 100 g contains 22.8 g carbohydrates, 3.5 g protein, 1.0 g fat, 3.0 mg calcium, 111 mg phosphorus, 400 SI vitamin A. The high glucose and fructose levels can be utilized by the body. LAB as a substrate to produce lactic acid [8]. Red beans are also a food that has good nutritional content, namely per 100 grams of red beans containing 22.1 grams of protein, 1.1 grams of fat, 56.2 grams of carbohydrates, 502 mg of calcium, 429 mg of phosphorus, 10.3 mg of substances. iron, 0.4 mg of vitamin B1, and also dietary fiber [12]. Carbohydrates contained in red beans are an oligosaccharide group in the form of raffinose and stakiose [7]. These oligosaccharides are used by LAB for the growth and maintenance of cells and the formation of products.

Yoghurt generally has good chemical properties including lactic acid content, protein content, fat content, ash content, and pH in accordance with the yoghurt quality standard SNI 2981-2009. In addition, good yoghurt also has the right consistency, which is not too runny and not too thick. As a functional food product, it must also be accepted by the community organoleptically, so it is also necessary to do a hedonic preference test to determine the level of people's preference for sweet corn yoghurt products with red bean substitution.

2. Materials and Methods

2.1 Materials

This plant-based yoghurt is made from sweet corn, kidney beans, yoghurt culture, sugar, and skim milk. Making yoghurt using a modified Illinois method which includes making vegetable juices, mixing the two types of vegetable juices, pasteurization, cooling, inoculation, and incubation.

Table 1. Sweet Corn Yoghurt Formula with Red Bean Substitution

No.	Name of Ingredients	Formula A1	Formula A2	Formula A3
1.	Sweet corn extract	450 gr	400 gr	350 gr
2.	Red bean extract	50 gr	10 gr	150 gr
3.	LAB (yoghurt culture) (5 %)	25 gr	25 gr	25 gr
4.	Milk skim (5%)	25 gr	25 gr	25 gr
5.	Sugar (5%)	25 gr	25 gr	25 gr

2.2 Methods

Yoghurt Making Procedure

Production uses a modified Illinois method which includes making vegetable juice, mixing the two types of vegetable juice, pasteurization, cooling, inoculation, and incubation.

1) Stages of making sweet corn juice The making of sweet

Corn juice refers to the research conducted [17] such us by doing several stages, starting from cleaning the skin and corn hair, blanching for 15 minutes, shelling the cobs, then crushing using a blender with additional water in a ratio of 1:2 (ingredient:water), and the last is filtering to separate the sweetcorn juice and the pulp.

2) Stages of making red bean juice

The stages of making red beans are not much different from making sweet corn, but making red bean juice needs to be soaked first to facilitate the crushing process [13]. Red bean juice is made by soaking dried red beans for one night or 8 hours, then followed by the boiling process in boiling water for 15 minutes, the next is the process of crushing red beans with boiled water in a ratio of 1:2 (material:water), and the last is filtering to separate the red bean juice and red bean pulp.

3) Vegetable juice blending and pasteurization

This step is carried out according to the formulation of red bean juice substitution in sweet corn juice yoghurt that has been made by researchers, namely A1 substitution of 10%, A2 substitution of 20%, and A3 substitution of 30%. After that, it was continued with the pasteurization process, namely boiling at 70°C for 2 minutes with the aim of killing pathogenic bacteria found in vegetable juices. Then the next step is to leave the vegetable juice at room temperature until the vegetable juice temperature reaches 45°C.

4) Inoculation

Inoculation is the stage of mixing all the main ingredients and additives for making yoghurt. These ingredients include vegetable juices, Greek yoghurt as a yoghurt culture containing LAB (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*), skim milk, and sugar.

5) Incubation

Incubation is a fermentation process, this process is carried out using an incubator that has been set at 45°C for 8 hours.

Analysis Method

Research conducted on sweet corn juice yoghurt with red bean juice substitution is a research experiment. The independent variable in this study was the ratio of different combinations of vegetable juices between sweet corn extract and red bean juice in the manufacture of vegetable yoghurt, namely 90%:10%, 80%:20%, and 70%:30% (sweet corn:red beans). The dependent variables in this study were lactic acid content, protein content, fat content, total carbohydrate content, ash content, acidity degree, and viscosity. The research design used was a Completely Randomized Design (CRD) with two repetitions in each formula. The data were analyzed statistically using the ANOVA (Analysis of Variance) test. A one-way ANOVA is used to test the real difference between the variances in each sample. If there is a difference from the analysis results (p 0.05 because = 0.05), then proceed with the DMRT (Duncan's Multiple Range Test) further test with the aim of knowing the significance of the difference between each treatment.

3. Results and Discussion

The results of statistical analysis on yogurt made from a combination of sweet corn and red beans can be seen in Table 3.1

Table 2. Data analysis of sweet corn and red bean yogurt

Formula	Lactic Acid(%)	Protein(%)	Fat(%)	Ash (%)	Degree Acidity (pH)
A1	1.889	3.489	1.519	0.374	4.30
A2	1.978	3.925	1.620	0.473	4.29
A3	2.070	4.360	1.743	0.573	4.06

1. Lactic Acid

Based on the data obtained, formulas A1, A2 and A3 have different levels of lactic acid. The highest lactic acid content was obtained from sample A3 with a substitution formulation of 30% red beans with a value of 2.070%. While the lowest levels of lactic acid were obtained from sample A1 with a substitution formulation of 10% red beans with a value of 1.889%. The data was continued for ANOVA analysis and resulted in a significance value of $0.000<\alpha=0.05$, which means that there are differences in lactic acid levels in each red bean substitution treatment. The data was continued with the DMRT test to determine the significance of the difference. Based on the results of the DMRT test, each formulation was significantly different from one another.

Lactic acid levels are influenced by the starter and also the ingredients used. Carbohydrates and protein in the material will affect the activity of LAB in producing lactic acid. Lactic acid

is the result of the metabolic activity of the bacteria *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. According to [13], the oligosaccharides in red beans in the form of raffinose and stachyose will be used by LAB for cell growth and maintenance and product formation. The raffinose and stakiose will be hydrolyzed into glucose, fructose and galactose. The glucose is then broken down by LAB to become lactic acid. This is what underlies red bean juice that can be used to replace cow's milk in making yoghurt [14]. Therefore, the higher the number of red beans substituted in the formula will produce higher lactic acid because its addition can optimize LAB activity in producing lactic acid.

2. Protein

The highest protein content was obtained from sample A3 with a substitution formulation of 30% red beans with a value of 4.360%. While the lowest protein content was obtained from sample A1 with a substitution formulation of 10% red beans with a value of 3.489%. Then the data continued to be analyzed using One Way ANOVA. The data obtained that the significance value is $0.000<\alpha=0.05$. This shows that there are differences in protein levels between each red bean substitution treatment, further analysis was carried out with DMRT. Based on the results of the DMRT test, each formulation was significantly different from one another.

Protein is the total amount of protein content in the ingredients and starters used. Protein in the ingredients in addition to affecting the final protein content in yoghurt products, will also affect the texture formed in yoghurt. according to research [13] the protein in the material will change shape due to LAB activity which creates acidic conditions at pH 4-4.6 so that the protein becomes unstable and coagulates, which is separated between 'curd' and 'whey'. The data obtained have shown that the higher the substituted red beans, the higher the protein produced, this is because the protein content in red beans is higher (21-27%) compared to sweet corn (4.1%) so that along with the addition of red beans will also increase the protein content in yoghurt.

3. Fat

The highest fat content was obtained from sample A3 with a substitution formulation of 30% red beans with a value of 1.743%. While the lowest fat content was obtained from sample A1 with a substitution formulation of 10% red beans with a value of 1,519%. Then the data continued to be analyzed using One Way ANOVA. seen that the significance value is $0.000<\alpha=0.05$. This shows that there is a difference in fat content between each red bean substitution treatment, then the analysis is carried out with the DMRT further test. DMRT test showed that there were significant differences in fat content in the three treatments.

[15] states that the fat content is influenced by the raw material itself, the higher the fat content in the raw material, the higher the fat content in the yoghurt produced. In the data, the fat content in yoghurt is getting higher along with the addition of red beans which are substituted for making yoghurt. The addition of red bean substitution resulted in an increase in fat content in yoghurt, and vice versa. This is due to the difference in fat content in red beans and sweet corn, red beans have a higher fat content (1.5gr) than sweet corn (1.0gr). The increase in fat content can also be caused by changes in amylose in starch to maltose and a small amount of glucose, the remaining glucose will be converted into fat [16]. So that the use of ingredients that are high in carbohydrates will also increase the fat content in yoghurt. The

results of the analysis showed that the amount of red beans substituted affected the fat content because the fat content of red beans was higher than that of sweet corn.

4. Ash

The highest ash content was obtained from sample A3 with a substitution formulation of 30% red beans with a value of 0.573%. While the lowest ash content was obtained from sample A1 with a substitution formulation of 10% red beans with a value of 0.374%. Then the data continued to be analyzed using One Way ANOVA. According to the ANOVA test, it can be seen that the significance value is $0.000<\alpha=0.05$. This shows that there is a difference in ash content between each red bean substitution treatment, then the analysis is carried out with the DMRT further test. The results of DMRT analysis showed that there were significant differences in ash content in the three treatments.

According to [15], the ash content proves how many minerals are contained in the yoghurt produced. [14] explains that the high or low ash content in yoghurt is influenced by the high or low mineral content in the raw materials used, the higher the minerals in the raw materials, the higher the ash content in yoghurt. According to SNI 2981-2009, the maximum ash content in yoghurt products is 1.0%. The resulting data shows that the fat content increases with the increase in the number of nuts which are substituted for making yoghurt. This is because the ash content in red beans is higher than the ash content in sweet corn. The ash content in the three existing formulas is also still within reasonable limits or in accordance with the quality requirements of yoghurt according to SNI 2981-2009, which is <1.0%.

5. Degree Acidity (pH)

The lowest pH (acid) was obtained from sample A3 with a 30% red bean substitution formulation with a value of 4.06. Meanwhile, the highest pH was obtained from sample A1 with a 10% red bean substitution formulation with a value of 4.30. Then the data continued to be analyzed using One Way ANOVA. In the ANOVA analysis, it can be seen that the significance value is $0.000<\alpha=0.05$. This shows that there is a difference in the degree of acidity between each red bean substitution treatment, then the analysis is carried out with the DMRT further test. The results of Duncan's DMRT test showed that there was a significant difference in the degree of acidity of the A3 formula. Formula A3 (30%) significantly different in acidity with formula A1 (10%) and A2 (20%). However, the degree of acidity of formula A1 (10%) and formula A2 (20%) was not significantly different.

The quality requirement for yoghurt is that it must have a pH between 4-4.5. The lower the pH, the more acidic the yoghurt is. The degree of acidity is directly proportional to lactic acid. The higher the level of lactic acid, the more acidic the pH of the yoghurt. In the data obtained, it is known that the most acidic pH is produced by the A3 formulation, with the highest substitution of red bean, which is 30%. This shows that red beans affect the fermentation process because their higher carbohydrate and protein content than sweet corn can support LAB to create an acidic atmosphere (low pH) in yoghurt.

4. Conclusions

Based on the data analysis in this study, it is known that there is a significant difference in the effect of the red bean substitution ratio in sweet corn yoghurt. The higher the number of red beans substituted, the lactic acid content, protein content, fat content, and ash content will also be higher. However, in the A2 and A3 pH tests there was no significant difference between the two formulations, but significantly different from A1. The three formulations met the quality requirements of yoghurt, but A3 had more lactic acid and protein content than the other two formulations, so it can be concluded that the A3 formulation was the best treatment in this study.

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