Study on Yoghurt Powder Probiotic Quality using Foam-Mat Drying Method

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Abstract. Yoghurt powder probiotic has been produced by fermentation of milk using yoghurt cultures, Streptococcus thermophilus ENCC 0040, Lactobacillus bulgaricus ENCC 0041, Lactobacillus casei FNCC 0090 and Bifidobacterium longum ATCC 15707. The aim of this research was to determine the concentration and type of foam material to produce the best quality of yoghurt powder. Two types of foaming agents were used at different concentration as egg albumin 15%, 20%, 25% and tween 80 for 0.75%, 1.25%, 1.75%. The yoghurt foam was dried at 50°C for 3 h in cabinet dryer. The results showed that characteristic of yoghurt powder probiotic using 20% egg albumin meets the standard of the SNI (2981:2009) requirements as it was characterized by physicochemical and microbiologically. Moisture content 6,29%; ash content 4,82%; fat content 15,29%; protein content 26,47%; phosphor (P) content 634,15 ppm; and calcium (Ca) content 5121,71 ppm; acidity (lactic acid) 1,57%; lactic acid bacteria (LAB) count 1.8x10¹⁰ CFU/g; and yield 19.05%.

1. Introduction
Powdered yoghurt made from dried liquid yoghurt. Yohurt is one of dairy products that have soft textured and semi-solid. It is produced from a fermentation process using lactic acid bacteria i.e. Streptococcus thermophilus, Lactobacillus bulgaricus, Lactobacillus casei and Bifidobacterium longum which are then dried. Yoghurt powder has long shelf life, expand storage temperature range and simplify the distribution process. Low moisture content of yoghurt powder could prevent contamination from other microbes.

Yoghurt is sensitive to heat, therefore it needs the proper processing method to obtain yoghurt powder. One drying method that can be done for producing yoghurt powder is by foam-mat drying method. This method is drying liquid form material that was previously made into foam first by adding a foaming agent. The addition of the foaming agent functions to speed up drying, and reduce moisture content [1]. According to [2] in the presence of foam, it will accelerate the process of evaporation of water even without too high temperature. Products dried using foaming agents at a temperature of 50-80 °C and can produce a product with 2-3% moisture content. The resulting powder from the foam mat drying method has a low density (density) and is crumbly.

Increasing foam concentration will increase the surface area and give a porous structure to the material. So, it will increase the drying speed. The coating on drying foam will dry faster than without foam in the same conditions [3]. According to [4] foods that dried by the foammat drying method have...
structures that easily absorb water, so that the food is easy to dissolve in cold water. This method relatively simple and cheaper compared to other drying methods such as spray drying and freeze drying. The success of foammat drying techniques depends on the speed of drying that can be done by setting the temperature and concentration of filler material. The research aimed to determine the concentration and type of foam material to produce the best quality of yoghurt powder.

2. Materials and methods
Material used was cow's milk, yoghurt starter from bacteria *Streptococcus thermophilus* ENCC 0040, *Lactobacillus bulgaricus* ENCC 0041, *Lactobacillus casei* FNCC 0090, *Bifidobacterium longum* ATCC 15707, Carboxy Methyl Cellulose (CMC), egg white, tween 80, maltodextrin, sugar, milk skim (Sunlac), *deMann Rogosa Sharpe Agar* (MRSA).

2.1 Liquid yoghurt processing
The composition of liquid yoghurt processing includes fresh cow's milk added with 5% skim milk, 5% sugar and CMC (Carboxy Methyl Cellulose) 0.03%. This composition then pasteurized at a temperature of 85-90 °C for 15-30 minutes, and cooled to 37-40 °C. After that inoculated with 2-3% starter and incubated at 37 °C for 18 hours [5].

2.2 Yoghurt powder processing
Egg white and tween 80 were added into liquid yoghurt. The egg white concentration treatment used were 15%, 20%, 25% and maltodextrin 0.5% was added at each concentration. While the tween 80 concentration treatment used were 0.75%, 1.25%, 1.75% and added with maltodextrin 20% at each concentration. Then, mixed using a mixer at high speed for ± 7 minutes.

The foamed yoghurt was then poured into a baking pan, spread using a spatula throughout the surface, and dried using a cabinet drying at 50°C for 3 hours. Dry yoghurt then cooled and crushed using a blender until it becomes yoghurt powder.

2.3 Characterisation of yoghurt powder
Analysis of yoghurt powder produced included color test using hunter method [6], yield [7], water content [7], ash content [7], fat content [7], protein content [7], calcium [8], phosphorus [8], analysis of lactic acid [5], Lactic Acid Bacteria (BAL), Total Plate Count (TPC) [5].

2.4 Research Design
The research design used was Completely Randomized Design (CRD) with two factors. The first factor was the type of foaming material (egg white and tween 80). The second factor was a concentration of foaming material (egg white 15%, 20%, 25% and tween 80 0.75%, 1.25%, 1.75%) with three replications and every replication was done twice.

3. Result and discussions

3.1 Physical characteristics of yoghurt powder

3.1.1 Colour test
Colour is a visual indicator of the main quality of food and beverage products. Based on the results analysis of the colour test (Table 1) showed that the average values of hue P1, P2, P3 and T1, T2, T3 are significantly different from C. But physically produced the same colour, that was yellow. The yellow colour of yoghurt was caused by the colour of casein and carotene in cow's milk which was used as the basic ingredient in yoghurt processing. The difference between the hue value of the powdered yoghurt formula was because of egg white foam was not transparent and able to covered the original colour of yoghurt (yellowish white).
Table 1. Colour value of yoghurt powder

| Hue   | Colour  |
|-------|---------|
| C     | 97.48c  |
| P1    | 99.71ab |
| P2    | 100.10ab|
| P3    | 100.30a |
| T1    | 99.40ab |
| T2    | 99.10b  |
| T3    | 99.01b  |

The value followed by the same letter showed no significant difference based on Duncan's test at the level of 5%.

C = without addition of foaming agents (control)
P1 = 15% egg white + 0.5% maltodextrin
P2 = 20% egg white + 0.5% maltodextrin
P3 = 25% egg white + 0.5% maltodextrin
T1 = 0.75% tween 80 + 20% maltodextrin
T2 = 1.25% tween 80 + 20% maltodextrin
T3 = 1.75% tween 80 + 20% maltodextrin

According to [9], when egg whites were shaken, air bubbles will join and gradually become smaller and change colour from translucent greenish yellow to invisibility. Occurrence of maillard reaction by amino acids from egg white and milk with reducing sugars can affect the brightness and yellowish level of yoghurt powder [10]. While the addition of maltodextrin at low concentration does not affect the colour of the powdered yoghurt therefore, that the colour of powdered yoghurt remains yellow. The addition maltodextrin at a higher concentration increased the brightness of the yoghurt powder. That was allegedly due to the colour of maltodextrin was white.

3.1.2 Yield of yoghurt powder

The yield was used to determine the economic value of a product. The results analysis in Table 2 showed that the T samples obtained high yield due to the addition of maltodextrin as much as 20%, while the addition of maltodextrin at treatment P was only 0.5%, so that the resulting yield was lower. According to [11], increasing of yield was influenced by a large number of maltodextrins added. The addition of maltodextrin caused total solids and yield increased.

Table 2. The yield of yoghurt powder

|       | Yield (%)         |
|-------|-------------------|
| C     | 19.35±0.88        |
| P1    | 19.74±2.05        |
| P2    | 19.05±2.06        |
| P3    | 19.02±1.97        |
| T1    | 30.62±0.67        |
| T2    | 31.50±1.54        |
| T3    | 31.24±1.02        |

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P3 = 25% egg white + 0.5% maltodextrin
T1 = 0.75% tween 80 + 20% maltodextrin
T2 = 1.25% tween 80 + 20% maltodextrin
T3 = 1.75% tween 80 + 20% maltodextrin
The difference addition of maltodextrin concentration was used at P and T treatment due to egg white foam (T treatment) can protect microbes from heating so that the addition of maltodextrin concentration is not too high. While the use of tween 80 (P treatment) as a surfactant and foaming agent cannot protect microbes from heating, thus requiring more concentration of maltodextrin. Maltodextrin was used in the encapsulation process, to protect oxidative and heat-sensitive compounds and protect flavour stability during drying process [12].

3.2 Chemical characteristics of yoghurt powder

The results of chemical analysis were presented in Table 3. The results showed that the addition of 20% egg white foaming agent (P2) produced the lowest moisture content of 6.29 ± 0.10%. It was supposed that more egg white foam added, obtained the material more porous and the water will more easily be evaporated. But in P3 there was slightly an increase in water content of 6.73 ± 0.05%. In accordance with [13], it was suspected that most of the egg white contains protein and water, so the higher concentration of egg white will cause higher water content in yoghurt powder. The highest water content of 7.35 ± 0.16% was found in the T3 sample, it can be said that there was an interaction between tween 80 and maltodextrin. In inappropriate dose addition ratio of tween 80 and maltodextrin, it will cause hardening on the material surface (case hardening), which can interfere with the evaporation of free water which was still present in the material, and causes more a lot of free water left in the material [14].

The low ash content in sample T compared to P sample were because tween 80 did not contain minerals so that the resulting ash content was relatively low. Whereas in the P sample there was an additional mineral from egg white so that resulting ash content becomes higher. According to [15], some of the minerals contained in eggs include iron, phosphorus, and calcium.

Table 3. Chemical characteristics of yoghurt powder

| Sample | Water content (%) | Ash content (%) | Lactic acid content (%) | Lipid content (%) | Protein content (%) |
|--------|------------------|----------------|-------------------------|------------------|--------------------|
| C      | 6.65±0.12        | 4.88±0.09      | 2.29±0.14               | 16.54±0.34       | 19.93±0.33         |
| P1     | 6.71±0.06        | 4.77±0.04      | 1.74±0.07               | 15.64±0.25       | 23.92±0.39         |
| P2     | 6.29±0.10        | 4.82±0.03      | 1.57±0.14               | 15.29±0.10       | 26.47±0.42         |
| P3     | 6.73±0.05        | 4.86±0.05      | 1.61±0.04               | 14.11±0.20       | 27.38±0.44         |
| T1     | 6.67±0.11        | 2.40±0.06      | 1.29±0.12               | 9.32±0.19        | 10.43±0.39         |
| T2     | 6.50±0.02        | 2.37±0.03      | 1.02±0.12               | 9.20±0.08        | 10.34±0.59         |
| T3     | 7.35±0.16        | 2.39±0.13      | 1.19±0.07               | 8.81±0.02        | 10.17±0.29         |

The value followed by the same letter showed no significant difference based on Duncan’s test at the level of 5%.

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P2 = 20% egg white + 0.5% maltodextrin
P3 = 25% egg white + 0.5% maltodextrin
T1 = 0.75% tween 80 + 20% maltodextrin
T2 = 1.25% tween 80 + 20% maltodextrin
T3 = 1.75% tween 80 + 20% maltodextrin

Lactic acid content in P and T samples met the requirements of acidity level (lactic acid) in yoghurt, according to SNI 2891:2009 [16] ranging from 0.5-2.0%. Decreasing acidity in P and T samples was suspected due to the addition of maltodextrin. The carbohydrate content in maltodextrin serves as a carbon source for lactic acid bacteria in the fermentation process. Therefore, the formation of organic acids, particularly lactic acid, from the breakdown of carbohydrates by bacteria was also high.
Based on the results of the analysis showed that the addition of the foaming agent and maltodextrin reduced the fat content compared to the control 4.88 ± 0.09%. From the results of the fat content analysis, it was known that there was a decrease in fat content in the probiotic yoghurt powder produced. In accordance with [17] that protein content in yoghurt powder probiotic will be inversely proportional to fat content. The decrease in fat content in yoghurt powder can also be caused by the addition of hydrocolloid ingredients so that it will reduce the proportion of initial fat content.

The highest protein content was found in the addition of egg whites 25% (P3), that is 27.38 ± 0.44%. Egg white contains 10.8 grams of protein [15], so that higher concentration of egg white addition will increase protein content of yoghurt powder. While in the T1, T2, and T3 samples there was a decrease in protein levels because tween 80 did not contain nutritional value so the protein content was relatively low.

Results analysis of phosphorus (P) and calcium (Ca) levels were presented in Table 4. The highest phosphorus levels were found in P2 634.15^b±90.85% but relatively not significantly different with other treatments. It was known that cow's milk had a high phosphorus content of 694 mg/100 g [18], that may caused phosphor content high enough in the yoghurt powder.

The high level of calcium (Ca) in P2 samples (5121.71^a±489.98%) and not significantly different among P treatments, but different with T treatments. The addition of egg white foaming ingredients which contain calcium of 6 mg [15] could be increase Ca content in yoghurt powder. Whereas the addition of tween 80 that has no nutritional content, so the calcium content were low in T treatments.

|       | Phosphorus (%) | Calcium (%) |
|-------|----------------|-------------|
| C     | 902.58^a±138.10| 5439.02^a±199.95 |
| P1    | 622.58^b±71.47 | 5049.21^a±599.06 |
| P2    | 634.15^b±90.85 | 5121.71^a±489.98 |
| P3    | 467.52^c±64.16 | 5084.48^a±432.24 |
| T1    | 360.69^b±20.03 | 3233.55^b±20.03 |
| T2    | 368.46^b±60.02 | 3377.05^b±60.02 |
| T3    | 304.36^b±44.40 | 2904.15^b±44.40 |

The value followed by the same letter showed no significant difference based on Duncan's test at the level of 5%.  
C = without addition of foaming agents (control)  
P1 = 15% egg white + 0.5% maltodextrin  
P2 = 20% egg white + 0.5% maltodextrin  
P3 = 25% egg white + 0.5% maltodextrin  
T1 = 0.75% tween 80 + 20% maltodextrin  
T2 = 1.25% tween 80 + 20% maltodextrin  
T3 = 1.75% tween 80 + 20% maltodextrin

3.3 Total lactic acid bacteria
According to SNI yoghurt [16], yoghurt must has a minimum starter bacteria content of 10^7 CFU / ml. Table 5 presented the results of microbiological analysis of yoghurt powder. From the table showed the viability of lactic acid bacteria found in yoghurt powder and after rehydration of yoghurt powder.
Table 5. Viability of lactic acid bacteria (LAB)

|                  | Yoghurt powder (CFU/g) | Yoghurt after rehydration (CFU/ml) |
|------------------|------------------------|-----------------------------------|
| C                | 5.0x10^8c              | 3.7x10^12d                        |
| P1               | 1.5x10^9b              | 6.4x10^12c                        |
| P2               | 1.8x10^10a             | 9.4x10^12a                        |
| P3               | 1.6x10^10a             | 8.0x10^12b                        |
| T1               | 6.5x10^5d              | 7.0x10^11g                        |
| T2               | 2.7x10^6e              | 8.8x10^11f                        |
| T3               | 2.2x10^7f              | 1.2x10^12e                        |

The value followed by the same letter showed no significant difference based on Duncan’s test at the level of 5%.

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P1 = 15% egg white + 0.5% maltodextrin
P2 = 20% egg white + 0.5% maltodextrin
P3 = 25% egg white + 0.5% maltodextrin
T1 = 0.75% tween 80 + 20% maltodextrin
T2 = 1.25% tween 80 + 20% maltodextrin
T3 = 1.75% tween 80 + 20% maltodextrin

Table 5 showed that the addition of 20% egg whites (P2) had the highest viability of 1.8x10^10 CFU/g. Egg white with the right concentration can protect bacteria. Egg white foam contains a type of albumin protein such as ovalbumin (54%), ovomucin (11%) and other proteins (17%) which can protect heat-sensitive materials such as bacteria or microbes [19]. Ovalbumin can form strong foam, so can be protected to heat-sensitive material from damage. Ovomucin serves to stabilize foam. While other proteins such as ovoglobulin can increase viscosity, strengthen the binding of air bubbles and soften the resulting foam texture. But, the addition of egg white foam too high (P3) can reduce bacterial viability to 1.6x10^10 cfu/g due to egg white foam that protects bacteria too strong so that bacteria cannot synthesize their food. So the bacteria will not get enough energy for their lives and become death. However, T treatments showed low bacterial viability, it was suspected that capability of egg white as foaming agent better than tween 80 to maintain the bacterial viability.

The viability of LAB was increased in rehydration yoghurt in all treatments. It was because that when rehydration process, there was the addition of skim milk which serves as a nutrient for growth and microbial activity.

4. Conclusion
The quality of probiotic yoghurt powder with the addition of egg whites concentration of 20% had met the requirements of SNI for liquid yoghurt. The characteristic were yield of 19.05%, ash content of 4.82%, water content of 6.29%, acidity level (lactic acid) 1.57%, fat content 15.29%, protein content 26.47%, phosphorus (P) 634.15 ppm, calcium (Ca) levels 5121.71 ppm, total bacteria lactic acid 1.8x10^10 CFU/g.

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Acknowledgement
We thanks to Indonesian Center for Agricultural Postharvest Research and Development (ICAPRD) for financial support to this research through APBN 2015 and Maharani Anjar, Pakuan University for assisting to this research.