THE EFFECT OF RED SWEET POTATO (*Ipomoea batatas* L.) SUBSTITUTION ON SKIM MILK AS PREBIOTIC ON SYNBIOTIC DRINK POWDER CHARACTERISTIC

Ratih Nawangwulan, Rohula Utami, Edhi Nurhartadi

Sebelas Maret University, Jl. Ir Sutami 36A, Surakarta, Indonesia
Corresponding Author:Tel.: +628561733165 ; E-mail: ratih.nawangwulan@gmail.com

Abstract
Red sweet potato (*Ipomoea batatas* L.) is known as a source of prebiotic because it contains oligosaccharide raffinose. Usage of prebiotic along with probiotic known as synbiotic. Powdered fermented synbiotic drink is one of the fermented drink diversification. The aim of this research was to study the effect of formulation ratio of red sweet potato filtrate (RSPF) and skim milk (SM) on probiotic bacterial count, physicochemical and sensory characteristic of synbiotic drink powder that dried using spray dryer. Formulation ratio of RSPF:SM = 75%:25% (F1), 50%:50% (F2), and 25%:75% (F3). Formulation ratio of RSPF and SM showed effect on pH, microencapsulation efficiency, solubility, and sensory properties. Lowest pH value (4.55), highest microencapsulation efficiency (4.47%) obtained from the formulation of 75% RSPF and 25% SM. Highest solubility obtained from the formulation of 50% RSPF and 50% SM. Based on sensory analysis, formulation of 75% RSPF and 25% SM had the highest sensory properties with 'neutral' aroma (3.20); 'neutral' flavor (3.3); and 'like' overall (3.50).

Keywords: *fermented drink, raffinose, red sweet potato, spray drying, synbiotic*

Abbreviations:
RSPF: Red Sweet potato filtrate
SM: Skim milk

1. Introduction
The awareness of the importance of healthy food has increased the public demand for healthier food products. This has resulted in a new concept of functional food products. The concept of functional food is becoming popular in various countries around the world, particularly in developing countries like Indonesia. Functional food is processed food that has one or more components that is based on scientific studies have specific physiological functions beyond its basic functions, proved to be harmless, and giving health benefits [1].

Basically all foods are functional because they can directly generate flavor, aroma and nutritional value. However, the food nowadays should be investigated for the physiological benefits that may reduce the risk of chronic diseases or improve health. The results generate global interest in the category of food that is being developed today and known as "functional foods" [2]. Kinds of functional food which has received recognition from the US Food and Drug Administration (FDA), United States, such as fortified margarine, products made from whole oats, cranberry juice, fish oil, green tea, tomatoes and processed tomato products, vegetables, meat and milk, and fermented drink products.

Fermented milk drink is a dairy product produced from the fermentation of milk or milk reconstitution or recombination milk obtained from fermentation with lactic acid bacteria and other microbes with or without other suitable microbes [3]. The fermentation process in food used microorganisms activity to produce a product with a distinctive flavor and aroma characteristic or to produce food with better quality. In the manufacture of fermented drink known the term of "synbiotic" which combines prebiotics and probiotics. Probiotics are defined as live microorganisms which when administered in sufficient quantity would provide health benefits to the host. While prebiotics are non-digestible substances that can promote the growth of bacteria [4].

Fermented synbiotic drink is one of the diversification of the fermented drink that was developed as a functional food ingredient as this product is enriched with prebiotic and probiotic bacteria such as *Lactobacillus acidophilus* and *Bifidobacterium longum* that are beneficial to health. The use of mixed cultures in fermented milk products has several advantages, namely the quality of the resulting product is better, higher bacterial growth, prevent contamination, and maximum substrate utilization [5].

The growth of lactic acid bacteria in the human intestine can be stimulated by providing substrates that can be digested by the bacteria so that the population increases and is against pathogens. Substrates that can be used by bacteria to stimulate the growth of lactic acid are known as prebiotics. Sweet potato is one of the types of tubers that has exuberant availability and often consumed by the people of Indonesia. In the diversification of food, sweet potato is a good material because it contains high carbohydrate and a source of vitamin A, especially on varieties that have a yellow-reddish flesh color [6]. Sweet potatoes contain a potential prebiotic such as oligosaccharides, one of which is raffinose. The content of raffinose in red sweet potatoes is 1.26% [7].

Fermented drinks have relatively short shelf life: one day at room temperature (25-30°C) and around five days at a temperature of 7°C [8]. Therefore, it is necessary to further process it to obtain a fermented drink that has a longer shelf life. Various methods can be done to extend the shelf life of fermented drinks, such as spray drying.

Spray drying is a suitable process for drying fermented drinks as it takes brief contact with heat and high evaporation rate, providing the products with high quality, stable, functional and low moisture content [9]. Fermented drinks in powder form is highly desirable because of the long shelf life and may reduce the cost of transportation and storage capacity as well as keeping the viability of starter bacteria.

Spray drying is also reported to have an unfavorable effect on the flavor of fermented powder and causes a decrease in probiotic bacteria [10]. However, the addition of hydrocolloids can increase the retention of probiotic bacteria, acetaldehyde and the solubility of fermented drinks that are spray dried [11]. The inlet and outlet temperature of the spray dryer apparatus, characteristics of the starter bacteria, storage process, and the formed flavor also need to be considered.

Based on this information, it is necessary to do research on synbiotic drink powder with the use of red sweet potato as a source of prebiotic which will be further examined how the effect of substitution of skim milk with red sweet potato on physicochemical characteristics (pH, antioxidant activity, moisture content, solubility, and microencapsulation efficiency), sensory characteristics, probiotic bacterial count of synbiotic drink powder.

2. Methods

2.1. Bacterial strains and culture preparations

Pure cultures of probiotic bacteria *Lactobacillus acidophilus* IFO 13951 and *Bifidobacterium longum* ATCC 15707 were obtained from Food and Nutrition Culture Collection (FNCC), Gadjah Mada University (Yogyakarta, Indonesia). Breeding of pure bacteria culture was done once obtained. Rejuvenation was done using liquid MRS media in test tubes and incubated at a temperature of 37°C for 24 hours and stored at a temperature of 4°C. Culture starters made by inoculating pure cultures in MRS broth to skim milk media (10% w/v) that has been pasteurized at 80-90°C for 30 minutes, and incubating at 37°C for 12 hours. Prime starters as much as 3% (w/v) were added to skim milk media that has been pasteurized pasteurized at a temperature of 80-90°C for 30 minutes and incubated at 37°C for 12 hours and used as starter inoculum. The starter inoculum used for the manufacture of synbiotic drink were as much as 3% (10^8 CFU/ml).

2.2. Synbiotic drink manufacture

Main materials used in this research were red sweet potato and skim milk. Red sweet potatoes were obtained from Tawangmangu market (Karanganyar, Indonesia) and skim milk were procured from Jaya Abadi (Surakarta, Indonesia) using a commercial skim milk 'Lactona'. Red sweet potatoes were washed, peeled, cut into small pieces, steamed, made into puree with water addition (1:1), and filtered. The filtrate was taken for further use. Skim milk was pasteurized at 80-90°C for 30 min. RSPF and SM were diluted with a ratio of 75%:25%; 50%:50%; 25%:75% and each sample was pasteurized at 80°C for 30 min and cooled down to 40-45°C. Afterward, inoculation was performed to each sample by inoculating 3% (v/v) culture starter at 10^8 CFU/ml and incubated for 18 h at 37°C to obtain probiotic bacteria ranged from 10^9-10^{10} CFU/ml.

2.3. Synbiotic drink microencapsulation

The synbiotic drink were microencapsulated according to the method as described by Su et al. [12] with a modification. Microcapsules were made by preparing a mixture of 80% (v/v) coating agent comprising 30% (w/v) maltodextrin and 20% (w/v) gum arabic and 20% fresh synbiotic drink. The mixture was spray-dried into powder using a laboratory scale spray dryer (Buchi 1940) with a constant inlet temperature of 100°C and an outlet temperature of 52.5°C.

2.4. Physicochemical analysis

2.4.1. Moisture content

Measurements were conducted using thermogravimetri method [63]. 2 g sample was dried in an oven at a temperature of 105°C for 3 h, and then cooled and weighed. The assessment was performed until a constant weight. Moisture content was calculated using the following formula:

$$\frac{w}{w_1} x100\% \quad (1)$$

w = weight of sample before drying
w_1 = weight of sample after drying

2.4.2. pH

pH measurements were carried out at room temperature (27°C) using a calibrated pH meter. 10 g of powder sample was dissolved in 100 ml distilled water at pH 7 in a beaker glass, the pH meter was dipped in and the pH value was read [64].

2.4.3. Antioxidant activity

1 g of powder sampel was dissolved in 100 ml of ethanol and allowed to stand overnight. DPPH solution (0.004% w/v) in 95% ethanol was prepared. 2 ml of DPPH solution in ethanol was added to 2 ml of the sample solution in ethanol and then homogenized using vortex. The solution was incubated in the dark for 30 min and the absorbance was measured using spectrophotometry at a wavelength of 517 nm. Ethanol was used as a blank while the control was DPPH solution in ethanol [65]. The antioxidant activity was calculated using the following formula:

$$\frac{A_{control} - A_{sample}}{A_{control}} x100\% \quad (2)$$

2.4.4. Microencapsulation Efficiency

Microencapsulation efficiency was calculated using Su et al. [12] method by the following formula:

$$\frac{sample(g)}{mixture(g)} x100\% \quad (3)$$

2.4.5. Solubility

0,75 g of powder sample was weighed and dissolved in 100 ml of distilled water and filtered with a vacuum filter. Before using, the filter paper was dry-heated first in oven at 105°C for 30 min and then weighed. After filtration, the filter paper was dried again in the oven at 105°C approximately 3 h and then cooled down in a desicator for 15 min and weighed until the constant weight was obtained [66]. The solubility was calculated using the following formula:

$$\left(1 - \frac{c-b}{\frac{100-\%d}{100} xa}\right) x100\% \quad (4)$$

a = weight of sample
b = weight of filtrate paper
c = weight of filtrate paper + residue
d = moisture content

2.5. Bacterial enumeration

1 g powder sample was dissolved in 9 ml of sterile distilled water and made into serial dilutions. Three last dilutions were plated in duplicate on MRS (deMan Rogosa and Sharpe) agar and incubated at 37°C for 48 h [66]. Probiotic bacterial count was expressed in units of CFU per gram.

2.6.Sensory analysis

Sensory analysis was performed using a method by Kartika et al. [13]. Samples were prepared by dissolving 10 g of sample powder in 90 ml of warm water. Hedonic test was performed on 30 panelists. The parameters tested were including color, aroma, flavor, viscosity, and overall.

3. Results and Discussion

3.1. Physicochemical characteristics of synbiotic drink

Tabel 1. Physicochemical caharacteristic of symbiotic drink powder

Analysis	Sample		
	F1	F2	F3
Moisture content (%)	3,04±0,18[a]	2,96±0,01[a]	2,95±0,06[a]
pH	4,55±0,00[a]	4,63±0,04[b]	4,70±0,00[c]
Antioxidant Activity (%)	38,56±0,87[a]	39,17±0,20[a]	37,37±1,92[a]
Microencapsulation Efficiency (%)	4,47±0,07[a]	4,07±0,05[a]	3,76±0,15[a]
Solubility (%)	99,60±0,09[a]	99,81±0,01[b]	99,70±0,01[a,b]

a Values are the average ± standard deviation. Different letters in the same row indicate significant differences ($p<0.05$) between F1 (75% RSPF : 25% SM), F2 (50% RSPF : 50% SM), and F3 (25% RSPF : 75% SM)

3.1.1. Moisture content

Results of analysis of variance showed that the variation in the ratio of RSPF with SM did not significantly affected ($p > 0.05$) on the moisture content of synbiotic drink powder. Graph of moisture content of synbiotic drink powder can be seen in Figure 1.

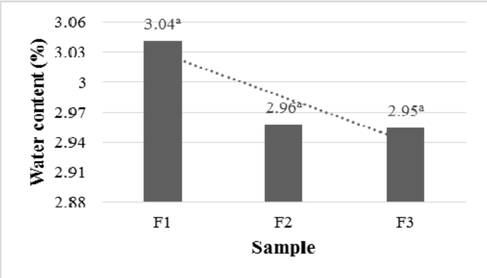

Figure 1 Moisture content of synbiotic drink powder

Based on the graph contained in Figure 1, it can be concluded that the formulation of the ratio between RSPF with different SM did not produce any significant difference in moisture content of each sample. The moisture content of synbiotic drink powder were ranged from 2.95 to 3.04. Based on the quality requirements of SNI 01-2970-1999 [14] nonfat milk powder, the maximum allowable moisture content is 4.00%, so all the samples had met the criteria of milk-based powder.

The highest moisture content contained in the synbiotic drink powder was found in the formulation of 75% RSPF and 25% SM (3.04%). While the lowest moisture content contained in synbiotic drink powder was found in 25% RSPF and 75% SM (2.95%). Basically, the ratio of formulation did not affect significantly in moisture level due to the manufacture of synbiotic drink powder. All the formulations underwent the same treatment when it was dried using spray dryer. The treatment was using a coating solution with a ratio of 80% fresh synbiotic drink: 20% carrier solution, with a coating material of maltodextrin and gum arabic and the inlet and outlet temperature of the spray dryer were set at 100 °C and 52.5 °C.

However, the higher the temperature of the outlet of the spray dryer, the lower moisture content obtained, but the possibility flavor and aroma loss of fermented drinks increased. Conversely, the lower the outlet temperature of the spray dryer, the moisture content produced would be higher but has good retention of volatile compounds and maintain the flavor of fermented drinks (Kumar and Mishra, 2004). In general, more microorganisms could survive at low moisture activity. However, excessive drying could reduce the viability of microorganisms [15].

3.1.2. pH

pH or acidity is one of the important factors in food products. The pH value indicates the real concentration of H+ (and OH-) in solution or equal to negative logarithmic value of the concentration of H+. Influenced by the pH value of the products produced during the fermentation process. Changes in pH in fermented products like yogurt are the result of decomposition of lactose into lactic acid which causes an increase in acidity, resulting in a decrease in the pH value [16]. The production of lactic acid by the metabolism of *Bifidobacterium longum* and *Lactobacillus acidophilus* caused a decrease in the pH value.

Based on Table 1, it can be seen that the ratio of RSPF and SM affected the acidity (pH). The greater the concentration of the RSPF, the lower the pH. Statistical analysis showed that the ratio of RSPF and SM in the manufacture of synbiotic drink has significant effect ($p < 0.05$), which can be seen in Figure 2.

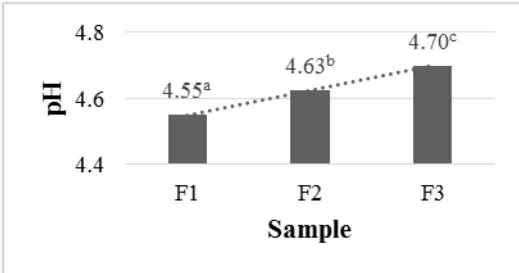

Figure 2 pH value of synbiotic drink powder

Graphs contained in Figure 2 showed that the ratio between the RSPF and SM affected the pH of the reconstituted synbiotic drink powder. Formulation of 75% RSPF and 25% SM gave the lowest pH (4.55) due to the oligosaccharide content of red sweet potato used by probiotic bacteria as a substrate for the growth and maintenance of cells, and was also used for product formation. The increase in lactic acid fermentation of milk was always followed by the decrease in pH of fermented drinks, so the greater the levels of lactic acid formed during fermentation, the pH of fermented drinks would be lower [17].

Formulation 25% RSPF with 75% SM had the highest pH of 4.7. This was because of the culture used in this study, namely *Lactobacillus acidophilus* and *Bifidobacterium longum*. Bifidobacteria were known as an organism that was quite difficult to grow in milk-based medium and therefore required specific growth factors [18]. This leaded to low production of lactic acid by probiotic bacteria and caused a decrease in pH, but not significantly. However, Lactobacillus was a homofermentative bacteria that was largely produced lactic acid [19] which could lower the pH significantly.

A decrease in pH due to the addition of the combination of sweet potato extract and skim milk would provide a carbon source for the activity of *Lactobacillus acidophilus* and *Bifidobacterium* sp [20]. The decrease in the final pH of the fresh synbiotic drink (before spray dried) was due to the activity of a mixed starter culture of *L. acidophilus* and *B. longum* in the manufacture of synbiotic drink. The activity of lactic acid-forming microorganisms increased with the increase of foods that contained sugars and other ingredients that were necessary for growth. Therefore, the addition of skim milk provided a source of lactose and the addition of sweet potato extract that was rich in oligosaccharides and might act as specific nutrients for the growth of *L. acidophilus* and *Bifidobacterium* sp. [20].

After spray drying process, the pH of the reconstituted synbiotic drink powder ranged from 4.55 to 4.70. Anonim[a] [21] found the pH of the final product of instant dried yogurt powder of 4.2; while the pH obtained in the manufacture of yoghurt powder by Hasanah [22] was 4.39. Terms of yogurt quality standards according to SNI 01-2981-1992 [23], recommended pH range from 4.0 to 4.5. pH was not qualified according to yogurt standar was due to the addition of 80% coating material made up from a mixture of maltodextrin and gum arabic. The maltodextrin used in this research had a pH of 5.47; while the gum arabic used had a pH of 4.2 to 4.8 so that with the addition of maltodextrin and gum arabic into synbiotic drink would raise the pH after the spray drying process.

3.1.3. Antioxidant activity

Antioxidants are substances required in very small concentrations to prevent or inhibit the prooxidant. Prooxidant is toxic substance that can cause oxidative damage to lipids, proteins, and nucleic acids, resulting in various diseases [24]. Food antioxidant is a substance in food that inhibit the adverse effects of reactive oxygen species (ROS), reactive nitrogen compounds (SNR) or both, in the normal physiological function in humans [26]. Antioxidants in human diet may play a role in the prevention of various diseases, including cardiovascular disease, cerebrovascular, cancer, diseases associated with aging and others.

Table 1 shows that the ratio of RSPF and SM did not affect significantly (p> 0.05) on the antioxidant activity of synbiotic drink powder. Highest antioxidant activity was shown by the formulation of 50% RSPF and 50% SM by 39.17%. While the lowest antioxidant activity was shown by the 75% RSPF with 25% SM by 37.37%.

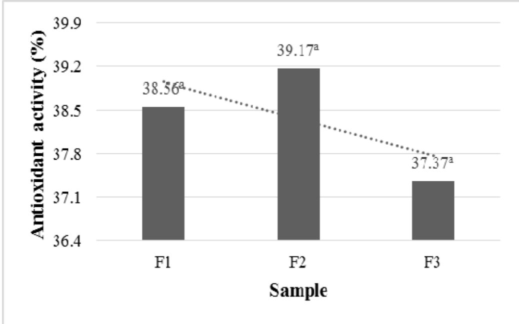

Figure 3 Antioxidant activity of synbiotic drink powder

In a study conducted by Umam et al. [26], banana synbiotic drink with the starter of *Bifidobacterium longum* and *Lactobacillus acidophilus* had the antioxidant activity of 21.24 to 30.87%. Lin and Chang [27] suggested that *Bifidobacterium longum* and *Lactobacillus acidophilus* might provide antioxidant effects, namely in inhibiting linoleic acid peroxidation. *Bifidobacterium longum* and *Lactobacillus acidophilus* by the number of 10^9 CFU/ml could produce antioxidants of 21-52% by DPPH radical scavenging analysis.

Research conducted by Retnati [28] showed that the antioxidant activity of fresh red sweet potatoes was 8.38%. Once processed into yogurt, the antioxidant activity of the red sweet potato ranged from 2.69 to 8.13%. Compared with the results of the research that has been done, this number was far below of the antioxidant activity obtained. There was no significant difference between all samples due to utilization of the prebiotic by probiotic bacteria contained in the synbiotic drink had the same activity. This can be seen in Table 1, where all the formulations had a total number of probiotic bacteria that were not significantly different.

In testing the antioxidant activity of *L. acidophilus* ATCC 4356 conducted by Virtanen et al. [29] with 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) method, the antioxidant activity obtained was 42%, while the combination with *Bifidobacterium infantis* obtained antioxidant activity by 27%. *L. acidophilus* had inhibitory activity of radicals and inhibiting lipid peroxidation and in most cases increased the antioxidant activity with the longer fermentation time.

The antioxidant activity of red sweet potato fermented drink was due to the probiotic bacteria that produced lactic acid. Lactic acid contained α-hydroxyacids (AHAs), which functioned as an antioxidant and often used for the manufacture of cosmetics and in food products [30]. In addition to producing lactic acid which was the main result of metabolism, probiotic bacteria also produced compounds that act as antioxidants. These antioxidant compounds were secondary metabolites produced by probiotic bacteria. Hatanaka et al. [31] also added that *Bifidobacterium longum* was able to produce vitamin C which was an antioxidant.

3.1.4 Microencapsulation efficiency

Microencapsulation is defined as the process of coating micron-sized solid particles or liquid droplets (droplet) or inert gas in the envelope, which can isolate and protect them from the external environment [32]. One common method to produce encapsulated products is spray drying, where in this study fresh synbiotic drink converted into powder form.

Table 1 showed that the ratio of RSPF and SM influenced the microencapsulation efficiency of the synbiotic drink powder (p<0,05). Highest microencapsulation efficiency was found in 75% RSPF and 25% SM at 4.47%. While the lowest microencapsulation efficiency was demonstrated by the 75% SM and 25% RSPF (3.76%). Graph of synbiotic drink powder's microencapsulation efficiency can be seen in Figure 4.

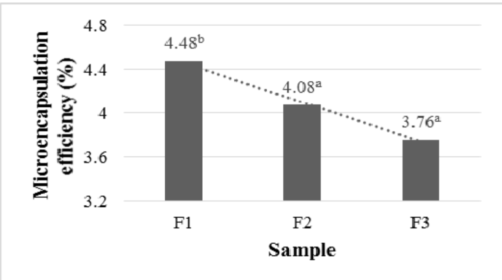

Figure 4 Microencapsulation efficiency of synbiotic drink powder

Chegini and Ghobadian [33] found that products with a high moisture content tend to have a higher bulk weight because it contained water, where it would be heavier than dry solids after a spray drying process. The exterior of this dried keeping the water content to remain in the droplet, as a consequence, the particle size enlarged. There were real differences between the sample formulations ratio due to syneresis occurred in all three samples, but in varying degrees. The three sample formulations were underwent syneresis because it contained skim milk, which in skim milk contained casein. Sakowati [34] stated that the fermented drink that had a pH around the isoelectric pH of casein would have a weaker water holding capacity than in normal pH. Hydrogen bonds between water molecules and protein molecules weaken and pores between casein molecules loosen so that it could be passed by the free molecules and resulted in syneresis.

Syneresis is a separation process of low molecular weight liquid on the surface of the gel because of the spontaneity and stimulation during storage. Gel contained 99.9% water but had a more distinctive properties such as solids, in particular the nature of elasticity and rigidity [35]. The greater content of the red sweet potatoes, the greater amount of fluid that came out so the water content of the synbiotic drink increased, resulted in a greater amount of moisture content after spray drying process because of the amount of bound water in the droplet. Conversely, the more the amount of skim milk, the less amount of the fluid that came out, which resulted in fewer yield after the spray drying process.

3.1.5. Solubility

Table 1 showed that the ratio of the RSPF and SM influenced significantly (p <0.05) on the solubility of synbiotic drink powder. Solubility of formulation 75% RSPF and 25% SM (99.60%) was significantly different compared to formulation 50% RSPF and 50% SM (99.81%), however 75% SM with 25 % RSPF was not significantly different from the other two formulations (99.70%). Setyaningsih et al. [36] stated that the higher the solubility, the resulting product would be better because the flavor would be released upon use.

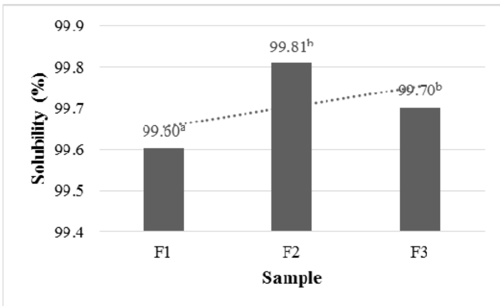

Figure 5 Solubility of synbiotic drink powder

Figure 5 showed that the highest solubility of synbiotic drink was found in 50% RSPF and 50% SM, followed by 25% RSPF and 75% SM, and 75% RSPF and 25% SM. The solubility of synbiotic drink powder ranged from 99.60 to 99.81%. Similar results were recently reported by Kumar and Mishra [37] that the solubility of industrial scale spray-dried yogurt ranged from 98-99% and would be coagulated 6 to 6.5 hours after reconstitution.

Solubility of synbiotic drink powder also affected by the addition of maltodextrin and gum arabic as a coating material which were hydrocolloids. In research conducted by Grabowski et al. [38], maltodextrin could increase the solubility of sweet potato puree powder to more than 20 units. In contrast, the addition of maltodextrin reduced water-holding capacity of sweet potato puree powder, so the more maltodextrin powder was added, the more difficult to bind the water contained in the powder and ultimately easier to dissolve in water. Gum arabic is soluble in water so it is suitable to use as a filler in the food to be dried with a spray dryer. In addition, gum arabic could maintain the flavor of the food dried by spray dryer [39].

Based on Table 1, the higher the concentration of skim milk, the higher the degree of solubility. This was proved by a study conducted by Sintasari et al. [40] that the more addition of skim milk, the total dissolved solids were getting higher. During the fermentation process, lactose would be overhauled into lactic acid by the starter culture in large quantities. Residual lactose and organic acids were what would be count as total dissolved solids. Organic acids (including lactic acid) were ones of total dissolved solids in addition to sugar, pigments, and vitamins [41]. Total dissolved solids also came from the breakdown of proteins into simpler molecules such as water-soluble amino acids and peptone, the breakdown of carbohydrates, and the breakdown of fat into free fatty acids and glycerol. Components of dissolved solids in addition to pigments, organic acids and proteins was sucrose. The longer the fermentation and the longer the cooking led to the increased of the dissolved components and caused softening on the cell wall tissue due to water penetration into the material so that more solid molecules were extracted [42].

3.2. Probiotic bacterial count of synbiotic drink powder

In the manufacture of synbiotic drink powder of RSPF and SM, the amount of the initial starter bacteria used prior to the spray drying process was 10^9 CFU/ml. In the study conducted by Kiiru and Ojijo [43], the temperature of the inlet and outlet of spray dryer was greatly affected the resistance of microorganisms. This is supported by Kumar and Mishra [37] which stated that the parameters that affected the resistance of bacteria during the spray drying process were included inlet and outlet temperature, atomizing type and direction of airflow in the spray dryer. The number of surviving bacteria in yogurt decreased with the increasing of the inlet and outlet air temperature and atomization pressure.

Based on the data in Table 2, it can be seen that the ratio of RSPF and SM did not affect significantly (p> 0.05) in the manufacture of synbiotic drink powder. It appeared that the total average of probiotic bacterial count ranged from $1{,}7x10^6$ to $3{,}8x10^6$ CFU/g. Graph of probiotic bacterial count can be seen in Figure 6.

Table 1. Probiotic bacterial count of symbiotic drink powder

Sample	Bacterial count CFU/g	Bacterial count Log CFU/g
F1	$1{,}7x10^6$	$6{,}14\pm0{,}41^a$
F2	$3{,}1x10^6$	$6{,}28\pm0{,}50^a$
F3	$3{,}8x10^6$	$6{,}56\pm0{,}12^a$

a Values are the average ± standard deviation. Different letters in the same column indicate significant differences (p<0.05) between F1 (75% RSPF : 25% SM), F2 (50% RSPF : 50% SM), and F3 (25% RSPF : 75% SM).

In a study conducted by Su et al. [12] in the manufacture of oriental fermented milk product, the total number of probiotic bacteria after spray drying were ranged from log 7.50 to log 8.50 and therefore samples have met the quality requirements of probiotic drinks. While the research conducted by Kiiru and Ojijo [43] found that the final probiotic bacterial count in yogurt powder was 1.06 x 10^6 CFU/ml.

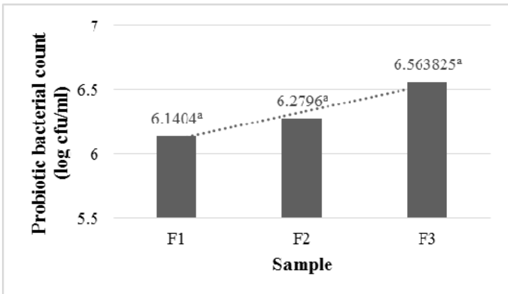

Figure 6 Probiotic bacterial count of synbiotic drink powder

According to Figure 6, the highest probiotic bacterial count produced by synbiotic drink powder was obtained from 25% RSPF and 75% SM at $3{,}8x10^6$ CFU/g. The number of probiotic bacteria has decreased but not significantly with the increased of RSPF. Formulations of 50% RSPF and 50% SM had the total probiotic bacteria of $3{,}1x10^6$ CFU/g, and the formulation of 75% RSPF and 25% SM had a total of probiotic bacteria of $1{,}7x10^6$ CFU/g. According to Fonden et al. [45], foods with probiotics should contain probiotics which ranged between 10^6-10^8 cells/g (not included with the starter culture) and persisted during the shelf life of the product, so that all three formulations had met the standards of probiotic drinks because they were above 10^6 CFU/g.

Viability and activity of probiotic bacteria is important because the bacteria must be able to survive in the food during shelf life and while in the acidic conditions in the stomach, and hold from degradation by hydrolysis enzymes and bile salts in the small intestine. It is important for commercial products that claimed to provide health effects to meet the minimum criteria for probiotic bacterial count at 10^6 CFU/ml at the time of the expiration date, because the least recommended dose per day ranged between 10^8-10^9 cells [46].

Bifidobacteria are Gram-positive, non-motile, and highly anaerobic. Bifidobacteria grows optimum at pH 6-7 and shows a decreased performance at a pH above 8.0 or below 4.5 and has an optimum temperature range between 37-41°C. *L. acidophilus* has an optimum pH of 6.0 and an optimum temperature for growth at 35°C [47]. Associated with the spray drying process, the high temperature of the inlet and outlet of the spray dryer could cause death in both the starter cultures. Factors that affected the survival of probiotic bacteria during the spray drying process were the inlet and outlet temperature of the spray dryer, the amount of probiotic bacteria prior to the spray drying process, and the coating material used to encapsulate the fresh synbiotic drink.

3.3. Sensory characteristics of synbiotic drink powder

3.3.1. Color

Color plays an important role in food commodities such as the attraction, identification, and quality attribute. Among the properties of the food product, the color quality is a factor that most attracted the attention of consumers and gave the fastest impression of liked or disliked [48].

Table 3 Sensory characteristics of reconstituted synbiotic drink powder

Sensory attributes	Sample		
	F1	F2	F3
Color	3,37±1,00[a]	3,40±0,77[a]	3,33±0,96[a]
Aroma	3,20±0,85[b]	2,97±0,71[a]	2,67±0,96[a]
Flavor	3,03±0,89[b]	2,87±0,90[a,b]	2,47±0,78[a]
Viscosity	3,17±0,91[a]	3,10±0,92[a]	3,33±1,09[a]
Overall	3,50±0,70[b]	3,30±0,75[b]	2,80±0,89[a]

a Values are the average ± standard deviation. Different letters in the same row indicate significant differences ($p<0.05$)

Based on the data in Table 3 to the sensory attributes of color, the ratio of RSPF and SM did not affect significantly ($p>0.05$) on panelists' color preferences on reconstituted synbiotic drink powder. Panelists tend to prefer the 50% RSPF and 50% SM formulation. The appearance of the formulation was considered the most attractive because it combined the yellow-reddish color from sweet potato flesh and white color from skim milk so it was not too flashy nor too pale. While the lowest value for the sensory attributes of color was obtained by 25% RSPF and 75% SM. This formulation scored the lowest (3.33) compared to the other two formulations because it had a pale yellow color which made it less attractive to the panelists.

Red sweet potato flesh contained carotenoids which caused a yellowish color on the results of the synbiotic drink powder [49]. According Sabuluntika [50], β-carotene level on red sweet potatoes were as high as 46.29 µg/g-120.32 µg/g.

3.3.2. Aroma

Aroma is a value that is contained in the product that can be noticed by the consumer directly [51]. Soekarto [48] stated that the aroma of a product in many ways determined whether or not a product smells, scents or odor even more complex than the taste. Sensitivity of smelling senses are usually higher than the senses of tasting. Even the smell of the food industry considers the test very important because it can quickly deliver a product assessment.

Table 3 showed that for the sensory attributes of aroma, there was a significant effect ($p<0.05$) of the ratio of RSPF and SM on the aroma of reconstituted synbiotic drink powder. Ratio formulation with the most preferred scent was 75% RSPF and 25% SM with a value of 3.20. While most undesirable aroma was obtained from 25% RSPF and 75% SM with a value of 2.67. This value indicated the level of panelists' preference in the range from 'do not like' to 'neutral'.

The aroma of fermented drink derived from the production of acids formed during fermentation. The aroma was caused mainly due to chemical changes and compounds forming with other materials, for example between an amino acids alteration in the protein resulted in the reduction of sugars that made up the food flavor and aroma compounds [52]. According to Pramono et al. [53], total solids would increase with the increased amount of RSPF. Total solids was strongly influenced by the amount of solids in the milk. Lactic acid bacteria also greatly affected the total solids of fermented product, if the activity of it were high. The incomplete acid accumulation in the substrate could affect the amount of total solids in milk fermentation. The increasing of total solids were important to provide good texture and aroma.

3.3.3. Flavor

Flavor or taste is an important attribute that affects a person's acceptance of a drink [51] and because this would affect the flavor of synbiotic drink. Flavor is the sense of taste perception in the form of salty, sweet, sour and bitter due to soluble compounds in the mouth. Generally, the acid is the dominating flavor of fermented drinks products. In yogurt, there is flavor and distinctive taste due to the presence of lactic acid, acetaldehyde, diacetyl or 2,3-pentanadion [54]. In the research that has been done was shown that the ratio of the filtrate formulations of red sweet potatoes and skim milk affected significantly to flavor attributes of reconstituted synbiotic drink powder.

Table 3 showed that the most preferred formulation was a formulation of 75% RSPF with 25% SM with a value of 3.03. Meanwhile formulations that was less preferred by the panelists was the formulation of 25% RSPF with 75% SM with a value of 2.47. This indicated that the greater the ratio of RSPF would increase the level of consumer preferences. Panelists' preferences on reconstituted synbiotic drink powder were in the range of 'dislike' to 'neutral'. In a study conducted by Pramono et al., [53], the greater the concentration of RSPF would increase consumer's preferences on fermented milk flavor that was not too sour but tasted sweet that was preferred by the panelists.

During the fermentation process, some flavor components were formed such as diacetyl, acetyl methyl carbinol, 2.3, butilen glycol and acetaldehyde which gave a distinctive taste to yogurt. The formation of lactic acid as a result of cellular metabolic activity of lactic acid bacteria would give a sour taste to yogurt, because that yogurt had a distinctive taste. In his research, Sayuti et al. [20] stated that the sweet corn yogurt with the addition of sweet potatoes and skim milk was preferred because of the flavor characteristic and bitterness caused by potato extract became vague. According Wennanda [55], the taste of drinks produced by fermentation of red sweet potatoes was formed from a combination of flavor that cane from the red sweet potato, milk and curd. Milk fat content also affected the taste. The resulting flavor in milk fat was derived from fatty acids [56]; [57].

3.3.4. Viscosity

Viscosity is a form of physical properties that are closely related to the texture of fermented drinks and fermented drinks affect acceptability by consumers [58]. Viscosity caused by the decomposition of solids by lactic acid bacteria in the fermentation process. Winarno and Fernandes [59] added that the viscosity of milk was influenced by the total solid contained in milk. In this case lactose, glucose, galactose in fermented milk and raffinose and stachiosse in RSPF were decomposed by lactic acid bacteria (*L. acidophilus*) that affected the viscosity of fermented milk. Viscosity can also be affected by damage to casein, homogenization, and heating the milk fat content [53]. Activity of lactic acid bacteria also greatly affected the viscosity of fermented drinks as lactic acid bacteria (*L. acidophilus*) and remodeled the lactose in the milk into lactic acid.

According to the data in Table 3, the viscosity of reconstituted synbiotic drink powder showed no significant difference ($p>0.05$) between all the three formulas. Formulation of 75% RSPF with 25% skim SM obtained a value of 3.17; formulation of 50% RSPF with 50% SM obtained a value of 3.10; and formulation of 25% RSPF and 75% SM obtained a value of 3.33. All of these formulations were within the level of preference from "neutral" to "like" for the viscosity.

Pramono et al. [53] stated that the total solid material would increase along with the increased number of RSPF. Total solids was strongly influenced by the amount of solids in the milk. Lactic acid bacteria also greatly affected the total solids fermentation product. The incomplete acid accumulation process in the substrate could affect the amount of total solids in milk fermentation. The increased number of total solids could affect the viscosity.

Beside of the thickened texture of the fresh synbiotic drink, other factors also affected the viscosity such as the addition of the coating material with a large ratio of 80% consisted of maltodextrin and gum arabic. Badaruddin [60] found that the addition of maltodextrin in the manufacture of yoghurt powders were significantly affected the viscosity. The use of maltodextrin DE 9

-12 in this study was able to increase the viscosity of the synbiotic drink when reconstituted. Gum arabic was also greatly affected the viscosity of the final fermented product. According to Nugroho et al. [61], gum arabic had a large molecular weight so that the addition of gum arabic could increase the viscosity. Gum arabic has unique high solubility characteristic, but the formation of viscosity is low [62].

3.3.5. Overall

Table 3 showed that the ratio of RSPF with SM gave a significant effect ($p<0.05$) on overall especially in the formulation of 75% RSPF and 25% SM; and 50% RSPF and 50% SM; and with the formulation of 25% RSPF and 75% SM. Concentration of 75% RSPF and 25% SM was the most preferred formulation with values of 3.50 and in the range from 'neutral' to 'like' because it seemed to be accepted by the panelists, had a distinctive aroma of fermented drink and the appearance of the desirable color, not too pale nor too yellow as the influence of the flesh of the red sweet potato. While the formulation of 75% RSPF with 25% SM was less preferred because it had less aroma of fermented drinks, a pale white color, and less flavor of fermented drink.

4. Conclusions

From the present study it can be concluded that in terms of physicochemical characteristics, the ratio of RSPF with SM affected the pH, microencapsulation efficiency, and solubility of the synbiotic drink powder but had no effect on the moisture content, and antioxidant activity. The formulation of RSPF and SM had no effect on probiotic bacterial count of the synbiotic drink powder where all samples have met the standards with a total probiotic bacteria were $1{,}7x10^6$-$3{,}8x10^6$ CFU/g.

In the sensory characteristics, for the parameters of the color and consistency, all three samples were equally preferred. For the parameters of aroma, taste and overall, the most preferred were formulations of 75% RSPF and 25% SM. Overall, the best formulation for the fermented drink was the formulation of 75% RSPF and 25% SM.

References

1. Badan POM. Pengawasan Klaim dalam Label dan Iklan Pangan Olahan Jakarta; 2011.
2. Hasler, Clare M. Functional Foods: Benefits, Concerns, and Challenges- A Position Paper from the American Council on Science and Health. *The Journal of Nutrition* 2002; **132** p. 3772-3781.
3. Badan Standardisasi Nasional. SNI 7552:2009. *Minuman Susu Fermentasi Berperisa*. Jakarta: Standar Nasional Indonesia; 2009.
4. Guarner, F. et al. Probiotics and Prebiotics. World Gastroenterology Organisation Practice Guidline; 2008.
5. Zeikus, J. Gregory and Eric A Johnson. *Mixed Cultures in Biotechnology*. Michigan: McGraw -Hill; 1991.
6. Bradburry, JH and WD Holloway. *Chemistry of tropical root crops" significance for nutrition and agriculture in the Pacific*. ACIAR Monograph No. 6; 1988.
7. Suryadjaja, Amanda. *Potensi Ubi Jalar Putih dan Merah (Ipomoea batatas L.) untuk Pertumbuhan Bakteri Asam Laktat dan Menekan Pertumbuhan Patogen*. Thesis. Bogor: Bogor Agricultural Institute; 2005.
8. Salji, JP, SR Saadi and A Mashadi. Shelf life of plain liquid yogurt manufactured in Saudi Arabia. *J. Food Protect* 1987; **50**:123-126.
9. Koc, Banu, Melike Sakin-Yilmazer, Figen Kaymak-Ertekin, and Pinar Balkir. Physical properties of yoghurt powder produced by spray drying. *J. Food Sci Technol* 2012; **51**: 1377-1383.
10. Groux, M. Flavour components of yoghurt. *Lait* 1973; **53**: 146-153.
11. Figueroa, ER, MAS Cervantes, GC Rodrigues, and HS Garcia. Addition of hydrocolloids to improve the functionality of spray dried yoghurt. *Milchwissenschaft* 2002; **57**: 87-89.
12. Su, Lieh-Chi, Chin-Wen Lin, and Ming-Ju Chen. Development of an Oriental-style dairy product coagulated by microcapsules containing probiotics and filtrates from fermented rice. *International Journal of Dairy Technology* 2007; **60**: 49-54.
13. Kartika, B, P Hastuti, and Supartono W. *Pedoman Uji Inderawi Bahan Pangan*. Yogyakarta: Pusat Antar Universitas Pangan dan Gizi UGM; 1988.
14. Badan Standardisasi Nasional. SNI-01-2970-1999. *Susu Bubuk*. Jakarta: Standar Nasional Indonesia; 1999.
15. De Valdez, GF, Giori FS, Holgodo AP, and Oliver G. Effect of drying medium on residual moisture content and viability of freeze-dried lactic acid bacteria. *Applied and Environmental Microbiology* 1985; **49**: 413-415.
16. Buckle, KA, Edwards RA, Fleet GH, Wooton M. *Ilmu Pangan*. Jakarta: Penerbit Universitas Indonesia; 1985.
17. Utami, Rohula, MAM Andriani, and Zoraya A Putri. Kinetika Fermentasi Yoghurt yang Diperkaya Ubi Jalar (*Ipomoea batatas*). *Caraka Tani* 2010; **25**: 50-55.
18. Chick, H, HS Shin, and Z. Ustunol. Growth and Acid Production by Lactic Acid Bacteria and Bifidobacteria Grown in Skim Milk Containing Honey. *Journal of Food Science* 2001; **66**: 478-481.
19. Kusumaningrum, Amalia Putri. *Kajian Total Bakteri Probiotik dan Aktivitas Antioksidan Yogurt Tempe dengan Variasi Substrat*. Thesis. Surakarta: Sebelas Maret University; 2011.
20. Sayuti, Irda, Sri Wulandari, and Dian Kurnia Sari. Penambahan Ekstrak Ubi Jalar Ungu (*Ipomoea batatas var. Ayamurasaki*) dan Susu Skim terhadap Organoleptik Yoghurt Jagung Manis (*Zea mays L. Saccharata*) dengan

Menggunakan Inokulum *Lactobacillus acidophilus* dan *Bifidobacterium sp*. *Prosiding Semirata FMIPA*. Lampung: Lampung University; 2013.
21. Anonim[a]. Natural yoghurt powder. *Confect Manuf Mark* 1983; **20**: 12.
22. Hasanah, Fitria. *Formulasi Granul Effervescent Berbahan Baku Yogurt Probiotik Bubuk dengan Metode Granulasi Basah*. Thesis. Bogor: Bogor Agricultural Institute; 2006.
23. Badan Standardisasi Nasional. SNI02981-1992. *Yogurt*. Jakarta: Standar Nasional Indonesia; 1992.
24. Wu, X, G Cai, and RL Prior. Abrsorption and metabolism of anthocyanins in elderly women after consumption of elderberry or blueberry. *Journal of nutrition* 2002; **132**: 1865-1871.
25. Silalahi, J. Antioksidan dalam Diet dan Karsinogenesis. *Cermin Dunia Kedokteran* 2006; **153**: 42-47.
26. Umam, M Faizul, Rohula Utami, and Esti Widowati. Kajian Karakteristik Minuman Sinbiotik Pisang Kepok (*Musa paradisiaca forma typical*) dengan Menggunakan Starter *Lactobacillus acidophilus* IFO 13951 dan *Bifidobacterium longum* ATCC 15707. *Journal Teknosains Pangan* 2012; **1**: 2-11.
27. Lin, MY, and FJ Chang. Antioxidative effect of intestinal bacteria *Bifidobacterium longum* ATCC 15708 and *Lactobacillus acidophilus* ATCC 4356. *Dig. Dis. Sci.* 2000; **45**: 1617-1622.
28. Retnati. *Pengaruh Penambahan Ekstrak Berbagai Jenis Ubi Jalar (Ipomoea batatas L.) terhadap Jumlah Sel dan Aktivitas Antioksidan Yoghurt*. Thesis. Surakarta: Sebelas Maret University; 2009.
29. Virtanen, T, A Pihlanto, S Akkanen, and H Korhonen. Development of antioxidant activity in milk whey during fermentation with lactic acid bacteria. *Journal of Applied Microbiology* 2006; **102**: 106-115.
30. Yu, RJ and EJ Van Scott. Hydroxycarboxylic acids, N-acetylamino sugars, and N-acetylamino acids. *Skinmed* 2002; **1**: 117-122.
31. Hatanaka, M, T Tachiki, H Kumagai, and T Tochikura. Distribution and some properties of glutamine sytnthetase and glutamate dehydrogenase in bifidobacteria. *Agric. Biol. Chem.* 1987; **51**: 251-252.
32. Ghosh, SK. Functional *Coatings and Microencapsulation: A General Perspective*. Weinheim: Ch.1 Wiley-VCH, Verlag GmbH & Co. KGoaA.
33. Chegini, GR and B Ghobadian. Spray Dryer Parameters for Fruit Juice Drying. *World Journal of Agricultural Sciences* 2007; **3**: 230-236.
34. Sakowati, Lyant. *Kajian Penambahan Tepung Gembolo (Dioscorea bulbifera) terhadap Karakteristik Mutu, Karakteristik Sensori, dan Total Bakteri Probiotik pada Minuman Fermentasi Sinbiotik*. Thesis. Surakarta: Sebelas Maret University; 2013.
35. Dwiyana, Dini Restu. *Perbandingan Konsentrasi Hidrokoloid dan Konsentrasi Asam Sitrat dalam Minuman Jeli Susu Sesuai Mutu dan Kualitas*. Thesis. Bogor: Universitas Pakuan; 2011.
36. Setyaningsih, Dwi, Reni Rahmalia, and Sugiyono. Kajian Mikroenkapsulasi Ekstrak Vanili. *J. Tek. Ind. Pert.* 2009; **19**: 64-70.
37. Kumar, P and HN Mishra. Yogurt Powder-A Review of Process Technology, Storage and Utilization. *Trans IChemE, Part C, Food and Bioproducts Processing* 2004; **82**: 133-142.
38. Grabowski, JA, VF Truong, and CR Daubert. Spray-Drying of Amylase Hydrolyzed Sweetpotato Puree and Physicochemical Properties of Powder. *Journal of Food Science* 2006; **72**: 209-217.
39. Fasikhatun, Tsani. *Pengaruh Konsentrasi Maltodekstrin dan Gum Arab terhadap Karakteristik Mikroenkapsulat Minyak Sawit Merah dengan Metode Spray Drying*. Thesis. Bogor: Bogor Agricultural Institute; 2010.
40. Sintasari, Rinelda Ayu, Joni Kusnadi, and Dian Widya Ningtyas. Pengaruh Penambahan Konsentrasi Susu Skim dan Sukrosa terhadap Karakteristik Minuman Probiotik Sari Beras Merah. *Jurnal Pangan dan Agroindustri* 2014; **2**: 65-75.
41. Jacobs, M. *Chemical Analysis of Food*. New York: D. Van. Nostrand Reinhold; 1968.
42. Fennema, OR. *Food Chemistry*. New York: Marcel Dekker Inc.; 1996.
43. Kiiru, SN and NK Ojijo. Production of Powdered Yoghurt and Its Quality Changes During Storage. Proceeding. *The 12th Biennial Scientific Conference* 2010: 837-842.
44. Badan Standardisasi Nasional. SNI 7552:2009. *Minuman Susu Fermentasi Berperisa*. Jakarta: Standar Nasional Indonesia; 2009.
45. Fonden, R, B Grenoy, R Reniero, M Saxelin, and SE Birkeland. Industrial panel statements: Technological aspect. *Functional foods for EU-Health* 2000. Finland.
46. Kailasapathy, Kaila and James Chin. Survival and therapeutic potential of probiotic organisms with reference to *Lactobacillus acidophilus* and *Bifidobacterium spp. Immunology and Cell Biology* 2000; **78**: 80-88.
47. Riaz, Saba, Syed Kashif Nawaz, and Shahida Hasnain. Bacteriocins produced by *L. fermentum* and *L. acidophilus* can inhibit cephalosporin resistant *E. coli*. *Braz. J. Microbiol.* 2010; **41**: 643-648.
48. Soekarto, TS. *Penilaian Organoleptik untuk Industri Pangan dan Hasil Pertanian*. Jakarta: Bharata Karya Aksara; 1985.
49. Diniyati, Bintang. *Kadar Betakaroten, Protein, Tingkat kekerasan, dan Mutu Organoleptik Mie Instan dengan Substitusi Tepung Ubi Jalar Merah (Ipomoea batatas) dan Kacang Hijau (Vigna radiata)*. Research Article. Semarang: Diponegoro University; 2012.
50. Sabuluntika, Novita. *Kadar β-karoten, Antosianin, Isoflavon, dan Aktivitas Antioksidan pada Snack Bar Ubi Jalar Kedelai Hitam sebagai Alternatif Makanan Selingan Penderita Diabetes Melitus Tipe 2*. Research Article. Semarang: Diponegoro University; 2013.
51. Hayati, Rita, Ainun Marliah, and Farnia Rosita. Sifat Kimia dan Evaluasi Sensori Bubuk Kopi Arabika. *J. Floratek* 2012; **7**: 66-75.

52. Sinaga, CM. *Pengaruh Konsentrasi Susu Skim dan Konsentrasi Sukrosa terhadap Yoghurt Jagung (Zea mays L.)*. Thesis. Bandung: Pasundan University; 2007.
53. Pramono, Yoyok Budi, Nurwantoro, Masykuri, and Bambang Dwiloka. *Karakteristik Mikrobiologis, Kimia, Fisik, dan Organoleptik Yoghurt dengan Penambahan Ubi Jalar Merah*. DIPA. Semarang: Diponegoro University; 2011.
54. Schonburn, R. *The Effects of Various Stabilizers on the Mouthfeel and Other Attributes of Yoghurt*. Thesis. Florida: University of Florida; 2002.
55. Wennanda, Nadya Gama. *Pembuatan Minuman Fermentasi Ubi Jalar Merah (Ipomoea batatas) dengan Menggunakan Starter Dadih dari Berbagai Daerah di Sumatera Barat*. Thesis. Padang: Andalas University; 2012.
56. Helferich W and Westhoff. *All About Yoghurt*. New York: Prentice Hall Inc; 1980/
57. Chairunnisa, H. Penambahan Susu Bubuk Full Cream Pada Pembuatan Produk Minuman Fermentasi Dari Bahan Baku Ekstrak Jagung Manis. *Jurnal Teknologi dan Industri Pangan* 2009; **20**.
58. Pramitaningrum, Yudhi. *Pengaruh Penggunaan Beberapa Jenis Pati terhadap Karakteristik Fisikokimia dan Organoleptik Yoghurt Kental*. Thesis. Surakarta: Sebelas Maret University; 2011.
59. Winarno, FG and IE Fernandez. Susu dan Produk Fermentasinya. Bogor: M-BRIO PRESS; 2007.
60. Badaruddin, Tahmid. *Penggunaan Maltodekstrin pada Yoghurt Bubuk Ditinjau dari Uji Kadar Air, Keasaman, pH, Rendemen, Reabsorpsi Uap Air, Kemampuan Keterbasahan, dan Sifat Kedispersian*. Research Article. Malang: Brawijaya University; 2006.
61. Nugroho, E, S Tamaroh and A Setyowati. Karakteristik Mikrokapsul Probiotic *Lactobacillus plantarum* yang Dienkapsulasi dengan Susu Skim dan Gum Arab. *Jurnal Logika* 2006; **3**: 78-85.
62. Widiantoko, RK and Yunianta. Pembuatan Es Krim Tempe-Jahe (Kajian Proporsi Bahan dan Penstabil terhadap Sifat Fisik, Kimia, dan Organoleptik). *Jurnal Pangan dan Agroindustri* 2014; **2**: 54-66.
63. Badan Standardisasi Nasional. SNI 01-2983-1992. *Kopi Instan*. Jakarta: Standar Nasional Indonesia; 1992.
64. Sulaksono, Anang Catur, Sri Kumalaningsih, Wignyanto, and Imam Santoso. Production and Processing of Yoghurt Powder Using Foam -Mat Drying. *Food and Public Health* 2013; **3**: 235-239.
65. Son, S and Lewis BA. Free radical scavenging and antioxidative activity of caffeic acid amide and ester analogues: Structure-activity relationship. *J. Agric. Food Chem.* 2001; **50**: 468-472.
66. Fardiaz, Dedi, Nuri Andarwulan, Hanny Wijaya, and Ni Luh Puspitasari. *Petunjuk Praktikum Teknik Analisa Sifat Kimia dan Fungsional Komponen Pangan*. Bogor: IPB Press; 1992.