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The effect of skim milk powder on physical, chemical, and microbiology characteristics of goat milk kefir powder

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Abstract

This research was to determine the effect of skim milk powder fillers on the physical, chemical, and microbiology of goat's milk kefir powder. The benefit obtained from this research is that it can increase the diversification of fermented milk products that have a long shelf life. This research used a Completely Randomized Design (CRD) with 5 treatments and 4 replications. The treatments were P1: Addition of 0% (w/v) powder skim milk filler, P2: Addition of 2.5% (w/v) powder skim milk filler, P3: Addition of 5% (w/v) powder skim milk filler, P4: Addition of 7.5% (w/v) powder skim milk filler and P5: Addition of 10% (w/v) powder skim milk filler. The results showed that the addition of skim milk fillers has a significant effect ($P<0.05$) on yield, solubility, total dissolved solids, total acid, pH value, water content, fat carbohydrate content, and microbiological quality which has no significant effect ($P>0.05$) on viscosity, protein content and ash content. The conclusion that can be obtained is the addition of 2.5% skim milk filler is the best treatment.

1. Introduction

Kefir is a probiotic beverage produced from lactic acid-producing bacteria and yeast originating from grains that are added to milk (Safitri and Swarastuti, 2013). Kefir characteristics and yoghurt are similar, where it has a sour taste with a soda sensation caused by the alcohol produced from the fermentation of yeast. Kefir is also known as a functional food product that offers a lot of health benefits (Julianto *et al.*, 2016), especially to the digestive system. The probiotic content inside the product can improve the microflora system inside the digestive tract, and it can also help against the microbial pathogen inside the body (Dewi *et al.*, 2018). Other than that, the benefits of kefir could control cholesterol metabolism, anti-tumour, anticancer, also immunomodulatory properties that can increase the body's immunity (Prastiwi *et al.*, 2018).

Kefir is usually made with cow's milk however, the use of other types of milk such as buffalo and goat has been recently developed to further increase the value of the product. Goat milk has a relatively similar nutritional content to cow milk, with a protein content of around 4.3% compared with cow milk which is about 3.8% (Arief *et al.*, 2018). Goat milk also has a higher digestibility due to the smaller fat molecules about 3.49 mm compared to cow milk about 4.55 mm, and has a much lower lactose content of about 4.1% compared to 4.7% on cow's milk, therefore, it is safe for lactose intolerance, and it does not contain β-lactoglobulin that can cause allergy (Sawitri, 2011). Nevertheless, the drawback of goat milk is the goaty flavour that came from the volatile short-chain fatty acid like caproate acid, caprylic acid, and capric acid (Kustyawati *et al.*, 2012) which made the product less desirable. One of the ways to reduce this aroma is by fermentation such as turning goat milk into kefir products (Kinteki *et al.*, 2018).

However, the main problem for functional food products is the relatively short shelf life compared to the other food product due to the high content of moisture and microbes in the product. Kefir can be stored at room temperature which makes optimal growth of lactic acid bacteria which in the end will cause damage to the kefir product itself (Nurhidayah, 2019). Kefir damage is characterized by an unpleasant odour with the formation of two-layer inside the product and over-production of gas. The method used in order to prolong the shelf-life of kefir is storing it at a low temperature around ~4°C. Nevertheless, the disadvantage of low-temperature storage is the need for space to place the chiller or cooler unit during distribution. Another method that is considered to be efficient is by converting the product from liquid to solid state such as creating it into a

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powder product. The principle of changing a liquid-state product that is perishable to a powder state is by utilizing the heat from a drying technology to reduce the water content of the product (Kalyankar *et al.*, 2016).

Applying heat to dry the product will result in a much lower water content, which resulted in a dry product that has a long product shelf life due to the inactivity of chemical and microbiological activity (Kusumawati *et al.*, 2012). One of the drying methods that can be used to produce kefir powder is the cabinet drying method with a cabinet dryer. The benefits of using a cabinet dryer are easy to use, fast as well as controllable temperature and time that can be set according to the physical properties of the product (Jamilah *et al.*, 2019). The drying process in the production of kefir powder also has a few weaknesses, such as the high temperature that is applied to the kefir product could lower the microbial viability of lactic acid bacteria and other types of microbes, where usually the temperature used in cabinet drying technology ranges between 50-60°C (Basroni *et al.*, 2018). Drying at a high temperature can cause damage to the microbial and other compounds that are sensitive to heat which can result in lower functional properties of the resulting product. One of the ways to prevent damage due to high temperatures during the drying process is the use of encapsulants to protect the microbes and other heat-sensitive components from high temperatures.

Encapsulation is a process that must be carried out for fermented milk products to be dried, this is needed to maximize the functional properties of the powdered kefir product. Encapsulation on kefir powder can protect the cell nuclei through a semipermeable membrane, thus facilitating the process of releasing cell nuclei during rehydration under bacterial-controlled conditions (Pratana *et al.*, 2019). The core release process from the encapsulant is one of the most important things, the main mechanism mainly uses the diffusion process using a solvent, where the better the encapsulant the better the cell nuclei release will be. Encapsulant usually comes from the class of hydrocolloids with one of the most potent ingredients being skim milk.

The benefits of skim milk as an encapsulant are the ability to increase the cell viability during the drying process, thus the lactic acid bacteria that is encapsulated has the ability of fast release and high fermentation ability (Pratana *et al.*, 2019). Other than that, skim milk could create a cracked encapsulation pore thereby facilitating heat dissipation after drying and preventing the encapsulated bacteria from drying and having high viability. The encapsulation method using skim milk as a filler and encapsulant makes use of the emulsion technique. The emulsion technique can be conducted because the protein inside skim milk has a good water-binding ability (Mega, 2010). Furthermore, the addition of skim milk powder as an encapsulant might also be able to increase the overall nutritional content of the product due to its nutritional content being almost the same as regular milk. Skim milk contains all the types of nutrition in milk except fat and fat-soluble vitamins (Amar and Lutfiati, 2013).

This study aimed to determine the effect of increasing the concentration of powdered skim milk filler on the physical, chemical and microbiological characteristics of goat milk powder kefir. The benefit obtained from this research is that it can increase the diversification of fermented milk products that have a long shelf life.

2. Materials and methods

2.1 Materials

This research was conducted using a Completely Randomized Design (CRD) with five treatments and 4 repetitions to each test parameter and treatment. The materials used in this research were goat milk, kefir grains, powdered skim milk (Indoprima), distilled water, 0.85% Physiological NaCl, de Man Rogosa Sharpe Agar (MRSA) medium, Potato dextrose Agar medium, Plate Count Agar medium, NaOH 40%, concentrated H_2SO_4, HCL 0.1 N, NaOH 0.1 N, boric acid, selenium catalyst, MR and MB traps, PP indicators, pH 4 and 7 buffers, tissue and filter paper

The tools used in this research are jars, Erlenmeyer, stove and gas, pan, cabinet dryer, Beaterbar miller Maksindo FCT-Z300, mixer, pH meter, aw meter, refractometer, oven, autoclave, desiccator, furnace, Ostwald viscometer, laminar, Kjeldahl flask, distillation, destructor, burette, funnel, porcelain cup, petri dish, ash plate, test tube, bunsen, micropipette and tip, aluminium foil, analytical balance, homogenizer, measuring cup, Erlenmeyer, beaker, dropper pipette, measuring pipette, volume pipette, and suction flask.

2.2.1 Goat milk kefir manufacture

Goat milk kefir was produced refers to Ningsih *et al.* (2017). Fresh goat milk was pasteurized at 70°C for 15 s, and cooled to room temperature. The milk is then added with 5% (w/v) kefir grains, then fermented in a container or closed jar at room temperature for 24 hrs. After 24 hrs the kefir is filtered to separate the grains.

2.2.2 Addition of skim milk filler

The addition of filler was referred to Sudaryati *et al.* (2016) and Nusa *et al.* (2014). The fermented kefir was then added with powdered skim milk filler with a

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concentration of 0%; 2.5%; 5%; 7.5%; 10% (w/v) and then homogenized using a homogenizer at 12000 rpm for 2 mins until homogenous. The addition of skim milk powder after the fermentation process is to prevent it from being fermented, thus optimizing the filler and encapsulant abilities of the product.

2.2.3 Kefir drying

Kefir drying using a cabinet dryer was referred to Al -Baarri *et al.* (2016). The homogeneous kefir was then placed on a tray in the chamber cabinet dryer and then dried at 55°C for 24 hrs. After drying, the kefir was subjected to powdering with Beater bar miller Maksindo FCT-Z300 for 45 s then sieved until the particles are homogeneous.

2.2.4 Parameter analysis

2.2.4.1 Yield

Yield analysis was carried out referring to Purbasari (2019). Wet kefir was weighed before drying as initial weight, and then after drying it was weighed as final weight. The yield calculation formula is as follows:

$$Yield = \frac{Initial\ Weight}{Final\ Weight} \times 100\%$$

2.2.4.2 Solubility

Solubility parameter analysis was referred to Hartatie (2016) with modification using the principle of measuring the number of samples that were not dissolved within a predetermined period of time and conditions. Firstly, filter paper used for the solubility measurement was dried in an oven at 105°C for 10 mins and weighed. Then, 5 g kefir powder was weighed and dissolved in 50 mL of water at 60°C. The sample was then filtered with the dried filter paper. The filter paper was placed back in the oven at 105°C for 3 hrs then cooled in a desiccator and finally weighed. The solubility was calculated using the following formula:

$$Solubility = \frac{Final\ weight - Initial\ weight}{Initial\ weight} \times 100\%$$

2.2.4.3 Viscosity

The viscosity parameter analysis was referred to Harjiyanti *et al.* (2013). The empty pycnometer was firstly weighted (m). Then the rehydrated powdered kefir sample (1:10) (w/v) was added to the pycnometer and re-weighted (m') to determine its density. The sample was then tested for the flow time on the Ostwald viscometer, where the time was calculated from the upper to the lower limit. Testing was also carried out on distilled water as a control. The viscosity of the sample was calculated using the following formula:

$$\text{Viscosity} = \frac{\rho\ \text{sample} \times\ \text{t sample} \times \eta\ \text{water}}{\rho\ \text{water} \times \text{t water}}$$

$$\rho\ \text{sample} = \frac{\text{m}-\text{m}'}{\text{v}}$$

Where m': mass of empty pycnometer (g), m: mass of pycnometer + sample (g), ρ: density (g/mL) (water = 1 g/mL), v: pycnometer volume (mL), t: time (s) and η: water viscosity

2.2.4.4 Total dissolved solids

The total dissolved solids were measured using methods referring to Ismawati *et al*. (2016) using a digital handheld refractometer (Atago, Japan). The powdered kefir sample was first diluted (1:10) (w/v) and filtered. One drop of filtrate was then added onto the refractometer in duplicate, resulting in °Bx measurement.

2.2.4.5 Total acid

The total acid parameter analysis was carried out by rehydrating the sample (1:10) adding 1% PP indicator, then titrating with 0.1 N NaOH until a pink colour appeared. The total acid level was calculated using the following formula:

$$Total\ Acid = \frac{v\ NaOH \times N\ NaOH \times BE\ Lactid\ Acid\ (90)}{weight\ sample \times\ 1000} \times 100\%$$

2.2.4.6 pH value

The pH value parameter analysis was referred to AOAC (2000). Powdered kefir was rehydrated in a 1:10 ratio (w/v). The cathode of the calibrated pH meter was then inserted into the sample solution to determine the pH level of the sample.

2.2.4.7 Water content

Water content parameter analysis was referred to AOAC (2000). The porcelain cup was preheated for 1 hr at 105°C, cooled in a desiccator, and weighed (A). Approximately 2 g of powdered kefir samples were then added into the porcelain cup and weighed (B). The porcelain was then dried at 105°C for 3 hrs, cooled in the desiccator, and weighed (C). Water content was then measured by the following formula.

$$Water\ Content = \frac{B - C}{B - A} \times 100\%$$

2.2.4.8 Fat content

Fat content analysis was referred to AOAC (2000). The filter paper was dried in an oven for 1 hr before use. Then, 2 g of sample (weight A) was added to the dried filter paper, dried for 4 hrs, and weighed (weight B). The sample was then extracted using Soxhlet with N-Hexane solution for 12 hrs and dried in the oven for 1 hr. The dried extracted sample was then weighed (Weight C), and the fat content of the sample was calculated using

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the following formula.

$$Fat\ Content = \frac{B - C}{A} \times 100\%$$

2.2.4.9 Protein content

Protein content parameter analysis was referred to AOAC (2000). In a Kjeldahl flask, 0.5 g of powdered kefir, 0.5 g of selenium catalyst, and 10 mL of H_2SO_4 were added. The sample was then digested until it resulted in a yellowish-green color. The sample was distilled to 40 mL with 100 mL distilled water, 40 mL of 45% NaOH, 5 mL of 4% boric acid, and Methylene Red and Methylene Blue indicator. The distillate of both the sample and blank was then titrated with 0.1 N HCL to a dark blue-purple color. Protein content was then calculated using the following formula.

$$Nitrogen\ Content = \frac{14.008 \times (Va - Vb) \times NHCl}{w} \times 100\%$$

$$Protein = Nitrogen\ Content \times 6.78$$

Where Va: mL of HCl used for sample titration, Vb: mL of HCL used for blank titration and W: sample weight.

2.2.4.10 Ash content

Ash content parameter analysis was referred to AOAC (2000). The ash plate was dried at 105°C for 1 hr and weighed. Then, 5 g of powdered milk sample was added onto the dried plate and dried for another 4 hrs to remove moisture. The sample was then furnace at 550°C for 24 hrs, cooled down in a desiccator, and weighed.

$$Ash\ Content = \frac{final\ weight\ after\ furnace}{initial\ weight} \times 100\%$$

2.2.4.11 Carbohydrate content

The carbohydrate content analysis was conducted using the by-difference method, as indicated by the following formula:

Carbohydrate content = 100% - (% water + % fat + % protein + % ash)

2.2.4.12 Total lactic acid bacteria

Total LAB analysis was referred to Rahayu and Adriani (2018) with modifications. A total of 1 g of kefir sample was diluted with 9 mL of distilled water to a dilution of 10^{-5}. The last three dilutions of the sample were inoculated on the sterile MRSA media and incubated for 24 hrs at 37°C.

2.2.4.13 Total yeast

Total yeast analysis was referred to Prastiwi *et al.* (2018) with modifications. A total of 1 g of kefir sample was dissolved with 9 mL of 0.85% Physiological NaCl to a dilution of 10^{-3}. All dilutions were inoculated on PDA sterile media, and incubated for 24 hrs at 25°C.

2.2.4.14 Total viable bacterial count

Total viable bacterial count analysis was referred to Safitri and Swarastuti (2013) with modifications. A total of 1 g of kefir sample was diluted with 9 mL of distilled water to a dilution of 10^{-5}. All dilutions were inoculated on PCA sterile media and incubated for 24 hrs at 37°C.

2.3 Data analysis

The data were analyzed using Analysis of Variance (ANOVA) in the SPSS for Windows 25.0 application with a significance level of 5%. If there was a significant effect the analysis is continued with the Duncan Multiple Range Test (DMRT) to determine the differences between treatments.

3. Results and discussion

3.1 Physical characteristics

Based on Table 1, It can be inferred that the addition of skim milk filler to kefir powder from goat's milk had a significant effect ($P<0.05$) on the yield of the product. Yield is the ratio of the final weight to the initial weight of the product after passing through the processing process, the value of yield is expressed in percent (Dewi and Satibi, 2015). The higher the concentration of filler that has been added the higher the resulting yield of the product. The result of kefir powder's yield ranges between 13-22%. A filler is a filling substance that can increase the mass of the product (Paramita *et al.*, 2015). This increase in mass is due to the filler's ability to increase the total solid (Agustini dan Gafar, 2018). The solid ingredient is all of the material components other than water, including carbohydrates, protein, fat, vitamin, and minerals (Achmad *et al.*, 2012)

Skim milk as a filler has a high number of total solids, as it is mainly composed mostly of solids material including lactose, protein, and mineral (Trisnaningtyas *et al.*, 2013). The constituent of skim milk powder consists of 49.5-52% lactose, 34 - 37% protein, 8.2 – 8.6% ash, and 0.6 – 1.25% fat (Sawitri *et al.*, 2010). The higher yield value is due to the increase in total weight resulting from the addition of skim milk. Casein as a dominant protein in skimmed milk has a molecular weight of 8 kDa at α-casein, 33 kDa in β-casein, and 45 kDa in k-casein (Susanti and Hidayat, 2016).

The addition of skim milk powder also has a significant effect ($P<0.05$) on the solubility of the resulting product, furthermore, the higher concentration of filler added also resulted in a higher solubility. The solubility of kefir powder ranges between 31.48 - 45.08%. The solubility is the physical quality of a

Table 1. Physical analysis of goat milk kefir powder with the addition of skim milk powder.

Parameters	Skim Milk Filler Concentration				
	0%	2.50%	5%	7.50%	10%
Yield (%)	13.00±0.00^{a}	15.00±0.00^{b}	16.50±0.58^{c}	19.75±0.96^{d}	22.00±1.15^{e}
Solubility (%)	31.48±5.00^{a}	36.40±1.80^{ab}	39.94±2.70^{bc}	43.80±1.85^{c}	45.08±4.52^{c}
Viscosity (cP)	1.529±0.14^{a}	1.567±0.06^{a}	1.597±0.08^{a}	1.599±0.08^{a}	1.610±0.08^{a}

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (p<0.05).

powder product, where the higher the solubility of the product the better the quality of the resulting product. Solubility is related to the speed of particles to absorb water, the higher the solubility the higher also particles to absorb water (Affandy dan Widjanarko, 2018). The drying process will lower the moisture content of the material, this process made the product to be hygroscopic due to the particle experiencing porosity because of the evaporation of water. The hygroscopic ability is required for the dissolving process, where the more soluble the component added will increase the solubility of the resulting product. The skim milk that is used as a filler has a solubility of around 80%.

Skim milk can bind water well because it has the ability as a natural emulsifier. Emulsifiers act to lower the strains between two insoluble phases and also reduce the speed of surface strains (Amar dan Lutfiati, 2013). Kefir powder with the addition of emulsifiers such as skim milk can increase soluble power when rehydrated. Protein as an emulsifier component that dominates skimmed milk acts as an amphiphilic compound that has lipophilic and hydrophilic groups in its chain structures. The hydrophilic part contains polar clusters such as hydroxyl, carbonyl, carboxyl, amino, and sulfonyl that play a role in bonding with water and lipophilic parts such as alkyl groups functioning to bind to fat (Pratiwi *et al.*, 2018). Fat is a non-polar component that can inhibit the dissolving process, and the lipophilic group of proteins binds to this component to form a good emulsion. In addition, lactose content as a natural sugar of milk also plays a role in the dissolving process because it includes compounds that can bind to water even though the solubility is only 20% (Agustina *et al.*, 2015).

Regardless, the addition of skim milk powder doesn't give any significant differences (P>0.05) to the viscosity of the powdered kefir (Table 1). Viscosity is the resistance of fluid flow due to friction between liquid molecules (Apriani *et al.*, 2013). The higher the viscosity indicates the more viscous and also the other way. The viscosity of the rehydrated powder kefir (1:10) has a value ranging between 1,529-1,610 Cp. The higher the concentration of skim milk fillers added the higher also the viscosity of kefir powder. This is because there is a relationship between the addition of filler that can increase the total solid and its effects on the viscosity. This is according to Wijayanti *et al.* (2015) who state that the more total solid on the product the level of viscosity will increase. The Hydroxyl group in skim milk protein can easily absorb water, thus making the solid particles even bigger. The bigger the particle the bigger the friction force that occurs between particles which results in the decrease in its flowing ability (Loekitoa *et al.*, 2013). Furthermore, the hydroxyl group in skim milk powder could bind water in the molecules resulting in much less water content, therefore, decreasing the flowability and increasing the viscosity of the product.

3.2 Chemical characteristics

Based on Table 2, shows that the addition of skim milk filler of goat milk kefir powder gives a significant effect (P<0.05) on the total dissolved solids of the

Table 2. Chemicals analysis of goat milk kefir powder with the addition of skim milk powder.

Parameters	Skim Milk Filler Concentration				
	0%	2.5%	5%	7.5%	10%
Total dissolved solids (°Bx)	4.45±0.24^{a}	4.62±0.30^{ab}	4.92±0.20^{bc}	5.10±0.14^{c}	5.12±0.26^{c}
Total acid (%)	10.05±1.06^{b}	8.97±0.92^{ab}	8.52±1.00^{a}	7.99±0.92^{a}	7.80±0.83^{a}
Ph	4.50±0.1^{a}	4.65±0.09^{b}	4.69±0.09^{b}	4.70±0.09^{b}	4.73±0.08^{b}
Water content (%)	6.24±1.00^{a}	7.23±1.28^{ab}	8.39±1.03^{ab}	9.24±2.28^{bc}	11.30±2.50^{c}
Fat content (%)	34.12±0.68^{e}	29.78±0.47^{d}	26.02±0.60^{c}	23.10±0.62^{b}	21.06 ±1.20^{a}
Protein content (%)	24.53±2.72^{a}	24.81±3.94^{a}	25.52±1.52^{a}	25.92± 1.36^{a}	26.28±2.90^{a}
Ash content (%)	5.84±0.63^{a}	5.94±0.20^{a}	5.94±0.10^{a}	6.09±0.12^{a}	6.14±0.18^{a}
Carbohydrate content (%)	29.26±3.55^{a}	32.25±3.50^{ab}	34.13±2.23^{b}	35.64±0.74^{b}	35.23±2.67^{b}

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (p<0.05).

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product. The total value of dissolved solids of powdered kefir ranges from 4.45–5.12°Bx. Total dissolved solids are the number of solids or components that are soluble in water (Farikha *et al.*, 2013). Dissolved solid components include total sugar, organic acids, vitamins, proteins, pigments, and other water-soluble solids (Ismawati *et al.*, 2016). Skim milk is milk that has removed most of the cream, it leaves only solid components such as lactose, protein, minerals, and ash (Sawitri *et al.*, 2010). The higher the concentration of skim milk fillers added, the higher the total dissolved solids contained in the product. This is in accordance with Basoti *et al.* (2018) which states that the addition of filler ingredients can increase the total dissolved solids and can improve the nutrients in them.

The addition of skim milk powder to the product also gives a pretty significant result ($P<0.05$) to the total acid and pH of the product (Table 2). Total acid is the number of acids contained in food products (Angelia, 2017), whereas pH is the number of hydrogen ion (H^+) concentrations in a solution which is expressed by the value of its degree of acidity (Ngafiffuddin *et al.*, 2016). The total acid of kefir powder ranges from 7.80 – 10.05%, and the pH value of rehydrated kefir powder (1:10) ranges from 4.50–4.73. According to Hanum (2016) kefir generally has a pH of 4.6 and according to Codex STAN 243 (2003), the minimum total acid kefir is 0.6%. The higher of skim milk filler added, the lower of total titrated acid content thus resulting in an increase of pH. The total titrated acid is inversely related to the total solids (Tazar *et al.*, 2017). This happens because fillers that contain solids that are high in OH^- could mask the amount of H^+ during titration. Skim milk as an emulsifier has a group that contains a lot of OH^- which made the total acid value detected decrease due to the dominance of alkaline substances. The resulting acid is a metabolite formed during the fermentation process of kefir, lactose is broken down by grains to form lactic acid ($C_3H_6O_3$) (Afriani *et al.*, 2011). This also implies the resulting pH value, because skim milk has a high pH value ranging around 6.3-7.1 therefore it contains a lot of OH^- ions (Kethireddipalli *et al.*, 2010). The hydroxyl group (-OH) can neutralize the acidic properties of the material which can make the pH increase (Retnaningsih and Tari, 2014). The pH value is directly related to the total acid, where the lower the pH the more acidic the food material is due to the dominance of H^+ ions, while the higher the pH value the more alkaline the product.

The increased addition of skim milk powder also resulted in a significant difference ($P<0.05$) in the moisture, fat, and carbohydrate content of the product (Table 2). Water content is the amount of water in materials including bound water and free water which is expressed in percentage (Asgar *et al.*, 2013). The higher the filler added, the higher the water content. Skim milk contains hydrophilic groups in its chain structure, these groups will bind water molecules through hydrogen bonds (Rosida *et al.*, 2014). The ability to bind water is influenced by hydrophilic polar groups such as hydroxyl, carboxyl, and sulfhydryl. The average water content of the kefir powder ranges from 6.24 to 11.30%.

Hydrogen bonds are bonds that occur between hydrogen atoms and electronegative atoms such as O, F, and N atoms (Abidin *et al.*, 2012). In the water absorption process, oxygen atoms in the hydrophilic protein group will bind hydrogen atoms from the water, hence the more skim milk added the more water is bound. The drying process will evaporate more free water and leave bound water. Bound water is more difficult to evaporate because it is attached to the cell wall (Lestari *et al.*, 2020). The more skim milk filler that is added, the more bound water is tied therefore resulting in higher water content.

The fat content of the powdered kefir ranges from 21.60–34.12%. Fat is an organic compound in the lipid group that is insoluble in water (Pargiyanti, 2019). Skim milk is a type of milk where the milk fat has been removed, therefore it only contains a maximum of 1% fat (Diputra *et al.*, 2016). Powdered skim milk is a material that can bind water well because it has hygroscopic components such as lactose and protein. Due to the presence of these two components, the amount of fat bound to the lipophilic side of the protein is less than the amount of water bound by the hydrophilic component. The fat in kefir will then undergo the decomposition or breakdown of triglyceride molecules. The higher the water content, the lower the fat content because water plays a role in the fat hydrolysis process (Maulinda *et al.*, 2017), microbes can also hydrolyze fat with the help of water (Rorong *et al.*, 2008) therefore resulting in a much lower content of fat in the product. Microbes will produce lipase enzymes that can hydrolyze fat, lipase enzymes naturally come from microbes such as lactic acid bacteria or natural microbes found in milk (Sari *et al.*, 2016). The microbes in kefir powder with the addition of fillers will have more colonies because of the encapsulation of skim milk. This causes the more skim milk that is added, the lower the fat content produced.

The carbohydrate content of the powdered kefir was 29.26–36.24% (Table 2). Carbohydrates are a group of organic substances consisting of elements of carbon, hydrogen, and oxygen which function as energy sources (Siregar, 2014). Lactose is a carbohydrate found in milk (Supriyono, 2016). Lactose is a combined carbohydrate of glucose and galactose (Prihatiningsih *et al.*, 2015).

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The addition of skim milk filler makes carbohydrate content increase when compared without adding, this is because skim milk contains a high amount of lactose. The lactose content in powdered skim milk ranges from 49.5-52% (Sawitri *et al.*, 2010). The carbohydrate content is calculated method by difference, therefore it is influenced by water content, fat content, protein, and ash content, if the other components are lower, the carbohydrate content will increase and vice versa (Wulandari *et al.*, 2016). Carbohydrates are a parameter that affects food ingredients, including taste, colour, and texture.

However, even though most of the chemical parameters are affected by the addition of skim milk powder, it does not give any significant differences (P>0.05) to the protein and ash content of the product (Table 2). The average protein content of powdered kefir ranges from 24.53–26.27%, whereas the average ash content of the product ranges from 5.84–6.14%. Protein content was identified using the Kjeldahl method, which calculates the amount of protein content of the sample roughly by calculating the elemental nitrogen (N%) with the conversion factor (Purnama *et al.*, 2019). The higher the skim milk filler added, the higher the protein content produced. Skim milk is milk that has reduced or eliminated fat content therefore most of its content is leaving dry and dense ingredients such as protein (Afrizal, 2019). The protein content of skim milk ranges from 34-37% (Sawitri *et al.*, 2010) with casein dominated which is around 80% of the total protein (Amar and Lutfiati, 2013). The types of protein in goat milk kefir include α-Casein, β-Casein, Lactoferrin, and Lactoperoxidase (Aristya *et al.*, 2013).

Ash is an inorganic substance that can withstand high temperatures from the combustion of organic substances in food (Putri *et al.*, 2019). The higher the filler added, the higher the ash content produced. This is because powdered skim milk is a material consisting of 98% dry matter, the more skim milk is added, the drier substances are greyed out, therefore increasing the ash content (Afrizal, 2019). The ash content in skim milk is also quite high at 8.2-8.6%, thus increasing the inorganic substance content when added to the product (Sawitri *et al.*, 2010). Ash content is an interpretation of the amount of mineral content in a foodstuff (Antari *et al.*, 2013). The types of minerals found in goat milk include calcium, Vitamins A, E, B complex, and phosphorus (Ariestya *et al.*, 2013). Minerals are one of the parameters for determining how well food is processed, determining nutritional value, and as an indicator of what ingredients are used (Afrizal, 2019).

3.3 Microbiological characteristics

Based on Table 3, it can be inferred that the addition of skim milk filler to goat milk kefir powder has a significant effect (P<0.05) on the total Lactic Acid Bacteria, Yeast and Total Microbes of the product. The total value of powdered kefir Lactic Acid Bacteria ranged from 1.11×10^5 to 2.47×10^5 CFU/g. Lactic Acid Bacteria (LAB) are gram-positive probiotic bacteria that are useful for repairing the digestive tract and enriching the microflora in the intestine (Basroni *et al.*, 2018). The higher the skim milk filler added can increase the total lactic acid bacteria, this is related to the ability of the filler as an encapsulant. Encapsulant is a material used for the encapsulation process (Permatasari *et al.*, 2015). Encapsulation is the process of coating materials for protection from damage to active compounds (Purukan *et al.*, 2020). The optimal temperature for lactic acid bacteria ranges from 37 - 42°C (Widodo *et al.*, 2015). Encapsulation in kefir powder is useful to protect bacteria when it goes through the drying process. Encapsulation protects bacteria from extreme environments by coating the bacteria with a semipermeable polymer wall (Safitri *et al.*, 2018). Skim milk is a type of hydrocolloid. Hydrocolloid is a polymer component that can form a gel when it binds to water (Herawati, 2018).

The total value of powdered kefir yeast ranges from 3.71×10^3 to 2.66×10^4 CFU/g, this amount meets the Codex STAN 243 (2003) standard which states a minimum yeast value of 10^4 CFU/g. Yeast is a group of unicellular fungi that has benefits for the development of biotechnology, especially in the food sector (Suryaningsih *et al.*, 2018). The yeast in kefir is useful as a breakdown of lactose into simple sugars and to form alcohol creating the soda sensation on kefir. The higher the skim milk filler added, the higher the amount of yeast available in the powdered product. This is because skim milk acts as an encapsulant that can protect the yeast

Table 3. Microbiological analysis of goat milk kefir powder with the addition of skim milk powder.

Parameters	Skim Milk Filler Concentration				
	0%	2.50%	5%	7.50%	10%
Total lactic acid bacteria (CFU/g)	1.11×10^{5a}	1.33×10^{5ab}	1.38×10^{5b}	1.47×10^{5b}	2.47×10^{5c}
Total yeast and mould (CFU/g)	3.71×10^{3a}	5.30×10^{3b}	7.07×10^{3c}	1.69×10^{4d}	2.66×10^{4e}
Total viable bacterial count (CFU/g)	1.42×10^{5a}	2.24×10^{5ab}	2.34×10^{5b}	1.07×10^{7c}	1.72×10^{7d}

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different (p<0.05).

from high temperatures during the drying process. The optimum temperature for yeast ranges from 25-30°C (Siagian *et al.*, 2015). Drying utilizes high temperatures in the process, in addition to evaporating water, it also evaporates other substances such as alcohol, alcohol has a lower boiling point than water, which is 70-78°C (Arimba, 2019). During heating, the alcohol in kefir is also heated and evaporated which resulted in a much lighter soda sensation.

Total microbes are the number of live microbes that are grown on non-selective media (Yunita *et al.*, 2015). The total number of microbes in kefir is the total number of microbes that grow in the fermentation process, including lactic acid bacteria and yeast (Safitri and Swarastuti, 2013). The encapsulation process of skim milk can protect the microbes in the kefir, therefore the higher the skim milk filler added the higher the total of powdered kefir microbes produced. The total value of powdered kefir microbes ranges from 1.42×10^5 to 1.72×10^7 CFU/g, this number meets the Codex STAN 243-2003 standard where the number of microbes contributing to the fermentation process is min 10^7 CFU/g. One of the parameters that make fermented milk products spoil quickly is the presence of excess microbial growth, and the purpose of drying is to inhibit microbial growth and prolong the shelf-life of the product.

4. Conclusion

The addition of skim milk filler to goat milk kefir powder can increase yield, solubility, viscosity, total dissolved solids, pH value, water content, protein content, ash content, carbohydrate content, total lactic acid bacteria, total yeast, and total microbes, while total acid and fat content decreased. The best treatment is the addition of 2.5% skim milk filler due to the increase in resulting characteristics with a much more economical use. This indicates that the use of skim milk powder as a filler and an encapsulant to the dried kefir product can protect and maintain most of its functionality and physical characteristics. Therefore, we can conclude that the use of skim milk powder to dried kefir products is an applicable and effective technology to be implemented in order to maintain its quality during and after the drying process.

Conflict of interest

The authors declare no conflict of interest.

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