

Effect of Maltodextrin Concentration as Filler on Proximate, Physicochemical and Microbial Characteristic of Powdered Buffalo Colostrum Kefir

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Abstract - The addition of fillers in the kefir drying process serves to improve stability and enhance the physical characteristics of kefir, resulting in a high-quality kefir powder. This study was conducted to determine the effect of different concentrations of maltodextrin filler (0%, 2.5%, 5%, 7.5%, 10%) on the proximate, chemical, and microbiological properties of buffalo colostrum kefir powder using the spray dryer method. Increasing maltodextrin concentration significantly affected ($p < 0.05$) the proximate, chemical, and microbiological properties of buffalo colostrum kefir powder. Higher maltodextrin concentrations led to an increase in solubility, total soluble solids, yield, pH, total lactic acid bacteria, yeast, and total microorganisms, but caused a decrease in water content, protein content, fat content, and total acid content. The addition of maltodextrin at the highest concentration produced a yield of 24.62%, attributed to the spray dryer drying factor, and yielded yeast at 5.37 log CFU/g. This yeast result was influenced by the drying and encapsulation processes. The addition of 10% (w/v) maltodextrin was identified as the best treatment, exhibiting desired powder product properties and a yeast count within the standards of CODEX STAN 243-2003.

Keywords: buffalo, colostrum, kefir, maltodextrin, spray dry.

I. INTRODUCTION

Buffalo colostrum is the first milk produced from the mammary glands of the mother buffalo which is secreted for 1 - 3 days after the buffalo gives birth. Buffalo colostrum has a lactose content of 3.78%, fat of 10.81%, total solids of 23.93% and ash of 0.97%, where these components are contained more in buffalo colostrum than cow colostrum [1]. This colostrum contains high protein, hormones, minerals, enzymes, cell elements, and various vitamins such as vitamin β -carotene, vitamins A, E, D and B [2]. The high nutrient content makes colostrum susceptible to damage due to microbial growth. This condition can be overcome by processing buffalo colostrum into fermented products such as kefir. Kefir is made

by inoculating kefir grains into colostrum, then incubated anaerobically [3], [4].

Transforming buffalo colostrum into kefir not only prolongs its shelf stability but also enriches its nutritional and functional qualities. The synergistic interaction between lactic acid bacteria and yeast during fermentation promotes the formation of organic acids, bioactive peptides, and other metabolites with notable antioxidant and antimicrobial effects [5]. These biochemical modifications enhance digestibility, and sensory attributes. To further develop buffalo colostrum kefir into a stable, marketable product, converting it into powder form is essential. Among available preservation methods, spray drying is regarded as an efficient approach capable of maintaining microbial viability and preserving key nutrients while improving handling, storage, and incorporation into various food systems [6].

Generally, kefir drink products have a liquid form so that they still support microbial activity and the shelf life is relatively low. One way to overcome this condition is by utilizing drying methods such as spray drying. Spray drying is one of the commonly used food drying methods for the conversion of liquid food into powder economically and efficiently [7]. This method of processing kefir into powder form can maintain the probiotic content of kefir products [8]. However, drying can also cause physical and chemical damage to kefir, so it is necessary to add fillers to cover a thin layer of sensitive compounds [9], [10]. One type of filler that is often used in the food industry is maltodextrin. Maltodextrin is a modified starch product, the result of chemical or enzymatic hydrolysis with a dextrose equivalent (DE) of less than 20 [11], [12] and is one of the fillers often used in the manufacture of dried foods [13]. Maltodextrin added in the manufacturing process of powdered products can preserve compounds such as antioxidants, beta-carotene and increase the free water content of ingredients without damaging the ingredients [14]. A comprehensive evaluation of buffalo colostrum kefir in powdered form is necessary to determine its potential as a functional product. Drying processes can modify key attributes such as moisture, solubility, and acidity, which

influence product stability, sensory quality, and shelf life. Maintaining the viability of lactic acid bacteria and yeast is also critical to preserving its probiotic functionality. Therefore, assessing the physicochemical characteristics and microbial survival of buffalo colostrum kefir powder is essential to ensure its quality and efficacy as a novel dairy-based probiotic formulation.

II. MATERIALS AND METHODS

2.1 Materials

The main material used in this study was buffalo colostrum obtained from a dairy buffalo farm located in Pampangan, Palembang, Indonesia. Kefir grains were sourced from Omah Kefir, a local kefir producer in Ungaran, Central Java. Other materials included maltodextrin (DE 10–12), plastic wrap, tissue paper, heat-resistant plastic bags, aluminum foil, silica gel, Sabouraud Dextrose Agar (SDA; Merck, Germany), distilled water, physiological saline solution (0.85% NaCl), 70% ethanol, filter paper, and cotton.

2.2 Methods

The resulting buffalo colostrum kefir powder was analyzed for proximate composition (moisture, protein, and fat contents) using standard AOAC and Kjeldahl methods, physicochemical characteristics (yield, total dissolved solids, solubility, pH, and titratable acidity), and microbiological quality (total plate count, lactic acid bacteria, and yeast enumeration) following standard plate count techniques. All analyses were performed in triplicate, and the data obtained were expressed as mean \pm standard deviation.

2.3 Buffalo Colostrum Kefir Production

Buffalo colostrum kefir production was based on the best results of the first year of the study. The equipment used was sterilized using boiling water first. Frozen buffalo colostrum obtained from Pampangan, Palembang, West Sumatra was thawed by soaking in warm water at 40 °C [15]. Kefir grains obtained from Omah Kefir producer, Ungaran were added as much as 20% (w/v) of the total colostrum and put into a container containing buffalo colostrum. Next, buffalo colostrum and kefir grain were fermented at 27 °C for 36 hours. Filter the fermented kefir to separate the kefir grain and store the colostrum kefir at 4 °C until the spray drying process.

2.4 Buffalo Colostrum Kefir Drying

Drying of buffalo colostrum kefir followed Khalilian Movahhed dan Mohebbi10 with modifications. The prepared colostrum kefir was added with maltodextrin filler with different predetermined concentrations, namely 0%; 2,5%; 5%; 7,5%; and 10% (w/v), then homogenized using an Ultra

Turrax homogenizer (T-25, IKA, Germany) at a speed of 4000 – 12000 rpm until homogeneous. Buffalo colostrum kefir that had been added with maltodextrin filler was placed on a magnetic stirrer at a temperature of 40 °C with a stirring level of 2 during the spray drying process (B-290, Buchi, Switzerland). The spray drying process was carried out using Q flow at 60 mm, inlet temperature at 120 °C, outlet temperature at 65 – 75 °C, aspirator at 100%, pressure at -60 mbar, nozzle cleaner at 2, and feed at 1. The powder obtained was stored in pouch packaging with silica gel, then tested proximate, physicochemical, and microbiological.

III. PARAMETER TESTING

3.1 Proximate Analysis

The proximate composition of buffalo colostrum kefir powder was determined by analyzing its moisture, protein, and lipid contents. The determination of moisture content followed a modified gravimetric procedure as described by [16]. Approximately one gram of the sample was accurately weighed into a pre-dried porcelain crucible, which had been heated at 105 °C for one hour. The sample was then dried in an oven at 105 °C for four hours, followed by cooling in a desiccator for 15 minutes before reweighing. The drying and weighing steps were repeated until a constant mass was obtained. The percentage of moisture was calculated using the corresponding formula.

$$\text{Water Content(\%)} = \frac{\text{Weight a} - (\text{Weight b} - \text{Weight c})}{\text{Weight a}} \times 100\%$$

*a = Sample; b= After Oven; c= cup

The determination of protein content was performed using a modified Kjeldahl method as described by Rizqiati et al. (2020). The procedure commenced with a digestion step, in which 0.5 g of sample was accurately weighed and combined with 0.5 g of catalyst and 10 mL of concentrated sulfuric acid. The mixture was digested until the solution turned clear green, indicating complete decomposition of organic matter. Subsequently, the distillation stage was conducted by adding 5 mL of 4% boric acid solution containing two drops of mixed indicators (methyl red and methylene blue) into the receiving flask. The digested sample was transferred to a distillation unit, followed by the addition of 100 mL of distilled water and 40 mL of 45% sodium hydroxide solution. The released ammonia was collected in the boric acid solution and titrated with 0.1 N hydrochloric acid until a purple endpoint appeared. The total protein content was then calculated using the standard Kjeldahl formula.

$$N (\%) = \frac{(mL HCl - mL Blanko) \times N HCl \times 14.008}{\text{Weight of Sample} \times 1000} \times 100\%$$

Protein Content (%) = N (%) x Conversion Factor

Fat content analysis was conducted using the Soxhlet method, according to AOAC (2005) with modifications. Powdered buffalo colostrum kefir samples were weighed as much as 1 gram, then wrapped in filter paper and dried in an oven at 105 °C for 4 hours. The sample was put into a desiccator for 15 minutes, then weighed. The sample was dried in the oven again at 105 °C for 1 hour until a constant weight was obtained. The samples were extracted with n-hexane for 8 hours, then aerated for 30 minutes and dried in an oven at 105 °C for 1 hour. The samples were put in a desiccator for 15 minutes, then weighed. Fat content was calculated using the following formula.

Fat Content (%)

$$\text{Fat Content}(\%) = \frac{\text{Weight a} - \text{Weight b}}{\text{Weight c}} \times 100\%$$

a= after Oven; b= After Soxhlet; c= Sample

3.2 Physicochemical Analysis

The physicochemical properties of buffalo colostrum kefir powder were evaluated through analyses of yield, total dissolved solids, solubility, pH, and titratable acidity. Determination of yield followed the procedure outlined by [17]. In this analysis, the mixture of buffalo colostrum kefir and maltodextrin used as a carrier material was first weighed to obtain the initial mass of the sample. After the spray-drying process, the resulting powder was reweighed to determine the final mass. The product yield was subsequently calculated based on the ratio between the final and initial masses using the established formula.

$$\text{Yield}(\%) = \frac{\text{Final Mass of Product (g)}}{\text{Initial Mass of Product (g)}} \times 100\%$$

The measurement of total dissolved solids (TDS) was performed using a digital refractometer, following the modified procedure of [15]. Approximately 1 g of sample was accurately weighed, diluted in 20 mL of distilled water, and subsequently filtered through filter paper to obtain a clear filtrate. A few drops of the filtrate were then placed on the surface of a pre-calibrated refractometer lens, ensuring complete coverage. The TDS value was directly read from the instrument display, and the obtained reading was adjusted by the applied dilution factor. The final results were expressed in % Brix units.

The solubility of buffalo colostrum kefir powder was determined following the procedure described by [16]. Initially, a filter paper was pre-dried in an oven at 105°C for 30 minutes, cooled in a desiccator for 15 minutes, and then

weighed (b). Subsequently, 1 g of the sample (a) was dissolved in 20 mL of distilled water and filtered through the pre-weighed filter paper. The residue retained on the filter was oven-dried at 105°C for 30 minutes, cooled in a desiccator, and reweighed. The drying and weighing process was repeated until a constant mass (c) was obtained. The solubility percentage was calculated using the corresponding formula.

$$\text{Solubility}(\%) = 1 - \left(\frac{c - b}{a} \right) \times 100\%$$

The pH value of the buffalo colostrum kefir powder was measured using a digital pH meter (PC 700, Eutech Instruments, Singapore) following the procedure described by [16]. Approximately 1 g of the powdered sample was dissolved in 10 mL of distilled water, after which the electrode probe was immersed in the solution to obtain a direct pH reading from the instrument display.

Determination of titratable acidity was performed using a titrimetric method as outlined by [18]. One gram of the kefir powder was reconstituted in 10 mL of distilled water and transferred into an Erlenmeyer flask. Two drops of 1% phenolphthalein indicator were added, and the sample was titrated with 0.1 N NaOH solution until a light pink endpoint was observed. The titratable acidity was then calculated using the standard formula. Titratable Acidity (%)

$$\text{Titratable Acidity}(\%) = \frac{\text{mL NaOH} \times \text{N NaOH} \times \text{WE Lactic Acid (90)}}{\text{Weight of Sample} \times 1000} \times 100\%$$

3.3 Microbiological Analysis

The microbiological evaluation of buffalo colostrum kefir powder included the enumeration of lactic acid bacteria (LAB), yeast, and total viable microorganisms. The analysis was conducted using a modified Total Plate Count (TPC) technique as described by [19]. Approximately 2.5 g of the powdered sample was suspended in 22.5 mL of 0.85% sterile physiological saline solution to obtain the initial dilution. Subsequently, 1 mL of this suspension was serially diluted in 9 mL of saline until a 10⁻⁵ dilution was achieved. Dilutions of 10⁻³, 10⁻⁴, and 10⁻⁵ were selected for LAB and total microbial enumeration. de Man, Rogosa, and Sharpe Agar (MRSA) (Merck, Germany) was used as the selective medium for LAB, while Plate Count Agar (PCA) (Merck, Germany) served as the medium for total microbial counts. All inoculated plates were incubated under anaerobic conditions at 37 °C. The incubation time for LAB testing was 72 hours, while the incubation time for total microbial testing was 48 hours. The yeast analysis used sample dilutions of 10⁻², 10⁻³, and 10⁻⁴ and the media used was Sabouraud Dextrose Agar (SDA). Yeast tested samples were incubated aerobically at 33 °C for 120

hours. After the incubation period, 30 – 300 colonies were counted.

3.4 Statistical Analysis

Proximate, physicochemical, and microbiological analysis data of powdered buffalo kefir colostrum obtained

were analyzed using Analysis of Variance (ANOVA). This data analysis was conducted using the Statistical Product and Service Solutions (SPSS) 26.0 for Windows application at a significance level of 5%, if there was a significant effect, a further test was conducted using the Duncan's Multiple Range Test (DMRT) method to determine if there was a significant difference between treatments.

IV. RESULTS AND DISCUSSIONS

4.1 Proximate Characteristic

Table 1: Proximate Properties of Powdered buffalo colostrum kefir samples

Properties	Maltodextrin Concentration (%w/v)				
	0	2.5	5	7.5	10
Water content (%)	7.35 ± 0.91 ^a	6.72 ± 0.53 ^{ab}	6.04 ± 0.17 ^{bc}	5.86 ± 0.22 ^{cd}	5.19 ± 0.45 ^d
Protein content (%)	58.21 ± 1.08 ^a	55.42 ± 1.22 ^b	53.33 ± 0.63 ^c	46.62 ± 1.25 ^d	39.8 ± 0.87 ^c
Fat Content (%)	16.64 ± 0.86 ^a	11.56 ± 0.74 ^b	10.06 ± 0.77 ^{bc}	8.66 ± 1.68 ^c	6.30 ± 1.34 ^d

*a-d Mean values having different superscript letters on the same column differ significantly at 5% significant level (p<0,5)

The concentration of maltodextrin filler shows a significant difference (P<0.05) in the parameters of water content, protein content, and fat content in buffalo colostrum kefir powder Table 1. Buffalo colostrum kefir powder has water content values ranging from 5.19% to 7.35%, protein content ranging from 39.8% to 58.21%, and fat content ranging from 6.30% to 16.64%. Based on the research results, it can be seen that the highest values for water content, protein content, and fat content are obtained in buffalo colostrum kefir powder with the addition of 10% (w/v) maltodextrin filler. This indicates that the higher the concentration of added maltodextrin filler, the higher the values of proximate characteristics, including water content, protein content, and fat content.

The water content decreases with the increasing addition of maltodextrin filler. Maltodextrin filler has hydrophilic properties that can bind water in a material, so the more filler material added, the more water is bound [20]. During the drying process, the water content bound by maltodextrin filler evaporates more easily than the water content present in the material's tissue, causing a reduction in the water content of the product[21]. According to [22], the lower the water content of a product, the higher its quality because low water content can prevent microbial growth and extend the shelf life of the product.

The protein content decreases with the increasing addition of maltodextrin filler. Maltodextrin filler is a carbohydrate group that does not contain protein [23], so the addition of maltodextrin filler can reduce the protein content in the resulting powder product. The protein content in kefir is also influenced by the proteolytic activity of bacteria during fermentation, where this activity breaks down proteins into peptides or amino acids [24]. Similarly, like protein content, the fat content in buffalo colostrum kefir powder also decreases with the higher concentration of added maltodextrin. This is because maltodextrin can encapsulate lipids, protecting them from oxidative degradation. For instance, in the encapsulation of flaxseed oil within maltodextrin matrices, it was observed that the matrices efficiently protect lipids from oxidation [25]. This encapsulation results in a reduced apparent concentration of free or exposed lipids, thus showing a lowered lipid level in the medium.

4.2 Chemical Characteristic

Table 2: Chemical properties of powdered buffalo colostrum kefir samples

Properties	Maltodextrin Concentration (%w/v)				
	0	2.5	5	7.5	10
Yield (%)	18.88 ± 0.57 ^a	19.14 ± 1.57 ^a	19.72 ± 1.46 ^a	22.76 ± 0.67 ^b	24.62 ± 1.40 ^c
Total Dissolved Solids (°Brix)	50.75 ± 0.18 ^a	67.75 ± 0.27 ^b	70.00 ± 0.35 ^b	70.25 ± 0.13 ^b	72.50 ± 0.32 ^b
Solubility (%)	28.99 ± 1.27 ^a	33.97 ± 1.28 ^b	43.84 ± 1.83 ^c	47.39 ± 1.57 ^c	58.00 ± 1.28 ^d

pH	3.91 ± 0.00 ^a	3.92 ± 0.01 ^a	3.95 ± 0.01 ^b	3.97 ± 0.01 ^b	3.99 ± 0.02 ^c
Titration acidity (%)	4.18 ± 0.10 ^a	4.14 ± 0.38 ^a	3.90 ± 0.06 ^a	3.26 ± 0.24 ^b	2.80 ± 0.08 ^c

*^{a-c} Mean values having different superscript letters on the same column differ significantly at 5% significant level (p<0,5)

The concentration of maltodextrin filler shows a significant difference (P<0.05) in the parameters of yield, total dissolved solids, solubility, pH value, and total acidity of buffalo colostrum kefir powder (Table 2). Buffalo colostrum kefir powder has a yield ranging from 18.88% to 24.62%, total dissolved solids ranging from 50.75% to 72.50%, solubility ranging from 28.99% to 58.00%, pH value ranging from 3.91 to 3.99, and total acidity ranging from 2.80 to 4.18. Based on the research results, it can be observed that the highest values for yield, total dissolved solids, solubility, and pH are obtained in buffalo colostrum kefir powder with the addition of 10% (w/v) maltodextrin filler, while the highest value for total acidity is obtained in buffalo colostrum kefir powder without the addition of maltodextrin filler. This indicates that the higher the concentration of added maltodextrin filler, the higher the values of chemical characteristics including yield, total dissolved solids, solubility, and pH, and the lower the total acidity.

The yield value increases with the higher concentration of added maltodextrin filler. According to [26] the added filler material in a process can increase the mass of the material, so the more filler material added, the higher the yield value produced. During the drying process, the maltodextrin filler added to the material can form a solid layer, protecting sensitive materials and creating a protective barrier, leading to an increase in the mass of the material [27]. The yield value of a material is also influenced by the total dissolved solids, where a higher value of total dissolved solids can result in a higher yield value. The function of maltodextrin as an added filler material during the drying process can contribute to the formation of more total dissolved solids in the material [28].

The solubility value increases with the higher concentration of added maltodextrin filler. Maltodextrin has free hydroxyl groups that interact with water, thereby enhancing the solubility of a substance [29]. Additionally, maltodextrin has high solubility. According to [30], the higher the solubility of an encapsulating material, the faster the dissolution of the resulting microencapsulated material. The pH value increases with the higher concentration of added maltodextrin filler. According to [31], maltodextrin is an oligosaccharide compound with hydroxyl (OH) groups and a pH range of 4 - 6, so the use of this filler material can reduce and neutralize the acidic taste of the material. The pH value has an inverse relationship with the total acidity value, where a higher pH value leads to a lower total acidity value.

4.3 Microbiological Characteristic

The concentration of maltodextrin filler shows a significant difference (P<0.05) in the parameters of total lactic acid bacteria, total yeast, and total microorganisms in buffalo colostrum kefir powder (Table 3). Buffalo colostrum kefir powder has total microorganism values ranging from 5.51 to 6.26 log CFU/g, total lactic acid bacteria ranging from 4.60 to 5.17 log CFU/g, and total yeast ranging from 3.65 to 5.37 log CFU/g. Based on the research results, it can be seen that the highest values for total lactic acid bacteria, total yeast, and total microorganisms are obtained in buffalo colostrum kefir powder with the addition of 10% (w/v) maltodextrin filler. This indicates that the higher the concentration of added maltodextrin filler, the higher the values of microbiological characteristics.

Table 3: Microbiological properties of powdered bovine colostrum kefir samples

Properties	Maltodextrin Concentration (%w/v)				
	0	2.5	5	7.5	10
Total Microbes (log CFU/g)	5,51 ^a	5,20 ^a	5,62 ^a	5,82 ^a	6,26 ^a
Lactic Acid Bacteria (log CFU/g)	4,60 ^a	4,74 ^a	4,97 ^b	4,99 ^b	5,17 ^b
Yeast (log CFU/g)	3,65 ^a	3,73 ^a	4,19 ^{ab}	4,41 ^b	5,37 ^c

*^{a-c} Mean values having different superscript letters on the same column differ significantly at 5% significant level (p<0,5)

The total yeast in kefir products can be influenced by the growth of lactic acid bacteria. According to [32], yeast and lactic acid bacteria have a symbiotic relationship in fermented food and beverages, such as kefir. The metabolic processes of lactic acid bacteria produce energy that yeast can use for growth, while yeast produces essential substrates for the growth of lactic acid

bacteria, such as amino acids and vitamins [5]. Therefore, their growth has a directly proportional correlation. According to [33], the higher the concentration of added filler material, the higher the total lactic acid bacteria, leading to an increase in the total yeast value. The total yeast value in buffalo colostrum kefir powder produced meets the CODEX STAN 243-2003 standard, which states that the minimum total yeast in probiotic products should be 4 log CFU/g.

The total microorganisms present in a food product are influenced by the viability of those microorganisms. Maltodextrin, as a filler material, can sustain the viability of microorganisms in buffalo colostrum kefir powder. According to [6], the addition of maltodextrin filler in the spray drying process helps maintain the viability of microorganisms by forming a glass matrix at the beginning of the drying process, leading to increased cell stability. Consequently, there is an increase in the total microorganisms with the higher concentration of added maltodextrin.

V. CONCLUSION

The treatment of adding maltodextrin filler with different concentrations resulted in significant differences in the proximate, physicochemical, and microbiological properties of buffalo colostrum kefir powder. The best treatment in this study is the addition of 10% maltodextrin, as it exhibits desired powder product properties and meets probiotic criteria based on the total yeast count, which complies with the standards of CODEX STAN 243-2003, with a value more than 4 log CFU/g.

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