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Potential of cabinet dried powdered colostrum kefir from local Pampangan buffalo as a functional food

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ABSTRACT

Introduction: Buffalo colostrum is a functional food source rich in nutrients but is prone to microbiological spoilage. To extend its shelf life, fermentation and drying processes are essential. This study aimed to develop buffalo colostrum kefir powder from Pampangan buffalo (swamp buffalo from South Sumatra, Indonesia) colostrum by fermenting and drying it using a cabinet dryer to improve shelf life and nutritional stability. **Methods:** Buffalo colostrum was fermented with kefir grains and dried at various temperatures (40°C, 45°C, 50°C, and 55°C). **Results:** Increasing drying temperature significantly decreased moisture content, protein content, yield, total dissolved solids, solubility, and rehydration capacity. Drying at 40°C was identified as the optimal treatment, as it preserved higher protein content (49.08%), yield (31.38%), total dissolved solids (2.67%), solubility (42.75%), rehydration capacity (1.84), and total lactic acid bacteria count (1.2×10^6) while maintaining adequate probiotic viability (≥6 log CFU/g), although moisture content levels remained above the CODEX standard for milk powder. **Conclusion:** The study demonstrated that a drying temperature of 40°C was the most effective treatment for maintaining physicochemical and microbiological quality of swamp buffalo colostrum kefir powder. Further studies are required to confirm its functional food properties through direct bioactivity assessments.

Keywords: buffalo colostrum, cabinet dryer, functional food, kefir powder, temperature

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INTRODUCTION

Following the COVID-19 pandemic, there has been a significant increase in the demand for functional foods that support immune health, including probiotic-based products that help maintain microbiota balance and enhance immune function. Pampangan buffalo is a native breed of swamp buffalo originating from South Sumatra. Their husbandry represents a long-standing, intergenerational practice of utilising swamp lands, primarily for milk and meat production. Buffalo colostrum is a functional food rich in nutrients, containing 10.81% fat, 7.97% protein, 3.78% lactose, and 0.97% ash (Salar *et al.*, 2021). Buffalo colostrum is the liquid produced by buffalo cows within 1 to 3 days after calving. Due to its high nutritional content, buffalo colostrum is prone to microbial spoilage, particularly when produced in large quantities (Setyawardani, 2017). Consequently, effective processing methods are required to extend the shelf life of buffalo colostrum, including fermentation and drying processes.

Common drying techniques for fermented dairy-based products include spray drying, freeze drying, and cabinet drying. The cabinet drying method was selected for this study because it is relatively simple to apply and has lower operational costs (Chaudhary *et al.*, 2020). The purpose of using cabinet drying is to produce powdered buffalo colostrum kefir with low moisture content, which can help extend its shelf life and maintain both microbiological stability and nutritional quality (Pratama *et al.*, 2018). A low moisture content also reduces the risk of contamination, while optimal rehydration properties ensure the powdered kefir dissolves easily, making it convenient for consumption.

This study focused on the development of powdered buffalo colostrum kefir from Pampangan buffalo, with testing of various parameters such as protein content, total acidity, yield, total dissolved solids (TDS), solubility, rehydration capacity, and colour characteristics (measured using L*a*b* values). The main aim of this research is to commercialise powdered buffalo colostrum kefir using cabinet drying and to maximise the utilisation of local resources. The results of this study are expected to contribute to the development of an innovative functional food product for the community, in the post-COVID-19 period and beyond.

METHODOLOGY

Preparation of buffalo colostrum kefir

The buffalo colostrum kefir was prepared using an incubated kefir method with modifications (Rizqiati *et al.*, 2021a). The working environment and equipment were chemically and thermally sterilised using 70% alcohol and pressurised steam, respectively. The primary materials used were buffalo colostrum and kefir grains. Frozen buffalo colostrum, obtained from a farm, was thawed by immersing it in warm water at approximately 40°C. Kefir grains, at a concentration of 20% (w/w) relative to the total weight of buffalo colostrum, were added to the colostrum in a container. The mixture (buffalo colostrum and kefir grains) was then fermented at approximately 27°C for 36 hours. After fermentation, kefir grains were filtered from the buffalo colostrum kefir to halt the fermentation process and the buffalo colostrum kefir stored at approximately 4°C. The buffalo colostrum kefir was then supplemented with skim milk powder at a concentration of 10% (w/w) relative to the total weight of buffalo colostrum kefir and homogenised using a homogeniser at a speed of 10,000–12,000 rpm for eight minutes.

Buffalo colostrum kefir drying

The drying process of powdered buffalo colostrum kefir followed a modified drying method (Rizqiati *et al.*, 2021b). Powdered buffalo colostrum kefir was subjected to different temperature treatments at 40°C, 45°C, 50°C, and 55°C. The homogenised buffalo colostrum kefir was poured into a baking tray and placed in a cabinet dryer set to the appropriate temperature for 24 hours. After drying, the buffalo colostrum kefir was ground using a grinder for 60 seconds. The resulting powdered buffalo colostrum kefir was placed into vacuum-sealed plastic bags along with silica gel.

Physical analysis

The physical tests conducted in this research included yield, total dissolved solids, solubility, rehydration capacity, and colour.

The yield test used the mass comparison approach (AOAC, 1995). A sample of buffalo colostrum kefir with added skim milk filler was placed in a beaker and weighed to determine the initial mass. The sample was then dried using a cabinet dryer, then weighed; the final mass was recorded. Yield was calculated using the following formula.

$$\text{Yield } (\%) = \frac{Final\ \ Product\ \ weight\ \ (g)}{Initial\ \ Weight\ \ of\ \ product\ \ (g)} \text{ x } 100\ \ (\%)$$

The total dissolved solids (TDS) test was performed using a digital refractometer based on the modified AOAC method (AOAC, 2005). The resulting solution was placed onto the lens of a refractometer, which had been calibrated with distilled water to ensure that it covered the entire lens surface. TDS value was then displayed on the refractometer screen and recorded in terms of %Brix.

The solubility test was performed based on the AOAC method (AOAC, 2005). The procedure began by weighing 1 g of the sample (a), which was then dissolved in 20 mL of distilled water at 50°C and filtered through a filter paper that had been preheated in an oven at 105°C for 30 minutes and weighed (b). The sample was filtered through the preheated paper, and the filtrate was then further heated at 105°C for 5 hours. After heating, the sample was placed in a desiccator for 15 minutes, then weighed again (c). The filter paper was then reheated at 105°C for 1 hour until a constant weight was achieved. Solubility was calculated using the following formula.

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

The rehydration capacity test followed the method according to Palijama, Breemerr & Topurmera (2020) with modifications. The sample was centrifuged at 3,500 rpm for 30 minutes. The supernatant was carefully removed and weighed. Rehydration capacity was calculated using the following formula.

$$\text{Rehydration capacity (ml/g)} = \frac{Initial\ volume\ of\ distilled\ water\ \ (mL)\ \ - Supernatant\ Volume\ \ (mL)}{Sample\ \ \ Weight\ \ \ (g)}$$

Colour testing of the sample followed the method outlined in Atalar & Dervisoglu (2015) using colourimetric analysis, with a colour reader application. The colour analysis included measurements of the L* value (lightness), a* value (redness), and b* value (yellowness).

Chemical analysis

The chemical analysis of powdered buffalo colostrum kefir included testing for moisture content, protein content, and total lactic acid.

Moisture content analysis was conducted using the gravimetric method in AOAC (2005) with modifications. Moisture content was calculated using the following formula.

$$\text{Moisture content (\%)} = \frac{Weight\ of\ sample\ (g) - (Final\ weight\ of\ sample(g) - Cup\ weight(g))}{Weight\ of\ sample(g)} \text{x } 100\ (\%)$$

Protein content analysis was conducted using the Kjeldahl method, modified from AOAC (2005). This analysis consisted of three stages: digestion, distillation, and titration. Protein content was calculated using the following formula.

$$\text{N (\%)} = \frac{(mL\ HCl\ -\ mL\ Blank)\ \times\ N\ HCl\ \times\ Molar\ Mass\ N(14{,}008)}{Sample\ weight\ (g)\ \times\ 1000} \times\ 100\ (\%)$$

$$\text{Protein content (\%)} = \text{N (\%)} \times \text{milk conversion factor (6.38)}$$

Note: Blank solution without sample (standard solution)

Total acid content was analysed using titration method, modified from AOAC (2005). This process began by weighing 1 g of powdered buffalo colostrum kefir sample into a conical tube, followed by the addition of 10 mL of distilled water. The sample was then centrifuged at 3,000 rpm for 30 minutes. The supernatant was collected and transferred to an Erlenmeyer. Two drops of 1% phenolphthalein indicator were added to the sample, which was then titrated with 0.1 N NaOH until a light purple colour appeared. Total acid content was calculated using the following formula.

$$\text{Total acid (\%)} = \frac{ml\ NaOH\ \times\ N\ NaOH\ \times\ Molar\ Mass\ of\ Lactic\ Acid\ (90)}{Sample\ weight\ (g)\ \times\ 1000} \times\ 100\ (\%)$$

Microbiological analysis

The microbiological analysis conducted on the powdered buffalo colostrum kefir sample involved determining the total lactic acid bacteria (LAB) count. This analysis used the total plate count (TPC) method with de Man Rogosa Sharpe agar (MRSA) as the medium, following the reference ISO (1998) with modifications. The analysis began by diluting 1 g of the powdered buffalo colostrum kefir sample in 9 mL of 0.85% NaCl as the first dilution. This process was then repeated to achieve a 10^{-5} dilution. The petri dishes were incubated in an inverted position for 48 hours at 37°C. Total lactic acid bacteria count was determined using the standard plate count (SPC) method and calculated as follows.

$$\text{Total LAB (CFU/g)} = \text{Total colony} \times \frac{1}{Dilution\ factor}$$

Data analysis

Data from the physical, chemical, and microbiological tests of the powdered buffalo colostrum kefir were analysed using analysis of variance (ANOVA) with the IBM SPSS Statistic for Windows version 26.0 (IBM Corp., Armonk, New York, United States), at a 5% significance level. If significant results were obtained, further testing was conducted using Duncan's multiple range test (DMRT) to assess the significance between treatments.

RESULTS

Based on the test results in Table 1, it was observed that the various drying temperature treatments affected the chemical characteristics of the product. Drying temperature had a significant effect ($p<0.05$) on water content and protein content, while no significant effect ($p\geq0.05$) was found on total acidity.

Based on the test results in Table 2, it was observed that increasing the drying temperature also affected the physical characteristics of the product. Drying temperature had a significant effect ($p<0.05$) on yield, TDS, solubility, rehydration capacity, and the a* and b* colour values, while no significant effect ($p\geq0.05$) was observed on the L* value. The lowest L* value was observed at 55°C, with a decrease in L* value as the drying temperature increased, resulting in a product with a L* value of 91.8.

Based on the test results in Table 3, it was observed that increasing the drying temperature resulted in different microbiological characteristics of the product. However, drying temperature did not have a significant effect ($p\geq0.05$) on total LAB count.

DISCUSSION

Chemical analysis of powdered buffalo colostrum kefir

The highest values for water content, protein content, and total acidity were obtained in the powdered buffalo colostrum kefir with skim milk at a drying temperature of 40°C, with a decrease observed as the temperature increased. Higher drying temperatures led to faster evaporation, resulting in lower water content in the material (Astuti, Ray & Rahayu, 2023). According to SNI 2970 (2015), the maximum allowable water content for powdered milk is 5%.

The decrease in protein content with increasing temperature was due to denaturation and changes in amino acid composition during the drying process (Yuniati *et al.*, 2024). The protein content of the buffalo colostrum kefir with skim milk was highest at 40°C and lowest at 55°C. All treatments met the protein content requirements for kefir as specified in the CODEX Standard for Fermented Milk (CODEX STAN 243, 2003), which mandates a minimum protein content of 2.7%. Additionally, all treatments met the protein content requirements for whole milk powder as outlined in CODEX STAN 207 (1999), which specifies a minimum protein content of 34% m/m.

The total acidity of the kefir product was influenced by the kefir grains and the fermentation process (Nurwantoro, Susanti & Rizqiati, 2020). Room temperature (approximately 27°C) is the optimal incubation temperature for kefir grains during fermentation (Manurung, Rizqiati & Bintoro, 2022). The microorganisms in kefir grains are predominantly lactic acid bacteria (Prayoga, Ramona & Suaskara, 2021). As the temperature increases, the lactic acid bacteria in the kefir product undergo protein denaturation and membrane damage, leading to a reduction in total acidity (Sionek *et al.*, 2024). Therefore, the drying temperature treatment did not significantly affect total acidity ($p\geq0.05$), as the drying temperatures exceeded the optimal fermentation temperature for kefir.

Table 1. Chemical characteristics of powdered buffalo colostrum kefir at different temperatures

Parameter	*Temperature (°C)*			
	40	*45*	*50*	*55*
Water content (%)	9.8±2.1[a]	9.5±0.8[a]	6.9±1.4[b]	6.2±0.5[b]
Protein content (%)	49.1±4.6[a]	45.2±1.5[ab]	44.6±2.1[b]	43.5±3.0[b]
Total acid (%)	0.5±0.1[a]	0.5±0.1[a]	0.5±0.1[a]	0.4±0.2[a]

Values are presented as mean±standard deviation. Different superscript letters ([a], [b], [ab]) within the same row indicate significant differences between drying temperature treatments based on Duncan's multiple range test (DMRT) at $p<0.05$.

Table 2. Physical characteristics of powdered buffalo colostrum kefir at different temperatures

Parameter	*Temperature (°C)*			
	40	*45*	*50*	*55*
Yield (%)	31.4±0.8[a]	29.8±0.6[b]	29.8±0.3[b]	29.8±0.3[b]
Total dissolved solids (%)	2.7±0.4[a]	2.5±0.3[ab]	2.4±0.2[ab]	2.2±0.2[b]
Solubility (%)	42.8±2.3[a]	40.5±2.1[ab]	40.2±0.8[b]	38.2±1.3[b]
Rehydration	1.8±0.2[a]	1.6±0.2[ab]	1.4±0.3[b]	1.4±0.3[b]
L*	92.7±0.5[a]	92.6±1.4[a]	92.0±1.1[a]	91.8±1.1[a]
a*	0.5±0.2[a]	0.6±0.2[a]	0.2±0.2[b]	0.2±0.1[b]
b*	12.8±0.5[a]	11.8±0.4[b]	10.5±0.5[c]	5.5±0.2[d]

Values are presented as mean±standard deviation. Different superscript letters ([a], [b], [ab], [c], [d]) within the same row indicate significant differences between drying temperature treatments based on Duncan's multiple range test (DMRT) at $p<0.05$.

Table 3. Microbiological characteristics of powdered buffalo colostrum kefir at different temperatures

Parameter	*Temperature (°C)*			
	40	*45*	*50*	*55*
Total LAB (CFU/g)	1.2×10^{6a}	9.9×10^{5a}	9.0×10^{5a}	8.2×10^{5a}

LAB: Lactic Acid Bacteria

Values are presented as mean±standard deviation. Means within the same row followed by the same superscript letter are not significantly differences at $p\geq0.05$ according to Duncan's multiple range test (DMRT).

Physical analysis of powdered buffalo colostrum kefir

As drying temperature increased, the yield decreased due to accelerated evaporation of unbound water (Naibaho *et al.*, 2021). Higher temperatures cause structural damage to proteins, leading to the breakdown of peptide chains, amino acids, and volatile ammonia, which results in a decrease in total dissolved solids (Rizqiati *et al.*, 2021a).

The solubility of powdered buffalo colostrum kefir is influenced by the hydrophilic groups in skim milk. A higher content of hydrophilic groups in the product increases its solubility (Rizqiati *et al.*, 2021b). However, these hydrophilic

components may denature at high temperatures, causing damage and a reduction in the number of hydrophilic groups in the product, which leads to a decrease in solubility.

Rehydration capacity depends on the material's ability to absorb water and restore its original structure (Amanah, 2020). High temperatures cause chemical structural damage, thereby reducing the material's rehydration capacity. The increase in drying temperature leads to protein denaturation, which lowers the ability of proteins to bind water, making it more difficult for the product to rehydrate (Fatmah, Mulyani & Dwiloka, 2022).

The colour of a product is influenced by its L*, a*, and b* values. The brightness level of powdered buffalo colostrum kefir was affected by the drying temperature. As temperature increased, the product tended to darken. This is associated with non-enzymatic browning reactions that occur due to the rise in temperature. The Maillard reaction takes place when primary amine groups interact with reducing sugars, forming darker colours in the product, which leads to a decrease in product brightness (Lisa, Lufthi & Susilo, 2015).

The a* value indicates the red-green colour spectrum of the product. Products with ared colour have a positive a* value. The a* value remained constant across all treatments because the product did not exhibit a high red colour spectrum, thus having no significant effect on the redness value (a*) (Fiorda *et al.*, 2016). The b* value represents the blue-yellow colour spectrum of the product. Products with a yellow or yellowish colour have a positive b* value. The b* value in the product decreased due to browning reactions caused by high temperatures, which changed the yellow colour to a brownish hue (Demasta, Al-Baari & Legowo, 2020).

Microbiological analysis of powdered buffalo colostrum kefir

The total lactic acid bacteria (LAB) count decreased with increasing drying temperature, which can be attributed to heat-induced protein denaturation and disruption of bacterial cell membranes (Lopes *et al.,* 2019). Powdered buffalo colostrum kefir dried at 40°C retained LAB levels above the minimum requirement for fermented products (≥6 log CFU/g), indicating acceptable microbial viability. Higher drying temperatures have important implications for probiotic efficacy beyond numerical survival. Sub-lethal thermal stress may impair key functional properties of LAB, thereby reducing their probiotic effectiveness despite detectable viable counts.

The incorporation of fillers provided partial thermal protection by reducing direct heat exposure to bacterial cells (Diza, Aspen & Anggraini, 2020). Nevertheless, a significant reduction in total LAB counts ($p<0.05$) was still observed at drying temperatures of 40°C and 45°C, indicating that this protective effect was limited at higher temperatures. Overall, these findings highlighted that elevated drying temperatures may compromise both LAB viability and functional integrity, underscoring the importance of optimising drying conditions to preserve probiotic efficacy rather than merely meeting microbial count standards.

CONCLUSION

Different cabinet drying temperatures significantly affected the chemical, physical, and microbiological characteristics of powdered buffalo colostrum kefir. An increase in drying temperature led to reductions in moisture content, protein content, yield,

total dissolved solids, solubility, and rehydration capacity, as well as noticeable changes in product colour. Based on a comprehensive evaluation of these quality attributes, a drying temperature of 40°C was identified as the optimal treatment. Although the moisture content obtained at this temperature did not fully comply with the CODEX standard for milk powder, drying at 40°C resulted in superior overall product quality by preserving higher protein content, yield, total lactic acid bacteria (LAB) count, solubility, rehydration capacity, total dissolved solids, and more desirable colour characteristics compared with higher drying temperatures. Importantly, the LAB count at 40°C met the minimum requirement for functional fermented products, indicating adequate probiotic viability. Therefore, a drying temperature of 40°C may be considered a promising processing condition for maintaining key physicochemical and microbiological attributes of powdered buffalo colostrum kefir. However, further studies are required to substantiate its functional food properties through direct bioactivity assessments.

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Authors' contributions

Heni R, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Edi P, developed implementation of the practical techniques used in this research; Arjin N, led the data collection and statistical analysis; Retno WS, prepared the analysis results and discussion section of the manuscript; Debby G, conducted the study, data analysis and interpretation, assisted in drafting of the manuscript, and reviewed the manuscript.

Conflict of interest

All authors declare no conflict of interest.

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