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# Nutritional composition, physicochemical, microbiological, and sensory properties of flavored biofermented camel milk containing chickpea milk

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**PAPER**

## Abstract

Worldwide, the consumption of plant-based dairy alternatives has increased rapidly due to numerous positive health effects. There is very little information available about the potential use of chickpea seed milk in the manufacture of fermented camel milk (FCM). This study investigated the effect of partial replacement of camel milk (CM) with chickpea milk (ChM) at different concentrations (0%, 25%, 50%, and 75%) as a prebiotic antioxidant on the probiotic viability, nutritional composition, and physicochemical and sensory properties of bio-flavored FCM with date syrup during storage at 4°C up to 21 days. The results obtained showed that replacing CM with ChM caused a decrease in the total solids (TS), fat, and ash contents and an increase in the fiber content of the bio-flavored FCM. The replacement of CM with ChM caused a significant ($p \leq 0.05$) decrease in the values of potential of hydrogen (pH), viscosity, and acetaldehyde in the bio-flavored FCM; this decrease was proportional to the increase in the replacement rate. The total phenolic content (TPC), total flavonoids content (TFC), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) inhibition percentage of bio-flavored FCM significantly ($p \leq 0.05$) increased with the replacement of CM with ChM. Also, ChM stimulated the growth of probiotic bacteria. The amino acid (AA) content of bio-flavored FCM was enhanced by replacing CM with ChM, where nonessential AA concentrations rose from 5.158 mg/g in control bio-flavored FCM to 54.964 mg/g in bio-flavored FCM + 50% ChM samples, a 50% increase over control bio-flavored FCM. The amount of essential AAs was also higher in the bio-flavored FCM + 50% ChM samples than in the control bio-flavored FCM, rising from 6.198 mg/g in the control bio-flavored FCM to 23.009 mg/g. The sensory evaluation revealed that samples with 50% ChM were

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preferred by panelists in sensory properties. The results obtained concluded that ChM could replace CM by up to 50% to enhance the quality of bio-flavored FCM and reduce production costs.

*Keywords*: camel milk; chickpea milk; probiotic viability; sensory properties; date syrup

## Introduction

Consumers today place a high value on the nutritional and health benefits of food for the prevention of diseases linked to poor nutrition and, of course, for eating. The best option for these consumer expectations is functional food as it contains potentially healthy substances that are either present in foods naturally or are introduced as functional ingredients that have a significant impact in improving health (Atwaa *et al*., 2023; Kaur *et al*., 2022). According to previous research by Hasani *et al*. (2017), functional foods with their components provide physiological advantages such as antioxidant activity, cholesterol reduction, immunomodulation, and blood pressure lowering. Additionally, functional foods include dairy products that incorporate probiotics, prebiotics, and vitamins or that contain omega-3 fatty acids, antioxidants, and phytochemicals (Ismail *et al*., 2018). Probiotics are one of the methods applied to modify dairy products to make them more useful (Kumar *et al*., 2015).

Because of its medicinal, nutritional, and microbial properties, fermented milk is regarded as a functional dairy product, which also offers several physiological advantages, including antibacterial activity, cancer-fighting properties, reduction in cholesterol, and immune system activation (Chandan *et al*., 2017). Camel milk (CM) has a high nutritional and health value as it lacks beta-lactoglobulin, and instead contains immunity proteins such as lysozyme (an antioxidant and anti-inflammatory molecule) and aminoglobulins, where iron, potassium, and vitamins C, E, and A are all present (Atwaa *et al*., 2022a; Shahein *et al*., 2022c). CM is usually consumed either raw or after it has been soured through fermentation. However, Middle Eastern and Arab countries now have access to fresh pasteurized CM (Kaskous; Salem *et al*., 2017). In contrast to cow's milk, CM has higher free AAs and peptides (Meena *et al*., 2014). Furthermore, CM has increased metabolic activity when employed in the starter culture preparation because nonprotein-bound AAs in CM are easily digested by microbes (Mudgil *et al*., 2018). Antioxidant activity, angiotensin-converting enzyme inhibitory activity, hypocholesterolemic impact, antibacterial activity, antidiarrhea activity, and anticancer activity are a few of the health benefits of FCM (Solanki and Hati, 2018), due to which fermented dairy products are gaining more attention (Atwaa *et al*., 2022a; Atwaa *et al*., 2022b; Shahein *et al*., 2022a; Shahein *et al*., 2022d).

Date syrup (DS) is a significant source of carbohydrates, minerals, vitamins, and antioxidants (Al-Farsi *et al*., 2018). According to Jafarpour *et al*. (2017), dates have a low glycemic index when consumed alone or in combination with plain yoghurt, and also have antitumor, antioxidant, anticancer, and antimutagenic effects (Ishurd and Kennedy, 2005; Maqsood *et al*., 2020). A dose-dependent inhibition of lipid and protein oxidation by aqueous date extract has been demonstrated (Allaith, 2008). Additionally, because it offers a variety of crucial nutrients and possible health advantages, date palm may be regarded as a nearly perfect food (Ganbi, 2012). Some dairy products have been produced using DS (dibs). An earlier work by Gad *et al*. (2010) produced date juice fermented milk with high nutritional value using DS, and also employed to flavor and sweeten yoghurt (Tammam *et al*., 2013). From DS and low-fat milk, date juice yoghurt was created for a long shelf life (Jafarpour and Amirzade, 2018).

As they provide the vitamins, dietary fiber, protein, antioxidants, energy, and minerals necessary for human health, cereals and its ingredients have been recognized as functional foods (Atwaa *et al*., 2020; Charalampopoulos *et al*., 2002). According to Shahein *et al*. (2022c), cereals can be fermented using the probiotic bacteria. Chickpea (*Cicer arietinum* L.) is the second highest producing pulse in the world (Xu *et al*., 2020), having great functional qualities, such as exceptional emulsifying and foaming properties, trophic value, and broad applicability (Boukid, 2021; Lu *et al*., 2022), making it a cheap source of plant proteins (Megías *et al*., 2016). Because they include a range of plant proteins, vitamins, minerals, and vital AAs, chickpeas have a high nutritional value (Zhu *et al*., 2023). In addition to possessing antioxidant, hypoglycemic, hypolipidemic, and other probiotic properties, chickpeas and their separated constituents help in treating bronchitis, mucositis, and dyspepsia (Pittaway *et al*., 2007; Zhu *et al*., 2023). A novel food beverage with high isoflavone, protein, and carbohydrate content but no cholesterol is chickpea milk (ChM) (Wang *et al*., 2018; Zhang *et al*., 2022b). As it doesn't induce allergies like other plant-based milk, and also because it helps in reducing the environmental burden of livestock farming, ChM has drawn significant attention (McClements, 2020; Sim *et al*., 2020).

In recent decades, the enhancement of dairy products by incorporating plant-derived by-products or

natural compounds to create functional foods has attracted increasing attention (Atwaa *et al*., 2022b; Atwaa *et al*., 2022c; Shahein *et al*., 2022b; Shahein *et al*., 2022c; Shahein *et al*., 2022d; Shahein *et al*., 2022e; Shahein *et al*., 2022f; Shahein *et al*., 2022g; Shahein *et al*., 2023; Swelam *et al*., 2021; Zommara *et al*., 2022). Nutritious plant-based protein drinks, including legume milk, are currently gaining popularity due to the promotion of environmental sustainability and health awareness (Zhang *et al*., 2022b). Compared to their dairy equivalents, these plant-based dairy substitutes have a reputation for having "health ingredients" that enhance food safety, minimize allergens, improve nutrient profiles, and reduce lactose intolerance (Mäkinen *et al*., 2016). The traditional method for creating yoghurt still leaves some flaws in plant-based products, such as a disagreeable odor and insufficient phytochemical ingredients. Nevertheless, they could be changed to make them more palatable (Sim *et al*., 2020). Therefore, it may not be in the best interest to use the formulas of traditional legume milk products for plant-based systems; further research should be conducted for enhancing flavor and quality. According to a review of the literature, there is no information about the potential effects of incorporating ChM into the production of FCM. The aim of this study was to investigate the impact of incorporating ChM into biofermented CM manufacture and to fortify different proportions regarding its functional properties.

## Materials and Methods

### Materials and reagents

The Desert Research Centre in Dokki, Egypt, provided fresh CM in bulk. The Ministry of Agriculture and Land Reclamation in Giza, Egypt, responsible for the Crops Research Institute, provided the chickpea seeds for this study. In Zagazig, EL Sharkia Governorate, Egypt, a local market sold DS, which was purchased from the institute. All extraction and analysis solvents utilized were of the analytical variety. Sigma (St. Louis, MO, USA) supplied the folin-Ciocalteu, gallic acid, and 2,2-diphenyl-1-picrylhydrazyl (DPPH). Starter cultures containing *Bifidobacterium bifidum* B-12 as a probiotic strain and *Streptococcus salivaris ssp. thermophillus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* as yoghurt starters were used in this study, which were obtained from Hansen's Laboratories Copenhagen/Denmark.

### Experimental procedure

#### *Preparation of chickpea milk*

Chickpeas were left to soak at room temperature for a whole night before being mashed into ChM. Chickpeas and water have a mass-to-volume ratio of 1:9 (w/v). The ChM was procured and sterilized for 12 minutes at 100°C.

#### *Preparation of biofermented camel milk*

Biofermented CM was produced according to the procedure described by Tamime and Robinson (2007). Raw CM was divided into four equal portions: the first served as the control (C), the second was mixed with 25% ChM (T1), the third was mixed with 50% ChM (T2), and the fourth was mixed with 75% ChM (T3). All treatments were flavored with 6% DS and homogenized at 55–60°C for two minutes. To ensure complete homogeneity between CM and plant-based milk, both were thoroughly mixed and homogenized using a high-speed mixer (KYHOPE High Speed Dispersion Homogenizer Lab Mixer, 10–1000 mL, 22,000 rpm, 185W, Japan), pasteurized in water bath for 15 seconds, and then cooled to 40°C. Each sample was injected with 2% yogurt starter culture comprising *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. The starter culture was dissolved in 50 mL of sterilized skimmed milk (autoclaved at 121°C for 15 minutes) and rated at 50 U per 250 L. It was activated at 42°C for 15 minutes before use. Additionally, a 5% *Bifidobacterium bifidum* probiotic culture was prepared by dissolving 45 mg of freeze-dried culture in 50 mL of milk with 10% TS. This mixture was sterilized by autoclaving at 121°C for 20 minutes. After preparation, 1.0 mL of the preculture was added to 500 mL Erlenmeyer flasks containing 250 mL skimmed milk. This mixture was thoroughly homogenized and activated at 42°C for 30 minutes. Finally, the samples were incubated at 37°C until complete coagulation, typically achieved within 12 hours. The resulting curd was stored for 21 days at 5 ± 1°C in 100 g plastic bottles after being mixed using an electric mixer (Moulinex LM2411EG Blender—400W, 1.25 L, Grinder, Stick). The refrigerator used was a Toshiba Model GR-EF37.

#### *Examination of physicochemical properties*

According to accepted procedures, samples of FCM were examined for TS, fat, total protein, ash, fiber content, and acidity values (Horwitz, 2010). Using a laboratory potential of hydrogen (pH) meter with a glass electrode (HANNA, Instrument, Portugal), the pH fluctuations in the samples were monitored. The presence of acetaldehyde was determined (Lees and Jago, 1969). According to Aryana (2003), the Rotational Viscometer Type Lab Line Model 5437 was used to calculate viscosity. After 15 seconds, measurements were made at a temperature of 30°C and the findings were expressed in centipoise (cP).

#### *Determination of mineral contents*

As described earlier by Bhinder *et al*. (2020), an atomic absorption spectrophotometer (iCE$^{TM}$ 3400, Agilent Technologies, USA) was used to estimate the mineral content of FCM, ChM, and DS. In a nutshell, the sample (1 g)

was combined with 2.5 mL (1 N) of nitric acid after being burned at 600°C in a porcelain crucible. The combination was filtered and Milli-Q water was used to adjust the filtrate's volume to 100 mL. The resulting solution's mineral content (mg/kg DWB [dry weight basis]) was then determined. The reference solution of minerals was used to calibrate the sensor.

*Determination of total phenolic content*

Using the Folin-Ciocalteu method described by Singleton *et al*. (1999), the TPC of the samples was determined. As previously described by Kaur *et al*. (2021), sample extract (100 µL), deionized water (4.8 mL), and Folin-Ciocalteu reagent (300 µL) were combined and incubated for 8 minutes in an amber glass tube. The mixture was vortexed, and then 20% sodium carbonate ($Na_2CO_3$) of 900 µl was added and maintained at 40°C for 30 minutes. A ultraviolet-visible (UV-VIS) spectrophotometer (Beckman DU 640B, Nyon, Vaud, Switzerland) was used to detect the mixture's absorbance at 765 nm, and the TPC of the sample was calculated as milligrams of gallic acid equivalent (GAE) per gram of DWB (mg GAE/g DWB).

*Determination of total flavonoids content*

The method described by Heimler and Cimato (2002) was used to assess the total flavonoids content (TFC) (free and bound extracts). As stated by Kaur *et al*. (2021) and Bhinder *et al*. (2019), sample extract (250 µL), deionized water (1.25 mL), and sodium nitrite (5%, 75 µL) were combined and allowed to react in an amber glass tube for 6 minutes. Following the addition of 150 µL of $AlCl_3H_2O$ (10%), the mixture was incubated for 5 minutes and then 2.5 mL of deionized water was added, followed by an addition of 0.5 mL of sodium hydroxide (NaOH) (1 M) and 275 µl of ethanol. A UV-VIS spectrophotometer (Beckman DU 640B, Nyon, Vaud, Switzerland) was used to detect the solution's absorbance at 510 nm, and the sample was reported in milligrams of quercetin equivalent (QE) per gram of DWB (mg QE/g DWB).

*Estimation of DPPH radical scavenging activity*

The method used to assess the stable (DPPH) radical's scavenging activity was performed as described by Lim and Quah (2007) and Miliauskas *et al*. (2004). In various dilutions, 2 mL of 0.15 mM DPPH was added to 1 mL of extracts. Then, 1 mL of methanol and 2 mL of DPPH were combined to create a control. After mixing the contents of the tubes and letting them stand for 30 minutes, an English-made spectrophotometer (Pg T80+) was used to measure the absorbance at 517 nm. The chickpea extract was produced in triplicate tubes. The outcome was expressed as a percentage of radical scavenging activity.

$$\text{Radical scavenging activity \%} = \frac{\text{A control} - \text{A sample}}{\text{A control}} \times 100$$

*Determination of amino acids*

According to Bhinder *et al*. (2020), the AAs of the samples were calculated using an high-performance liquid chromatography (HPLC) (LC-30 AD Shimadzu) system outfitted with a C18 column (4.6 mm, 250 mm, 5 µm) and fluorescence detector. In summary, a 100 mg sample was hydrolyzed with 6 N HCl for 24 hours at 110°C in a closed vessel system under anaerobic conditions. Prior to injection into the HPLC system, the AAs in the samples were derivatized using o-phthaladehyde, 9-fluorenylmethyl chloroformate, and mercaptopropionic acid. As described by Kaur *et al*. (2021), the gradient conditions for the mobile phase composed of methanol, acetonitrile, water (40:45:15 v/v/v) and a 20 mM/L phosphate buffer were followed. The flow rate and column temperature were set to 1 mL/minute and 40°C, respectively. The peaks were analyzed at 254 nm using 5.54SP 5 LAB Solutions software. To validate the procedure, the AA standard mixture (Thermo Scientific, NCI0180) was employed. As described by Bhinder *et al*. (2020), the AA concentrations were expressed in mg/100 g DWB. This standard mixture was utilized to ensure the accuracy of the procedure, allowing for reliable determination of AA concentrations in the sample.

*Sensory evaluation*

According to Tamime and Robinson (2007), all therapies made with FCM underwent organoleptic evaluation after being stored in the refrigerator for 1 day and 21 days. Samples were given a 50-point flavor rating, a 30-point consistency rating, and a 20-point appearance rating. A group of 10-trained panelists, ranging in age from 25 to 30, conducted the sensory examination. The samples were sealed in bags and given a three-digit code. The panelists were then shown the encoded samples in a tray and given plain water to rinse their palates after assessing each sample before going on to the next.

*Microbiological examinations*

Each sample was diluted as needed after being added to 9.0 mL of 0.85% sterile saline (sodium chloride) in 1.0 mL. To count the microorganisms, the traditional pour plate method was used. The procedure previously published by Salfinger and Tortorello (2015) was used to count the total number of bacteria in samples of probiotic FCM. Bifidobacterium agar was used for plate counts of *B. bifidum*, which were incubated anaerobically at 37°C for 72 hours. Plates containing between 30 and 300 colonies were used for the microbiological counts and the results were expressed as the logarithm of the number of colony-forming units per milliliter (Log cfu/mL).

*Statistical analysis*

One-way analysis of variance (ANOVA) was used to compare data between treatment groups. This was followed by the least significant difference (LSD) test.

Data were expressed as mean ± SD and analyzed using Statistics version 9 (http://www.statistix.com/freetrial.html; accessed on June 20, 2023). When the LSD was greater than 5%, the treatment means were deemed significantly different. Each treatment was replicated three times.

## Results and Discussion

### Nutritional composition of camel milk, chickpea milk, and date syrup

The chemical composition of CM, ChM, and DS are illustrated in Table (1). TS, protein, fat, ash and fiber contents of CM were 11.86 g, 3.42 g, 3.55 g, 0.75 g, and 0.0 g/100 g, respectively. These results are in agreement with the data obtained by Shahein *et al*. (2022e) who found that TS, protein, fat, ash, and fiber contents of CM were 11.42%, 3.26%, 3.18%, 0.72%, and 0.0 %, respectively. In this work, TS, protein, fat, ash, and fiber contents of ChM were 9.78 g, 3.72 g, 0.32 g, 0.28 g, and 4.20 g/100 g, respectively. These results are in agreement with the data obtained by Vallath *et al*. (2021) who found that the contents of ChM were 9.37 g, 4.20 g, 0.26 g, 0.25 g, and 3.98 g/100 g, respectively, and that of DS were 80.94 g, 1.48 g, 0.75 g, 2.33 g, and 2.72 g/100 g, respectively. These results are in agreement with the data obtained by Shahein *et al*. (2022e) who found that TS, protein, fat, ash, and fiber contents of DS were 80.42 g, 1.76 g, 0.98 g, 2.08 g, and 2.44 g/100 g, respectively. Sodium (Na), potassium (K), and iron (Fe) contents of CM were 71.20 mg, 174.50 mg, and 0.42 mg/100 g, respectively; these results are in line with those obtained by Aludatt *et al*. (2010), who reported that Na, K, and Fe contents of CM ranged from 217.9 mg to 488 mg, from 1106 mg to 19,895 mg, and from 0.42 mg to 3.46 mg/100 g, respectively. Na, K, and Fe contents of ChM were 15.30 mg, 42.60 mg, and 0.54 mg/100 g, respectively; these results are in the line with those obtained by Duarte *et al*. (2022), who reported that Na, K, and Fe contents of ChM were 14.20 mg, 35.23 mg, and 0.36 mg/100 g, respectively and those of DS were 86.14 mg, 290.24 mg, and 6.04 mg/100 g, respectively. These results align with those obtained by Shahein *et al*. (2022e), who found K, Na, and Fe contents of DS were 272.36 mg, 78.62 mg, and 4.78 mg/100 g, respectively. The TPC, TFC, and DPPH inhibition (percentage) of CM were 7.02 mg, 0.65 mg/100 g, and 8.70%, respectively; these results are in the line with those obtained by Shahein *et al*. (2022e), who found that TP,TF, and DPPH inhibition (percentage) of CM were 6.34%, 0.42%, and 5.24%, respectively. Moreover, TP, TF, and DPPH inhibition (percentage) of ChM were 6.34%, 0.42%, and 5.24%, respectively. These results agree with those obtained by Zhang *et al*. (2022a), who found that ChM had a high TPC, TFC, and DPPH inhibition (percentage) and those of DS were 280.50%, 13.35 mg/100g, and 75.20%, respectively. These results are in line with those obtained by Farahnaky *et al*. (2018), who found that TPC, TFC, and DPPH inhibition (percentage) of DS were 453.04 mg/100 g, 11.93 mg/100 g, and 68.20%, respectively, and those found by Shahein *et al*. (2022e) were 472.14 mg/100 g, 16.52 mg/100 g, and 72.84%, respectively. From the results presented in Table 1, it is noted that DS showed the highest content of TS by 80.94% while ChM showed the lowest by 9.78%. In terms of protein content, ChM showed the highest protein content (3.72%), followed by CM (3.42%), and finally DS (1.48%). In terms of fat content, CM showed the highest fat content compared to ChM and DS. As for ash content, DS showed the highest ash content, while ChM showed the highest fiber content compared to DS and CM. In terms of Na, K, and Fe content, DS showed the highest value compared to ChM and CM and also gave the highest TPC, TFC, and DPPH inhibition (percentage), followed by ChM, and finally CM.

### Chemical composition of the bio-flavored fermented camel milk containing chickpea milk

Table 2 shows the effect of partial replacement of CM with ChM on the chemical composition of the bio-flavored FCM. The results revealed that by replacing CM with ChM, there was a significant decrease in the TS content in the bio-flavored FCM; this was due to a decrease in the TS content of ChM compared to CM (Table 1). The percentage of TS increased in all treatments by increasing the storage period until the end of the storage period. As for the fat content, it was noted that by replacing the CM with ChM, there was a significant ($p \leq 0.05$) decrease in the fat content of the bio-flavored FCM. The fat content increased nonsignificantly in all treatments by increasing the storage period. As for the protein content, it was noted that by replacing the CM with ChM, there were no significant differences in the protein content of the bio-flavored FCM due to the closeness of the fat content of ChM compared to CM (Table 1). The protein content nonsignificantly decreased in all treatments with an increase in the storage period. Regarding the ash content, it was noted that by replacing the CM with ChM, there were nonsignificant decrease in the ash content of the bio-flavored FCM due to the closeness of the ash content to ChM compared to CM (Table 1). The ash content significantly ($p \leq 0.05$) increased in all treatments by increasing the storage period. Referring to the fiber content, it was noted that a significant ($p \leq 0.05$) increase in the fiber content of the bio-flavored FCM was proportional to the increase in the replacement ratio due to the high fiber content of ChM compared to CM (Table 1). The fiber content increased ($p \leq 0.05$) gradually in all treatments by increasing the storage period. Generally, replacing CM with ChM caused a decrease in

**Table 1. Comparison of the nutritional composition of camel milk, chickpea milk, and date syrup.**

| Components (%) | Camel milk | Chickpea milk | Date syrup |
|---|---|---|---|
| Total solids | 11.86 ± 0.42$^{C}$ | 9.78 ± 0.74$^{B}$ | 80.94 ± 2.32$^{A}$ |
| Protein | 3.42 ± 0.10$^{B}$ | 3.72 ± 0.22$^{A}$ | 1.48 ± 0.13$^{C}$ |
| Fat | 3.55 ± 0.12$^{A}$ | 0.32 ± 0.02$^{C}$ | 0.75 ± 0.06$^{B}$ |
| Ash | 0.75 ± 0.04$^{B}$ | 0.28 ± 0.06$^{C}$ | 2.33 ± 0.05$^{A}$ |
| Fiber | 0.00$^{C}$ | 4.20 ± 0.85$^{A}$ | 2.72 ± 0.30$^{B}$ |
| Minerals (mg/100 gm ) | | | |
| Na | 71.20 ± 3.80$^{B}$ | 15.30 ± 1.60$^{C}$ | 86.14 ± 4.03$^{A}$ |
| K | 174.50 ± 9.10$^{B}$ | 42.60 ± 2.14$^{C}$ | 290.24 ± 12.2$^{A}$ |
| Fe | 0.42 ± 0.05$^{C}$ | 0.54 ± 0.04$^{B}$ | 6.04 ± 0.66$^{A}$ |
| Phytochemical properties | | | |
| TPC mg/100 g | 7.02 ± 0.70$^{c}$ | 11.40 ± 1.45$^{B}$ | 280.50 ± 7.14$^{A}$ |
| TFC mg/100 g | 0.65 ± 0.05$^{C}$ | 9.20 ± 0.96$^{B}$ | 13.35 ± 1.60$^{A}$ |
| DPPH inhibition (%) | 8.70 ± 1.03$^{C}$ | 36.70 ± 1.32$^{B}$ | 75.20 ± 3.02$^{A}$ |

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$).

the TS, fat, and ash contents and an increase in the fiber content of the bio-flavored FCM. This can be attributed to the chemical composition of ChM, which demonstrates reduced levels of TS, fat, and ash compared to CM (Shahein *et al*., 2022e; Vallath *et al*., 2021). The same results were observed when a portion of cow's milk was replaced by ChM in yoghurt drinks fortified with ChM by Aguilar-Raymundo and Vélez-Ruiz (2019) where the result was a decrease in the TS content.

## Physiochemical proprieties of the bio-flavored fermented camel milk containing chickpea milk

The effect of partial replacement of CM with ChM on the pH, acidity, viscosity values, and acetaldehyde content of bio-flavored FCM is shown in Table 3. Data indicated that replacing CM with ChM caused a significant ($p \leq 0.05$) decrease in the values of pH, viscosity, and acetaldehyde in the bio-flavored FCM; this decrease was proportional to the increase in the replacement rate. On the first day, the titratable acidity (TA) values for control bio-flavored FCM (C), bio-flavored FCM + 25% ChM (T1), bio-flavored FCM 50% ChM (T2), and bio-flavored FCM + 75% ChM (T3) were 0.80, 0.88, 0.92, and 0.97, respectively; however, these values experienced a significant increase ($p \leq 0.05$) after 21 days of storage period and reached 0.95, 1.06, 1.12, and 1.18, respectively. Clearly, the increase in acidity values in the treatments in which CM was replaced with ChM may be due to the fact that ChM contains compounds such as dietary fiber which act as prebiotics stimulating the starter culture (Hussein *et al*., 2020). During the 21 days of storage, the pH values of all bio-flavored FCM treatments dramatically declined ($p \leq 0.05$) while the acidity significantly rose ($p \leq 0.05$) as the storage duration extended. The starter culture type, lactic acid conversion to lactose, storage time, and temperature of fermentation could all contribute to pH drop during storage. Additionally, switching from CM to ChM revealed a substantial ($p \leq 0.05$) increase in the viscosity of the end products. This could be because ChM increased the fiber content of bio-flavored FCM, which altered the structure of the material and enhanced viscosity by attaching to water molecules. Acetaldehyde is regarded as one of fermented milk's flavoring ingredients. It is evident from Table 3 that replacing CM with ChM caused a decrease in the values of acetaldehyde; this may be the result of replacement of CM with ChM, the latest decrease in the percentage of fat in the bio-flavored FCM and thus a decrease in the acetaldehyde content. The ability of lactic organisms to hydrolyze acetaldehyde and diacetyl into acetone may be the cause of the significant ($p \leq 0.05$) drop in acetaldehyde values that was observed over the storage period. These results are in agreement with those reported by Aguilar-Raymundo and Vélez-Ruiz (2019), who observed that the production of yoghurt-type beverage with partial substitution of milk by a ChM caused a significant increase in the acidity and viscosity of yoghurt.

## Mineral contents of the bio-flavored fermented camel milk containing chickpea milk

Both organic and inorganic salts are found in milk. The stability of milk and milk products is significantly

**Table 2. The effect of partial replacement of camel milk with chickpea milk on the chemical composition of the bio-flavored fermented camel milk during the cooled storage period.**

| Storage period (days) | Treatments | | | |
|---|---|---|---|---|
| | C | T1 | T2 | T3 |
| Total solids (%): LSD = 0.2695 | | | | |
| 1 | 16.86 ± .12$^{B}$ | 16.00 ± .14$^{CD}$ | 15.0 ± .18$^{GH}$ | 14.5 ± .22$^{I}$ |
| 7 | 16.98 ± .35$^{B}$ | 16.32 ± .12$^{C}$ | 15.24 ± .14$^{FG}$ | 14.78 ± .25$^{HI}$ |
| 14 | 17.40 ± .13$^{A}$ | 16.80 ± .12$^{B}$ | 15.84 ± .15$^{DE}$ | 15.22 ± .16$^{FG}$ |
| 21 | 17.62 ± .24$^{A}$ | 16.96 ± .15$^{B}$ | 16.08 ± .18$^{CD}$ | 15.50 ± .15$^{EF}$ |
| Fat (%):LSD = 0.2844 | | | | |
| 1 | 3.25 ± .11$^{B}$ | 2.55 ± .12$^{C}$ | 1.80 ± .14$^{F}$ | 1.05 ± .12$^{H}$ |
| 7 | 3.30 ± .65$^{AB}$ | 2.60 ± .65$^{C}$ | 1.94 ± .62$^{EF}$ | 1.24 ± .66$^{GH}$ |
| 14 | 3.48 ± .28$^{AB}$ | 2.74 ± .28$^{C}$ | 2.18 ± .25$^{DE}$ | 1.35 ± .24$^{G}$ |
| 21 | 3.55 ± .23$^{A}$ | 2.80 ± .26$^{C}$ | 2.25 ± .28$^{D}$ | 1.42 ± .22$^{G}$ |
| Protein (%): LSD = 0.2664 | | | | |
| 1 | 3.34 ± .52$^{AB}$ | 3.38 ± .55$^{AB}$ | 3.44 ± .50$^{AB}$ | 3.48 ± .55$^{A}$ |
| 7 | 3.25 ± .14$^{AB}$ | 3.32 ± .16$^{AB}$ | 3. 38 ± .14$^{AB}$ | 3.42 ± .15$^{AB}$ |
| 14 | 3.20 ± .65$^{AB}$ | 3.26 ± .64$^{AB}$ | 3.33 ± .62$^{AB}$ | 3.38 ± .64$^{AB}$ |
| 21 | 3.16 ± .15$^{AB}$ | 3.20 ± .16$^{B}$ | 3.26 ± .14$^{AB}$ | 3.30 ± .12$^{AB}$ |
| Ash (%): LSD = 0.0428 | | | | |
| 1 | 0.86 ± .12$^{EFG}$ | 0.84 ± .11$^{FGH}$ | 0.80 ± .13$^{HI}$ | 0.78 ± .12$^{I}$ |
| 7 | 0.95 ± .08$^{C}$ | 0.88 ± .06$^{DEF}$ | 0.84 ± .07$^{FGH}$ | 0.82 ± .08$^{GHI}$ |
| 14 | 1.02 ± .07$^{B}$ | 0.92 ± .08$^{CD}$ | 0.88 ± .06$^{DEF}$ | 0.86 ± .10$^{EFG}$ |
| 21 | 1.15 ± .04$^{A}$ | 0.96 ± .04$^{C}$ | 0.92 ± .03$^{CD}$ | 0.90 ± .08$^{DE}$ |
| Fiber (%): LSD = 0.0665 | | | | |
| 1 | 0.18 ± .04$^{L}$ | 1.20 ± .04$^{I}$ | 2.24 ± .05$^{F}$ | 3.32 ± .03$^{C}$ |
| 7 | 0.22 ± .02$^{KL}$ | 1.25 ± .03$^{HI}$ | 2.28 ± .02$^{EF}$ | 3.40 ± .02$^{B}$ |
| 14 | 0.28 ± .03$^{JK}$ | 1.32 ± .05$^{GH}$ | 2.34 ± .03$^{DF}$ | 3.45 ± .04$^{AB}$ |
| 21 | 0.30 ± .04$^{J}$ | 1.36 ± .02$^{G}$ | 2.38 ± .04$^{D}$ | 3.52 ± .03$^{A}$ |

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$). Each fermented milk sample underwent a triplicate analysis after each experiment was carried out in triplicate. LSD, the smallest difference; C, control bio-flavored fermented camel milk; T1, bio-flavored fermented camel milk + 25% chickpea milk; T2, bio-flavored fermented camel milk + 50% chickpea milk; T3, bio-flavored fermented camel milk + 75% chickpea milk.

impacted by the interaction of all the minerals with milk proteins, which are dispersed between soluble and colloidal phases (Mehta, 2015). Table 4's findings demonstrate that the bio-flavored FCM's Na and K contents were considerably ($p \leq 0.05$) reduced as a result of the partial replacement of CM with ChM. These outcomes may be related to the greater amounts of Na, K, and Fe in ChM compared with CM as well as the higher levels of Na, K, and Fe in CM (Duarte *et al*., 2022; Shahein *et al*., 2022e). Values of Na, K, and Fe content of all bio-flavored FCM considerably increased as the storage period progressed. These results are in agreement with El-Karmany *et al*. (2013), who reported that the addition of chickpea flour to yoghurt milk significantly increased the Fe content of the resultant yoghurt.

## Phytochemical properties of the bio-flavored fermented camel milk containing chickpea milk

Plant phytochemicals called polyphenols are utilized to prevent several disorders. Stronger free radical inhibition and significant antioxidant activity are demonstrated by greater polyphenol content (Yu *et al*., 2021). The antioxidant activity is taken into account, which depends on the purity of the active chemicals, the test system, and the substrate that the antioxidant is intended to protect (Terpinc *et al*., 2012). Results presented in Table 5 show TPC, TFC, and DPPH inhibition (percentage) of bio-flavored FCM treatments. As shown, the TPC, TFC, and DPPH inhibition (percentage) of control bio-flavored FCM on the first day were 24.50 mg/100 g, 1.45 mg/100 g,

**Table 3. The effect of partial replacement of camel milk with chickpea milk on the pH, acidity, viscosity values, and acetaldehyde of bio-flavored fermented camel milk during cooled storage period.**

| Storage period (days) | Treatments | | | |
|---|---|---|---|---|
| | C | T1 | T2 | T3 |
| pH – LSD = 0.0268 | | | | |
| 1 | 4.51 ± .02$^{A}$ | 4.48 ± .03$^{AB}$ | 4.44 ± .02$^{B}$ | 4.40 ± .04$^{C}$ |
| 7 | 4.48 ± .07$^{AB}$ | 4.42 ± .02B$^{C}$ | 4.35 ± .03$^{D}$ | 4.30 ± .03$^{E}$ |
| 14 | 4.36 ± .14$^{D}$ | 4.32 ± .03DE | 4.28 ± .04$^{EF}$ | 4.22 ± .02$^{F}$ |
| 21 | 4.28 ± .18$^{EF}$ | 4.18 ± .05G | 4.14 ± .05$^{H}$ | 4.10 ± .04$^{I}$ |
| Acidity (as lactic acid %): LSD = 0.2181 | | | | |
| 1 | 0.86 ± 0.05$^{DE}$ | 0.88 ± 0.03$^{CDE}$ | 0.92 ± 0.06$^{BCD}$ | 0.97 ± 0.04$^{ABCD}$ |
| 7 | 0.90 ± .06$^{BCDE}$ | 0.94 ± 0.05$^{ABCD}$ | 0.98 ± 0.05$^{ABCD}$ | 1.06 ± 0.06$^{ABCD}$ |
| 14 | 0.96 ± .10$^{ABCD}$ | 1.0 ± 0.04$^{ABCD}$ | 1.05 ± 0.04$^{ABCD}$ | 1.14 ± 0.05$^{AB}$ |
| 21 | 1.02 ± .12$^{ABCD}$ | 1.06 ± 0.05$^{ABCD}$ | 1.12 ± 0.05$^{ABC}$ | 1.18 ± 0.03$^{A}$ |
| Acetaldehyde (µg/100 g): LSD = 1.4025 | | | | |
| 1 | 32 ± .15$^{B}$ | 27 ± .14$^{DE}$ | 25 ± .16$^{F}$ | 22 ± .12$^{G}$ |
| 7 | 35 ± .12$^{A}$ | 30 ± .22$^{C}$ | 28 ± .26$^{D}$ | 25 ± .24$^{F}$ |
| 14 | 30 ± .23$^{C}$ | 28 ± .42$^{D}$ | 26 ± .30$^{EF}$ | 22 ± .32$^{G}$ |
| 21 | 26 ± .18$^{EF}$ | 22 ± .30$^{G}$ | 20 ± .22$^{H}$ | 16 ± .20$^{I}$ |
| Viscosity (as cP): LSD = 2.5394 | | | | |
| 1 | 58 ± .84$^{EF}$ | 53 ± .80$^{HI}$ | 46 ± .94$^{J}$ | 40 ± .85$^{K}$ |
| 7 | 62 ± .92$^{D}$ | 57 ± .72$^{EFG}$ | 50 ± .84$^{I}$ | 45 ± .90$^{J}$ |
| 14 | 66 ± .55$^{B}$ | 63 ± .56$^{CD}$ | 56 ± .92$^{FGH}$ | 50 ± .83$^{I}$ |
| 21 | 70 ± .22$^{A}$ | 66 ± .40$^{BC}$ | 60 ± .90$^{DE}$ | 54 ± .80$^{GH}$ |

Means in the same row that are denoted by several little letters differ significantly (p≤ 0.05). Each fermented milk sample underwent a triplicate analysis after each experiment was carried out in triplicate. LSD, the smallest difference.

**Table 4. The effect of partial replacement of camel milk with chickpea milk on the Na, K, and Fe contents of bio-flavored fermented camel milk during the cooled storage period.**

| Storage period (days) | Treatments | | | |
|---|---|---|---|---|
| | C | T1 | T2 | T3 |
| Na (mg/100 gm): LSD = 3.6968 | | | | |
| 1 | 88.5 ± .95$^{D}$ | 82.0 ± .82$^{E}$ | 78.0 ± .94$^{F}$ | 73.0 ± .68$^{G}$ |
| 7 | 95.4 ± .84$^{C}$ | 90.7 ± .55$^{D}$ | 84.9 ± .75$^{E}$ | 77.5 ± .88$^{F}$ |
| 14 | 103.6 ± .77$^{B}$ | 98.5 ± .64$^{C}$ | 88.4 ± .80$^{D}$ | 84.7 ± .94$^{E}$ |
| 21 | 120.7 ± .74$^{A}$ | 102.6 ± .72$^{B}$ | 95.8 ± .54$^{C}$ | 90.2 ± .90$^{D}$ |
| K (mg/100 gm): LSD = 3.9967 | | | | |
| 1 | 236.4 ± .90$^{D}$ | 212.0 ± .80$^{H}$ | 200.0 ± .94$^{I}$ | 188.0 ± .70$^{K}$ |
| 7 | 240.5 ± .78$^{C}$ | 222.4 ± .82$^{F}$ | 209.3 ± .88$^{H}$ | 194.6 ± .86$^{J}$ |
| 14 | 246.3 ± .80$^{B}$ | 227.8 ± .68$^{E}$ | 217.5 ± .74$^{G}$ | 202.5 ± .90$^{I}$ |
| 21 | 258.4 ± .87$^{A}$ | 236.5 ± .94$^{D}$ | 224.8 ± .66$^{EF}$ | 209.4 ± .94$^{H}$ |
| Fe (mg/100 gm): LSD = 0.0341 | | | | |
| 1 | 0.85 ± .07$^{I}$ | 0.88 ± .05$^{HI}$ | 0.90 ± .06$^{GH}$ | 0.93 ± .04$^{EF}$ |
| 7 | 0.88 ± .08$^{HI}$ | 0.90 ± .06$^{GH}$ | 0.94 ± .04$^{EF}$ | 0.97 ± .06$^{DE}$ |
| 14 | 0.92 ± .05$^{FG}$ | 0.94 ± .04$^{EF}$ | 0.97 ± .07$^{DE}$ | 1.0 ± .08$^{CD}$ |
| 21 | 0.98 ± .06$^{D}$ | 1.02 ± .03$^{BC}$ | 1.04 ± .05$^{AB}$ | 1.06 ± .03$^{A}$ |

Means in the same row that are denoted by several little letters differ significantly (p ≤ 0.05). Each fermented milk sample underwent a triplicate analysis after each experiment was carried out in triplicate. LSD, the smallest difference.

and 28.40%, respectively. Replacing CM with ChM significantly ($p \leq 0.05$) increased TPC, TFC, and DPPH inhibition (percentage) of bio-flavored FCM. As highlighted by Zhu *et al*. (2023), these results are likely due to the elevated levels of TPC, TFC, and DPPH inhibition percentage in ChM in comparison to CM. As outlined by Fernandez-Orozco *et al*. (2009), a higher quantity of phenolic compounds was found in chickpea flour throughout the fermentation process. According to Hur *et al*. (2014), total phenols increased when lactic acid bacteria fermented plant components; this rise in total phenolic compounds led to an increase in antioxidative activity. Phenolic substances have the ability to function as hydrogen donors, reducing agents, and singlet oxygen quenchers, lowering the product's oxidation.

Compared to their initial values on the first day of production, a significant decline in TPC was observed in all samples over the 21-day storage period at 4°C, which is consistent with findings reported in other studies (Trigueros *et al*., 2014). The phenolics may be somewhat protected by the gel matrix of yoghurt during storage, but the declination is thought to be caused by the phenolic compounds' oxidative destruction, which is impacted by oxygen interaction (Mang *et al*., 2015). Despite TPC declining throughout the 21-day storage period, a sizable quantity was still present in the bio-flavored FCM with ChM. The most persistent phenolics in yoghurt matrix are flavonoids, which may be to blame for this observation (Trigueros *et al*., 2014). According to Dufresne and Farnworth (2001), the oxidative degradation and polymerization of phenolic compounds during bio-flavored FCM storage is likely to blame for the decrease in antioxidant activities (DPPH scavenging activity). This decline is linked to the protein-binding properties of dairy proteins and polyphenols. By reducing the amount of free hydroxyls, binding proteins and polyphenols lower antioxidant activity (Dubeau *et al*., 2010). Similar results were reported by Hussein *et al*. (2020), who found that the addition of chickpea flour significantly increased TPC, TFC, and DPPH inhibition (percentage) of stirred bio-yoghurt. Another study (Elbahnasi *et al*., 2021) observed that the addition of chickpea flour to functional yoghurt significantly increased TPC, TFC, and DPPH inhibition (percentage) of yoghurt.

## Total bacterial and bifidobacteria counts of bio-flavored fermented camel milk containing chickpea milk

According to Korbekandi *et al*. (2011), the amount of active cells at the time of ingestion determines how healthy the probiotic food products are. Therefore, it is crucial to have a high probiotic culture survival rate across the shelf life of the finished goods (Cruz *et al*., 2010). The average total bacterial and bifidobacteria

**Table 5. The effect of partial replacement of camel milk with chickpea milk on total phenolic, total flavonoids contents, and DPPH inhibition (percentage) of the bio-flavored fermented camel milk during the cooled storage period.**

| Storage period (days) | Treatments | | | |
|---|---|---|---|---|
| | C | T1 | T2 | T3 |
| TPC mg/100 g: LSD = 3.4910 | | | | |
| 1 | $24.50 \pm .28^{EFG}$ | $28.40 \pm .55^{CD}$ | $32.40 \pm .48^{AB}$ | $35.60 \pm .62^{A}$ |
| 7 | $22.80 \pm .34^{GH}$ | $26.50 \pm .84^{DEF}$ | $29.70 \pm .55^{BCD}$ | $32.90 \pm .74^{AB}$ |
| 14 | $21.60 \pm .72^{GH}$ | $23.40 \pm .90^{FGH}$ | $26.80 \pm .84^{CDEF}$ | $30.20 \pm .88^{BC}$ |
| 21 | $20.40 \pm .84^{H}$ | $22.30 \pm .74^{GH}$ | $24.20 \pm .82^{EFG}$ | $27.30 \pm .90^{CDE}$ |
| DPPH inhibition%: LSD = 4.1801 | | | | |
| 1 | $28.40 \pm .74^{DE}$ | $30.70 \pm .78^{CD}$ | $34.20 \pm .88^{B}$ | $40.50 \pm .68^{A}$ |
| 7 | $24.50 \pm .80^{EFGH}$ | $27.60 \pm .94^{DEF}$ | $30.40 \pm .90^{CD}$ | $37.60 \pm .84^{AB}$ |
| 14 | $22.30 \pm .94^{H}$ | $24.70 \pm .82^{EFGH}$ | $26.90 \pm .74^{DEFG}$ | $33.80 \pm .90^{BC}$ |
| 21 | $20.55 \pm .88^{H}$ | $22.80 \pm .78^{GH}$ | $24.30 \pm .85^{FGH}$ | $28.60 \pm .74^{DEF}$ |
| TFC mg/100 g: LSD = 0.1073 | | | | |
| 1 | $1.45 \pm 0.04^{EF}$ | $1.58 \pm 0.02^{CDE}$ | $1.72 \pm 0.03^{B}$ | $1.86 \pm 0.06^{a}$ |
| 7 | $1.28 \pm 0.08^{GHI}$ | $1.34 \pm 0.03^{FGH}$ | $1.58 \pm 0.04^{CD}$ | $1.65 \pm 0.02^{BC}$ |
| 14 | $1.05 \pm 0.05^{K}$ | $1.18 \pm 0.04^{IJ}$ | $1.36 \pm 0.08^{FG}$ | $1.48 \pm 0.05^{DE}$ |
| 21 | $0.98 \pm 0.04^{K}$ | $1.06 \pm 0.05^{JK}$ | $1.22 \pm 0.06^{HI}$ | $1.33 \pm 0.07^{FGH}$ |

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$). Each fermented milk sample underwent a triplicate analysis after each experiment was carried out in triplicate. LSD, the smallest difference.

**Table 6. Total bacterial and bifidobacteria counts of bio-flavored fermented camel milk produced from the partial replacement of camel milk with chickpea milk during the cooled storage period.**

| Storage period (days) | Treatments | | | |
|---|---|---|---|---|
| | C | T1 | T2 | T3 |
| Total bacterial counts (Log CFU/g-1): LSD = 0.0391 | | | | |
| 1 | 8.36 ± 0.04$^{I}$ | 8.50 ± 0.05$^{H}$ | 8.62 ± 0.04$^{FG}$ | 8.74 ± 0.08$^{E}$ |
| 7 | 8.58 ± 0.03$^{G}$ | 8.66 ± 0.02$^{F}$ | 8.84 ± 0.05$^{CD}$ | 8.90 ± 0.04$^{B}$ |
| 14 | 7.79 ± 0.05$^{G}$ | 8.72 ± 0.04$^{E}$ | 8.88 ± 0.08$^{BC}$ | 8.96 ± 0.05$^{A}$ |
| 21 | 7.56 ± 0.02$^{K}$ | 8.58 ± 0.02$^{G}$ | 8.76 ± 0.04$^{E}$ | 8.80 ± 0.02$^{D}$ |
| Bifidobacteria counts (Log CFU/g-1): LSD = 0.0417 | | | | |
| 1 | 8.52 ± 0.06$^{F}$ | 8.69 ± 0.06$^{D}$ | 8.75 ± 0.02$^{B}$ | 8.94 ± 0.05$^{A}$ |
| 7 | 8.34 ± 0.05$^{I}$ | 8.50 ± 0.03$^{F}$ | 8.63 ± 0.03$^{E}$ | 8.70 ± 0.04$^{C}$ |
| 14 | 8.18 ± 0.04$^{J}$ | 8.33 ± 0.08I | 8.45 ± 0.04$^{G}$ | 8.54 ± 0.06$^{F}$ |
| 21 | 7.82 ± 0.05$^{K}$ | 8.05 ± 0.02$^{K}$ | 8.24 ± 0.03$^{J}$ | 8.40 ± 0.05$^{H}$ |

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$). Each fermented milk sample underwent a triplicate analysis after each experiment was carried out in triplicate. LSD, the smallest difference.

counts in bio-flavored FCM treatments are shown in Table 6. The findings showed that switching from CM to ChM considerably ($p \leq 0.05$) boosted the total bacterial and bifidobacteria numbers. The level of substitution was related to the rise. There was an association between ChM concentration and probiotic bacterial survival in the bio-flavored FCM during storage. The reason for these findings may be that, among pulses, chickpeas have the highest concentration of total oligosaccharides at 144.9 mg/g (Han and Baik, 2006); the prebiotics raffinose and stachyose found in chickpeas are regarded as an excellent source. *Bafidobacterium lactis* Bb-12 and *L. acidophilus*La-5 both fared better after the addition of the raffinose family oligosaccharides (Martinez-Villaluenga *et al*., 2006). Galacto oligosaccharides, according to Hernández-Hernández *et al*. (2012), are a great supplement for promoting the growth and enhancing the survival of probiotic *Lactobacillus* strains.

Additionally, ChM improved the survivability of probiotic bacteria throughout the 21-day storage period, where the probiotic culture's viable counts are lowest in the control sample and which lacks ChM. On the first day, the bio-flavored FCM containing 75% ChM showed the best probiotic bacteria survival ($p \leq .05$). Even though the probiotic culture's viable count significantly reduced over the course of the 21-day storage, bio-flavored FCM samples still contained log 8 CFUg-1 of probiotics on day 21. The viable count of the control sample, a probiotic culture of *B. bifidum*, was at a log 7 CFU/g1 level at day 21. According to the FDA's definition of yoghurt, the minimum required level of live and active cultures after production should be log 7 CFU/mL. Additionally, as outlined by Hill *et al*. (2014), the ideal level of these cultures should remain around log 6 CFU/mL$^{-1}$ throughout its shelf life. ChM showed the largest stimulatory effects on the viable counts of probiotic culture at concentrations of 50% or 75%. Chickpeas include natural substances that may function as an additional energy source or as antioxidants. The primary components of chickpeas, dietary fiber, oligosaccharides, certain ions, particularly iron, and phenolic compounds, have been implicated in the reported increase in viability of probiotic culture (Aharon *et al*., 2011). These findings are in line with those of Agil *et al*. (2013), who utilized lentil as a prebiotic to improve probiotic growth survivability in yoghurt. The probiotic bacteria survived the 28-day storage period that supported the antioxidant activity of lentil polysaccharides in yoghurt making and promoting probiotic bacterial development.

## Sensory evaluation of bio-flavored fermented camel milk containing chickpea milk

To the best of the authors' knowledge, the success of the included product is ultimately determined by its sensory quality. The sensory analysis considers a variety of strong and delicate techniques incorporated to gauge consumer and other product reactions. Results that are strong and repeatable are produced by testing under ideal conditions and by analyzing the data. The sensory tests are conducted on a specific product to illustrate customer perceptions and how volatile chemical analyses are interpreted for flavor perception (Drake, 2007). The average ratings for sensory evaluation of FFCM treatments are displayed in Table 7's results. The sensory scores for flavor, consistency, appearance, and overall scores of the

**Table 7. Sensory evaluation of bio-flavored fermented camel milk produced from the partial replacement of camel milk with chickpea milk during the cooled storage period.**

| Sensory properties | Storage periods (days) | Treatments | | | |
|---|---|---|---|---|---|
| | | C | T1 | T2 | T3 |
| Flavor (50) | 1 | 42.20 ± .35$^{GH}$ | 43.60 ± .45$^{F}$ | 45.20 ± .66$^{CD}$ | 46.50 ± .60$^{AB}$ |
| | 7 | 43.60 ± .55$^{F}$ | 44.70 ± .52$^{DE}$ | 46.50 ± .45$^{AB}$ | 47.20 ± .35$^{A}$ |
| | 14 | 40.50 ± .94$^{I}$ | 42.50 ± .36$^{G}$ | 44.30 ± .74$^{DEF}$ | 45.70 ± .28$^{BC}$ |
| | 21 | 38.20 ± .228$^{J}$ | 41.40 ± .62$^{HI}$ | 43.50 ± .65$^{F}$ | 44.20 ± .75$^{EF}$ |
| | LSD = 1.0325 | | | | |
| Consistency (30) | 1 | 27.50 ± .42$^{A}$ | 26.60 ± .70$^{B}$ | 24.60 ± .52$^{E}$ | 21.40 ± .62$^{H}$ |
| | 7 | 26.10 ± .33$^{BC}$ | 25.80 ± .82$^{CD}$ | 23.80 ± .66$^{F}$ | 20.70 ± .66$^{I}$ |
| | 14 | 25.50 ± .74$^{D}$ | 24.50 ± .65$^{E}$ | 22.60 ± .58$^{G}$ | 19.50 ± .75$^{G}$ |
| | 21 | 24.40 ± .57$^{E}$ | 23.60 ± .84$^{F}$ | 21.50 ± .82$^{H}$ | 18.20 ± .80$^{K}$ |
| | LSD = 0.6307 | | | | |
| Appearance (20) | 1 | 13.80 ± .63$^{CDE}$ | 14.20 ± .66$^{C}$ | 14.80 ± .74$^{B}$ | 15.60 ± .70$^{A}$ |
| | 7 | 12.50 ± .94$^{G}$ | 13.70 ± .80$^{DE}$ | 14.10 ± .66$^{CD}$ | 14.80 ± .78$^{B}$ |
| | 14 | 11.40 ± .55$^{H}$ | 12.90 ± .75$^{FG}$ | 13.60 ± .82$^{E}$ | 13.10 ± .80$^{F}$ |
| | 21 | 10.90 ± .72$^{I}$ | 11.80 ± .90$^{H}$ | 12.70 ± .75F$^{G}$ | 12.60 ± .76$^{G}$ |
| | LSD = 0.4106 | | | | |
| Total (100) | 1 | 83.50 ± .65$^{B}$ | 84.40 ± .48$^{A}$ | 84.60 ± .55$^{A}$ | 83.50 ± .68$^{B}$ |
| | 7 | 82.20 ± .84$^{D}$ | 84.20 ± .72$^{A}$ | 84.40 ± .88$^{A}$ | 82.70 ± .42$^{C}$ |
| | 14 | 77.40 ± .55$^{H}$ | 79.90 ± .78$^{F}$ | 80.50 ± .90$^{E}$ | 78.30 ± .65$^{G}$ |
| | 21 | 73.50 ± .62$^{K}$ | 76.80 ± .66$^{I}$ | 77.70 ± .75$^{H}$ | 75.00 ± .74$^{J}$ |
| | LSD = 0.4220 | | | | |

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$). Each fermented milk sample underwent a triplicate analysis after each experiment was carried out in triplicate. LSD, the smallest difference.

resulting bio-flavored FCM were considerably ($p \leq 0.05$) enhanced by replacing CM with ChM, increasing these scores by up to 50%. Furthermore, the maximum sensory scores were obtained with the addition of ChM at a level of 50%. Although there is no difference between the 25% and 50% bio-flavored FCM samples ($p \leq 0.05$), the sample with 75% ChM obtained a low sensory property score. This is due to the high dosage of ChM reducing the body and texture features and changing the color to a yellowish hue, although the flavor was still deemed acceptable. After storage, the bio-flavored FCM augmented with ChM's acidity progressively increased without appreciably changing the flavor. The salty flavor of CM might have been disguised by the addition of ChM, which could account for these results. These findings are consistent with those made by Hussein *et al.* (2020), who claimed that stirring bio-yoghurt with chickpea flour enhanced its sensory qualities.

## Amino acids contents of the bio-flavored fermented camel milk containing chickpea milk

For protein synthesis, essential AAs such as arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and valine need to be present in the body in the right amounts all at the same time, which can only be supplied from nutrition (Lopez and Mohiuddin, 2020). There were 17 different types of AAs found in both the control bio-flavored FCM and the bio-flavored FCM + 50%ChM (Table 8). In comparison to control bio-flavored FCM, the bio-flavored FCM + 50% ChM substantially contained more of the essential AAs arginine, histidine, isoleucine, leucine, lysine, phenylalanine, threonine, and valine ($p \leq 0.05$). The methionine content of CFM was higher than that of bio-flavored FCM + 50% ChM. Aspartate, serine, glutamate, glycine, alanine, tyrosine, and proline were among the nonessential AAs with substantially greater concentrations in the bio-flavored FCM + 50% ChM than in the control bio-flavored FCM ($p \leq 0.05$). In contrast, bio-flavored FCM under control had more cysteine than bio-flavored FCM + 50% ChM. The bio-flavored FCM + 50% ChM should be regarded as highly nutritive yoghurt with a lot of high-quality protein.

Nonessential AA concentrations rose from 5.158 mg/g in control bio-flavored FCM to 54.964 mg/g in bio-flavored FCM + 50% ChM samples, a 50% increase over control bio-flavored FCM. The amount of essential AAs was also higher in the bio-flavored FCM + 50% ChM samples

**Table 8. The effect of replacing camel milk with chickpea milk on the amino acid content of the bio-flavored fermented camel milk.**

| Amino acids | Treatments | |
|---|---|---|
| | C mg/g | T2 mg/g |
| THR | 0.366 ± .02[b] | 1.661 ± .14[a] |
| VAL | 1.170 ± .08[b] | 2.988 ± .12[a] |
| MET | 0.431 ± .02[a] | 0.363 ± .08[b] |
| ILE | 0.668 ± .05[b] | 2.455 ± .70[a] |
| LEU | 0.912 ± .04[b] | 4.299 ± .92[a] |
| PHE | 0.369 ± .02[b] | 2.379 ± .66[a] |
| HIS | 0.750 ± .05[b] | 1.769 ± .74[a] |
| LYS | 0.415 ± .02[b] | 3.879 ± .82[a] |
| ARG | 1.117 ± .14[b] | 3.216 ± .60[a] |
| EAA total | 6.198 ± 1.05[b] | 23.009 ± 1.44[a] |
| ASP | 0.991 ± .05[b] | 4.466 ± .90[a] |
| SER | 0.284 ± .02[b] | 2.064 ± .62[a] |
| GLU | 1.214 ± .06[b] | 9.723 ± 1.04[a] |
| GLY | 0.079 ± .002[b] | 1.440 ± .22[a] |
| ALA | 0.514 ± .04[b] | 2.128 ± .14[a] |
| CYS | 0.258 ± .05[a] | 0.199 ± .02[b] |
| TYR | 0.354 ± .04[b] | 1.628 ± .16[a] |
| PRO | 1.500 ± .12[b] | 3.316 ± .42[a] |
| NEAA total | 5.158 ± .92[b] | 54.964 ± 3.70[a] |
| Total AA | 11.365 ± 1.62[b] | 77.973 ± 2.68[a] |
| % EAA/TAA | 54.53 ± 2.12[a] | 29.50 ± 1.66[b] |
| % NEAA/TAA | 45.47 ± 3.02[b] | 70.50 ± 2.82[a] |

Means in the same row that are denoted by several little letters differ significantly ($p \leq 0.05$).

than in the control bio-flavored FCM, rising from 6.198 mg/g in the control bio-flavored FCM to 23.009 mg/g. The control bio-flavored FCM and bio-flavored FCM + 50% ChM had AA compositions that were remarkably close to those of yoghurt and soy milk. This rise in AAs appears to be connected to the rise in the total protein found in yoghurt-like products. These findings support the findings of El-Karmany *et al*. (2013), who discovered that adding chickpea flour to yoghurt improved the amount of AAs present in the final product. Nonessential and conditionally nonessential AAs were present in sufficient amounts in all chickpea genotypes, and there were notable variances across the genotypes in both categories. As outlined by Shah *et al*. (2020), the total quantity of essential and nonessential AAs in chickpea genotypes ranged from 40.81 g to 59.18343 g 100 g-1 protein.

## Conclusions

This study successfully developed a novel bio-flavored FCM and demonstrated that incorporating ChM positively impacts both probiotic viability and product quality during storage. Over a 21-day storage, ChM significantly enhanced the growth of probiotic bacteria in the FCM. The formulation with 50% ChM stood out for its desirable sensory attributes, particularly in terms of overall consumer preference. ChM has proven to be a valuable addition to fermented dairy products, promoting probiotic activity and increasing antioxidant capacity. The enhanced nutritional profile of bio-flavored FCM makes it a functional food with potential health benefits. Additionally, the appealing taste and appearance of chickpea-enriched CM can attract new consumers, broadening its market appeal. Future studies involving animal models and clinical trials in humans are necessary to further confirm the health benefits of this product and other fermented dairy products. The potential medicinal effects and nutritional advantages highlighted in this study underscore the promising role of bio-flavored CM as a functional food.

## Informed Consent Statement

Not applicable.

## Data Availability Statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

## Author Contributions

H.A.H.A-R., A.A.A-N., D.A.A., S.A.K., E.S. S., A.A.A., A.A H., A.A., and E.K.E were involved in conceptualization, formal analysis, investigation, methodology development, software implementation, and validation. H.A.H.A-R., A.A.A-N., D.A.A., S.A.K., E.S. S., A.A., A.A H., A.A., and E.K.E wrote the original draft of the manuscript. The final version of the manuscript was read, reviewed, and approved by all authors.

## Conflicts of Interest

The authors declare no conflict of interest.

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