Assiut Journal of Agricultural Sciences 55 (4) 2024 (1-15)
ISSN: 1110-0486 / EISSN: 2356-9840
Website: http://ajas.journals.ekb.eg/
E-mail: ajas@aun.edu.eg

(Original Article)

Assessment of Low-Fat Fermented Milk Beverage Produced by Combining Camel and Corn Milk

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DOI: 10.21608/AJAS.2024.312350.1388

Abstract

The current study investigated producing low-fat fermented milk beverage from different ratios of camel and corn milk and evaluated their chemical, color and antioxidant properties. Camel milk was adjusted to 1.5% fat and homogenized with sodium alginate and skim milk powder and heated to 85±1°C, then cooled at 45°C, the starter was added after that, percentages of 0, 10, 20, 30, 40 and 50% of corn milk were added to low-fat camel milk and the final product stored at 4 ±1°C for two weeks, chemical, color, antioxidant and sensory properties were assessed. Results showed a significant reduction in fat, pH, TS, protein and TN by intensified corn milk ratio to 50%. According to sensory evaluation, T2 appeared to be the most acceptable treatment. Total phenolic compounds, total flavonoids, tannins and antioxidant capacity were increased by elevating corn milk portion. It can be concluded that the production of low-fat fermented camel milk beverage mixed with corn may offer a novel functional beverage based on plant milk origin with low-fat content with higher antioxidant capacity which meets the requirements of those who adopted vegetarian and DASH diets.

Keywords: *Camel milk, Corn milk, Plant milk origin, Fermented beverage.*

Introduction

Camel milk is widely consumed in remote areas in the form of raw milk or fermented milk products. It has some distinguished characteristics from other kinds of milk it possesses low cholesterol, low sugar, high minerals (sodium, potassium, iron, copper, zinc and magnesium), and high vitamin C. Camel milk composes probable therapeutic characteristics, such as antidiabetic, anti-hypertensive, and anti-carcinogenic effects. It can reduce the higher levels of bilirubin, globulin and granulocytes (Yadav *et al*., 2015). Additionally, it seems to be easily digested by lactose-intolerant individuals. Camel milk has an opaque white appearance with a normal smell and salty taste. Opaque white colors that emerge from the fats are finely distributed throughout the milk (Al-Hashem, 2009).

Received: 20 July 2024/ Accepted: 25 August 2024/ Published online: 27 August 2024

Recently, in urban areas, it is preferable to use new dairy products more than raw milk (Konuspayeva *et al.*, 2009). Therefore, it has been an improvement in the production of some other products, including cheese, either in the traditional methods or by using new technology (El-Gendy and Abdeen, 2020). Traditional preparation of fermented milks may be beneficial by including other ingredients from plant origins (Shori and Baba, 2011) to enhance the camel milk flavor as well as the nutritional quality (El-Deeb *et al.*,2017).

Corn, scientifically known as *Zea mays* L., is an extensively cultured tropical crop that exists as a communal principal food. It plays a significant role in the diets of millions of people (Wang *et al.*, 2017). Corn consists of starch, low protein content and an insufficient amino acid profile (Ajala *et al.*, 2013). This adaptable crop is used in the production of numerous foodstuffs, including noodles, tortillas, porridge, bread, and corn drinks. Corn milk is a soft beverage, which offers potential health benefits owing to phytonutrients, dietary fiber antioxidants, and minerals (Sangkam *et al.*, 2019). However, its content of several vitamins, fermented corn-based yoghurt-like products, particularly corn drinks, are still limitedly marketed (Göçer *et al.*, 2023).

Corn milk is regarded as a recent breakthrough, particularly when used to create cheese-based goods. It contains bioactive substances, including lutein, folic acid, and phenolic compounds, which have nutritional advantages (Dewanto *et al.*, 2002). Due to its delicious flavor and nutritional content, corn milk contributes to solving lactose intolerance and saturated fat issues related to cow milk (Khalil, 2023; Padghan *et al.*, 2015).

The nutritional value of food and beverages plays a crucial role in meeting consumers' dietary needs and reducing the risk of chronic diseases. In supermarkets worldwide, there is a strong recommendation for chemical-additive-free beverages made from various fruits and vegetables with minimal processing (Shiekh *et al.*, 2023).

In developing countries, cow milk products are expensive and not the first choice for vegetarianism or allergies, substantial efforts are being directed toward producing fermented products from a variety of food sources (Ifediba and Nwafor, 2018). Non-dairy alternatives, principally cereal-based products, have expanded much attention as a response to the rising trends of lactose intolerance, vegetarianism, veganism, and low-fat diets (Menezes *et al.*, 2018). Therefore, there is an increase in the demand for vegetable milk, which serves as a substitute for animal milk and dairy products that are not suitable for a vegan diet. Moreover, the Dietary Approach to Stop Hypertension (DASH) diet involves low-fat dairy products and focuses on plant sources, this diet is designed to prevent blood pressure and keep the heart healthy (Göçer *et al.*, 2023).

Milk or its dairy-based beverages are one of the commonly used beverages, they have had tremendous alternations during the last decades owing to the socio-economic status of consumers. Milk-based beverages can be categorized into numerous classes according to milk species source, fat percentage present in milk, production method and source of added ingredients (Singh *et al.*, 2018). Fermented milk beverages are classified into 1) Fermented milk, 2) Flavored fermented milk, 3) Drinks based on fermented milk, 4) Concentrated fermented milk (FSSR, 2011).

According to Food Safety and Standards Acts, Rules and Regulations FSSR, (2011), the current study creates products that can fall into the third class "Drinks based on fermented milk", which is defined as milk products, obtained by mixing fermented milk with potable water with or without the addition of whey, other milk and milk products, and other permitted non-dairy ingredients and flavors. Drinks based on fermented milk contain a minimum of 40% fermented milk.

So, this study aimed to produce a novel low-fat fermented milk beverage with different ratios from camel and corn milk and evaluate their chemical, antioxidant, color and sensory properties, which introduce an innovative product with the management of the salty taste attributed to camel milk, low fat content with aid of plant-based sources.

Materials and Methods

Materials

Fresh camel's milk was collected from some private farm in Aswan Governorate, Egypt and used for making fermented camel milk with fat standardization (1.5 % fat). Freshly harvested green corn cob grains (milky stage) were taken from a private field located in El-Fayoum governorate. Skim milk powder (97 % TS, product of Dairy America ™ USA) was purchased from the local market. Yoghurt starter (YS) consisting of *Streptococcus thermophiles* and *Lactobacillus delbrueckii* sp. *bulgaricus* was obtained from Chr. Hansen's Lab., Denmark. Sodium alginate was provided by El-Nasr company.

Preparation of Corn Milk

White cob corn was gathered when the grain was at its most juicy (milky) stage of maturity. Hairs and other foreign objects were removed from the grains after they had been separated from the cob. Using a blender, corn grains were combined with tap water in a 1:2 (w/w) ratio. The resulting liquid was then filtered through cheesecloth.

Preparation of fermented camel milk beverages

Standardized fresh camel milk, 4 % skim milk powder and 0.2 % (w/v) sodium alginate were mixed and homogenized at 55-60 ˚C for 2 min., heated in a water bath at 85±1°C for 5 min. After cooling to 45°C, the mixture was inoculated with 3% (v/v) of activated yoghurt starter. The milk mixtures were divided into 6 portions. The first portion was considered as a control (without adding corn milk) sample and the other 5 portions were subjected to corn milk at a ratio of 10%, 20%, 30 %, 40 % and 50 %. The control and the treated camel milk were homogenized well individually. All samples were incubated at 42±1°C until pH reached 4.5-4.6, then immediately cooled to 5±1°C overnight (El-Gendy and Abdeen, 2020).

Analytical methods

Chemical composition

Total solids (TS), total nitrogen, protein, fat and ash contents; as well as pH values (using pH meter, HANNA HI 2211) and titratable acidity were determined in camels', corn milk and different fermented beverages according to the methods of (AOAC, 2016).

Antioxidant activity

The amount of total phenolic compounds (TPC), total flavonoid content (TFC), tannins and total antioxidants were determined as discussed by Abdel-Aleem *et al.* (2019); Abu Bakar *et al.* (2009); Kanika *et al.* (2015); Schanderl (1970).

Color attributes determination

Using a colorimeter (Model: CR-400, Konica Minolta, Inc., JAPAN.) and the International Commission on Illumination (ICI) color coordinates L*, a* and b* (10° observer at D65 illuminant), the color values of fermented milk beverage samples were measured according to Elwakeel *et al.* (2023).

Sensory analysis

Sensory analysis was performed by the staff members of the Dairy Science and Technology Department and others according to Mehanna *et al.* (2000).

Statistical analysis

Means and standard deviation were calculated, and data were analyzed by two-way ANOVA followed by the Duncan test using CoStat software (Steel and Torrie, 1980).

Result and Discussion

The blending of plant-origin milk with natural milk become trendier in dairy processing to serve a special category of consumers and aid sustainable concepts. Table 1 explains the chemical composition of standardized camel milk and corn milk. It appeared from Table 1 that corn milk had low acidity, fat, total nitrogen, protein and ash as 0.14, 0, 0.237, 1.510 and 0.413% respectively. Camel milk had a richer content than corn milk concerning the previously mentioned items with values of 0.187, 1.5, 2.617, 2.617 and 0.730%, respectively. Regarding TS, SNF, and carbohydrates corn milk composed higher percentages estimated at 10.81, 10.81 and 8.887%, respectively.

Tawfek *et al.*, (2021) highlighted camel milk had 12.52 ± 1.05, 3.82 ± 0.10, 3.56 ± 0.15, 4.32 ± 0.10, 0.82 ± 0.10, 0.133 ± 0.05 and 6.70 ± 0.05 for T.S%, fat %, protein %, carbohydrate%, ash %, acidity% and pH value, respectively. El-Deeb *et al.*, (2017) who analyzed full-fat camel milk found that TS was 12.15± 0.4, protein 3.32±0.1, fat 3.6±0.1, ash 0.97±0.03, carbohydrates 4.26±0.3, acidity 0.16± 0.08, pH 6.6± 0.03 which logically higher than detected in our study for half fat camel milk. Variations in camel milk composition between the previous study and ours may refer to factors correlating to geographical origin, feeding, seasonal, genetic and health reasons (Konuspayeva *et al.*, 2009). Regarding corn milk, Göçer *et al.*, (2023) demonstrated that corn milk TS, protein, ash, acidity% and pH was 7.99±0.16,1.062±0.03, 0.02±0.02, 0.11±0.01,6.29± 0.03, respectively. Moreover, in accordance with our results Ibrahim *et al.*, (2019) reported that corn milk TS, protein, ash, fat, specific gravity and pH were 15.62, 1.58, 0.54,0, 1.056 and 7.04, respectively. Differences in chemical composition may refer to the variety of corn, also the preparation of corn milk method, it is worthwhile to mention that vegetable milks did not have standard criteria excluding coconut milk (Meghrabi and Yamani, 2023).

Table 1. Chemical composition of camel and corn milk utilized in the manufacturing of fermented beverage

Composition	Standardized camel milk	Corn milk
pH	6.477	6.840
Acidity % lactic acid	0.187	0.140
Total solids%	10.03	10.81
Solids not fat%	8.53	10.81
Fat%	1.5	0
Total nitrogen%	0.410	0.237
Protein%	2.617	1.510
Carbohydrates %	5.183	8.887
Ash %	0.730	0.413

Results as means of three replicates.

Results in Table 2 show the chemical composition of different combinations of corn and camel milk with ratios of 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50 for control, T1, T2, T3, T4 and T5, respectively. It was found that pH values were decreased statistically at $P<0.05$ compared to control by increasing the ratio of corn milk, the same trend was also observed during storage for one and two weeks at 4°C uncorrelated with results in Table 1 indicating higher pH in corn milk 6.84 than in camel milk 6.4. Acidity was developed from 0.83±.028 in control to 1.20±0.0 in T5 (50 % substituting), all treatments differed statistically at $P<0.05$, and the highest acidity was recorded after 2 weeks of cold storage for T5 which was 1.56±0.012. In contrast with our results, Göçer *et al.*, (2023) investigated the effect of storage for 30 days at 4°C and concluded that the probiotic corn milk drink had the highest pH value and the lowest acidity.

Camel milk buffering capacity is influenced negatively by increasing the amount of added water, also removal of fat and pasteurization had a slight effect on the buffering capacity (Al Saleh and Hammad, 1992). Corn has a majority of its sugar in the form of glucose 3.43 %, whoever milking stage correlated with a 25% alleviation in the sugar content (Singh *et al.*, 2014). We should take into consideration that *S. thermophilus* and *Lb. delbrueckii* subsp. *bulgaricus* can metabolize glucose, converting it into lactic acid by the Embeden-Meyerhof-Parnas (EMP) pathway (Estévez *et al.*, 2010). The higher amount of glucose in corn encourages the development of acidity, which explains higher acidity in T5 compared to control 1.20±0.0 vs 0.83±.028, furthermore it is accompanied by a significant decrease in pH 4.55± 0.0 vs 4.71± 0.040 at $P <0.05$, thus may attributed to the dual effect of the higher buffering capacity of camel milk and higher glucose and monosaccharides in corn milk.

Table 2. Chemical parameters of fermented camel milk made with different mixing ratios of corn milk

Parameter	Storage period	Treatment					
		Control	**T1**	**T2**	**T3**	**T4**	**T5**
pH	Fresh	4.71± 0.040^{a}	4.67± 0.015^{b}	4.64± 0.012c	4.61± 0.0^{d}	4.59± 0.0^{e}	4.55± 0.0^{f}
	One week	4.55± 0.010^{f}	4.48± 0.006^{gh}	4.49± 0.00^{g}	4.44± 0.006^{i}	4.42± 0.006^{i}	4.43± 0.0^{i}
	Two weeks	4.53± 0.006^{f}	4.47± 0.006^{h}	4.44± 0.00^{i}	4.43± 0.006^{i}	4.42± 0.006^{i}	4.40± 0.006^{j}
acidity%	Fresh	0.83±.028^{k}	0.90±0.00^{j}	0.95±0.00^{ij}	1.00±0.0^{hi}	1.10±.0^{g}	1.20±0.0^{f}
	One week	1.03±0.058^{h}	1.17±0.058^{f}	1.22±0.029^{ef}	1.27±0.017^{de}	1.30±0.012^{d}	1.42±0.006^{b}
	Two weeks	1.22±0.058^{ef}	1.32±0.029^{cd}	1.37±0.029^{c}	1.43±0.058^{b}	1.52±0.029^{a}	1.56±0.012^{a}
Fat%	Fresh	1.53±0.057^{b}	1.30±0.0^{de}	1.23±0.057^{de}	1.20±0.0^{e}	1.03±0.057^{f}	0.83±0.057^{g}
	One week	1.57±0.058^{b}	1.33±0.058^{cd}	1.23±0.058^{de}	1.20±0.0^{e}	1.07±0.058^{f}	0.87±0.115^{g}
	Two weeks	1.67±0.058^{a}	1.43±0.058^{c}	1.43±0.058^{c}	1.33±0.058^{cd}	1.07±0.058^{f}	1.00±0.00^{f}
TS%	Fresh	16.58±0.040^{e}	15.82±0.065^{f}	14.78±0.165^{g}	14.84±0.035^{g}	12.20±0.025^{j}	11.14±0.020^{k}
	One week	17.88±0.090^{d}	16.69±0.153^{e}	15.60±0.035^{f}	14.93±0.031^{g}	12.77±0.135^{i}	12.29±0.075^{j}
	Two weeks	19.77±0.061^{a}	19.23±0.139^{b}	18.63±0.275^{c}	16.79±0.166^{e}	15.04±0.660^{g}	14.23±0.629^{h}
Ash%	Fresh	1.04±0.006^{c}	1.02±0.006^{f}	0.88±0.006^{g}	0.85±0.006^{h}	0.70±0.006^{j}	0.63±0.006^{m}
	One week	1.16±0.010^{b}	1.05±0.023^{e}	0.97±0.015^{g}	0.86±0.006^{h}	0.73±0.010^{i}	0.71±0.010^{l}
	Two weeks	1.26±0.015^{a}	1.22±0.015^{d}	1.13±0.010^{d}	1.02±0.015^{e}	0.88±0.006^{i}	0.82±0.012^{k}
TN%	Fresh	0.55±0.010^{c}	0.47±0.015^{f}	0.42±0.006^{h}	0.38±0.020^{i}	0.28±0.015^{l}	0.28±0.010^{kl}
	One week	0.58±0.006^{b}	0.49±0.006^{e}	0.44±0.006^{gh}	0.39±0.015^{i}	0.30±0.017^{jk}	0.30±0.017^{jk}
	Two weeks	0.62±0.006^{a}	0.53±0.006^{d}	0.45±0.010^{fg}	0.43±0.012^{h}	0.31±0.006^{j}	0.30±0.012^{jkl}
Protein%	Fresh	3.51±0.060^{c}	2.98±0.097^{f}	2.66±0.035^{h}	2.42±0.125^{i}	1.77±0.097^{l}	1.79±0.065^{kl}
	One week	3.68±0.035^{b}	3.15±0.035^{e}	2.79±0.040^{gh}	2.51±0.101^{i}	1.91±0.110^{jk}	1.92±0.110^{jk}
	Two weeks	3.94±0.040^{a}	3.36±0.035^{d}	2.87±0.060^{fg}	2.72±0.075^{h}	2.00±0.035^{j}	1.87±0.069^{jkl}

Control:0%, T1:10%, T2:20%, T3:30 %, T4:40 % and T5:50 % corn milk. TS: total solids. TN: total nitrogen. Data expressed as mean ± SD of 3 replicates. Means that have different letters in each parameter are significantly different ($P < 0.05$).

In respect of fat, it was decreased by blending more ratios of corn milk, which reflects the fat-poor composition of corn milk (0%) compared to 1.5% in low-fat camel milk Table 1, it diminished from 1.53± 0.057 (control) to 0.83±0.057 (T5), with significant differences at $P<0.05$, cold storage for 2 weeks led to growing in fat content while it did not trigger statistical differences at $P<0.05$.

The addition of corn milk decreased total solids, which were 16.58±0.040, 15.82±0.065, 14.78±0.165, 14.84±0.035, 12.20±0.025 and 11.14±0.020 in C, T1, T2, T3, T4 and T5, respectively. Moreover, ash decreased by replacing camel milk with corn milk which was 1.04±0.006, 1.02±0.006, 0.88±0.006, 0.85±0.006, 0.70±0.006, 0.63±0.006 and after two weeks was 1.26±0.015, 1.22±0.015, 1.13±0.010, 1.02±0.015, 0.88±0.006 and 0.82±0.012 for 0,10,20,30,40 and 50% substitution ratio, respectively, storage affect statistically. A slight increase in TN and protein emerged from cold storage, on the other hand, substitution with corn milk contracted TN and protein percentages results differed statistically. The differences observed in columns (effect of storage) express significant values at $P<0.05$. Supavititpatana *et al.*, (2010) found that corn milk yoghurt chemically composed of protein, fat, carbohydrate and TS were 4.17±0.08, 0.35±0.01, 7.66±0.12 and 12.25±0.07%. The same authors stated that corn milk yoghurt had lower fat content and higher protein content with harder and higher consistency than cow milk yoghurt. Moreover, Göçer *et al.*, (2023) reported that fermented probiotic corn milk composed of TS, protein, and ash as 8.05±0.01, 1.76±0.11 and 0.2±0.02, respectively.

Table 3 presented the color attributes for experimental groups, all treatments showed slightly similar L values however, only T1 did not differ from T2 and T3 ($P>0.05$), L* values were decreased by storage in all treatments by the second week of storage, which reflected the diminished of whiteness. Regarding a* values all samples showed negative values, T5 after 2 weeks of storage, appeared a* value of -1.26±0.155 the lowest value in the experiment. Concerning b* values, all b* values were positive and highlighted yellow color, increasing of corn milk ratio resulted in lower b value in zero time, while T1 and T2 were associated with the highest yellowish degrees after 2 weeks of storage at (6.09±0.270 and 6.06±0.360, respectively), T5 was decreased significantly (5.38±0.029) compared to all treatments after 2 weeks of storage. El-Gendy and Abdeen, (2020) reported that L*, a *and b* values for camel milk were 22.09, -14.13 and 4.4, respectively.

From previous studies, this is the first study to blend camel and corn milks, so most of studies discussed mixing of cow and corn milk.

The color of the probiotic drinks made from corn milk was noticeably more yellow in comparison to the probiotic drink made from cow's milk(Göçer *et al.*, 2023). The color of the corn milk yoghurt was noticeably more yellow as compared with the cow milk yoghurt. Thus, the corn milk yoghurt had a higher yellow component (lower h value) than the cow milk yoghurt. Carotene, which is primarily responsible for the yellow color of corn and cow milk (Fox *et al.*, 2015 and Omueti and Ajomale, 2005), should be considerably higher for corn milk yoghurt. The storage time did not significantly ($P\geq0.05$) influence the purity and color shade of both yoghurts while the lightness was reduced with a longer storage time (Supavititpatana *et al.*, 2010). Also, Yousef *et al.*, (2024) reported that L*, a* and b* values of 73.98, -2.06 and 8.43, respectively for FBE, an alternative milk formula composed of 25%white corn milk, 25% potato flour milk and 50%tiger nut milk.

Results in Table 4 indicate that total phenolic compounds (TPC) achieved their minimum level in control at zero time 3.606± 0.829 with moderate modifications emerged by two weeks of cold storage, increasing corn milk concentrations led to enhancement in TPC, also extended cold storage period improved TPC levels, the best treatment in this manner was T5 at 2 weeks of storage that was 31.991±0.157. About TFC, they achieved their maximum levels of 124.503± 1.992 in a 50% replacement ratio after 2 weeks of storage, cold storage elevates TFC concentrations statistically compared to fresh samples. The same trend was detected in tannins and TAC after 2 weeks with values of 40.134±0.954 mg/100g and 202.511 ±1.980 mg/100g, respectively.

El-Deeb *et al.*, (2017) investigated camel milk in items of antioxidant activity (AOA) and phenolic compound mg/100g which were 87.94± 3.40 and 7.98±0.1, respectively. Furthermore, Khalil *et al.*, (2022) found that phenolic compounds in camel milk were increased during storage which was 3.31±0.05, 3.34±0.05 and 3.44±0.05 mg/100g, these results are very close to ours at zero time also they evaluated AOA were 77.72±0.16, 77.82±0.14 and 77.56±0.29 mg/100g for zero time and 7 days and 14 days of storage, respectively.

In agreement with our results, Ateteallah and Abbas Osman, (2019) found that corn milk had phenolic compounds exceeded three times those detected in buffalo milk 7.07 ± 0.66 vs 2.10 ± 0.26, mixing ratios of 0:100, 30:70 and 40:60% corn milk: buffalo milk resulted in 10.15 ± 0.56, 11.47 ± 0.31 and 12.36 ± 0.58 mg/100 g TPC, 3.04 ± 0.28, 12.08 ± 0.20 and 15.20 ± 0.77 for DPPH scavenging activity, respectively.

Ateteallah *et al.*, (2022) investigated antioxidant properties of corn milk cheese with mixing ratios of 0:100, 80:20, 30:70 and 40:60% corn milk: cow milk, they proved that TPC and DPPH scavenging activity was significantly enlarged in all cheese samples by increasing the corn milk ratio. Control sample recorded the lowest value, 13.84. On the other hand, the addition of 40% corn milk cheese exhibited the highest score, with value of 21.39. The high TPC content in corn milk corresponds to its antioxidant activity, providing health benefits. Many authors also confirmed the higher antioxidant capacity and total phenol content of corn milk (Dewanto *et al.*, 2002 and Sangkam *et al.*, 2019).

Table 3. Instrumental color of fermented camel milk made with different mixing ratios of corn milk

Parameter	Storage period	Treatment					
		Control	T1	T2	T3	T4	T5
L	Fresh	67.73±2.185^d	67.73±0.235^a	67.73±0.565^ab	67.73±0.700^abc	67.73±0.300^bcd	67.73±1.255^d
	One week	75.08±2.066^a	73.32±1.581^a	73.15±2.191^a	69.83±1.855^cd	72.62±1.321^ab	68.79±1.471^d
	Two weeks	74.38±1.316^a	73.79±1.705^a	73.08±0.765^a	69.75±1.990^cd	73.37±1.860^a	69.15±1.441^d
a	Fresh	-2.523±0.550^def	-2.703±0.135^efg	-2.473±0.135^def	-2.347±0.115^de	-2.203±0.340^cd	-1.813±0.035^b
	One week	-3.25±0.195^h	-2.82±0.247^fg	-2.36±0.154^de	-2.21±0.061^cd	-2.19±0.103^cd	-1.75±0.076^b
	Two weeks	-2.96±0.215^gh	-2.50±0.195^def	-2.20±0.011^cd	-1.94±0.110^bc	-2.92±0.175^bc	-1.26±0.155^a
b	Fresh	5.1±0.130^def	4.81±0.220^ef	4.81±0.374^ef	4.86±0.456^ef	4.46±0.070^f	4.87±0.335^ef
	One week	5.79±0.424^abc	5.62±0.320^abcd	5.65±0.793^abcd	5.31±0.174^bcde	5.30±0.300^bcde	5.17±0.255^cde
	Two weeks	5.89±0.538^ab	6.09±0.270^a	6.06±0.360^a	5.74±0.021^abcd	5.74±0.390^abcd	5.38±0.029^bcde

Control:0%, T1:10%, T2:20%, T3:30 %, T4:40 % and T5:50 % corn milk. Data expressed as mean ± SD of 3 replicates. Means that have different letters in each parameter are significantly different ($P < 0.05$).

Table 4. Antioxidant biomarkers of fermented camel milk made with different mixing ratios of corn milk

Parameter	Storage period	Treatment					
		Control	T1	T2	T3	T4	T5
TPC (mg/100g)	Fresh	3.606±0.829 ^j	17.450 ± 0.862 ^i	18.563 ± 0.323 ^hi	18.731 ± 0.332 ^hi	19.341 ± 0.497 ^hi	20.791 ± 0.778 ^gh
	One week	23.739± 0.598 ^f	20.019 ± 1.024 ^hi	19.481 ± 0.098 ^hi	25.230 ± 2.360 ^def	22.859 ± 1.483 ^fg	30.181 ± 1.403 ^ab
	Two weeks	25.485 ± 0.398 ^def	24.252 ± 0.707 ^ef	26.472 ± 1.069 ^cde	27.076 ± 0.346 ^cd	28.319 ± 0.448 ^bc	31.991 ± 0.157 ^a
TFC (mg/100g)	Fresh	60.467±2.286 ^h	74.929 ± 1.189 ^g	77.102 ± 0.838 ^g	79.182 ± 1.143 ^g	94.489 ± 5.229 ^ef	98.560 ± 0.985 ^def
	One week	76.209±0.913 ^g	76.513 ± 0.869 ^g	82.132 ± 2.092 ^g	100.352 ± 6.307 ^def	106.325 ± 1.290 cd	104.748 ± 0.988 ^cde
	Two weeks	93.512±1.204 ^f	94.557 ± 0.371 ^ef	96.182 ± 0.915 ^def	112.774 ± 5.881 ^bc	119.321 ± 1.435 ^ab	124.503 ± 1.992 ^a
Tannins (mg/100g)	Fresh	18.795 ±7.177 ^i	23.139 ± 1.039 ^h	26.237 ± 1.029 ^fgh	28.689 ± 1.685 ^def	30.002 ± 1.642 ^cdef	30.345 ± 1.172 ^cde
	One week	24.379 ± 1.364 ^gh	26.357 ±2.005 ^fgh	28.056 ± 1.087 ^efg	29.282 ± 1.467 ^def	31.163 ± 2.473 ^cde	33.510 ± 0.539 ^bc
	Two weeks	32.586 ±0.517 ^cd	32.292 ± 0.280 ^cd	32.044 ± 0.374 ^cd	33.412 ± 0.375 ^bc	36.448 ± 1.101 ^b	40.134 ± 0.954 ^a
TAC (mg/100g)	Fresh	113.240 ± 3.961 ^h	149.819 ± 6.543 ^fg	154.045 ± 0.837 ^fg	156.525 ± 2.018 ^efg	164.445 ± 4.006 ^ef	186.291 ± 0.388 ^abc
	One week	142.305 ±6.503 ^g	154.766 ± 6.729 ^fg	161.157 ± 1.296 ^ef	168.147 ± 2.060 ^def	172.986 ±1.205 ^cde	198.907 ± 2.641 ^ab
	Two weeks	154.040 ±2.265 ^fg	163.478 ± 4.046 ^ef	173.288 ± 3.952 ^cde	184.529 ± 2.957 ^bcd	186.361 ±1.029 ^abc	202.511 ± 1.980 ^a

Control:0%, T1:10%, T2:20%, T3:30 %, T4:40 % and T5:50 % corn milk. Data expressed as mean ± SD of 3 replicates. Means that have different letters in each parameter are significantly different ($P < 0.05$). TPC: total phenolic compounds, TFC: total flavonoids compounds, TAC: total antioxidants compounds

Organoleptic properties for experimental groups are presented in Table 5. Regarding appearance, T2 did not differ statistically compared to control at (P>0.05), in the case of storage for one week, T1, T2, T3 and T4 did not differ statistically compared to control, where storage for 2 weeks revealed that only T4 and T5 were differed significantly compared to control at (P<0.05). Concerning body and texture, all treatments differ statistically at zero time, after one week of storage 20% substitution (T2) did not emerge a statistical difference to control. In respect to flavor, it received a judgment score of 45, the best scores in zero time were related to control, T1, T2 and T3 which were 44.2±1.095, 44.2±0.836, 42.6±1.673 and 41.6±1.516, respectively without statistical differences.

Table 5. Sensory evaluation of fermented camel milk made with different mixing ratios of corn milk

Parameter	Storage period	Treatment					
		Control	T1	T2	T3	T4	T5
Appearance (10)	Fresh	9.8±0.447[ab]	10.0±0[a]	9.6±0.547[ab]	9.0±0.707[bcd]	8.6±0.547[cde]	8.0±0.707[c]
	One week	9.4 ±0.547[abc]	9.4±0.547[abc]	9.2±0.447[abc]	9.2±0.447[abc]	9.2±0.447[abc]	9.0±0.707[bcd]
	Two weeks	8.2±0.447 [def]	8.2±0.447[def]	8.2±0.447[def]	8.2±0.447[def]	8.0±0.707 [ef]	7.4±0.894 [f]
Body & Texture (35)	Fresh	34.6±0.547[ab]	34.8±0.447[a]	33.4±0.547 [cde]	32.4±0.894 [efg]	31.0± 1.00[h]	29.8±1.095[i]
	One week	34.4±0.547[abc]	34.6±0.547[ab]	34.4±0.547[abc]	33.2±0.447 [def]	32.2±0.836 [fg]	31±1.414[h]
	Two weeks	34.0±0.707[abcd]	34±0.707 [abcd]	33.6±0.894 [bcd]	33±0.707 [defg]	32.2±0.836[fg]	32±0.707[gh]
Flavor (45)	Fresh	44.2±1.095[a]	44.2±0.836 [a]	42.6±1.673 [abc]	41.6±1.516 [abcd]	37±2.738 [ef]	34.4±4.277 [fg]
	One week	43.6±1.140[a]	44±1.224 [a]	43.2±1.923 [ab]	41±3.391 [abcd]	39.8±2.863[cde]	33.6± 4.979 [g]
	Two weeks	42.2± 1.303[abc]	42.2±0.836 [abc]	41.2±1.095 [abcd]	40.2±1.095 [bcd]	38.8±1.303[de]	33.6± 1.341[g]
Acidity (10)	Fresh	9.8±0.447 [a]	9.4±0.547 [ab]	9.4± 0.547 [ab]	8.6±0.547 [bcd]	8.2±0.447 [cde]	7.6±0.547 [efg]
	One week	9.2± 0.447 [ab]	9.2±0.447 [ab]	9.2±0.447 [ab]	8.0±0.707 [def]	7.4±0.547 [efg]	7.2±0.447 [fg]
	Two weeks	9.0±0.707 [abc]	9.0±0.707 [abc]	8.8±0.447 [bcd]	8.0±.707 [def]	7.4±0.894 [efg]	7.0±1.000 [g]

Control:0%, T1:10%, T2:20%, T3:30 %, T4:40 % and T5:50 % corn milk. Data expressed as mean ± SD of 3 replicates. Means that have same letters in each parameter are not significantly different (P < 0.05).

Also, after one week of cold storage up to 40 % substitution level, there was not any statistical difference compared to control, whoever up to 30% substitution level there was not any statistical difference compared to control after two weeks of cold storage. Göçer *et al.*, (2023) who made a probiotic drink from 100% corn milk and sugar reported that the lowest scores in taste & smell and general acceptability were received to this product, after 30 days of storage, and there was a significant decrease in sensory scores (P<0.05). Serum separation was responsible for lower scores in texture and consistency of the fermented products (Kizzie-Hayford *et al.*, 2016). The lowest evaluation in acidity was received to T5, after 2 weeks of cold storage with statistical variance compared to control (P<0.05), 7.0±1.000 vs 9.0±0.707.

From the results in Table 5, it can be said that the replacement of 20% camel milk with corn milk was the best substitution level following sensory evaluation. According to Supavititpatana *et al.*, (2010) cow milk yoghurt was preferred to corn milk yoghurt in terms of texture and mouth-feel. The same authors reported that corn milk yoghurt had low scores as a result of the greater whey drainage. Corn is still acceptable for up to two weeks of storage. Cow milk yoghurt was not significantly different to corn milk yoghurt in appearance, color and flavor attributes. Khalil, (2023) who made labneh from mixing goat and corn milk demonstrated that overall acceptability was the highest in substitution level of 20%, he also reported that a 30% substitution appeared more acceptable than control (100% goat milk), however, 40% corn milk resulted in lower acceptability to control.

Conclusion

Adding corn milk to camel milk is considered a fortification process by plant-origin milk, thus gathering the benefits of animal- and plant-based milk. Camel milk partially replaced with corn milk up to 50% correlated with maximum levels of TPC, TFC, tannins and TAC, however, up to 20% corn milk led to desirable organoleptic characteristics, besides fortification of antioxidants and phytochemicals. This product also provides a slightly low level of fat, which may offer a variety of products suitable for those who adopt low-fat, DASH, or Mediterranean diets, to convey the market requirements of novel products with functional properties.

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تقييم مشروب لبني متخمر قليل الدسم المنتج بخلط لبن الإبل ولبن الذرة

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الملخص

تناولت الدراسة الحالية إنتاج مشروب لبني متخمر قليل الدسم من نسب مختلفة من لبني الإبل والذرة وقيمت خصائصها الكيميائية واللونية وكذلك الخواص المضادة للأكسدة. تم تعديل حليب الإبل إلى1.5% دهن وخلطه مع الجينات الصوديوم واللبن المجفف خالي الدسم وسخن عند 85±1 درجة مئوية ثم برد عند 45 درجة مئوية ويضاف بعد ذلك البادئ تم إضافة لبن الذرة إلى لبن الإبل قليل الدسم بنسب 0،10،20،30،40،50 % وتخزينه عند درجة حرارة 4 ±1 درجة مئوية لمدة 14 يوماً، وتم تقييم الخواص الكيميائية واللونية ومضادات الأكسدة. أظهرت النتائج انخفاضاً معنوياً في كل من نسبة الدهن، درجة الحموضة والقلوية الجوامد الصلبة، البروتين والنيتروجين الكلي بزيادة نسبة لبن الذرة إلى 50%، ووفقاً للتقييم الحسي، يبدو أن T2 هي المعاملة الأكثر قبولاً، ولم يؤثر التخزين على التركيب الكيميائي بصورة معنوية. تم تقدير القدرة المضادة للأكسدة والفلافونويدات الكلية والتانينات والفينولات الكلية. يمكن الاستنتاج أن خلط لبن الذرة مع لبن الإبل قليل الدسم في إنتاج مشروب لبني متخمر قليل الدسم مما قد يقدم مشروبًا وظيفيًا جديدًا يعتمد على أصل نباتي مع محتوى قليل الدسم وقدرة أعلى من مضادات الأكسدة مما يلبي متطلبات هؤلاء الذين يتبعوا النظام الغذائي النباتي ونظام DASH.

الكلمات المفتاحية: *لبن الإبل، لبن الذرة، لبن ذو أصل نباتي، مشروب متخمر*