JMBFS

Journal of Microbiology, Biotechnology and Food Sciences

International peer-reviewed scientific online journal

Published by Faculty of Biotechnology and Food Sciences


# PHYSIOCHEMICAL, RHEOLOGICAL AND ORGANOLEPTIC ASSESSMENT OF CAMEL MILK YOGURT PREPARED FROM VARIOUS LOCATIONS OF PUNJAB-PAKISTAN


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https://doi.org/10.55251/jmbfs.7560

ARTICLE INFO

Received 16. 2. 2022
Revised 10. 5. 2022
Accepted 27. 5. 2022
Published 1. 6. 2022

Regular article

OPEN ACCESS



## ABSTRACT

The current study was planned to prepare the camel milk yogurt (CMY) collected from different ecological zones of Punjab province (Pakistan).CMY was prepared with the addition of stabilizers and stored for 21 days at refrigeration temperature to evaluate the effect on physicochemical (pH, titratable acidity, total solids, fat, solids not fat, crude protein, ash, minerals, fatty acids, insulin, organic acids), rheological (viscosity, syneresis, color, textural, water holding capacity) and organoleptic characteristics (color, body & texture, flavor, appearance, mouth feel, overall acceptability). The overall comparison of CMY composition for 21 days storage exhibited that all the parameters, except acidity, had maximum components at the start of storage study and decreased gradually throughout the storage span. The data regarding rheological properties of CMY showed that viscosity, water holding capacity and texture was high on the start of storage period that gradually decreased during storage in comparison to syneresis that increased throughout the storage span. A significant effect of the source of camel milk was also observed on the insulin content of yogurt. The mean values of the sensory parameters depicted highly significant (P<0.01) effect for the sources of camel milk yogurt and storage days.



**Keywords:** Camel milk; Yogurt; Physicochemical; Rheological; Organoleptic properties


## INTRODUCTION

Camel milk is the unique one because of its composition and functionality as it is a good source of vitamins (A, B-2, C and E) and minerals (sodium, potassium, iron, copper, zinc and magnesium). As well, it is low in protein, sugar and cholesterol **(Khaliq et al., 2018)** which is beneficial for heart patients. In addition, camel milk is a rich source of lacto peroxidase, secretory immunoglobulin A, immunoglobulin G along with antimicrobial potential **(Konuspayeva *et al.*, 2009; El-Said *et al.*, 2010)**. The milk composition of camel includes important insulin which has a medicinal benefit and impart various health benefits as pointed out by **(Jilo and Tegegne, 2016)** which were also confirmed by the findings of **(Al-Juboori *et al.*, 2013; Sharma and Singh, 2014; Gul *et al.*, 2015)** stating several health promoting benefits for the consumer.
The yogurt preparation from camel milk is quite challenging because it is low in casein (necessary for gel formation), devoid of beta-lactoglobulin (essential for BK complex formation) and owing to significant concentration of antimicrobial agents, that reduces the lactic acid bacteria (LAB) efficiency **(Ibrehem and El Zubair, 2016)**. **Mayssoun and Nadine (2010)** reported that Laban (drinking yogurt) prepared from camel milk fermentation exhibited good keeping and organoleptic properties during storage.
**Al-Saleh *et al*. (2011)** noticed the physicochemical properties of bifidobacteria fortified camel milk yogurt and concluded that higher rheological and sensory attributes as compared to cow yogurt. Likewise, banana flavored frozen yogurt was prepared from camel milk to elucidate quality attributes during storage and significant results were observed in pH, fat, TS and SNF of all the subjected treatments **(Ahmed *et al.*, 2010).** In one of the studies, skim milk powder (SMP) used to optimize total soluble solids for the yogurt production that imparts additional sensory features to camel milk yogurt (CMY) **(Salih and Hamid, 2013)**. For the preparation of set-type, flavored camel milk yogurt additives can be added such as gelatin, calcium and alginate **(Hashim *et al.*, 2009)**. However, there was need to check the effect of camel milk collected from different ecological zones on yogurt manufacturing. Therefore, in current study camel milk yogurt was prepared, after collecting milk from different ecological zones of Punjab, Pakistan. After preparation of yogurt, it was subjected to physicochemical, rheological, and organoleptic evaluation.

## MATERIAL AND METHODS

### Camel milk yogurt (CMY) preparation

Camel milk for yogurt production was collected from various ecological locations of Punjab region with five samples from each region. The yogurt was produced by following protocol explained by **Ibrahim and Khalifa (2015).**

**Table 1** Camel milk yogurt production treatments plan

| Region 1 (Lower Punjab) | Region 2 (Central Punjab) | Region 3 (Upper Punjab) |
|---|---|---|
| YLP1 | YCP1 | YUP1 |
| YLP2 | YCP2 | YUP2 |
| YLP3 | YCP3 | YUP3 |
| YLP4 | YCP4 | YUP4 |
| YLP5 | YCP5 | YUP5 |

YLP= Set type yogurt Production of camel milk from lower Punjab
YCP= Set type yogurt Production of camel milk from central Punjab
YUP= Set type yogurt Production of camel milk from upper Punjab

### Product analyses and storage studies

### Physicochemical analysis of yogurt

Physicochemical (pH, titratable acidity, total solids, fat, solids not fat, crude protein, ash, minerals, fatty acids, insulin, organic acids) analysis of yogurt was carried out on weekly basis until the acceptability of the prepared camel milk yogurt by following their respective protocols. Briefly, these methods are discussed as under.

**pH of CMY was measured according to AOAC (2006) by using calibrated digital pH meter**

Acidity of CMY was determined by direct titration method of AOAC (2006). Fat was determined by Gerber method as described by Smiddy *et al*. (2012). Total protein by the international dairy federation method, IDF 20-1 (2001). Lactose, Ash, Solids not fat (SNF) and TS content in CMY was assessed by following **AOAC (2006)**.

**Mineral analysis**

Minerals profiling of CMY was done by using flame photometer and atomic absorption spectrophotometer (AAS). Calcium (Ca), Sodium (Na), potassium (K) was quantified using flame photometer (Sherwood Scientific Ltd., Cambridge, Model 410) whereas Iron (Fe), zinc (Zn) and magnesium (Mg) concentrations were determined by atomic absorption spectrophotometer (AA240, Varian) **(Shamsia, 2009)**.

**Fatty acid analysis of yogurt**

The fatty acid analysis of CMY was assessed by using gas chromatography as described by Ahmed et al. (2013). The method is described as under.

**Extraction of fat**

Fat from CMY was extracted by following method of **Feng *et al*. (2004)**.

**Fatty acids methyl esters (FAME) preparation**

The 100µL ±5µL of oil sample was taken into the Pyrex test tube and 5 mL of hexane was added in the test tube and vortex for a short time to dissolve lipid. Then 250 µL sodium methoxide was added and again vortex for one min. After that 5mL of saturated NaCl was added in it and shaken strongly for 15sec and kept for 10 mins. Then hexane layer was transferred to a vial containing a small volume of sodium sulphate and kept for fifteen mins prior to run samples on GC.

**Gas chromatographic operating conditions**

GC (Agilent 6890) equipped with flame ionization detector (FID) was then used to run FAME by using method as described by **Korobko *et al*. (2007).**

**Insulin determination**

Insulin in CMY was measured by using UV-Vis spectrophotometer (RayLightw, UV-1600, China) **Royatvand *et al.* (2013).**

**Organic acids**

Organic acids of yogurt were assessed by the method given by Seckin and Ozkilinc, (2011) using HPLC (Perkin Elmer, USA) equipped with UV-visible detector.

**Rheological analysis of yogurt**

The rheological analysis (viscosity, syneresis, color, textural, water holding capacity) of CMY was done as per their respective protocols during the storage study.

**Viscosity**

The viscosity analysis of yogurt was done by following protocol as described by **Ayar and Gurlin (2014)**.

**Syneresis**

It was measured by following the method of **Hematyar *et al.* (2012)**. The yogurt sample (5mL) was centrifuged at 5000 rpm and 4℃ for 20 min.

**Color**

The Color analysis of yogurt was carried out by adopting the protocol of **Chouchouli *et al.* (2013**).

**Textural analysis**

Texture analysis was performed using TAXT2 plus texture analyzer (Stable Micro Systems, Godalming, Surrey, UK) using back extrusion plate Probe P-75 (75 mm Dia.) as described by **Gharibzahedi *et al*. (2014)**.

**Water holding capacity (WHC)**

Water holding capacity of yogurt was measured by using the method as described by **Hassan *et al*. (2014)**.

**Organoleptic evaluation**

Organoleptic evaluation of CMY was conducted according to the protocol given by **Amerinasab et al. (2015)**.

**Statistical analysis**

The results of the present study were subjected to two factorial design under CRD to check the level of significance for statistical analysis **(Montgomery, 2008).**

## RESULTS AND DISCUSSION

**Physicochemical analysis of camel milk yogurt**

The results for physicochemical analysis of CMY made from three ecological regions of Punjab are given in Table 2. The pH showed a highly significant (P<0.01) effect during the storage interval (Table 3) which exhibited declining behavior as a function of storage during 21 days of storage period. Overall, the pH decreased from (4.34±0.17) to (3.92±0.03) from 0 to 21 day of storage, respectively. The yogurt made from milk of lower Punjab region showed maximum pH (4.22±0.27) observed in YLP1 whereas, minimum (3.97±0.07) was found in YUP1. The decline in pH throughout storage is due to activity of lactic acid bacteria that convert lactose to lactic acid and ultimately increasing acidity and correspondingly decreasing pH of the yogurt. The results of our studies are supported by **Khalifa and Asem (2018)** who evaluated the physicochemical and functional properties of camel milk yogurt.

Statistical analysis showed a highly significant (P<0.01) effect on the acidity of CMY during storage days (Table 2). Mean values for acidity illustrate increasing trend in acidity of the product during storage interval of 0 to 21$^{st}$ days (Table 3). The findings for this parameter exhibited minimum acidity value (1.21± 0.38%) in YLP1 whereas; maximum acidity (1.33± 0.08%) was found in YUP4. On overall basis percent acidity increased from 0.84±0.03 to 1.73± 0.07% during the storage period. The increasing trend in percent acidity attributes to the conversion of lactose to lactic acid during the storage days. The findings agree with the studies of **Jumah *et al.* (2001),** who reported increase in acidity as a function of storage while studying attributes of the rheological properties of yogurt during the gelation process. **Salih and Hamid (2013)** strengthened the idea reflected in the present work (increase in acidity) when they assessed quality attributes of fortified camel milk yogurt. **Amerinasab *et al*. (2015)** and **Ibrahim and Khalifa, (2015)** also observed increasing trend of acidity in yogurt studies due to activity of LAB as well as stabilizers impact. Similarly, in another study, **Khalifa *et al*. (2011)** reported elevated trend in acidity as a function of yogurt storage. **Chougrani *et al*. (2008)** also reported similar trend while carrying studies on different strains of yogurt production. Likewise, **Gueimonde *et al*. (2003)** also documented increment in acidity due to the activity of bacteria that convert lactose to lactic acid during storage.

The fat contents in yogurt was found to be highly significant (P<0.01) due to milk source and storage days (Table 2 and 3). It is clear from the results that maximum fat value was noticed in milk from lower Punjab (3.28±0.14%) in YLP5 however, minimum fat percent was recorded in yogurt made from milk of central Punjab was (2.96 ±0.02%) found in YCP2. On overall basis fat contents in camel milk yogurt was decreased from (3.28 ±0.20%) to (2.95 ±0.07%) during the storage interval of 21 days, which could be related to lipolytic activity of enzymes. The results of fat contents are acknowledged with **Salih and Hamid (2013)** who studied compositional properties of fortified yogurt. **Skinadar *et al*. (2013)** also observed the decrease in fat contents as per effect of storage when physicochemical properties were evaluated with different hydrocolloids. **Kavas and Kavas, (2016)** studied nutritional and compositional attributes of different thickening agents incorporated set type yogurt and reported a reduction in fat contents after 10 days of storage. Other researchers also reported reducing trend in fat contents of yogurt as a function of storage **(Ahmad and Kanwal, 2004); Huma et al., 2003; Dublin-Green and Ibe, 2005).**

The statistical analysis showed that protein contents were highly significant (P<0.01) because of various regions and storage days (Table 1 and 2). Protein decreased from (4.36± 0.30%) to (3.98±0.25%) from 0 to 21 days of storage period. The effect of treatment (Regions) showed momentous changes on protein contents of yogurt. In lower Punjab region, on start of storage, maximum protein contents were noticed in YLP3 (5.03±0.221%) that decreased up to (3.70±0.15%) on 21$^{st}$ day of storage. However, yogurt of central Punjab showed highest protein contents in YCPI that varied in between (3.70±0.15 to 3.98±0.19%). The yogurt prepared from milk of upper Punjab showed maximum protein content in YUP5 at the start of storage that varied in between 4.50±0.225 and 4.18±0.19%. The overall highest protein content (4.61±0.12%) was observed in yogurt from lower Punjab YLP1 whereas, minimum protein content (3.72±0.13%) was found in YCP5 (Table 2). The results of protein content agree with **El-Owni and Mahgoub (2012),** who reported variation in protein contents during storage study of goat milk yogurt. **Eissa *et al*. (2010)** also observed protein reduction of yogurt while evaluating microbiological, sensory, and compositional properties of goat milk yogurt. The results obtained are also in accordance with **Sah *et al*. (2016)**, who studied the compositional and rheological properties of probiotic yogurt fortified with pineapple peel during refrigerated storage.

The statistical results depict that lactose contents were found to be significantly (P<0.01) affected as the function of yogurt made from various camel milk sources (regions) and storage days affected the lactose highly significantly. The maximum lactose content (5.44±0.11%) was found in YLP1 and minimum (5.36±0.12%) was calculated in YUP4. Generally, the lactose content of camel milk yogurt was decreased from (5.55±0.04%) to (5.24±0.02%) till the day of product acceptability i.e. 21 days of storage studies. The decreasing trend of lactose in camel milk yogurt is attributed to its conversion by LAB into product formation. The results are in accordance with the findings of **Ahmadoon, (2012)** who evaluated quality attributes of yogurt made from the blend of cow and camel milk during storage. Other researchers have also reported reduction in lactose contents during storage of yogurt made from milk of various milch animals **(Saccaro *et al*. 2009; Egwaikhide and Faremi, 2010; Salih and Hamid 2013).** Reduction in lactose has observed as a function of storage of yogurt during their experiment **(Kavas and Kavas, 2016).**

Statistical analysis regarding ash contents of yogurt prepared from various camel milk source (region) was found to be highly significant (P<0.01, Table 2) while the effect of storage days was found to be non-significant (P>0.05, Table 3). The results indicated maximum value of ash (1.09±0.054%) in YLP5 and minimum (0.91±0.039%) was found in YUP4. The results obtained are in accordance with the **Salih and Hamid, (2103)** who worked on camel milk yogurt, detailed previously. The findings of ash contents agree with the results reported by **El-Owni and Mahgoub (2012)** who evaluated yogurt attributes during storage. **Kavas and Kavas (2016)**, studied properties of set type yogurt and reported ash contents as non-significant during storage study.

The statistical data indicate that SNF was affected at highly significant level (P<0.01) because of camel milk source (yogurt) and storage days (Table 2 and 3). The mean values of SNF content of camel milk yogurt are shown in Table 2. Maximum value of SNF was (10.93±0.27%) found in case of YLP1 while minimum SNF.

**Table 1** Physicochemical analysis of camel milk yogurt

| Yogurt | pH | % Acidity | Crude fat | Crude protein | Lactose | Ash | SNF | Total Solids |
|---|---|---|---|---|---|---|---|---|
| YLP1 | 4.22±0.27a | 1.20±0.38 | 3.11±0.17a | 4.61±0.129a | 5.44±0.11 | 1.04±0.389ab | 10.93±0.27a | 14.16±0.364a |
| YLP2 | 4.17±0.24ab | 1.20±0.38 | 3.08±0.09ab | 4.18±0.109c-f | 5.44±0.12 | 1.09±0.381a | 10.49±0.25ab | 13.62±0.488ab |
| YLP3 | 4.16±0.17ab | 1.25±0.33 | 3.00±0.07abc | 4.36±0.702abc | 5.41±0.11 | 1.03±0.331ab | 10.73±0.81ab | 13.83±0.961ab |
| YLP4 | 4.06±0.16bc | 1.29±0.42 | 3.28±0.14a-d | 4.49±0.166ab | 5.38±0.14 | 1.063±0.428ab | 10.79±0.29ab | 13.86±0.535ab |
| YLP5 | 4.11±0.23abc | 1.26±0.38 | 3.28±0.35a-d | 4.29±0.142b-e | 5.39±0.11 | 1.09±0.381a | 10.74±0.32ab | 13.73±0.395ab |
| YCP1 | 4.22±0.29a | 1.20±0.35 | 3.04±0.11a-d | 4.13±0.129c-g | 5.39±0.15 | 1.02±0.354b | 10.54±0.28ab | 13.58±0.384ab |
| YCP2 | 4.21±0.30ab | 1.27±0.40 | 2.96±0.02a-d | 3.87±0.109gh | 5.40±0.11 | 1.01±0.409bc | 10.29±0.21ab | 13.25±0.244b |
| YCP3 | 4.18±0.21ab | 1.28±0.35 | 3.13±0.21a-d | 3.87±0.147gh | 5.38±0.12 | 1.02±0.358b | 10.26±0.26ab | 13.39±0.375ab |
| YCP4 | 4.10±0.17abc | 1.30±0.35 | 3.13±0.18bcd | 3.97±0.166fgh | 5.38±0.15 | 1.06±0.355ab | 10.42±0.31ab | 13.55±0.496ab |
| YCP5 | 4.10±0.22abc | 1.32±0.36 | 3.03±0.06cd | 3.72±0.136h | 5.40±0.17 | 1.01±0.360bc | 10.13±0.30b | 13.16±0.373b |
| YUP1 | 3.97±0.07c | 1.20±0.34 | 3.23±0.09cd | 4.34±0.129a-d | 5.40±0.15 | 0.92±0.343d | 10.82±0.24a | 14.01±0.178ab |
| YUP2 | 3.98±0.07c | 1.28±0.42 | 3.13±0.26d | 4.22±0.109b-f | 5.36±0.15 | 0.95±0.422cd | 10.75±0.23ab | 13.81±0.295ab |
| YUP3 | 3.99±0.06c | 1.29±0.38 | 3.10±0.17d | 4.03±0.147efg | 5.36±0.12 | 1.01±0.383bc | 10.47±0.26ab | 13.44±0.286ab |
| YUP4 | 4.23±0.24a | 1.33±0.40 | 3.07±0.24d | 4.08±0.166d-g | 5.38±0.13 | 0.91±0.401d | 10.53±0.31ab | 13.78±0.415ab |
| YUP5 | 4.16±0.15ab | 1.31±0.39 | 2.98±0.08d | 4.32±0.142bcd | 5.42±0.18 | 1.03±0.395ab | 10.81±0.25ab | 13.94±0.399ab |

The values are the mean± SD (n=3). Mean values containing different letters are significantly from others (*P*≤ 0.05). Overall yogurt means; Maximum value= 4.23; Minimum value=3.97

**Table 2** Effect of storage on physicochemical properties of camel milk yogurt prepared

| Parameters | 0 Day | 7th Day | 14th Day | 21st Day |
|---|---|---|---|---|
| pH | 4.34±0.17a | 4.20±0.14b | 4.03±0.07c | 3.92±0.03d |
| Acidity (%) | 0.84±0.03a | 1.12±0.092b | 1.37±0.068c | 1.73±0.07d |
| Crude Fat (%) | 3.28±0.20a | 3.11±0.13b | 3.07±0.10b | 2.95±0.07c |
| Crude Protein (%) | 4.36±0.31a | 4.25±0.30b | 4.07±0.26c | 3.98±0.25c |
| Lactose (%) | 5.55±0.05a | 5.46±0.04ab | 5.34±0.05bc | 5.24±0.03c |
| Ash (%) | 1.016±0.03 | 1.0173±0.09 | 1.02±0.07 | 1.016±0.08 |
| SNF (%) | 10.93±0.29a | 10.72±0.28a | 10.43±0.25b | 10.23±0.25b |
| Total Solids (%) | 14.13±0.39a | 13.84±0.33ab | 13.52±0.30bc | 13.2 ±0.30c |

SNF contents were found to be higher in yogurt samples as compared to the raw camel milk because SNF were increased deliberately by the addition of SMP, gelatin and *Metrozylon sagu* as a recipe during the yogurt production. On overall basis, SNF varied from (10.93±0.29% to 10.23±0.25%) during storage from 0 to 21 days of storage. The reason of decreasing trend may be due to the effect of changes found in protein and lactose as detailed in previous respective discussions and generally considered as biochemical changes (proteolysis, saccharolytic behavior) in yogurt due to fermentation through lactic acid bacteria during the storage. The results are strengthened by other researchers who acknowledged that SNF was decreased during storage studies of yogurt as they are the part of total solids **(Hematyar et al., 2012; Al-Otaibi and El-Demerdash, 2013; Sakandar et al., 2014).**

The statistical results pertaining to total solids showed highly significant (P<0.01) results for camel milk yogurt and storage days (Table 2 and 3). The means of total solids of camel milk yogurt are exhibited in Table 2 with maximum value of 14.16±0.36%, observed in YLP1 whereas minimum of 13.16±0.37% was found in YCP5. The total solids significantly varied from 14.13±0.39% to 13.2 ±0.30% during 0 to 21 days of storage study. The degradation of total solids in camel milk yogurt may be attributed to the biochemical reduction of compositional constituents (fat, protein, lactose) of yogurt and $CO_2$ production by the bacterial action during the storage. The results pertaining to total solids of camel milk yogurt are supported by **Anjum et al. (2007)** who reported decreasing trend of total solids during yogurt storage. In another study **Kavas and Kavas, (2016)** evaluated the physiochemical properties of set type camel yogurt supplemented with rice flour and SMP and reported reduction in total solids during 10 days of storage. The decreasing trend of total solids of yogurt as a function of storage was acknowledged by many other researchers in different parts of the world who explored the functional and rheological properties of yogurt **(Khalifa et al., 2011; Hematyar et al., 2012; Al-Otaibi1 and El-Demerdash 2013; Sakandar et al., 2014).**

The overall comparison of composition of camel milk yogurt during storage of 21 days is mentioned in Table 3 which is showing that all the parameters, except acidity, have maximum components at the start of storage study and decrease gradually throughout the storage span. The yogurt made from milk of lower Punjab contains maximum composition of fat, protein, ash, SNF and total solids lagged by yogurt prepared from milk collected from region of upper Punjab and central Punjab.

**Rheological analysis of camel milk yogurt**

Results pertaining to viscosity of the yogurt samples exhibited declining trend as far as source of milk and storage days are concerned. Maximum mean value for viscosity was (6047.3±368.0 cp) at 0 day which reduced to minimum (5287.1±292.6 cp) after 21 day of storage. On overall basis, maximum value (6539.5±548.6 cp) was noticed in YLP5 whereas, minimum (5266.0±197.9 cp) was observed in YUP3 Table 4. The decreasing trend in viscosity of CMY is related to production of lactic acid during the storage studies. Higher the amount of lactic acid produced, higher was the syneresis resulting in lowering the viscosity of the yogurt. The decreasing trend in viscosity was also reported by other researchers who evaluated the yogurt properties as a function of storage due to biochemical actions of enzymes and acid production **(Aryana and McGrew, 2007; Teles and Flores 2007; Ramasubramanian *et al*., 2008)**. Current findings are in harmony of **Rohart and Michon (2013)** who declared that the different levels of stabilizer exhibited different effect on the gelling properties of the yogurt during the storage and concluded that viscosity is affected by the level of stabilizer addition during storage. Akalin et al. (2012) who studied the textural and sensory attributes of probiotics yogurt incorporated with sodium calcium caseinate and whey concentrate also support the viscosity of yogurt.

The Statistical analysis results of syneresis depicts highly significant effect ($P<0.01$) as a function of source of CMY and storage days. Syneresis mean values are exhibited in Table 4 with a maximum mean value of syneresis as 60.50±10.47percentage in YCP3 while minimum of 53.50±10.47% in YCP2. Increase in syneresis percent *i.e.,* from 68.08±2.25 to 44.53±3.16 % was observed during storage which could be attributed to LAB activity, as a one factor, ultimately producing more acid and consequently weakening the gel networking of the yogurt during storage. Syneresis results are in agreement with **Mudgil et al., (2018)** who observed increasing trend of syneresis in yogurt storage studies as a function of microbial and enzymatic activities. Likewise, **Athar *et al*. (2000)** conducted the comparative study on yogurt, with and without addition of stabilizers. They reported increasing trend of syneresis in treatment without stabilizer during storage studies. Other researchers suggested different stabilizers could reduce that syneresis; however, they observed the whey separation due to storage of yogurt particularly emphasizing the factors other than stabilizers in such conditions **(Guven *et al*., 2005: Guzel-Seydim *et al.,* 2005; Ahmad *et al.,* 2008).**

The Statistical results regarding water holding capacity showed highly significant variation in CMY and storage days (Table 4 and 5). The WHC in the product exhibited maximum value (68.92±10.5%) in YLP1 and minimum (64.10±10%) in YCP5. On overall basis descending behavior, exhibiting water-holding capacity from 81.62±1.12% at zero day to 55.48±1.32% at 21st day was observed. Whereas maximum correlation with the possible reason of increasing acid production due to physicochemical changes resulting in weak and rearranged gel networking with the passage of time could be expected. The results are in accordance with the findings of **Bahrami *et al*. (2013)** who explored the behavior of yogurt with respect to WHC when conducted experiments on potential of different stabilizers to control the syneresis and water holding capacity. Abou-Soliman ***et al.,* (2017)** also authenticated the findings while investigating impact of polymerized whey protein isolates (PWPI) on rheological attributes of yogurt. They concluded that PWPI can be a better choice to maintain the water holding capacity and syneresis of yogurt. Others have also reported comparable judgements when they evaluated rheological and compositional traits of yogurt **(Galal *et al*., 2003; Milanović *et al*., 2007; Singh and Muthukumarappan, 2008).**

Statistics for textural analysis exhibited highly significant ($P<0.01$) effect as a function of CMY and storage days (Table 4 and 5). Decreasing trend was observed during storage with maximum value of 1.26±0.12 kg at 0 day and minimum value of 0.90±0.057kg after 21 days of storage when overall means were taken. In case of regional milk source effect, yogurt (YLP1) got maximum score as 1.21±0.15 kg whereas, minimum of 1.00±0.10kg was found in YCP3. The decreasing trend in textural properties of the came milk yogurt may be attributed to the biochemical, enzymatic changes or acid production that increase the syneresis and yogurt texture weakens as concluded by **Seckin and Ozkilinc (2011), Salvador and Fiszman (2004) and Yadav *et al*. (2007)** in their respective experiments.

The overall effect of storage on rheological properties of camel milk yogurt prepared from various regional sources of milk is mentioned in Table 5. The data is showing that viscosity, water holding capacity and texture was high on start of storage period that gradually decreased during storage in comparison to syneresis that increased throughout the storage span.

***Color analysis (L* a* b*) of camel milk yogurt (Hunter Lab Values)**

The Statistical results regarding L* exhibited highly significant ($P<0.01$) effect due to CMY and storage days (Table 3 and 4). The L* values of camel milk yogurt revealed decreasing trend with maximum overall mean value (65.09±1.61) at 0 day and minimum value (44.78±2.04) at 21 days of storage time. The maximum L* value (59.03±8.32) of yogurt was found in YLP1 whereas minimum (54.81±9.67) in YUP5, on overall basis, if regions of milk source are considered (Table 3).

a* values showed significant ($P<0.01$) effect of camel milk yogurt and highly significant due to storage days (Table 3 and 4). The a* values revealed decreasing trend with maximum mean value (1.61± 0.041) at 0 day and minimum (1.51 ± 0.031) after 21 days of storage. Source of milk for yogurt exhibited minimum value (1.51±0.038) in YUP5 and maximum value (1.61±0.036) value in case of YLP2 on overall basis (Table 3).

The statistical analysis pertaining to b* value showed highly significant ($P<0.01$) effect due to storage days whereas, the effect due to CMY was found to be non-significant (Table 3 and 4). The b* values exhibited increasing trend as a function of storage period and maximum value (2.92±0.058) was observed at 21st day whereas minimum (2.54±0.028) at 0 day (Table 4). In case of regional milk source maximum b* value of yogurt was 2.77±0.188 in YUP2 while minimum was 2.67±0.143 in YLP4 (Table 3). Storage exhibited the significant variation in L* a* b* values of the camel milk yogurt. Variation in color analysis of camel milk yogurt is attributed to the proteolysis, increase in acidity, and fluctuation in temperature and storage time. The enzymes present in yogurt hydrolyse the anthocyanin that may also cause the variation in color of the yogurt during storage. Chouchouli et al. (2013) who reported variation in color during the storage study of fortified yogurts support findings. Likewise, **Zare *et al*. (2011)** elucidated the similar results who evaluated the quality and sensory attributes of lentil flour supplemented yogurt. In another study, **Kavas (2016)** reported variation in L* a* b* during storage period of the CMY fortified with different hydrocolloids and Molasses.

**Table 3** Means of Color analysis (L* a* b*) of camel milk yogurt prepared from various milk source at refrigerated temperature

| Yogurt | L* | a* | b* |
|---|---|---|---|
| YLP1 | 59.03±8.32a | 1.59±0.046ab | 2.71±0.167 |
| YLP2 | 58.01±9.04ab | 1.61±0.036a | 2.75±0.165 |
| YLP3 | 56.78±9.33bcd | 1.58±0.074abc | 2.70±0.159 |
| YLP4 | 56.91±7.80bc | 1.56±0.051abc | 2.67±0.143 |
| YLP5 | 56.72±9.00bcd | 1.55±0.061abc | 2.69±0.168 |
| YCP1 | 56.19±9.14bcd | 1.55±0.028abc | 2.72±0.170 |
| YCP2 | 56.55±9.16bcd | 1.59±0.050ab | 2.75±0.186 |
| YCP3 | 56.54±9.00bcd | 1.56±0.062abc | 2.70±0.169 |
| YCP4 | 56.04±9.35bcd | 1.58±0.042abc | 2.69±0.152 |
| YCP5 | 55.79±9.04cd | 1.56±0.070abc | 2.74±0.130 |
| YUP1 | 56.15±10.5cd | 1.56±0.046abc | 2.73±0.181 |
| YUP2 | 55.61±9.78cd | 1.55±0.038abc | 2.77±0.188 |
| YUP3 | 55.03±9.72cd | 1.54±0.044abc | 2.72±0.213 |
| YUP4 | 55.18±8.95cd | 1.53±0.017bc | 2.73±0.171 |
| YUP5 | 54.81±9.67d | 1.51±0.038c | 2.76±0.176 |

**Table 4** Effect of storage at refrigerated temperature on Color analysis in camel milk yogurt prepared from various milk source

| Parameters | 0 Day | 7th Day | 14th Day | 21st Day |
|---|---|---|---|---|
| L* | 65.09±1.61a | 62.07±0.96b | 53.50±1.08c | 44.78±2.03d |
| a* | 1.61± 0.04a | 1.58 ±0.04b | 1.55±0.03b | 1.51 ±0.03c |
| b* | 2.54±0.03d | 2.64±0.04c | 2.78±0.04b | 2.92±0.06a |

**Minerals analysis of camel milk Yogurt**

Yogurt is the rich source of minerals with more bioavailability of calcium, zinc, magnesium and iron as compared to the raw milk. Maximum level of Ca (132.51±2.55 mg/100g) was recorded in YLP1 while minimum (106.05±3.91 mg/100g) was observed in YCP4. Results of Ca in CMY are in harmony with **Aryana and McGrew (2007)**, who explained the quality attributes of prebiotic yogurt during storage study. In another study, Güler **(2007)** studied the 24 minerals in salted and raw goat milk yogurt using inductively coupled plasma optical emission spectrometry (ICP-OES) which strengthens the current results of calcium contents in camel milk yogurt. Statistical results of iron exhibited highly significant ($P<0.05$) effect in CMY from lower Punjab region however, results were found at par in central and upper Punjab milk yogurt. Mean values of Fe indicate a maximum (0.56±0.14mg/100g) in YLP4 while minimum (0.25±0.12 mg/100g) was observed in YUP1. Results of Umbelino *et al*. (2001) also supported the present study who explained the sensory attributes of soy yogurt with the addition of salts.

Statistical results found to be highly significant (P<0.05) for CMY of lower Punjab region whereas results observed for CMY of central and upper Punjab region were at par. Maximum mean value (0.76±0.13 mg/100g) for Zn was observed in YLP2 whereas minimum (0.39±0.08 mg/100g) was calculated in YCP4. de la Fuente *et al*. (2003) supported the results of Zn in the present study, who examined the calcium, magnesium, phosphorus and zinc contents in yogurt. The Zn contents are also in line with Isleten and Karagul-Yuceer, (2008) who premeditated the quality attributes of non-fat yogurt fortified with proteins. Maximum mean value of Na was 64.62±2.65mg/100g observed in YLP1 while minimum of 50.11±3.05mg/100g was reported in YCP4. The current results of Na contents in CMY are in a range as described by Sanchez-Segarra *et al*. (2000), who evaluated mineral contents of fruit yogurt. The present outcomes of sodium are also supported by Stelios and Anifantakis (2004) who characterized the set type yogurt made from mixture of caprine and ovine milk. Statistically, results of potassium were highly significant ($P<0.05$) for CMY of lower Punjab region while the results of other two CMY were at par. Highest K value was 158.74±3.22 mg/100g in YLP4 while minimum lowest of 143.67±3.73 mg/100g was observed in YLP1. Results of the present study are in harmony with de la Fuente *et al*. (2003) who elucidated the mineral contents in yogurt during storage period. Similarly, Temiz *et al*. (2017) premeditated the quality attributes and minerals contents of yogurt fortified with fruit marmalades. The statistical analyses of magnesium revealed that there was highly substantial ($P<0.01$) variation observed in magnesium contents of CMY. The maximum contents of magnesium were noticed in yogurt from lower region while the results of central and upper Punjab were at par. The maximum magnesium contents (10.85±0.23 mg/100g) were found in YLP1 whereas minimum (8.98±0.35 mg/100g) was observed in YUP3. Results pertaining to the magnesium contents in present study are in congruence with the findings of **Bilandžić *et al*. (2015)**, who revealed the mineral contents in yogurt. Likewise, results of Mg in current study are supported by Bakircioglu *et al*. (2018), who investigated the minerals and toxic compounds in raw and fermented milk by using ICP technique.

**Fatty acids profiling of camel milk yogurt**

The mean values of fatty acids composition of CMY samples are demonstrated in Table 5. It is indicated from analysis that fatty acids content in CMY from lower region are relatively higher as compared to the CMY samples from central and upper Punjab regions. In fatty acids compositional analysis of CMY from lower region, linolenic acid was found to be minimum (1.05±0.04 g/100g) whereas the oleic acid was found to be maximum (22.14±1.40 g/100g), followed by palmitic acid (11.79±0.11 g/100g), stearic acid (6.41±0.04 g/100g), Lauric acid (6.09±0.09 g/100g), heptadecanoic acid (3.55±0.03 g/100g) and capric acid (3.40±0.04 g/100g) respectively. The fatty acids patterns of CMY samples from central region exhibited lowest quantity of linolenic acid (0.75±0.11 g/100g) while oleic acid was reported to be highest (19.04±0.95 g/100g) followed by palmitic (10.43±0.45 g/100g), palmitoleic (6.13±0.09 g/100g), lauric (5.85±0.14 g/100g) and steric acid (5.83±0.51 g/100g) correspondingly. The mean concentration values of fatty acids in CMY samples of upper Punjab region depicted the lowest concentration (0.74±0.11 g/100g) of linolenic acid and a highest concentration (18.04±0.95 g/100g) of oleic acid, followed by palmitic (10.43±0.45 g/100g), palmitoleic (6.13±0.05 g/100g), lauric acid (5.85±0.14 g/100g) and stearic acid (5.83±0.51 g/100g). The fatty acid patterns of CMY samples are exhibiting that oleic acid was found to be maximum (22.14±0.16 g/100g) in Lower Punjab milk yogurt samples followed by central (19.04±0.95 g/100g) and upper regions (18.04±0.95 g/100g). Linolenic acid was quantified as minimum among all the quantified fatty acids of CMY samples from all the regions, depicting an amount of 0.74±0.11 g/100g in upper Punjab region. Variations in fatty acids composition of CMY milk yogurt may be due to the difference in raw camel.

**Table 5** Mean Values of fatty acids (g/100g) composition of camel milk yogurt prepared from various milk source

| Fatty acid | YLP | YCP | YUP |
|---|---|---|---|
| Caprylic acid | 1.77±0.01 | 1.56± 0.05 | 1.56±0.05 |
| Capric acid | 3.40±0.04 | 2.83±0.11 | 2.80±0.11 |
| Lauric acid | 6.09± 0.09 | 5.85±0.14 | 5.85±0.14 |
| Tri-decanoic acid | 3.25±0.03 | 2.67±0.33 | 2.64±0.33 |
| Myristic acid | 3.06±0.05 | 2.82±0.09 | 2.81±0.09 |
| Myristoleic acid | 1.76±0.02 | 1.76±0.09 | 1.73±0.09 |
| Pentadecanoic acid | 1.66±0.02 | 1.68±0.04 | 1.68±0.04 |
| Palmitic acid | 11.79±0.11 | 10.43±0.45 | 10.43±0.45 |
| Palmitoleic acid | 2.95±0.55 | 6.13±0.10 | 6.13±0.10 |
| Heptadecanoic acid | 3.55±0.03 | 2.92±0.39 | 2.92±0.39 |
| Stearic acid | 6.41±0.04 | 5.83±0.51 | 5.83±0.51 |
| Oleic acid | 22.14±0.16 | 19.04±0.95 | 18.04±0.95 |
| Linoleic acid | 1.91±0.04 | 0.98±0.11 | 0.95±0.11 |
| Arachidic acid | 1.57±0.16 | 1.65±0.06 | 1.61±0.06 |
| Eicosaenoic acid | 1.75±0.04 | 1.75±0.04 | 1.71±0.04 |
| Linolenic acid | 1.05±0.04 | 0.75±0.11 | 0.74±0.11 |
| Behenic acid | 1.75±0.02 | 1.71±0.08 | 1.70±0.08 |
| Erucic acid | 1.75±0.01 | 1.72±0.05 | 1.71±0.05 |

Milk and fermentation changes like proteolytic and lipolytic actions of the starter culture bacteria. The existing outcomes of the fatty acids are in accordance with the Gerchev and Mihaylova (2012) who explored the fatty acids contents of sheep milk yogurt. The fatty acid results of CMY samples are also in line with the Serafeimidou *et al*. (2012), who premeditated the fatty acids pattern and conjugated linoleic acid in Greek yogurt samples.

**Insulin in camel milk yogurt**

Statistical analysis of insulin showed highly significant ($P$<0.01) result in CMY of lower Punjab region. Maximum mean concentration (26.58±0.99 IU/L) was observed in YLP2 while minimum (18.44±1.19 IU/L) was found in YUP3. Variations in concentration of insulin in yogurt samples are attributed to heat treatment and fermentation by the starter culture used for yogurt production. Current findings of insulin concentration are in harmony with the **Wernery *et al*. (2006),** who elucidated the effects of different processing condition on insulin concentration of camel milk in United Arab Emirates. Likewise, **Kang *et al*. (2006)** supported the current findings of insulin who premeditated dairy processes and storage effects on insulin-like growth factor-I (IGF-I) content in milk and in model IGF-I–fortified dairy products.

**Organic acids**

The mean values of organic acids in CMY samples from different regions and the effect of storage days on acids. Statistical results pertaining to acetic acid concluded that storage days and yogurt source put a highly significant effect ($P$<0.01). Acetic acid contents exhibited increasing trend as a function of storage and maximum value (297.47±25.07 mg/L) was observed on 21st day of storage while minimum (210.00±31.23mg/L) was found at 0 day. For overall yogurt means highest contents of acetic acid (290.00±28.142 mg/L) was reported in YLP1 and lowest (212.50±41.58 mg/L) was found in YUP1. The current findings of acetic acid in CMY are in harmony with the **Adhikari *et al*. (2002),** who evaluated the 30 days storage effects on organic acids of set, stirred and plain yogurt and stated the increasing behavior of acetic acid during storage due to LAB activity. The statistical analysis of butyric acid professed the highly significant effect ($P$<0.01) of source of CMY and storage days. The mean of storage shows decreasing trend and maximum (1779±16.8 mg/L) was observed at 0 day and minimum (1754±15.24 mg/L) was found at the 21st day of storage period. Highest butyric acids contents (1754±15.2 mg/L) were found in YLP1 whereas lowest (1735±10.7 mg/L) observed in YUP5. The outcomes attained in this study are in agreement with **Adhikai *et al*. (2002)** who studied the organic acid contents of the symbiotic set type yogurt. They elucidated that the butyric acid contents decreased from 195mg/100g to 172 mg/100 g during the storage study of 30 days. Likewise, decreasing trend of butyric acid was perceived during storage of probiotic yogurt as reported by **Vaseji *et al*. (2012)**. The statistical assessment concluded that the effect of CMY source was highly significant ($P$<0.01) whereas the effect of storage days was found to be non-significant ($P$>0.05). The citric acid found to be varied non-significantly from 5207.67±137.8 mg/L to 5246.27±198.9 mg/L during the storage period of 21 days. The maximum citric acid content (5335.75±3.7 mg/L) was found in YLP1 whereas minimum (4908.50±27.7 mg/L) was reported in YCP3. The asymmetrical changes were observed in citric acid contents during storage study of yogurt as described by **Seckin and Ozkilinc (2011)**. This may be due to the irregular metabolism of some organic acids and being converted to some other by products. Statistical results showed CMY and storage days found to significant ($P$<0.05). The maximum mean value of citric acid was (8589.25±37.7 mg/L) found in YLP3 while minimum was (6042.00±32.9 mg/L) observed in YUP1. Results pertaining to lactic acid contents varied from 6918.73±687.2 mg/L to 6996.40±687.1 mg/L during 21-day storage period. The augmentation in lactic acid is attributed to the activity of starter culture which converts lactose to lactic acid during storage.

**Sensory Evaluation**

The statistical results depicting highly significant ($P$<0.01) effect were observed for the camel milk yogurt and storage days. Mean table exhibited the deceasing trend in color of the yogurt from 6.72±0.29 to 5.47±0.16 during the 21 day of storage study. The maximum mean value for yogurt was (6.51±0.63) reported in YLP3 while minimum color score was 5.84±0.41 obtained for YUP4.
The results for color analysis of the yogurt are in comparison with **Brennan and Tudorica (2008)**, who studied the inulin effects on yogurt sensory attributes and reported the decreasing trend in color during sensory evaluation of yogurt by the seosry panelists. Likewise, **Bano *et al*. (2011)** reported the decrement in color of the yogurt from 7.50 to 4.88 during the storage period of 28 days. Similarly, **Zare *et al*. (2011)** results are also in comparison who observed the variation in color during the investigation of the organoleptic, physical, microbial properties of the yogurt fortified with skim milk powder and lentil flour.
The statistical data for body and texture of CMY is showing highly significant ($P$<0.01) results for yogurt and storage days. The mean values are showing decreasing trend in body and texture values during storage with a maximum value of 6.80±0.43 observed at 0 day while minimum of 5.47±0.20 at 21st day of storage. Maximum mean score was 6.69±0.90 observed in YLP1 whereas minimum of 6.10±0.91 was calculated for YUP5. The current results of body and texture values are in harmony with the other researchers findings who elucidated the sensory attributes of yogurt during the storage study and reported a decreasing trend in body and texture values by the sensory panelists **(Tarakci and Kucukoner, 2003; Aryana and McGrew, 2007; Yi *et al*. 2010; Moeenfard and Tehrani, 2008).**
The statistical results pertaining to flavor indicted a highly significant ($P$<0.01) effect for CMY and storage days. The flavor showed the decreasing pattern and maximum score (6.72±0.25) was observed at 0 day while minimum (5.46±0.12) was reported at 21st day of storage. The maximum score (6.35±0.76) was obtained by YLP2 whereas minimum score (5.9±0.44) was given to YUP4 by the sensory panelists. The present results are in harmony with **Hoppert *et al*. (2013)**, who evaluated the consumer acceptability for flavor characteristic of normal and fiber enriched yogurt and found the decreasing trend in flavor values of yogurt during the sensory evaluation by the sensory panelists.
In another study, **Tarakci and Kucukoner (2003)** reported the decreasing trend in flavor of fruit yogurt during the 10 days' storage study at 5°C. **Yadav *et al*., (2007) and Bano *et al*., (2011)** also reported the decrement in flavor as a storage function.
The perceiving of the value-added food product is mainly influenced by the appearance of the food product as it is considered as a vital parameter for the

attraction at the consumer's end. In the present study, a highly significant ($P$<0.01) effect was found for CMY and storage days. Likewise, color, flavor and body texture, score for appearance of CMY exhibited decreasing trend during the storage study. The score for appearance was deceased from 6.69±0.36 to 5.43±0.12 during 21 days of storage. The maximum mean value (6.5±0.84) was found for YLP1 while minimum score (5.9±0.40) was gained by YCP3. Decreasing scores for appearance was reported by **Tarakci and Kucukoner (2003)** who evaluated the sensory attributes of the fruit flavored yogurt during storage at refrigerated temperature. The current findings are also in line with **Salwa *et al*. (2003)**, who elucidated the sensory evaluation of carrot yogurt and reported the reduced scores for appearance during storage period. Likewise, **Yadav *et al*. (2007)** announced decreasing scores for appearance of the yogurt during the storage.

The statistical results pertaining to mouth feel showed highly significant ($P$<0.01) effect for CMY and storage days. The mean scores for mouth feel exhibited decreasing trend from 6.75±0.24 to 5.44±0.12 during the storage study of 21 days. The maximum mouth feel score (6.34±0.68) was taken by YLP1 while minimum (6.19±0.50) was observed in YUP5. The current outcomes are in harmony with the findings of **Brennan and Tudorica (2008)** who studied the effect of prebiotic on yogurt quality attributes during the storage study. Another research reported by the other researchers who elucidated the effects of storage on sensory attributes of different yogurt **(Meyer *et al*., 2011; Rohart and Michon, 2013).**

The statistical analysis regarding the overall acceptability showed highly significant ($P$<0.01) results for the CMY. The storage time negatively affected the overall acceptability of the yogurt. Overall acceptability score decreased from 6.8±0.32 to 5.14±0.15 at 0 and 21 days respectively. The maximum overall acceptability score (6.5±0.77) was obtained by YLP3 while minimum (5.7±0.64) was reported in YUP3. The current findings are in line with the **Brennan and Tudorica (2008)** who evaluated the effect of sugar-based fat replacers on sensational and rheological properties of the yogurt during storage period. Likewise, **Irvine and Hekmat (2011)** analyzed the organoleptic properties of yogurt enriched with prebiotic fibers and reported that the sensory properties was increased by the addition of food hydrocolloids.

## CONCLUSIONS

CMY prepared after collection of camel milk from different ecological zones of Punjab province in Pakistan exhibited acceptable organoleptic properties during 21 days of storage at refrigeration temperature. A comparison of CMY composition for 21 days storage exhibited a decreasing trend however, the acidity increased due to the production of lactic acid. The results depicted that rheological properties effect negatively hroughout the storage span. The different zones of Punjab showed significant difference in the insulin content of CMY prepare from different milk of different sources. The organoleptic properties depicted highly significant ($P$<0.01) effect for the sources of CMY and storage days.

**Funding:** This research received no external funding.

**Acknowledgments:** The authors are thankful to Institute of Food Science and Technology, Khwaja Fareed University of Engineering and Information Technology, Rahim for, Pakistan, for research facilities and technical support.

**Conflicts of Interest:** The authors declare no conflict of interest.
Ethical Approval: There are no biological studies involve in this article.

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