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INVESTIGATION OF ALTITUDE EFFECT ON SOME PHYSIOCHEMICAL PROPERTIES OF MILK SAMPLES OBTAINED FROM CAMELS AND SMALL RUMINANTS

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ABSTRACT

This article investigated the effect of altitude on milk of camel, goat and sheep with regard to their laser induced fluorescence spectra, pH, conductivity, moisture, Total Dissolved Solids (TDS), specific gravity and ash percentage. The altitude significantly affected the specific gravity and the ash percentage of all the studied milk's samples while it with the altitude significantly affected the pH and conductivity of the camel and goat milk samples. The high altitude sheep and goat milk samples were characterised by the highest fluorescence intensity compared to their low altitude milk while the low altitude camel milk had the highest fluorescence intensity compared to the high altitude camel milk. The laser induced fluorescence (LIF) technique was very useful in differentiating between the altitude and animal source of the studied milk samples.

Key words: Altitude effect, ash, camel, conductivity, laser induced fluorescence, milk

The camel milk is composed of approximately 79% water, 11.9% total solids, 4.4% lactose, 3.5% fats, 3.1% proteins and 0.79% ash (Khaskheli *et al*, 2005; Al haj and Al Kanhal, 2010). Compared to the other animal milk, the camel milk is characterised by low sugars and cholesterol and high minerals and vitamins (Zibaee, 2015).

Goat milk has a creamy texture and is characterised by the highest buffering capacity, viscosity, surface tension and specific gravity. It has high concentration of vitamins and minerals. It is reported that the goat milk has an anti-inflammatory properties and it increases nutrients uptake, decreases blood cholesterol and boost immune system activity (Park, 2006; Lopez-Aliaga *et al,* 2005; McCullough, 2003).

Similar to the goat milk, the sheep milk has creamy texture, sweet and distinctive flavour due to its high concentration of fatty acids (Jooyandeh and Aberoumand, 2010). The sheep milk is characterised by its high content of proteins, minerals and fatty acids compared to the other mild samples. Also, the sheep milk has the lowest moisture and ash within the other types of natural milk. Worldwide, it is widely used for the production of fine and highly nutrient cheese and yoghurt (Balthazar *et al*, 2017).

Several Factors are well known to affect the physiochemical properties of milk including the milking animal and its age, genetic and environmental factors, type of nutrients, level of production, stage of lactation, season and presence of diseases (National Research Council (US), 1988). Recently, the altitude was reported to affect the physiochemical properties of milk (Quinn *et al,* 2016; Leiber *et al,* 2005).

Laser Induced Fluorescence (LIF) technique is widely used in different fields of research and industry including investigation of milk and milk products quality (Hui *et al,* 2018; Andrei *et al,* 2014; Marques *et al,* 2018; Abdel-Salam *et al,* 2015; Abdel-Salam *et al,* 2017). The best known fluorescent compounds in milk and milk products are the aromatic amino acids, riboflavin, vitamin A and nucleic acids (Sádecká and Tóthová, 2007). This article investigated the effect of milking animal and altitude on the physiochemical properties of milk of camel and small ruminants.

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Materials and Methods

Milk samples

Eighteen milk samples from camels and small ruminants, i.e. sheep and goats were collected from high (2400 metre above sea level) and low (20 metres above sea level) altitudes. Nine samples were collected from each altitude (3 each). The milk samples were analysed immediately or within one week from the sample collection and were stored at -20°C. The various physiochemical properties of milk sampled and their estimation methods are given below—

Milk pH

pH of each milk sample (20 ml) was determined using HANA pH meter (HI 8314 HANNA, Italy) after it was calibrated by two buffers with pH 4 and 7.

Milk conductivity (mS/cm)

The conductivity of the milk samples (20 ml) was determined by a calibrated Metrohm conductometer (712 conductometer, Switzerland).

Milk moisture (%)

The milk moisture was determined using the oven. The 5 gm milk sample was weighed (B) and was heated for 1 hour at 70°C and then for 6 hours at 105°C (Bradley, 2017). After heating, the milk was weighed (A) and the moisture percentage was calculated as follows:

$$Moisture\% = \left(\frac{B-A}{B}\right) \times 100$$

Total Dissolved Solids (%)

The TDS of the milk samples was measured by heating 5grams (B) of milk for one hour at 70°C and for six hours at 120°C (Bradley, 2017). The milk residue was weighed (A) and the TDS was calculated using the equation given below:

$$TDS\% = \left(\frac{A}{B}\right) \times 100$$

Specific gravity

The specific gravity of the milk is the ratio of its density to the density of the water. A 50 ml specific gravity determination bottle was used and the weight of the 50 ml milk was divided by the volume.

Ash percentage

The sample of moisture determination was heated to 600°C in a furnace oven and the weight of the ash was divided by the weight of the milk sample and multiplied by 100 to obtain the ash percentage (Marshall, 2017).

Laser Induced Fluorescence Technique

The laser excitation source of this experiment was a diode laser (Pro100 -Toptica Photonics Inc.). It provides a maximum output average power of 29 mW at wavelength 398 nm. A laser control unit was used to control the output power of the laser beam through changing the current and temperature of the diode. The output average power of this experiment was 2 mW. Each milk sample was put in a cuvette and the laser beam was focused to 2 mm onto one side of the cuvette. A lens that focuses the radiation and sends it to monochromator (ScienceTech 9055, ScienceTech lnc. Canada) was used to collect the milk emitted fluorescence. The excitation laser was blocked by a long pass filter (Thorlabs Inc. USA) that permits the emitted fluorescence radiation to pass only. The sample holder and the monochromator were arranged perpendicular to each other. The monochromator slit was opened at a width of 0.2 mm. This arrangement offers a spectral resolution of 0.2 nm. The monochrome analyses the fluorescence signal and permits it to exit through another slit to fall on a photomultiplier tube (PMT). The PMT converts the light signal to a voltage. The signal passes to the data acquisition unit connected to a computer to read and draw the signal as a wavelength change.

Statistical analysis

The ANOVA test of the SPSS statistical programme was used for the analysis of the results. The difference between the means of the parameters was considered significant if the p- value was ≤ 0.05.

Results and Discussion

General

The camel milk had the highest moisture and conductivity while the sheep milk had the highest TDS percentage and the specific gravity irrespective of the altitude. The low altitude goat milk was characterised by the highest ash percentage compared to the low altitude camel and sheep milk. The highest pH value of the low altitude milk was reported for the sheep milk. The altitude significantly affected the specific gravity and the ash percentage of all the milk, while it nonsignificantly affected the moisture and TDS percentages. The altitude significantly affected the pH and conductivity of the camel's and goat's milk (Table 1).

Table 1. Mean ± SD values of the studied parameters in the low and high altitude milk and their variation significance.

Parameters		Sheep milk	Goat milk	Camel milk
pH	High altitude	6.54 ± 0.1	6.53 ± 0.7	6.64± 0.07
	Low altitude	6.46 ± 0.002	6.37 ± 0.009	6.27± 0.04
p- value		0.23	0.031	< 0.001
Conductivity mS/cm	High altitude	4.54 ± 0.5	5.56 ± 0.14	5.97±0.8
	Low altitude	4.55 ± 0.00	7.42 ± 0.28	8.25± 0.49
p- value		0.98	0.003	0.001
Moisture%	High altitude	73.5 ± 7.9	84.3 ± 4.4	88.1±2.7
	Low altitude	74.2 ± 0.00	81.5 ± 0.14	88.75± 1.06
p- value		0.88	0.51	0.89
Ash%	High altitude	4.6 ± 0.9	3.5 ± 0.6	0.12 2.6±
	Low altitude	0.51 ± 0.001	0.58 ± 0.15	0.32± 0.06
p- value		<0.001	<0.001	0.001
Specific gravity	High altitude	1.04 ± 0.1	1.02 ± 0.05	1.01± 0.02
	Low altitude	1.03 ± 0.00	1.013± 0.004	1.015± 0.007
p- value		0.004	<0.001	0.005
TDS%	High altitude	26.5 ± 7.8	14.1 ± 6.4	12.2± 3.6
	Low altitude	25.8 ± 0.001	18.43 ± 0.25	11.21±1.09
p- value		0.88	0.37	0.829

The milk of camel and goat were more affected by the altitude than the sheep milk.

There was nonsignificant variation between the means of the studied parameters in the milk of camel and goat of the low and high altitudes. All the studied parameters except the pH of the camel and sheep milk were significantly different, irrespective of the altitude. The comparison between the goat and sheep milk showed that there was significant variation between the conductivity (p- value=0.037 and p-value< 0.001), moisture (p- value= 0.017), TDS (p-value= 0.015), specific gravity (p- value< 0.001) and ash percentage (p- value= 0.03).

The altitude may be responsible for the increased fluorescence intensity of the sheep and goats milk, while it decreased the fluorescence intensity of the camel milk (Fig 1).

According to the results of the pH, conductivity, moisture, TDS and ash, there was nonsignificant variation between the goat and camel milk (one class). The laser induced spectra showed that the pattern of flaorescence of the goat and sheep milk were similar (one class) while the camel milk was with different fluorescence pattern. According to animal taxonomy, the goats and sheep belong to one family (Bovidae) while the camel is within another family (Camelidae) (Gentry *et al,* 1999). Comparing the results of the laser induced fluorescence of the different milk samples and the animal taxonomy, it is evident that the LIF can be used as a tool for milk classification rather than the other physiochemical properties besides its ability to differentiate between low and high altitude milk. However, Sun *et al* (2019) concluded that the LIF is a very good technique for the prediction of yogurt quality. LIF was used before to differentiate between low and high altitude Switzerland cheese samples (Karoui *et al,* 2005). It was proved that the LIF is

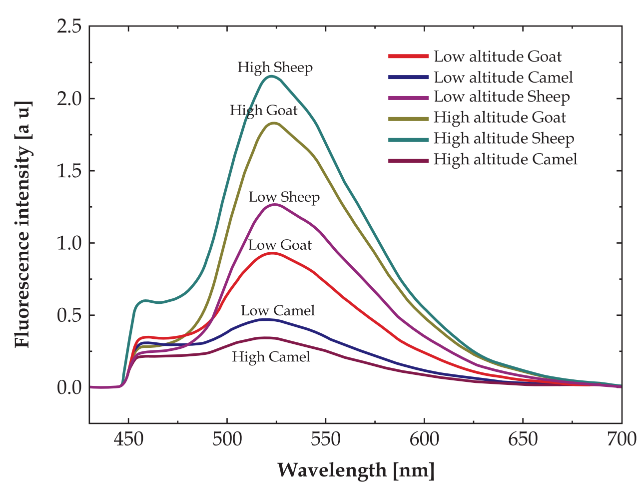

Fig 1. The fluorescence spectra of the studied milk samples. The high altitude sheep and goat milk were with high fluorescence intensity compared to the low altitude ones while the high altitude camel milk exerted low fluorescence intensity compared to the low altitude camel milk.

useful in evaluation of milk heat treatment (Birlouez-Aragon *et al*, 2002).

The results of the present study showed similar pattern of the results as observed by Sabahelkhier *et al* (2012); the camel milk had the highest moisture percentage (88.35%) compared to sheep (80.7%) and goat (88%) milk. Also, the camel milk of Sabahelkhier *et al* (2012) study was characterised with the lowest TDS (11.7%) compared to goat milk (12%) and sheep milk (19.3%). Unlike our findings the study of Sabahelkhier *et al* (2012) found that the camel milk had a higher ash percentage (0.75%) than that of the goat milk (0.7%) and lower than the sheep milk (0.85%). This study unlike results of an Egyptian study which reported that the camel milk had TDS and ash percentages more than goat milk and less than sheep milk (Hayam *et al*, 2017). The values of the studied parameters in the low altitude milk samples are much comparable to the previous studies compared to the results of the high altitude milk samples (Table 2).

Concerning the camel milk, it was characterised by high pH values with a range starting from 6.5 up to 6.7 (Sisay and Awoke, 2015). The moisture of the camel milk was in the range of 87- 90% which was comparable to the finding of this study (Singh *et al*, 2017).

The previous studies showed that the electrical conductivity of the camel milk was around 6.08 millimohs and it was mostly due to its high content of sodium, potassium and chloride ions (Yoganandi *et al*, 2014).

The mean ash percentage of the camel milk in this study was 2.6%. The results of the ash percentage disagreed with the findings of most of the previous studies such as Jilo and Tegegne (2016), Al haj and Al Kanhal (2010) and Singh *et al* (2017) who stated that the ash percentage of camel milk had a range of 0.6 - 0.9% while it was comparable to the results of Yagil (1982) who stated that the camel colostrum milk had ash percentage range of 1.44–2.80% and a mean value of 2.6%. Also, Kavas (2015) found that the mean percentage of camel milk ash was 2.932%. However, the ash percentage results reflected the effect of the lactation stage on the physiochemical properties of camel milk.

The viscosity of the camel milk was the least within the 3 milk samples (1.94 centipoise). The previous studies showed that the mean viscosity of the camel milk was 1.77 centipoise which was similar to that of buffalo milk (1.79 centipoise) and more than the viscosity of cow milk (1.54 centipoise) (Yoganandi *et al*, 2014). However, it is well known that the viscosity of milk is fat content, moisture content and temperature dependent (Bakshi and Smith, 1984).

This study revealed that the camel milk had the lowest specific gravity (1.01) which is due to the high moisture percentage of the camel milk. The previous studies showed that the specific gravity of camel milk starts from 0.96 up to 1.1 (Yagil, 1982). Yoganandi *et al* (2014) stated that the camel milk had a mean value of specific gravity of 1.029 compared to 1.029 and 1.033 in cow and buffalo milk, respectively. The TDS results had the lowest TDS value between the goat and sheep milk (12.2%). Khan and Iqbal (2001) reviewed that other researchers found the TDS of camel milk between 11.29 to 14.30%.

Table 2. The significance of the variation between the mean values of the studied parameters in the low and high altitude milk.

Parameters	High altitude Milk		p- value	Low altitude milk		p- value
pH	Camel	Goat	0.19	Camel	Goat	0.16
		Sheep	0.21		Sheep	0.02
Conductivity	Camel	Goat	0.41	Camel	Goat	0.136
		Sheep	0.02		Sheep	<0.001
Moisture	Camel	Goat	0.42	Camel	Goat	0.14
		Sheep	0.02		Sheep	0.01
Ash	Camel	Goat	0.17	Camel	Goat	0.66
		Sheep	0.01		Sheep	0.74
Specific gravity	Camel	Goat	0.12	Camel	Goat	0.41
		Sheep	≥ 0.01		Sheep	0.001
TDS	Camel	Goat	0.73	Camel	Goat	0.19
		Sheep	0.03		Sheep	0.019

There was insignificant variations between the means of the studied parameters in the camel and goat milk of the low and high altitudes. All the studied parameters except the pH of the camel and sheep milk were significantly different irrespective of the altitude. The significance was set at the level of ≤ 0.05.

In goat milk the ash percentage, TDS percentage and specific gravity were 0.71- 0.88%, 11.5- 18.68% and 1.022 - 1.026, respectively (Jenness, 1980; Clark and García, 2017). Sabahelkhier *et al* (2012) found that the mean pH value and moisture percentage of goat milk in Sudan was 6.6 and 88%, respectively. The physiochemical properties of goat milk reported by the previous studies were close to the findings of this study.

The findings of previous studies of the sheep milk pH, moisture, electrical conductivity, specific gravity, viscosity and conductivity were comparable to the findings of this study. This study reported the highest ash and TDS percentage in sheep milk; 26.5 and 4.6 compared to the previous studies which may be due to the different geographical origin or lactation stage (Balthazar *et al*, 2017; Junior *et al*, 2015; Kanwal *et al*, 2004; Hoxha and Mara, 2012; Park, 2007; Bateman and Sharp, 1928). However, high percentage of ash was reported before in camel's and cow's milk (1.44- 2.932%) (Yagil, 1982; Kavas, 2015).

Conclusions

The studied physiochemical properties of milk samples (pH, conductivity, moisture, specific gravity, TDS and ash) showed that there were insignificant variations between the camel and goat milk samples while the sheep's milk was significantly different from the camel and goat milk samples (conductivity, moisture, specific gravity and TDS).

The laser induced fluorescence intensity of the sheep and goat followed similar patterns while that of camel was with a vice versa pattern. The LIF proved its suitability to be used for the determination of the milk source and altitude. The altitude significantly affected the physiochemical properties of camel's, sheep's and goat's milk. In conclusion, more samples will be needed to confirm our findings.

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