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The acid–base buffering properties of Alxa bactrian camel milk

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ABSTRACT

The buffering properties of Alxa bactrian camel whole milk was investigated by titrating with base or acid. A "loop" was observed in the pH range 6.6–4.3 when sample was firstly titrated with acid and then back titrated with base. A "loop" was not observed when sample was firstly titrated with base and then back titrated with acid. When the milk sample was titrated from initial pH to 2.0 with HCl, camel milk exhibited a pronounced maximum buffering at approximately pH4.4 and the value of dB/dpH was about 0.073. When acidified camel milk sample was back titrated from pH 2.0 to 11.0 with NaOH, there was low buffering index at approximately pH 4.9 (0.024), and maximum buffering index occurred at approximately pH 6.1 (0.051). The sample was firstly titrated from initial pH to 11.0 with NaOH, camel milk exhibited a weaker buffering peak at approximately pH 7.1 and the value of dB/dpH was about 0.018, when the alkalized milk sample was back titrated from pH 11.0 to 2.0 with HCl, the maximum buffering index occurred at approximately pH 5.1 and the value of dB/dpH was about 0.047.

1. Introduction

There are three fine breeds of Camelus bactrianus in China, namely Xinjiang, Alxa bactrian and Sunite camel (Zhang et al., 2005). Alxa camels can be further divided into Gobi and Desert camels based on their stature, physical features, and breeding distinctions. Alxa camels are reared mainly by natural grazing in different herd sizes ranging from 10 to 100 camels with a grazing radius of 40–50 km. Alxa camel belong to low milk yield category, an Alxa camel can produce 0.25–1.5 kg of milk daily in addition to the amount taken by the calf.

The chemical composition of camel milk was similar to that of cow milk (Yagil, 1982; Farah, 1993). Camel milk can be used for making various dairy products such as butter, shubat, cheese and milk tea. Camel milk not only supplies nutrition for local people, but also has therapeutic properties. Considerable information had been published concerning the variation of the chemical composition of dromedary camel milk (Yagil, 1982; Farah, 1993; Mehaia et al., 1995; Gorban and Izzeldin, 1997; Guliye et al., 2000; Zhang et al., 2005; JiRiMuTU, 2006), but little knowledge was available concerning the buffering properties of camel milk. The buffering properties of cow, goat and buffalo milks had been reported (Buchanan and Peterson, 1927; Whittier, 1929; Watson, 1931; Ismail et al., 1973; Park, 1991; Lucey et al., 1993). Interest has been directed recently to the importance of the buffering value of milk, particularly, in regard to certain processes in the manufacture

Abbreviations: BI, buffering index; BC, buffering capacity; TN, total nitrogen; NPN, non-protein nitrogen; WPN, whey protein nitrogen; CN, casein nitrogen.

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of casein, cheese, condensed milk products and nutritional studies.

The buffer capacity of a solution may be expressed as its power to resist change in pH upon the addition or loss of acid or base (Ismail et al., 1973). Buffering index was defined as the number of equivalents of acid or base required to shift the pH of 1 L of milk by one unit (Ismail et al., 1973). The buffering index of a solution was not constant and had an exact value only at a definite pH, and therefore the value calculated over an observed pH range was an average one. In practise, a close approximation was made if the buffering index was calculated for the mean pH over a small pH interval (Watson, 1931).

Objectives of this study were to characterize the buffering properties, report the BC, demonstrate that the forward and back titration curves are not identical in Alxa bactrian camel milk.

2. Materials and methods

2.1. Preparation of animal milk samples

Ten 5-year old Alxa bactrian female camels close to giving birth for the first time were randomly selected from different herds that depended on natural grazing. The camels, which all belonged to the Alxa nomads in Inner Mongolia, were kept under muster management before giving birth and fed with hay supplemented with corn after parturition. Sampling collection started following parturition at 90 d post partum (PP). Representative sample was collected 500 ml each camel, and the sample was cooled in ice-water and stored at 4 °C, for a period not exceeding 72 h, 10 samples were warmed to 20 °C and mixed thoroughly until analyzed. The control cow The bovine milks (Holstein, breed) as a control which were obtained from the Inner Mongolia Agricultural University farm.

2.2. Physical parameters analysis

Milk sample physical parameters were measured as follows: titratable acidity (TA) and specific gravity were determined according to the method of Association of Official Analytical Chemists (AOAC, 1990).

2.3. Chemical analysis

The mixed sample was analyzed and the data was determined by triplicates. Nitrogen was determined by the Kjeldahl method. A nitrogen conversion factor of 6.38 was used for calculation of protein contents of milk samples. Non-protein nitrogen (NPN) fraction was calculated as follows: NPN = TN–CN–WPN. Milk The casein nitrogen (CN) was determined according to the method of Rowland (1938) with some modifications. Trichloroacetic acid (36%) was added into the whey to a final concentration of 12% (v/v) to precipitate the whey proteins for determination of whey protein nitrogen (WPN). Dry matter (DM) of the samples was determined gravimetrically after drying in a forced-draft oven at 105 °C until a steady weight was achieved. Fat percentage was determined according to the method of Rose-Gottlieb and ash content was measured gravimetrically (Aggarawala and Sharma, 1961). Lactose content was determined by the difference of DM minus other solid components. Levels of Ca in the milk samples was determined with an atomic absorption spectrophotometer (Hitachi U-2000, Japan) according to standard methods in the AOAC (1980). Phosphorus content was determined spectrophotometrically using the procedure of Watanabe and Olson (1965).

2.4. Titration methods

Titrations were performed on 30 ml mixed sample at 20 °C by a automatic titrator (Model ZDJ-5, Lei-Ci Instruments, Shanghai, China) using 0.5 N HCl or 0.5 N NaOH, added in 0.1 ml increment at 30 s intervals to allow for equilibrium while the sample was stirred with an electrically driven agitator. Two different titration methods were used in this experiment (Lucey et al., 1993). In the first method involved the sample was titrated from the initial pH 6.6 to 2.0 with 0.5 N HCl (was termed acidification) and then back titrated to pH 11.0 with 0.5 N NaOH (was termed alkalinization). The second method involved sample titration from the initial pH 6.6 to 11.0 with NaOH (was termed alkalinization) and then back titrated to pH 2.0 with HCl (was termed acidification).

Table 1
Comparison of chemical composition and physiochemical properties between Alxa bactrian camel and bovine milk (mean values ± sd, 10 camel milk mixed).

	Camel milk	Bovine milk
Protein (%)	3.55 ± 0.04	3.15 ± 0.08
Fat (%)	5.65 ± 0.12	3.90 ± 1.03
Lactose (%)	4.24 ± 0.12	4.17 ± 0.24
Total solid (%)	14.31 ± 0.19	11.09 ± 0.42
Ash (%)	0.87 ± 0.03	0.79 ± 0.04
Acidity (%)	0.17 ± 0.013	0.16 ± 0.016
Density	1.028 ± 0.001	1.028 ± 0.001
TN (g/100 ml)	0.56 ± 0.02	0.49 ± 0.01
NPN (g/100 ml)	0.04 ± 0.01	0.03 ± 0.01
Ca (mg/100 ml)	155 ± 4.90	122 ± 3.72
P (mg/100 ml)	116 ± 3.57	93 ± 3.12

Data are means of triplicate determinations.

2.5. Titration curve

From these data a titration curve was drawn by plotting the amount of alkali or acid used, against the change in pH produced.

2.6. Buffering curve

In this work Van Slyke's method of measuring buffering values was used (Van Slyke, 1922). Van Slyke revealed that the volume change due to the added acid or alkali may be ordinarily neglected, if the maximum increase was below 50 per cent of the original volume. Inasmuch as the volume changes which occurred in the present work were below these limits, no correction for them was considered necessary in the formula. The buffering index for each 0.2 pH interval was calculated by the formula.

$$\frac{dB}{dpH} = \frac{(\text{ml acid added})\ \ (\text{normality factor})}{(\text{volume of milk})\ \ (\text{pH change})}.$$

A plot of buffering index against pH produced a buffer intensity (dB/dpH–pH) curve, the "peak" in the graph, was a characteristic of the kind of buffer.

3. Results and discussion

3.1. Chemical composition

The gross composition of camel milk and cow milk was showed in Table 1. The titratable acidity was denoted in terms of lactic acid content (g/100 g). The contents of fat, protein, lactose, total solids, TN, NPN, P, Ca and ash in camel milk were higher than that of in bovine milk. However, the values of acidity (%) and density were similar with that of in bovine milk.

3.2. Titration curves for samples

The titration curves for camel and bovine raw milk samples had a similar shape and were essentially superimposable. The typical curves had been shown in Figs. 1 and 2. A "loop" was observed in the pH range 6.6–4.3 and 6.6–5.0 for camel and bovine milk, when the titration were performed according to the first method (Fig. 1). Both milks exhibited a similar shape of the titration curves, were similar with that of bovine milk published (Lucey et al.,