Evaluation of Some Physicochemical Properties of Milk Caused by Acidification

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Abstract
The objective of this study was to evaluate changes in some physicochemical properties of milk during acidification. The milk samples were analyzed for titratable acidity expressed as % lactic acid (LA), pH, electrical conductivity (EC) and lactose content. In fresh milk LA and pH exhibit a weak negative correlation (r=-0.3210). When acid production starts, LA increases proportionally, whereas the pH decreases (r=-0.8043). The acidifying process induced concomitantly an increase in EC. The decrease in pH from 6.578±0.088 to 5.732±0.195, and in lactose content from 5.469±0.256g% to 4.97±0.385g% was accompanied by an increase in EC from 5.337±0.434 mS/cm to 5.940±0.493 mS/cm.

Keywords: electrical conductivity, lactic acid, milk, pH

1. Introduction

In terms of physical chemistry, milk is an opaque, whitish fluid of multidisperse phases. Milk is a complex colloidal dispersion of fat globules and protein (casein, whey) in an aqueous solution of lactose and minerals, Milk also contains trace amounts of other substances such as pigments, enzymes, vitamins, phospholipids, and gases.

Milk's physical characteristics are influenced by several factors including the composition and processing of milk [1, 2]. Various physical and chemical properties of milk have been reviewed previously [3, 4]. Measurement of some of the physicochemical properties is used to assess milk quality.

The normal pH values of cow's milk range between 6.3-6.8 [3, 5]. The weak acidity is due to the presence of acid salts, acid groups from proteins, and small amounts of carbon dioxide. The higher the concentration of these components, the higher the acidity level observed. The pH of milk is higher, or more alkaline, outside of the cow than inside the cow due to loss of carbon dioxide to the air.

Colostrum is more acidic than normal milk. Milk of late lactation cows usually has a higher pH, which approximates the pH of the blood. Milk from cows with mastitis has higher pH (up to 7.5) than normal milk of mid-lactation.

Milk acidity can be expressed as a percentage of lactic acid, with normal values from 0.10% to 0.30%.

The milk composition has a significant impact on the initial acidity of milk, as the acidity increases with the concentration of proteins and other indigenous buffering constituents. Acid-base equilibria and buffer action of milk [6] influences many of its physicochemical properties during processing, e.g. rate of pH change in cheese, the pH of cheese at the end of manufacture, rennet coagulation, etc.

The phosphoric acid, the citric acid and the acid salts have a buffer effect in milk. At normal pH values the phosphoric acid appears 65% as primary salts and 35% as secondary salts. The incipient milk acidification, consequently to the

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formation of the lactic acid from lactose by the lactic bacteria, is firstly buffered [7]. L-Lactic acid is a critical parameter in the production of milk and milk products, confirming the degree of freshness in milk and determines the taste and aromas in fermented products such as yogurt.

Changes in acidity appear also during thermal treatment. Heating causes the loss of carbon dioxide, can break down the lactose into various organic acids or cause blockage of amino groups of proteins and then causes an increase in acidity. At high temperature, the tricalcium phosphate may precipitate and cause an increase in acidity triggered by dissociation of the phosphate radicals.

The two common ways to measure acidity are pH and titratable acidity (TA). pH measures the concentration of disassociated hydrogen ions in the solution, and titratable acidity measures the concentration of both disassociated and un-disassociated hydrogen ions. TA measures all the acid in solution, both molecules that have given up their protons and those that have not.

Because lactic acid is a weak acid, and all of it does not disassociate in water, pH does not measure the exact quantity of lactic acid present, just the dissolved H^+ ions. Even TA doesn't measure the exact amount of lactic acid because milk and whey contain other acids and buffers.

Milk has conductive properties because of the existence of charged compounds such as mineral salts. Due to decrease of pH and increase of acidity, minerals of milk are converted from colloidal forms to soluble forms [8, 9]. The conductivity of milk and dairy products has been studied to provide values of the fat, water and protein content [10-12] and to detect mastitis [13].

The objective of this study was to evaluate changes in some physicochemical properties of milk during acidification. The research had also in view to investigate the relationship among EC, pH, and lactic acid in milk, depending on different storage periods and temperatures.

2. Materials and methods

Twenty fresh milk samples collected from healthy cows were analyzed for titratable acidity, pH, electrical conductivity (EC) and lactose content. Physicochemical analysis of milk samples was carried out in the Biochemistry Laboratory in our university. Reagents and chemicals of analytical grade and deionized double distilled water were used throughout this work.

Titratable acidity expressed as % lactic acid was determined by titration of a known amount of milk with 0.1N NaOH using phenolphthalein as indicator, as described by AOAC (2000) [14].

pH and EC were measured with a multi-parameter analyzer (Consort, model C861).

The lactose content was determined by refractometry from milk serum obtained after precipitation of casein at the isoelectric pH (4.6) with 2N acetic acid solution. The refractive index of a sample relative to the refractive index of water was measured with a refractometer Krüss DR301-95. The instrument was blanked with distilled water before each series of measurement. All readings were made at room temperature (approximately 20°C).

The values of the refractive indices measured are converted in lactose concentrations [15].

Correlations between physicochemical parameters were investigated by regression analysis.

3. Results and discussion

The experimental data are presented in Tables 1 and 2.

The pH values in fresh milk ranged between 6.394 and 6.719 with an average value of 6.578±0.088. LA of milk samples was between 0.116% and 0.182% with a mean of 0.167±0.0146%. In fresh milk, average value of lactose was 5.469±0.256g% and average value of EC was 5.337±0.434 mS/cm.

In fresh milk LA and pH exhibit a weak negative correlation (r=-0.3210) (Figure 1). When acid production starts, LA increases proportionally, whereas the pH decreases (r=-0.8045) (Figure 2).

The acidification of the milk and consequently the decrease of pH are due to the lactose fermentation, when from one molecule of lactose four molecules of lactic acid are formed [16].

No correlation was observed between the measured pH and EC in fresh milk. The acidifying process induced concomitantly an increase in EC. The decrease in pH from 6.578±0.088 to 5.732±0.195, and in lactose content from 5.469±0.256g% to 4.97±0.380g% was accompanied by an increase in EC from 5.337±0.434 mS/cm to 5.940±0.493 mS/cm.

Table 1. The pH, LA, EC and lactose in fresh milk

Sample	pH	LA (%)	EC (mS/cm)	Lactose (g%)
1	6.536	0.174	4.614	5.35
2	6.678	0.116	4.902	5.40
3	6.587	0.174	4.665	5.85
4	6.638	0.163	5.098	5.80
5	6.394	0.157	5.634	5.80
6	6.688	0.179	5.809	5.35
7	6.577	0.157	5.438	5.60
8	6.455	0.182	6.283	5.35
9	6.658	0.168	5.603	5.40
10	6.607	0.168	5.974	5.25
11	6.496	0.182	5.520	5.90
12	6.627	0.179	5.263	5.35
13	6.719	0.163	5.634	5.35
14	6.465	0.173	5.438	5.85
15	6.526	0.174	5.098	5.24
16	6.668	0.166	5.098	4.95
17	6.617	0.163	5.170	5.25
18	6.475	0.182	5.376	5.40
19	6.556	0.157	4.717	5.35
20	6.597	0.168	5.417	5.60
X±DS	6.578±0.088	0.167±0.0146	5.337±0.434	5.469±0.256

Table 2. The pH, LA, EC and lactose in acidified milk

Sample	pH	LA (%)	EC (mS/cm)	Lactose (g%)
1	5.680	0.286	5.144	5.25
2	6.020	0.212	5.044	5.58
3	5.979	0.238	5.144	5.08
4	5.781	0.254	5.743	4.8
5	5.544	0.319	6.518	4.68
6	5.620	0.328	5.919	4.8
7	5.791	0.300	5.784	5.1
8	6.020	0.263	5.402	5.5
9	5.880	0.279	5.919	5.4
10	5.880	0.264	5.859	4.25
11	5.623	0.343	6.177	4.54
12	5.401	0.334	6.712	5.2
13	5.821	0.259	6.318	4.44
14	5.643	0.368	6.001	5.64
15	5.761	0.262	6.435	5.23
16	5.781	0.259	5.712	4.75
17	5.959	0.308	5.743	4.85
18	5.623	0.360	5.919	4.77
19	5.420	0.363	6.601	4.75
20	5.420	0.362	6.715	5.25
X±DS	5.732±0.195	0.298±0.0470	5.940±0.493	4.97±0.385

Figure 3 shows the negative correlation (r=0.7655) between pH and EC in acidified milk. A part of the milk salts occur in the form of molecular dispersion. So, casein contains phosphocalcic salts in suspension [17]. By acidification the calcium caseinate is transformed into free casein, and so increases the proportion of the ionic dispersed salts.

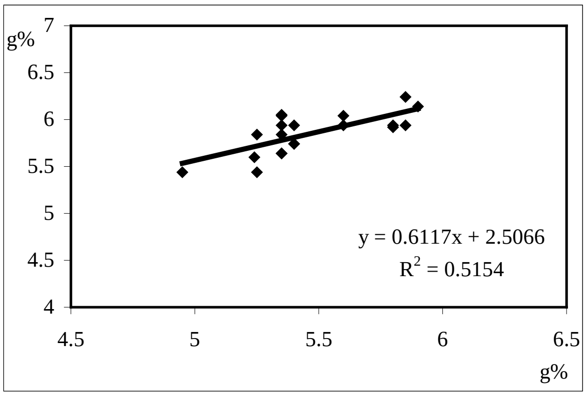

Figure 1. Correlation between pH and LA in fresh milk

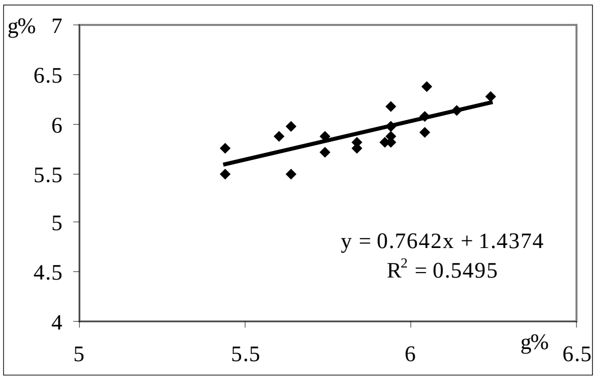

Figure 2. Correlation between pH and LA in acidified milk

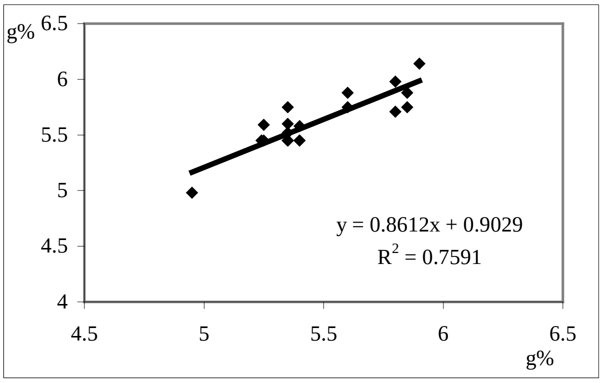

Figure 3. Correlation between pH and EC in acidified milk

4. Conclusions

In fresh milk LA and pH exhibit a weak negative correlation (r=-0.3210).

No correlation was observed between the measured pH and EC in fresh milk.

The decrease in pH and in lactose content by acidifying was accompanied by an increase in EC.

We observed a negative correlation (r=-0.7655) between pH and EC in acidified milk.

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