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EFFECTS OF SODIUM BICARBONATE ON MILK PRESERVATION

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ABSTRACT

The present investigation was carried out to assess the effect of sodium bicarbonate ($NaHCO_3$) on the keeping quality of raw cow milk. Milk samples were collected from Bangladesh Agricultural University (BAU) Dairy Farm and initial quality were evaluated using physical and chemical tests at Dairy Technology Laboratory of the Department of Dairy Science, BAU. Then, collected samples were preserved at room temperature (28-30°C) with 0.0 (control), 0.3, 0.4 and 0.5 per cent $NaCHO_3$. The quality of milk samples were measured at every two hours interval up to 6 hours, one hour interval upto 16 hours and thereafter every half an hour interval until spoilage. Initially, colour, flavour and texture of all milk samples were normal (100%), but with progressive storage time colour, flavour and texture of all samples deteriorated gradually, which was more rapid for control samples than that of the $NaHCO_3$ treated samples. Acidity per cent of all samples increased gradually during storage period and the differences in acidity of milk samples in different treatments were significant ($p<0.01$). Control samples spoiled after $11\frac{1}{4}^{th}$ hours but that of 0.3, 0.4 and 0.5 percent $NaHCO_3$ treated samples spoiled after $16\frac{3}{4}^{th}$, $17\frac{3}{4}^{th}$ and $18\frac{3}{4}^{th}$ hours,, respectively. It may be concluded that $NaHCO_3$ is the effective chemical neutralizing the acids produced by acid producing bacteria and can be used as a short term preservation of milk under rural condition of Bangladesh where scientific cooling or pasteurization facilities are not available.

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INTRODUCTION

Milk is the nature's almost perfect food. According to Eckles et al. (1971) milk contains on an aver average 87.25% water and 3.80% fat, 3.50% protein, 4.80% of lactose and 0.65% minerals. Besides these milk contains considerable amount of fat soluble vitamins (Vit. A, D, E, K) and water soluble vitamins (Vit. B-complex and Vit.C). The nutritive value of milk depends on its freshness, cleanliness, purity and wholesomeness. For this reason, the time interval between milk collected from the small farmers to the consumers is primarily most important. There is every possibility of spoilage of milk during that time. So, it is very important to adopt some technique for increasing the shelf life of milk. The presence of different types of microorganisms or undesirable bacteria in milk may cause deterioration of flavour, colour, taste or physical appearance. At the same time spoilage takes place rapidly due to the formation of excess lactic acid from the breakdown of lactose by lactic acid producing bacteria. To make the milk safe for public health and also to increase its shelf life it is very important to preserve milk scientifically. Due to lack of proper milk preservation facilities, a huge quantity of milk undergoes spoilage every year in our country.

Milk can be preserved for a while for human consumption by using some chemical substances such as hydrogen peroxide (H_2O_2) (Hossain et al*.,* 1989), sodium bicarbonate ($NaHCO_3$) (Kukde et al., 1991), etc. and by regulating the temperature i.e. cooling, pasteurization and boiling. Cooling and pasteurization facilities are not available throughout the country. At the same time, heated boiled milk is not also popular in our country. Established dairy farms have modern facilities for milk preservation but small farmers or the poor formers or vendors or goalas who live in rural areas have no such types of facilities for milk preservation. Most of the farmers or vendors are illiterate and they do not know how to preserve milk scientifically. It is urgently needed to develop low cost short time milk preservation technology in order to reduce the spoilage of milk which usually occurs during transportation and keeping long time without applying any scientific technique before marketing.

Sodium bicarbonate (NaHCO3) is a cheap chemical available in local market, present in powder form, white in colour and very easy to handle. Haddadin et al. (1996) from a preliminary study found that sodium bicarbonate is useful for short time preservation of milk. It is expected that handling of this chemical will be very easy by the farmers and there will be no hazards effects on public health. Local goalas or vendors or farmers are using this chemical for milk preservation but scientifically its feasibility as milk preservative has not been carried out widely. Hence, this experiment was conducted to monitor the usefulness of sodium bicarbonate ($NaHCO_3$) as milk preservative.

MATERIALS AND METHODS

Site of experiment

The experiment was conducted at Dairy Technology and Dairy Microbiology laboratory of the Department of Dairy Science, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh.

Sources of milk

Whole milk was collected from, BAU Dairy Farm, Mymensingh-2202, Bangladesh. Suggestions were given to the milkers before milking the cows for maintaining all hygienic measures. Milk was poured from one pail to another after milking. To avoid the incorporation of air it was allowed to stand for a while and thereafter milk was taken to the Laboratory for experimental purpose.

Experimental procedure

The collected milk samples after thoroughly mixing was divided into four equal parts. Out of four parts, one was kept as whole milk without $NaHCO_3$ (control) and the other three parts were preserved with different levels of $NaHCO_3$ such as milk sample with 0.3% $NaHCO_3$; milk sample with 0.4% and milk sample with 0.5% $NaHCO_3$.

The physical, chemical and microbiological parameters used to monitor the qualities of milk were determined initially just before adding $NaHCO_3$ and then after two hours interval upto 6 hours, one hour interval upto 16 hours and thereafter every half an hour interval until the milk samples were spoiled.

Physical and chemical tests

The physical and chemical tests of each milk sample were performed in the laboratory. The physical test comprised of organoleptic tests, viz., colour, flavor and texture, specific gravity, clot-in-boiling and stability using alcohol test of milk. The chemical test included the acidity test only. Organoleptic tests were performed with an expert panel of judges. Specific gravity, clot-on-boiling and alcohol test was done as per method described by Tessama and Tibbo (2009). Acidity test was done by titrating milk with N/10 NaOH solution as per method described by Bilkis et al. (2013).

Statistical analysis

Statistical analysis was done by using Randomized Complete Block Design (RCBD) as per Bailey (2008). Analysis of variance was done to find the statistical difference (Significant or not) among the different treatments and in case of significant difference LSD value was calculated to make a comparison among the treatment means.

RESULTS AND DISCUSSION

Initial quality of milk

The physical, chemical and microbiological qualities of milk were determined before adding $NaHCO_3$ with milk sample. Results obtained from initial analysis were in the standard level and are presented in Table 1.

Table 1. Observation of the quality of milk before adding the preservative

Parameters	Initial quality*
Fat (g/kg)	42.0 ± 0.23
Specific gravity	1.031±0.0016
Colour (% of normal condition)	Normal 100% (golden yellowish)
Flavour (% of normal condition)	Normal 100%
Texture (% of normal condition)	Normal 100%
Alcohol test	(-Ve)
Clot-on-Boiling (COB)	(-Ve)
Acidity (%)	0.1173 ± 0.49
Temperature	28-30°C

*Initial quality of milk before starting the experiment

Physical parameters

Colour

Colour of all milk samples before starting experiment was normal (golden yellowish white). No abnormality in colour was detected (Table 1). Regarding milk colour, Eckles et al. (1971) stated that milk ranges in colour from a bluish-white to a golden yellowish, depending upon the breed of animal, the kind of feed and the amount of fat and solids present. In large qualities, milk appears entirely opaque while in thin layers, it is slightly transparent. Milk from which the fat has been removed or milk which is low in fat percentage shows a bluish tint.

From the Table 2, it is evident that for whole milk (control) and 0.3, 0.4 and 0.5 percent $NaHCO_3$ treated milk samples, color was normal upto 10½th, 16th, 17th and 18th hours, respectively and after which color became bleached. Colour deterioration was very rapid in whole milk (control) followed by 0.3, 0.4 and 0.5 percent $NaHCO_3$ treated milk samples. This indicates that $NaHCO_3$ could be used as a short term milk preservative under rural areas where scientific cooling or pasteurization facilities are not available.

Table 2. Colour quality of control and different proportions of sodium bicarbonate treated milk samples during preservation period

Hour	Control*	Treatments		
		0.3%**	0. 4%**	0.5%**
0-6th Hour	Golden yellowish	Golden yellowish	Golden yellowish	Golden yellowish
7th Hour	Do	Do	Do	Do
8th Hour	Do	Do	Do	Do
9th Hour	Do	Do	Do	Do
10th Hour	Do	Do	Do	Do
10½th Hour	Do	Do	Do	Do
11¼th Hour	Bleached	Do	Do	Do
12th Hour	Do	Do	Do	Do
13th Hour	Do	Do	Do	Do
14th Hour	Do	Do	Do	Do
15th Hour	Do	Do	Do	Do
16th Hour	Do	Do	Do	Do
16½th Hour	Do	Bleached	Do	Do
16¾th Hour	Do	Do	Do	Do
17th Hour	do	do	Do	Do
17½th Hour	Do	Do	Bleached	Do
17¾th Hour	Do	Do	Do	Do
18th Hour	Do	Do	Do	Do
18½th Hour	Do	Do	Do	Bleached
18¾th Hour	Do	Do	Do	Do
19th Hour	Do	Do	Do	Do
19¼th Hour	Do	Do	Do	Do
19½th Hour	Do	Do	Do	Do
19¾th Hour	Do	Do	Do	Do

*Control means milk sample without sodium bicarbonate
**Percentage of sodium bicarbonate in milk

Flavour

The flavour of all milk samples before starting the experiment was normal (100%). All samples showed pleasing aromatic flavour. It has been shown that the pleasing aromatic flavour of milk may be correlated with high lactose and relatively low chloride content. Low lactose and high chloride content probably would mean milk with salty flavour (Eckles et al., 1971). Biswas (1997) found that flavour of all milk samples collected from BAU dairy farm was normal.

Table 3. Flavour quality of control and different proportions of sodium bicarbonate treated milk samples during preservation period

Hour	Control	Treatments		
		0.3%	0. 4%	0.5%
0-6th	Pleasing	Pleasing	Pleasing	Pleasing
7th	Pleasing	Pleasing	Pleasing	Pleasing
8th	Pleasing	Pleasing	Pleasing	Pleasing
9th	Pleasing	Pleasing	Pleasing	Pleasing
10th	Pleasing	Pleasing	Pleasing	Pleasing
10½th	Pleasing	Pleasing	Pleasing	Pleasing
11¼th	Pleasing	Pleasing	Pleasing	Pleasing
12th	Slightly sour	Pleasing	Pleasing	Pleasing
13th	Slightly sour	Pleasing	Pleasing	Pleasing
14th	Sour	Pleasing	Pleasing	Pleasing
15th	Sour	Pleasing	Pleasing	Pleasing
16th	Sour	Pleasing	Pleasing	Pleasing
16½th	Sour	Pleasing	Pleasing	Pleasing
16¾th	Bitter	Slightly sour	Pleasing	Pleasing
17th	Bitter	Slightly sour	Pleasing	Pleasing
17½th	Bitter	Sour	Pleasing	Pleasing
17¾th	Bitter	Sour	Slightly sour	Pleasing
18th	Bitter	Sour	Slightly sour	Pleasing
18½th	Bitter	Sour	Sour	Pleasing
18¾th	Bitter	Sour	Sour	Pleasing
19th	Bitter	Bitter	Sour	Slightly sour
19¼th	Bitter	Bitter	Sour	Slightly sour
19½th	Bitter	Bitter	Sour	Slightly sour
19¾th	Bitter	Bitter	Sour	Slightly sour

Legends: Control = whole milk without $NaHCO_3$ (control) and the other three parts were preserved with different levels of $NaHCO_3$ such as milk sample with 0.3% $NaHCO_3$; milk sample with 0.4% $NaHCO_3$ and milk sample with 0.5% $NaHCO_3$

In this experiment, flavour of whole milk (control) and 0.3, 0.4, and 0.5 percent $NaHCO_3$ treated milk samples were acceptable upto 11¼th, 16½th, 17½th and above 18¾th hours, respectively (Table 3). After that time, the flavour was becoming unacceptable. This result showed that $NaHCO_3$ is effective for controlling the flavour of milk. This was due to the fact that in fresh milk (control) lactic acid produced from the fermentation of lactose was not neutralized. But in $NaHCO_3$ treated milk samples lactic acid produced was neutralized by $NaHCO_3$ and hence the keeping quality of milk was increased.

Texture

All milk samples before starting the experiment was normal in Texture. The texture of all milk samples is shown in Table 4. Texture of normal milk is designated as free flowing liquid. Its viscosity is higher than water. Some solids exits in true solution phase, some are at colloidal state and some other portions as coarse dispersion phase. Texture of milk changes if some portion of fat is removed or water is added for adulteration purpose. In such case, milk becomes less viscous. Acidity development can also change the texture of milk.
So the present results indicate that milk collected from BAU Dairy Farm was fresh and no fat had been removed from the milk. The normal texture of milk is stated as “free flowing liquid”. From the Table 4, it is evident that the texture of whole milk (control) and 0.3, 0.4, and 0.5 percent $NaHCO_3$ treated milk samples were normal upto 10½th, 16th, 17½th and above 18¾th hours of study, respectively. Thereafter samples become clotted. The whole milk (control) sample clotted earlier than $NaHCO_3$ treated milk samples. The clotting time depends upon the percent of $NaHCO_3$ used for preserving milk. Texture deterioration was rapid in fresh milk due to lactic acid production than treated milk with $NaHCO_3$.

Specific gravity

Average specific gravity of milk samples was 1.031±0.0016. The specific gravity was within the normal range of specific gravity of milk. Generally the specific gravity of fresh milk is within the range of 1.027 to 1.035 having an average value of 1.031 (Eckles et al., 1971). Adulteration of milk by adding water decreased its specific gravity. In our experiment, the average specific gravity of milk samples was within the normal range but slightly below the average specific gravity of milk (1.031). This might be due to high fat and slightly low SNF content of milk. Eckles et al. (1971) stated that as milk fat is the lightest constituents of milk, the more that is present, lower the specific gravity will be and in a like manner, the greater the percentage of SNF the heavier the milk will be. Similar type of specific gravity was obtained by Biswas (1997) for BAU Dairy Farm milk.

Clot-on-boiling test (COB)

The results of acidity tests were confirmed by clot-on-boiling (COB) test. The test showed negative results indicated that there was no developed acidity and the quality of the milk sample was good. The results of COB test are shown in (Table 5). The COB test was positive at 11½th, 16¾th, 17¾th and 18¾th hours for whole milk (control) and 0.3, 0.4 and 0.5 percent $NaHCO_3$ treated milk samples, respectively. From this result, it is clear that whole milk (control) sample clotted earlier than that of $NaHCO_3$ treated milk samples. This was due to more acid production in fresh milk samples. On the other hand, $NaHCO_3$ neutralized the acids produced by lactic acid producing bacteria from the breakdown of lactose. Clot-on-boiling test confirms the results of acidity test. This test also indicates that $NaHCO_3$ could be used as milk preservative under village or rural areas of Bangladesh. The result of this study agrees with the results of El-Safety et al. (1978), Hossain (1989) and Barabas (1995).

Table 4. Texture quality of control and different proportions of sodium bicarbonate treated milk samples during preservation period

Hour	Treatments			
	Control	**0.3%**	**0. 4%**	**0.5%**
0-6th	Free flowing	Free flowing	Free flowing	Free flowing
7th	Do	Do	Do	Do
8th	Do	Do	Do	Do
9th	Do	Do	Do	Do
10th	Do	Do	Do	Do
10½th	Do	Do	Do	Do
11¼th	Slightly clotted	Do	Do	Do
12th	Do	Do	Do	Do
13th	Clotted	Do	Do	Do
14th	Do	Do	Do	Do
15th	Do	Do	Do	Do
16th	Curd	Do	Do	Do
16½th	Do	Slightly clotted	Do	Do
16¾th	Do	Do	Do	Do
17th	Do	Do	Do	Do
17½th	Do	Do	Do	Do
17¾th	Do	clotted	Slightly clotted	Do
18th	Do	Do	Do	Do
18½th	Do	Do	Do	Do
18¾th	Do	Do	Do	Do
19th	Do	Curd	Do	Slightly clotted
19¼th	Do	Do	clotted	Do
19½th	Do	Do	Do	Do
19¾th	Do	Do	Do	Do

Legends: Control = whole milk without $NaHCO_3$ (control) and the other three parts were preserved with different levels of $NaHCO_3$ such as milk sample with 0.3% $NaHCO_3$; milk sample with 0.4% $NaHCO_3$ and milk sample with 0.5% $NaHCO_3$

Table 5. Average positive COB time of milk treated under various treatments

Hour	Treatments			
	Control	0.3%	0.4%	0.5%
0-6th Hour	-	-	-	-
7th Hour	-	-	-	-
8th Hour	-	-	-	-
9th Hour	-	-	-	-
10th Hour	-	-	-	-
10½th Hour	-	-	-	-
11¼th Hour	+	-	-	-
12th Hour	+	-	-	-
13th Hour	+	-	-	-
14th Hour	+	-	-	-
15th Hour	+	-	-	-
16th Hour	+	-	-	-
16½th Hour	+	-	-	-
16¾th Hour	+	+	-	-
17th Hour	+	+	-	-
17½th Hour	+	+	-	-
17¾th Hour	+	+	+	-
18th Hour	+	+	+	-
18½th Hour	+	+	+	-
18¾th Hour	+	+	+	+
19th Hour	+	+	+	+
19¼th Hour	+	+	+	+
19½th Hour	+	+	+	+
19¾th Hour	+	+	+	+
Average COB positive time	11.25±0.24	16.38±0.05	17.63±0.03	18.50±0.4

Legends: Control means whole milk without $NaHCO_3$ and 0.3%, 0.4%, 0.5% indicates the levels of $NaHCO_3$; Hour means hours after treatment; - = COB negative, + = COB positive

Alcohol test

Initially alcohol test was negative for all type of samples but the alcohol test was positive at 12th, 17th, 18th and 19th hours for whole (control) milk and 0.3, 0.4 and 0.5 percent $NaHCO_3$ treated milk samples, respectively (Table 6). The alcohol test confirmed the results of COB test. It is clear that fresh milk samples clotted earlier than that of $NaHCO_3$treated milk samples.

Table 6. Average positive Alcohol time of milk

Hour	Treatments			
	Control	0.3%	0.4%	0.5%
0-6th Hour	-	-	-	-
7th Hour	-	-	-	-
8th Hour	-	-	-	-
9th Hour	-	-	-	-
10th Hour	-	-	-	-
10½th Hour	-	-	-	-
11¼th Hour	-	-	-	-
12th Hour	+	-	-	-
13th Hour	+	-	-	-
14th Hour	+	-	-	-
15th Hour	+	-	-	-
16th Hour	+	-	-	-
16½th Hour	+	-	-	-
16¾th Hour	+	-	-	-
17th Hour	+	+	-	-
17½th Hour	+	+	-	-
17¾th Hour	+	+	-	-
18th Hour	+	+	+	-
18½th Hour	+	+	+	-
18¾th Hour	+	+	+	-
19th Hour	+	+	+	+
19¼th Hour	+	+	+	+
19½th Hour	+	+	+	+
19¾th Hour	+	+	+	+
Average alcohol positive time	12.03±0.46	17.12±0.04	18.01±0.03	19.04±0.07

Legends: Control means whole milk without $NaHCO_3$ and 0.3%, 0.4%, 0.5% indicates the levels of $NaHCO_3$; Hour means hours after treatment; - = Alcohol negative, + = Alcohol positive

Table 7. Average acidity of control and different proportions of sodium bicarbonate treated milk samples during preservation period

Hour	Treatments			
	Control	**0.3%**	**0.4%**	**0.5%**
0	0.1175	0.1172	0.1175	0.1170
2nd	0.1250	0.1185	0.1185	0.1188
4th	0.1288	0.1263	0.1220	0.1225
6th	0.1413	0.1345	0.1333	0.1325
7th	0.1525	0.1375	0.1375	0.1363
8th	0.1567	0.1400	0.1388	0.1363
9th	0.1638	0.1463	0.1400	0.1375
10th	0.1800	0.1483	0.1438	0.1410
10½th	0.1938	0.1500	0.1458	0.1423
11¼th	0.2150	0.1518	0.1488	0.1438
12th	0.2225	0.1553	0.1600	0.1538
13th	0.2400	0.1688	0.1663	0.1613
14th	0.2503	0.1788	0.1713	0.1675
15th	0.2713	0.1960	0.1888	0.1813
16th	0.2963	0.2188	0.1988	0.1913
16½th	0.3390	0.2195	0.2075	0.1950
16¾th	0.3565	0.2308	0.2138	0.2000
17th	0.3875	0.2463	0.2225	0.2063
17½th	0.4113	0.2700	0.2300	0.2175
17¾th	0.4238	0.2963	0.2425	0.2238
18th	0.4503	0.3320	0.2563	0.2338
18½th	0.4768	0.3703	0.2900	0.2488
18¾th	0.4975	0.3985	0.3158	0.2625
19th	0.5280	0.4280	0.3400	0.2958
19¼th	0.5478	0.4438	0.3798	0.3173
19½th	0.5628	0.4623	0.4165	0.3478
19¾th	0.5825	0.4980	0.4538	0.3693
Mean	0.280229	0.211575	0.189692	0.177967
SD	0.15	0.12	0.09	0.07
LSD			0.0123	
Significance	**			

Chemical parameters

Acidity test

Results of acidity test are shown in Table 7. Mean initial acidity of experimental samples was 0.1173±0.49.Generally acidity of normal milk samples are within the range of 0.10 to 0.20 (Eekles *el al.,* 1971). Similar types of acidity (0.13%) were reported by Biswas (1997) for BAU Dairy Farm milk. Acidity test of milk is a good indicator of milk quality. Fresh milk shows an acidity of about 0.12% which is due to the presence of citrate, phosphate, carbon-dioxide and milk casein. If the milk samples is kept for several hours without

pasteurization or cooling or any kind of heat treatment then its lactose undergoes fermentation and produces lactic acid in milk. This additional acidity is known as developed acidity and is responsible for quick spoilage of milk. Mean acidity of fresh milk (control) and 0.3, 0.4 and 0.5 percent $NaHCO_3$ treated milk samples were 0.280± 0.03, 0.212 ±0.02, 0.189±0.05 and 0.178±0.02 respectively. Statistical analysis showed that there were significant differences ($p<0.01$) within the mean acidity of milk samples of control and different proportions of $NaHCO_3$ treated milk samples. Mean acidity of milk preserved with 0.5 percent $NaHCO_3$ was significantly ($p<0.01$) lower than that of control milk sample. Acidity production had an important relationship with time. Acid production increased significantly ($p<0.01$) with increase in time. Table 7 showed that acid production was low at the beginning but was very high at the end of 19¾th hours of study.

From the result of this section it appears that the deterioration was more rapid for control samples than that of the sodium bicarbonate ($NaHCO_3$) treated samples. Acidity percent of all samples increased gradually during storage period. The result of acidity test was supported by COB test. Control samples spoiled after 10½th hours but that of 0.3%, 0.4% and 0.5% sodium bicarbonate treated samples spoiled after 15th, 16½th and 16¾th hours, respectively. It can be said that 0.5% $NaHCO_3$ is the effective chemical which is enough to preserve milk upto 19th hours under rural condition of Bangladesh.

CONCLUSION

The present study revealed that 0.5% $NaHCO_3$ is enough to preserve milk samples upto 19 hours. So, it may be concluded that $NaHCO_3$ is the effective chemical neutralizing the acids produced by acid producing bacteria and can be used as a short term preservative of milk under rural condition of Bangladesh where scientific cooling or pasteurization facilities are not available.

COMPETING INTERESTS

The authors have clearly declared that they have no competing interests.

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