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Effect of sodium bicarbonate on the keeping quality of milk

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Abstract

The present experiment was carried out to know the effect of sodium bicarbonate on the keeping quality of raw milk. For this purpose, milk samples were collected from Bangladesh Agricultural University Dairy Farm. Initial quality of the collected milk samples were evaluated at Dairy Technology Laboratory of the Department of Dairy Science through some physical and chemical tests. There after collected samples were preserved at room temperature (32-34°C) with 0.10, 0.150 and 0.20 percent sodium bicarbonate. One group was kept without sodium bicarbonate and was considered as control group. The quality of milk samples were measured at every two hours interval until upto 12 hours and thereafter every one hour interval until spoilage to asses the quality of milk. 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. The deterioration was more rapid for control samples than that of the sodium bicarbonate treated samples. Acidity percent of all samples increased gradually during storage period and the differences in acidity of milk samples in different treatments were significant ($p<0.01$) increased was significantly ($p<0.01$) more in control samples than that of the treated samples. The result of acidity test was supported by COB test. Control samples spoiled after 12 hours but that of 0.10, 0.15 and 0.20 percent sodium bicarbonate treated samples spoiled after 13,14 and 16 hours respectively. It may be concluded that $NaHCO_3$ is the effective chemical for neutralizing the acids produced by acid producing bacteria and can be used for a short term preservation of milk under rural condition of Bangladesh where scientific cooling or pasteurization facilities are not available.

Keywords: Sodium bicarbonate, Preservation, Keeping quality, Deterioration/spoilage

Introduction

Milk is an ideal and complete food having all the nutrients essential for normal functioning of the body system. 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 delivery to the consumers is primarily most important to ensure fresh, clean, pure and wholesome milk. 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 break down 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, 1989), sodium bicarbonate (Kukde, 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 farmers 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.

So, in this experiment an attempt was made to preserve milk samples by sodium bicarbonate ($NaHCO_3$). It is well known that sodium bicarbonate is a cheap and available alkaline substance used mostly in the bakery for preparation of different types of cakes, breads and biscuits. So, it is expected that handling of this chemical will be very easy by the farmers and their 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. It is suggested that 0.2 percent sodium bicarbonate (2gm in 1000 ml milk) is optimum to preserve raw milk upto 16 hours. Ghafoor *et al* (1985) indicated that raw milk could be preserved upto 12 hours without any preservative when the room temperature is about 29^0c. Mahboob (1992) from a preliminary study found that sodium bicarbonate is useful for short time preservation of milk. Hence this experiment was conducted to monitor the usefulness of sodium bicarbonate ($NaHCO_3$) as milk preservative.

Materials and Methods

Time and place of experiment

The experiment was conducted at Dairy Technology and Dairy Microbiology Laboratory of the Department of Dairy Science, Bangladesh Agricultural University, Mymensingh during the period of May to October, 2001.

Source of milk

Whole milk was collected from Bangladesh Agricultural University dairy farm. 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 in into four equal parts. Out of four parts, one was kept as whole milk (control) without $NaHCO_3$ and the other three parts were preserved with different levels of $NaHCO_3$.

The four treatment groups were :

(1) Milk sample without $NaHCO_3$.(control)
(2) Milk sample with 0.1% $NaHCO_3$
(3) Milk sample with 0.15% $NaHCO_3$
(4) Milk sample with 0.2% $NaHCO_3$

The parameter used to monitor the physical chemical and microbiological quality of milk were determined initially just before adding $NaHCO_3$ and then after two hours interval upto 12 hours and thereafter one hour interval until the milk samples were spoiled.

Tests

The following tests were performed with each milk sample :

(1) Physical test : a) Organoleptic tests (i) Colour (ii) Flavour (iii) Texture (b) Specific gravity (c) Clot-on-boiling (COB) test

(2) Chemical test : Acidity (%).

Organoleptic test were performed with an expert pannel of judges. Specific gravity, clot-on-boiling test was done as per method described by Aggarawala & Sharma (1961).

Statistical Analysis

Statistical analysis was done by using Randomized Complete Block Design (RCBD) as per steel and Torrie (1980). Analysis of variance was done to find the statistical difference (Significant or not) between the different treatments and in case of significant difference LSD value was calculated to make a comparison between treatment means.

Result and Discussion

In this experiment, an attempt was made to preserve milk samples with different levels sodium bicarbonate ($NaHCO_3$). Results obtained from this study are presented below :

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 are presented in table 1.

Physical parameters

1) Colour: Colour of all milk samples before starting experiment was normal (yellowish white). No abnormality in colour was detected (Table-1). Regarding milk colour, Eckles *et al.* (1951) 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.

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

Parameters	Initial quality of milk before starting the experiment.
Fat (g/kg)	44.0 ± 0.1
SNF (g/kg)	83.84±1.8
TS (g/kg)	127.84±2.41
Water (g/kg)	872.16±2.41
Protein (g/kg)	35.0±0.7
Lactose (g/kg)	42.0±1.7
Ash (g/kg)	6.84±.11
Specific gravity	1.030±0.0007
Colour (% of normal condition)	Normal100% (yellowish white)
Flavour (% of normal condition)	Normal 100%
Texture (% of normal condition)	Normal 100%
Clot-on-Bioling (COB)	(Vc)
Acidity (%)	0.150±0.002
Temperature	32-34^{0}C
Total viable bacteria /ml	42000 cfu/ml
Coliform bacteria /ml	120 cfu/ml

In this experiment, normal colour of milk samples indicated that no fat had been removed or fat percent in milk was not too low before starting the experiment. The colour of whole milk (control) and NaHCO3 treated milk samples are shown in table 2. From the table 2, it is evident that for whole milk (control), 0.1, 0.15 and 0.2 percent $NaHCO_3$ treated milk samples, colour was normal upto 12,13,14 and 17 hours respectively and after which colour became bleached. Colour deterioration was very rapid in whole milk (control) followed by 0.1, 0.15 and 0.2 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 pesteurization 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		
		0.1%	0.15%	0.2%
0-8th hour	Yellowish White	Yellowish White	Yellowish White	Yellowish White
10th hour	Yellowish White	Yellowish White	Yellowish White	Yellowish White
12th hour	Bleached	Yellowish White	Yellowish White	Yellowish White
13th hour	Bleached	Bleached	Yellowish White	Yellowish White
14th hour	Bleached	Bleached	Bleached	Yellowish White
15th hour	Bleached	Bleached	Bleached	Yellowish White
16th hour	Bleached	Bleached	Bleached	Yellowish White
17th hour	Bleached	Bleached	Bleached	Bleached

ii) Flavour: The flavour of all milk samples before starting the experiment was normal (100%). All samples showed pleasing flavour. It has been shown that the pleasing flavour of milk may be correlated with a high lactose and a relatively low chloride content . A low lactose and a high chloride content probably would mean a milk with salty flavour (Eckles *et al.* 1951). Biswas (1997) found that flavour of all milk samples collected from BAU dairy Farm was normal.

In this experiment, flavour of whole milk (control), 0.1, 0.15, and 0.2 percent $NaHCO_3$ treated milk samples were acceptable upto 13,14,15 and above 16 hours respectively (table 3). After that time, the flavour was becoming unacceptable and the flavour of whole milk (control) showed bitter flavour may be due to proteolysis. This result showed that $NaHCO_3$ is effective for controlling the flavour of milk. This was due to the fact that in fresh milk lactic acid produced from the fermentation of lactose was not neutralized. But in $NaHCO_3$ treatment milk samples lactic acid produced was neutralized by $NaHCO_3$ and hence the keeping quality of milk was increased.

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

Hour	Treatment			
	control	0.1%	0.15%	0.2%
0-8th hour	Pleasing	Pleasing	Pleasing	Pleasing
10th hour	Pleasing	Pleasing	Pleasing	Pleasing
12th hour	Pleasing	Pleasing	Pleasing	Pleasing
13th hour	Slightly sour	Pleasing	Pleasing	Pleasing
14th hour	Slightly sour	Slightly sour	Pleasing	Pleasing
15th hour	Sour	Sour	Slightly sour	Pleasing
16th hour	Sour	Sour	Sour	Pleasing
17th hour	Bitter	Sour	Sour	Slightly sour

iii) Texture: All milk samples before starting experiment was normal in Texture. The texture of all milk samples shown in table 4. Texture of normal milk is designated as free flowing liquid. Its viscosity is higher than water.

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

Hour	Treatments			
	Control	0.1%	0.15%	0.2%
0-8th hour	Free flowing	Free flowing	Free flowing	Free flowing
10th hour	Free flowing	Free flowing	Free flowing	Free flowing
12th hour	Slightly clotted	Free flowing	Free flowing	Free flowing
13th hour	Slightly clotted	Slightly clotted	Slightly clotted	Free flowing
14th hour	Clotted	Slightly clotted	Slightly clotted	Free flowing
15th hour	Clotted	Clotted	Clotted	Free flowing
16th hour	Clotted	Clotted	Clotted	Free flowing
17th hour	Curd	Curd	Curd	Slightly clotted

Total solids content of milk are dissolved in water of milk. 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 changes the texture of milk.

So the present results indicated 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 this table it is evident that the texture of whole milk (control), 0.1,0.15 and 0.2 percent $NaHCO_3$ treated milk samples were normal up to 12.13, 14 and above 16 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 $NaHCO_3$.

b) Specific gravity: Average specific gravity of milk samples was 1.030±0.0007 The specific gravity was within the normal range of specific gravity of milk. Generally the specific gravity of fresh milk are within the range of 1.027 to 1.035 having an average value of 1.032 (Eckles, 1951) 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 (1.032). This might be due to high fat and slightly low SNF content of milk. Eckes *et al.* (1951) 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.

c) Clot-on-boiling test: 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 samples was good. The results of COB test are shown in (Table 5). The COB test was positive at 13.05± 0.229, 14.08± 0.07, 15.30± 0.06 and 17.01± 0.3 hours for whole milk (fresh), 0.1, 0.15 and 0.2 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.

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

Hour after treatment	Treatments			
	Control	0.1%	0.15%	0.2%
0-12th hour	-	-	-	-
13th hour	+	-	-	-
14th hour	+	+	-	-
15th hour	+	+	-	-
16th hour	+	+	+	-
17th hour	+	+	+	+
Average COB positive time	13.05 ± 0.29	14.08 ± .07	15.30± 0.06	17.01 ± 0.3

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 break down 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 Hussain (1989), El- safety *et al.* (1978) and Barabas (1995)

Chemical parameters

i) Fat, solids-not-fat (SNF) and total solids (T.S): Fat, SNF, T.S, water, protein, lactose and ash contents of milk samples were 44.0±0.01,83.84±1.8,127.84±2.41, 872.16±2.41, 35.0±0.7, 42.0±1.7, 6.84±.11 g/kg respectively. The result indicated that the quality of milk samples used in this experiment were good.

Acidity test: Results of acidity test are shown in table 1. Mean acidity of experimental samples was 0.15± 0.002. Generally acidity of normal milk samples are within the range of 0.10 to 0.20 (Eckles, *et al.* 1951). Similar types of acidity (0.13%) was 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 0.15% 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. Acidity results of our samples indicated that there was no developed acidity in milk samples and its quality was good. The results of average acidity of control and different proportions of sodium bicarbonate treated milk samples during the preservation period are presented in table 6. Acidity of experimental samples were measured on every two hours interval upto 12 hours and thereafter every one hour interval starting from zero (0) to 17 hours (table 6). Overall mean for 17 hours of study of control and different proportions of $NaHCO_3$ treated milk samples. Mean acidity of fresh milk (control), 0.1, 0.15 and 0.2 percent $NaHCO_3$ treated milk samples were 0.188± 0.05, 0.176 ±0.04, 0.168±0.03 and 0.159±0.02 respectively.

Table 6. Average acidity of control and different Proportions of sodium bicarbonate treated milk samples during preservation period

Time (hour)	Treatments			
	Control	0.1%	0.15%	0.2%
'0' hour	0.150	0.150	0.150	0.150
2nd hour	0.150	0.150	0.150	0.150
4th hour	0.152	0.152	0.152	0.150
6th hour	0.156	0.154	0.152	0.150
8th hour	0.159	0.154	0.154	0.150
10th hour	0.17	0.165	0.158	0.154
12th hour	0.181	0.175	0.165	0.158
13th hour	0.218	0.192	0.186	0.163
14th hour	0.241	0.218	0.194	0.165
15th hour	0.264	0.234	0.216	0.17
16th hour	0.332	0.264	0.243	0.207
17th hour	0.387	0.315	0.294	0.228
x±SD	0.188±0.05	0.176±0.04	0.168±0.03	0.159±0.02
Level of sig.	**			
LSD value	0.0055			

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 0.2 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 and of 17 hours of study. Interaction effect of treatment and time of milk also significant ($p<0.01$). Bogdanova *et al.* (1976) found that acidity increased with storage time. Duncan *et al.* (1991) also reported that average daily acidity increased with storage time.

Microbiological parameters

Total viable bacteria and coliform bacteria before starting the experiment was 42000 C.F.U/ml and 120 CFU/ml respectively. Bacteriological standards of raw milk not exceeding 2,00,000/ml. The pasteurized milk should have a SPC/ml not exceeding 30,000/ml (American Public Health Association, 1960). Fresh milk samples contain not more than 10 per ml or 1000 CFU/ml coliform bacteria, which is a lenient standard (Foster *et al.*1958).

Summary and Conclusion

From the results of the experiment, it was found that colour, flavour and texture of fresh milk samples deteriorated earlier than that of the sodium bicarbonate treated milk samples. Acidity and COB tests also confirmed that lactic acid production of whole milk (control) samples were significantly higher ($P<0.01$) than that of $NaHCO_3$ treated milk samples. It was observed that addition of 0.2 percent $NaHCO_3$ is optimum level for preserving milk upto 16 hours at room temperature (32-34^{0}C). It may be concluded that NaHCO3 is the effective chemical for 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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