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EXPLORING THE EFFECT OF UV TREATMENTS ON THE FATTY ACID PROFILE OF THE BUFFALO MILK

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Milk is a highly nutritious and valuable food throughout the world. A major portion of its production is wasted due to low processing rate and if processed then the high temperature affects its nutritional quality. This study was specifically designed to process buffalo milk by ultraviolet (UV) radiation and checking its effect on the fatty acid profile of the milk as compared to heat treatment. Two variables were used each at three levels that were UV intensity (1780uW/cm^2, 2300uW/cm^2 and 3000uW/cm^2) and time duration (5min, 10min, 15min). The results of these UV treatments were compared with the thermal treatment (82^{o}C for 15 seconds). It was observed that the heat treatment had a significant effect on the Total Solids changed from 15.88-18.57%), total fat (changed from 6.35-6.78%) and Solids not fat (changed from 9.61-10.63%) content of the milk. Whereas, the heat treatment had non-significant effect on the pH (changed from 7.11-7.32) and titratable acidity (changed from 0.09-0.08) of the milk. Fatty acid profile was also significantly affected by heat treatment as a lot of isomerization took place that also caused the increase in the trans fatty acids (content of Linoleic acid trans increased from 0.14 to 0.45). Oxidation was also responsible for the changed fatty acid profile of the buffalo milk. Whereas, UV light treatment did not affect the fatty acid profile of the milk significantly. Sensory characteristics of the milk were significantly changed by the action of the heat treatment as compared to the UV treatments that did not have any impact on the sensory characteristics of the milk. Conclusively, the UV treatment had far better results on the physicochemical properties and fatty acid profile of the milk as compared to the heat treatment.

Keywords: Ultraviolet, fatty acid profile, heat treatment, milk, buffalo, physico-chemical.

INTRODUCTION

Milk is a lacteal secretion by the mammary glands of all mammals. Milk is being consumed by the people in the world from primitive times. Milk is a complete diet as it has all the nutrients necessary for the growth and development of the human body (Awan *et al*., 2014).

These nutrients include proteins, carbohydrates, lipids, vitamins and minerals etc. As milk is an excellent source of nutrients required for the growth and development of the body so, it is also an excellent source of nutrients required for the growth and development of other living organisms (Medhammar *et al*., 2012). Different microorganisms attack the milk once it is secreted from the animal's udder and spoil the milk that makes the milk a sensitive and short life product. These microbial attacks not only shorten the shelf life of the milk but also have negative effects on the organoleptic properties of the milk. Due to these microbial attacks number of unwanted changes appears in the milk that reduces its quality and safety status (Swaminathan and Gerner, 2007). For maintaining the safety and quality status of the milk, different processing operations are applied to the milk. These include conventional and non-conventional processing operations. Conventional processing operations include the thermal treatment of milk at different temperatures and time combinations. These processing operations kill the harmful bacteria in the milk but besides killing the harmful agents in the milk, these also disturbs the organoleptic and nutritional properties of the milk (Butz and Tauscher, 2002).Milk fatty acid profile is also one of the factors that get affected by the conventional heat processing operations. Milk fatty acid profile is an important parameter that is responsible for the sensory properties of the milk and its liking and disliking among the consumers (Alberini *et al*., 2015).Buffalo milk has more fat content as compared to cow milk (Batool *et al*., 2012).So, buffalo milk was used to conduct this research. The current study was conducted to check the effect of different UV treatments on the fatty acid profile of the milk and compared it with the fatty acid profile of the heat-treated milk.

MATERIALS AND METHODS

***Procurement of milk*:** Fresh buffalo milk was taken in washed and sterilized bottles directly from the farm. This was done to avoid any type of contamination and for avoiding any kind of change in the Physico-chemical parameters due to the presence of the bacteria.

***Application of different treatments*:** An instrument (Fig. 1) was designed to treat the milk with different intensities and time combinations. Firstly, a process was developed where any UV can be applied on a liquid sample using a UV source lamp fixed in a hollow tube. Multiple UV source lamps were attached in the hollow tube and the intensity that was given to the samples was controlled by adjusting the distances between the lamps and the samples that ultimately affect the area of the sample to be exposed to the intensity of the UV. The intensity was also measured by the following formula.

Intensity ($\mu W/cm^2$) = Light Power / Sensor Area

Three intensities were selected for the treatment of buffalo milk samples with three different exposure times. The three intensities selected were 1780 uW/cm^2, 2300 uW/cm^2, and 3000 uW/cm^2. All these three intensities were applied before the pre-heating treatment of the samples. These intensities were used because these are the possible intensities that are being used for food commodities as well as these could easily be developed after using the market-based equipment.

Figure 1. Panel for UV treatment of liquids

Physico-chemical analysis

***pH*:** Digital pH meter (Hanna 99165, Woonsocket RI, USA) was used to measure the pH of the milk sample. The buffer solution of pH 7.01 and pH 4.01 was used to calibrate the pH meter. The pH was determined by the procedure described in AOAC (2006).

***Titratable acidity*:** Acidity was measured according to the method given by AOAC (2006). In a conical flask 10 ml of milk sample was taken, then few drops of phenolphthalein indicator were added and titrated against 0.1 N NaOH till pink color appeared. The % titratable acidity was determined by using the following formula:

$$\% \text{ Acidity} = \frac{0.009 \times \text{Volume of 0.1 N NaOH used(mL)}}{\text{Weight of sample}} \times 100$$

***Total solids*:** The procedure of AOAC (2006) was used to measure the total solids. Five ml milk sample of buffalo was taken in a pre-weighed china dish. Then sample was kept in hot air oven at 105 °C in china dish for 24 hours. Then it was kept in desiccator till constant weight obtained. The percentage of total solids was calculated as following:

$$\text{Total solids} = \frac{\text{Weight of dried milk sample}}{\text{Weight of milk sample}} \times 100$$

***Fat content*:** Fat in the milk sample was determined by the Gerber method AOAC (2006). Clean and dry butyrometer was put in the butyrometer stand. Sulphuric acid (10 mL) was added to the butyrometer. Milk sample (10.94 mL) was pipette out gently by the side of butyrometer, whose temperature was about 15 to 21°C. Then 1.0 mL of amyl alcohol was poured. Butyrometer was stopped with the lock stopper. The tube was well (mixed) shaken till black color was obtained. Then place the butyrometer in the Gerber centrifuge machine at 1100 rpm for 5 mins. Afterwards, butyrometer was kept in hot water bath at 60 °C for 30 mins. Reading was noted directly from the butyrometer scale from bottom of the fat column to lower border of meniscus on the scale.

***Solids not fat*:** Solids not fat is a parameter of the milk that includes the solid portion or soluble solids of the milk that are other than fat. These were calculated by subtracting the total fat portion from the total solids portion.

***Fatty acid analysis*:** Fatty acid profile was analyzed by the GC (Elgersma *et al*., 2004). Fatty acids that were determined include saturated fatty acids (SFA), Monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) by the standard procedure of AOAC (2006).

***Fat extraction*:** Fat of milk samples was extracted through centrifugation with the help of a 15 ml conical plastic tube(Conte *et al.*, 2016). In these tubes, 13 ml volume milk sample was taken and centrifuged for twenty minutes at the speed of 2000 rpm at 4°C. Cake layer of fat was obtained which was then transferred in a clean test tube and sealed with a tight sealing cap. Extracted fat was then reserved in refrigerated environments until further preparation(AOAC,2006).

***FAME preparation*:** Before the fatty acids analysis, fatty acids were changed into methyl esters. 100 µg±5 µg of fat samples were transferred into test tubes with sealing caps by using Pasteur pipettes. The lipids were dissolved by adding 5 ml of hexane in test tube and vortex succinctly. In test tube 250 µL of sodium methoxide was added, caped and vortex for 1 minute and let the vortex to downfall by resting every 10 seconds. In test tube, 5 mL of saturated NaCl was added, caped and mixed well by shaking for fifteen seconds and then left for ten min. Hexane layer was detached and transferred into small volume of sodium sulphate vial. Before analysis, sodium sulphate was remained in touch with hexane layer for at least 15 minutes. After that hexane layer was shifted into a vial for gas chromatography analysis.

***GC-MS operating conditions*:** Analysis of fatty acid methyl esters was done by using Flame Ionization Detector (FID) equipped GC (Agilent 6890). An Agilent 6890N Network GC system was used for GC analysis, under the following conditions: column, DB wax Capillary; 60.0 m×0.25 mm×0.25 m; oven temperature programmed: the column held initially at 60°C for 3 min after injection, then increased to

185ºC with 10ºC/m in heating ramp for one min and increased to 200ºC with 5ºC/min heating ramp for 10 min. Then, the final temperature was increased to 220ºC with5ºC/m in heating ramp for 20 min; injector temperature, 250ºC; detector (FID) temperature, 275ºC; carrier gas, nitrogen; inlet pressure, 40.65 psi; linear gas velocity, 39 cm/s; column flow rate, 2.7 mL/m in; split ratio, 40:1; injected volume, 1 µL.

***Sensory Analysis*:** Sensory evaluation of thermally treated milk and UV treated milk was carried out by panelists, using hedonic scale according to the method described by Meilgaard *et al*. (2007). The panelists were asked to express their opinion about the milk samples by giving a score (9= like extremely; 1= dislike extremely).

***Statistical Analysis*:** Descriptive statistics were used to analyze the results and means were compared to check the level of significance as per the method of Mason *et al*. (2003).

RESULTS

***Physicochemical Analysis*:** Results showed that the mean values of pH of the control sample and the sample that was treated thermally showed a little increase in pH. The mean values for the pH of control sample and the thermally treated samples were 7.11±0.01 and 7.32±0.01, respectively and it shows that there was not a considerable effect of heat treatment as compared to control sample. Likewise, the values of UV treatments did not show any considerable change in the pH value of the milk as compared to the control sample.

Results of TA showed that there was not a considerable effect of heat treatment T_1 on TA of the milk as compared to the control sample that was 0.094±0.001in control and 0.082±0.001in T_1. Similarly, The UV treatments with different intensities and time durations had no significant change in the TA of the milk samples. The highest change in TA of the samples had been observed in the T_6 that was 0.091±0.001. Most of the treatments showed a minor change as compared to control. The overall UV treatments had shown a non-significant impact on TA of the milk.

Results of TS showed that there was a considerable effect of heat treatment T_1 on TS of the milk as compared to the control sample that was 15.88±0.01in control and 18.57±0.01in T_1. Contrary to that, the UV treatments with different intensities and time durations did not show any significant change in the TS of the milk samples. The highest change in TS of the samples had been observed in the T_6 that was 15.793±0.159. The lowest change was observed in the T_2 that

Table 1. Mean Values of Physico-chemical parameters of milk

Treatments	pH	TA (%)	TS (%)	FAT (%)	SNF (%)
T_o	7.11±0.012^b	0.09±0.001^a	15.88±0.011^b	6.35±0.021^b	9.61±0.122^b
T1	7.32±0.021^a	0.08±0.001^b	18.57±0.011^a	6.78±0.011^a	10.93±0.843^A
T2	7.14±0.022^b	0.09±0.002^a	15.85±0.108^b	6.37±0.051^b	9.44±0.033^b
T3	7.16±0.008^b	0.09±0.001^a	15.92±0.021^b	6.31±0.016^b	9.63±0.021^b
T4	7.11±0.014^b	0.09±0.002^a	15.98±0.029^b	6.32±0.024^b	9.65±0.016^b
T5	7.13±0.025^b	0.10±0.001^a	15.84±0.026^b	6.31±0.063^b	9.54±0.017^b
T6	7.14±0.008^b	0.09±0.001^a	15.79±0.159^b	6.32±0.008^b	9.48±0.008^b
T7	7.15±0.041^b	0.10±0.001^a	15.82±0.246^b	6.36±0.029^b	9.47±0.017^b
T8	7.13±0.017^b	0.09±0.001^a	15.92±0.021^b	6.32±0.008^b	9.62±0.012^b
T9	7.14±0.008^b	0.09±0.001a	15.84±0.026^b	6.36±0.029^b	9.48±0.008^b
T10	7.13±0.025^b	0.09±0.002^a	15.98±0.029^b	6.32±0.024^b	9.62±0.008^b

T_o= Control, T6= Intensity 2 at 10 mint stay time, T1= 72°C for 15 seconds, T7= Intensity 2 at 15 mint stay time, T2=Intensity 1 at 5 mint stay time, T8= Intensity 3 at 5 mint stay time, T3= Intensity 1 at 10 mint stay time, T9= Intensity 3 at 10 mint stay time, T4= Intensity 1 at 15 mint stay time, T10= Intensity 3 at 15 mint stay time, T5= Intensity 2 at 5 mint stay time

Table. 2.Effect of heat treatment on fatty acid profile of milks.

Sr. No.	Fatty acid	Carbon no	T_o	T1
1	Butyric acid	C:4:0	5.34±0.021	6.75±0.021
2	Capric acid	C:10:0	3.34±0.011	4.50±0.012
3	Lauric acid	C:12:0	3.77±0.011	4.89±0.012
4	Myristic acid	C:14:0	10.76±0.142	11.74±0.141
5	Palmitic acid	C:16:0	32.43±1.131	33.44±1.132
6	Stearic acid	C:18:0	12.25±0.041	13.55±0.043
7	Oleic acid	C:18:1	21.24±0.031	22.54±0.034
8	Linoleic acid	C:18:2	3.41±0.012	4.89±0.013
9	Linoleic acid	C:18:2 trans	0.14±0.023	0.45±0.022
10	Linolenic acid	C:18:3	0.54±0.021	0.79±0.053

T_o= Control, T6= Intensity 2 at 10 mint stay time, T1= 72°C for 15 seconds, T7= Intensity 2 at 15 mint stay time, T2=Intensity 1 at 5 mint stay time, T8= Intensity 3 at 5 mint stay time, T3= Intensity 1 at 10 mint stay time, T9= Intensity 3 at 10 mint stay time, T4= Intensity 1 at 15 mint stay time, T10= Intensity 3 at 15 mint stay time, T5= Intensity 2 at 5 mint stay time

was15.85±0.108 but the overall UV treatments had shown a non-significant impact on TS of the milk.

Results of fat showed that there was a considerable effect of heat treatment T_1 on the fat content of the milk as compared to the control sample that was 6.35±0.021in control and 6.78±0.01in T_1. While UV treatments with different intensities and time durations did not show any significant change in the fat content of the milk samples. The highest change in fat content of the samples had been observed in the T_3 and T_5 that was 6.31±0.016 and 6.313±0.063, respectively. The lowest change was observed in the $T_7$and T_9 that was 6.36±0.029 and 6.36±0.029, respectively but the overall UV treatments had shown a nonsignificant impact on fat contents of the milk.

Results of SNF showed that there was a considerable effect of heat treatment T_1 on SNF of the milk as compared to the control sample that was 9.61±0.122 in control and 10.933±0.84in T_1. Contrary to that, the UV treatments with different intensities and time durations did not show any significant change in the fat content of the milk samples. The highest change in SNF of the samples had been observed in the T_3 that was 9.443±0.033. The lowest change was observed in the T_8 that was 9.617±0.012but the overall UV treatments had shown a nonsignificant impact on SNF of the milk.

***Fatty acid profile*:** Different thermal and non-thermal treatments when applied to the buffalo milk also showed a significant impact on the fatty acid profile of the milk. It was observed that when the heat treatment was applied to the milk the major impact was seen on the linoleic acid (trans). It had shown highly significant impact as compared to the raw milk when heat treatment was applied to the milk. The increase of about 200% has seen in the amount of linolenic acid. The minimum effect was seen on palmitic acid but still the impact of heat treatment was significant. Oleic acid was also affected minimally by the action of thermal treatment. Butyric acid, Capric acid, Lauric acid, Myristic acid, Stearic acid and Linolenic acid also showed a highly significant effect when the buffalo milk was treated thermally.

Three types of UV-treatments UV-1 (1780uW/cm^2), UV-2 (2300uW/cm^2) and UV-3 (3000uW/cm^2) were used with respect to time 5, 10 and 15 seconds for each treatment to explore the behaviour of different fatty acids to these diverse conditions.

It was seen that when buffalo milk was exposed to the first UV intensity that was 1780uW/cm^{2}for three different time intervals then it influenced the fatty acids profile in an interesting way. T_2 was the value of UV-1 at 5 seconds and T_4 was the value of UV-1 at 15 seconds. Butyric acid (5.30±0.03 T_2, 5.28±0.05 T_4), Linoleic acid (3.50±0.04 T_2, 3.47±0.09 T_4) and Lauric acid (3.74±0.05T_2, 3.70±0.04 T_4) values showed more prominent downward trend than Capric acid (3.33±0.02T_2, 3.32±0.02 T_4) and Oleic acid (21.20±0.40 T_2, 21.22±0.01 T_4) when compared with T_o. Stearic acid content was found significantly decreasing for both treatments at 5 seconds (11.69±0.67) T_2 and 15 seconds T_4 (11.76±0.33) for UV-1. When intensity of UV-1 applied for 15 seconds T_3 then slightly increase in values of Butyric acid, Capric acid, Oleic acid and linoleic acid was noted (5.35±0.01), (3.44±0.04), (21.33±0.03), (3.45±0.07), respectively but Lauric acid (3.66±0.07) showed decreasing trend at this intensity and time combination. No change was observed for Linoleic acid (C: 18:2 trans) and Linolenic acid mean value at T_2 and T_4 when UV-1 was used.

Application of UV-2 (2300 uW/cm^2) on buffalo milk revealed that Butyric acid mean value at T_5 (5.30±0.03) and T_6 (5.30±0.01) with respect to control sample did not change but Capric acid upward trend was shown at T_5 (3.59±0.02) and T_6 (3.65±0.04). In contrast to both Butyric acid and Capric acid decreasing trend of Lauric acid at T_5 (3.66±0.05) and T_6 (3.56±0.07) was observed. When UV-2 intensity (2300 uW/cm^2) was applied for 15 seconds T_7 mean value of fatty acids, Butyric acid (5.79±0.05), Capric acid (3.35±0.02), Lauric acid (3.98±0.04), Palmitic acid (32.78±0.03), Linoleic acid (3.44±0.09), Linoleic acid as C:18:2 trans (0.16±0.02) and Linolenic acid (0.59±0.02) increased significantly except Myristic acid (10.56±0.07), Stearic acid (11.75±0.33) and Oleic acid (21.23±0.01) that decreased with respect to T_o. Timespan did not have any effect on mean value of Stearic acid at T_6 (11.75±0.45) and T_7 (11.75±0.33).

When buffalo milk was subjected to high intensity (3000 uW/cm^2) of UV light for 5 seconds Myristic acid mean value

Table 3. Mean values of fatty acids profile of buffalo milk treated with different intensities of UV

Sr.	Fatty acid (mg/g)	Carbon no.		UV 1			UV 2			UV 3		
			To	T2	T3	T4	T5	T6	T7	T8	T9	T10
1	Butyric acid	C:4:0	5.34±0.02	5.30±0.03	5.35±0.01	5.28±0.05	5.3±0.03	5.3±0.01	5.79±0.05	5.35±0.03	5.44±0.01	5.59±0.05
2	Capric acid	C:10:0	3.34±0.01	3.33±0.02	3.44±0.04	3.32±0.02	3.59±0.02	3.65±0.04	3.35±0.02	3.45±0.02	3.98±0.04	3.65±0.02
3	Lauric acid	C:12:0	3.77±0.01	3.74±0.05	3.66±0.07	3.70±0.04	3.66±0.05	3.56±0.07	3.98±0.04	3.65±0.05	3.78±0.07	3.72±0.04
4	Myristic acid	C:14:0	10.76±0.14	10.76±0.01	10.71±0.013	10.62±0.07	10.66±0.01	10.45±0.013	10.56±0.07	10.28±0.01	10.1±0.013	10.16±0.07
5	Palmitic acid	C:16:0	32.43±1.13	32.59±0.08	32.67±0.05	32.83±0.03	32.98±0.08	32.55±0.05	32.78±0.03	32.45±0.08	32.92±0.05	32.85±0.03
6	Stearic acid	C:18:0	12.25±0.04	11.69±0.67	11.70±0.45	11.76±0.33	11.73±0.67	11.75±0.45	11.75±0.33	11.71±0.67	11.72±0.45	11.85±0.33
7	Oleic acid	C:18:1	21.24±0.03	21.20±0.40	21.33±0.03	21.22±0.01	21.35±0.40	21.22±0.03	21.23±0.01	21.45±0.40	21.42±0.03	21.42±0.01
8	Linoleic acid	C:18:2	3.41±0.01	3.50±0.04	3.45±0.07	3.47±0.09	3.48±0.04	3.49±0.07	3.44±0.09	3.44±0.04	3.46±0.07	3.48±0.09
9	Linoleic acid	C:18:2 trans	0.14±0.02	0.14±0.01	0.15±0.01	0.14±0.01	0.15±0.01	0.14±0.01	0.16±0.02	0.15±0.01	0.15±0.01	0.16±0.01
10	Linolenic acid	C:18:3	0.54±0.02	0.55±0.01	0.6±0.01	0.58±0.02	0.54±0.01	0.54±0.01	0.59±0.02	0.49±0.01	0.6±0.01	0.58±0.02

T_o= Control, T6= Intensity 2 at 10 mint stay time, T1= 72°C for 15 seconds, T7= Intensity 2 at 15 mint stay time, T2=Intensity 1 at 5 mint stay time, T8= Intensity 3 at 5 mint stay time, T3= Intensity 1 at 10 mint stay time, T9= Intensity 3 at 10 mint stay time, T4= Intensity 1 at 15 mint stay time, T10= Intensity 3 at 15 mint stay time, T5= Intensity 2 at 5 mint stay time

at T_8 (10.28±0.01) decreased unlike T_2 (10.76±0.01) but Butyric acid behaved differently by slightly increase in mean value at T_8 (5.35±0.03) unlike T_2 (5.30±0.03) when compared with T_o (5.34±0.02) ,respectively. Mean of Linoleic acid as C: 18:2 trans for T_8 (0.15±0.01) and T_9 (0.15±0.01) increased slightly from the control mean of sample (0.14±0.02) unlike T_2 (0.14±0.01) and T_4 (0.14±0.01) mean value. The same mean value of (0.58±0.02) for Linolenic acid recorded at T_{10} likewise it was observed at T_4 (0.58±0.02). Application of UV-3 (3000 uW/cm^2) for 10 seconds (T_9) on milk caused the eloquent increase in mean value of fatty acids like Butyric acid (5.44±0.01), Capric acid (3.98±0.04), Lauric acid (3.78±0.07), Palmitic acid (32.92±0.05) and Oleic acid (21.42±0.03) except Myristic acid (10.10±0.013) and Stearic acid (11.72±0.45) regarding T_o.

Among all fatty acids least change in the mean of Linoleic acid as C: 18:2 was recorded from 0.14±0.01 to 0.16±0.01 by comparing with controlled sample mean value (0.14±0.02) in relation to any time (5,10 and 15 seconds) and UV-intensity (1780, 2000 and 3000 uW/cm^2) combination. Myristic acid and Stearic acid were only two fatty acids among all others included in this study that produced no increasing trend in any treatment combination compared to their control mean T_o (10.76±0.14) and (12.25±0.04) respectively. Both Myristic acid and Stearic acid showed upward trend in mean (11.74±0.14) and (13.55±0.04) was only observed at T_1 when milk was thermally treated at 82°C for 15 second**.**

***Sensory evaluation*:** Graphical representation of results pertaining to sensory attributes is presented in Fig.2. Results showed that milk treated with heat pasteurization had a less yellowish color, as heat is applied milk color turns to whiter appearance from yellow appearance. Thermally treated milk sample was scored lower in terms of flavor. Panelist reported cooked flavor for the heat-treated sample. The aroma of milk was also affected to a little extent as shown by the results. While UV treated milk reports no effects in terms of flavor and aroma because it did not disturb the volatile profile and constituents of milk such as fat and protein that play significant role in taste and aroma. Milk treated with three different UV intensities and three different stay times had shown no significant difference in terms of color.

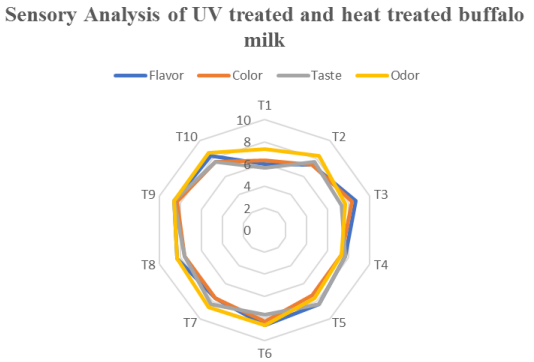

Figure 2. Sensory Evaluation of Buffalo Milk

T_o= Control, T6= Intensity 2 at 10 mint stay time, T1= 72°C for 15 seconds, T7= Intensity 2 at 15 mint stay time, T2=Intensity 1 at 5 mint stay time, T8= Intensity 3 at 5 mint stay time, T3= Intensity 1 at 10 mint stay time, T9= Intensity 3 at 10 mint stay time, T4= Intensity 1 at 15 mint stay time, T10= Intensity 3 at 15 mint stay time, T5= Intensity 2 at 5 mint stay time

DISCUSSION

Application of thermal and non-thermal treatments showed a significant effect on the pH of milk. Microbes are the basic agents responsible for the decrease in pH. This is because of the effect that both treatments killed the microbes that are the basic cause of a decrease in pH. These results are like the results of Orlowska *et al.* (2013) as these results showed that pH of milk was not changed by the UV treatment. Energy from the UV light source had no impact on the pH of the product (Rossitto *et al.*, 2012).

When thermal and non-thermal treatments were applied to milk, results showed non-significant effect on the titratable acidity. This is because titratable acidity and pH are correlated with each other. pH and titratable acidity had inverse relationship i.e., increase in pH cause a decrease in titratable acidity and vice versa. As in present study, the effect of application of thermal and non-thermal treatments on the milk had non-significant effect, so the same was observed for titratable acidity. These results are also in agreement with the results of Hassan *et al.* (2009) who demonstrated that when milk is heated and stored, lactose is degraded and converted into acids, that's why titratable acidity value increases.

When milk was subjected to thermal and non-thermal treatments, results revealed that thermal treatment had a significant effect on total solids of milk as compared to non-thermal treatment that showed non-significant effect (Hossain *et al.*, 2011). When heat is applied in case of thermal treatment milk gets condensed and water contents also decreased but this did not happen for non-thermal treatment. These results are in contrast with the results of Guneser and Yuceer (2012) who observed the Ultra-violet light application significantly impacts the solid content of milk. Application of thermal treatment on milk significantly affected the fat while in contrast to thermal treatment, application of non-thermal treatments showed non-significant effect on the fat content. This is because application of heat treatment cause alteration in the structure of the fat which results in formation of non-fat compounds but no alteration in the total fat content of the milk was observed on the application of non-thermal treatments. These results are also confirmed by Elias-Argote (2011) who stated that UV treatment does not affect the fat, lactose and protein content of milk.

In milk, SNF is referred to as the total solids excluding fat content. Application of heat treatments on SNF of milk showed a significant effect when milk was subjected to a heat treatment while the application of non-thermal treatments showed a non-significant effect on the SNF content of milk. As discussed earlier, application of heat treatments affected

the total solids and fat content significantly while this effect was non-significant when milk was subjected to non-thermal treatments.

Table 2 & 3 shows the fatty acids profile of milk when milk was treated with conventional heating method and different ultraviolet treatments, respectively. Results show minor change in different fatty acids content i.e., the content of Butyric acid (C:4:0), Capric acid (C:10:0), Lauric acid (C:12:0), Myristic acid (C:14:0), Palmitic acid (C:16:0), Stearic acid (C:18:0), Oleic acid (C:18:1), Linoleic acid (C:18:2), CLA (Conjugated Linoleic acid, C:18:2 trans) and Linolenic acid (C:18:3). These changes were so minor that these were regarded as to be of significant effects. Heat treatment causes oxidation of fats which results in transformation of fatty acids to different aldehyde and ketones which are responsible for the rancid smell. These oxidative changes are very minute which are negligible when milk is subjected to different ultraviolet treatments (Hossain *et al.*, 2011). These minor changes are regarded as non-significant and it can be deduced that the fatty acids of the buffalo milk are stable to UV light treatments. The continuous aqueous phase of milk system provides a barrier against the functioning of oxygen, which results in becoming a barrier towards the process of oxidation which is responsible for degradation and rancidity of fatty acids.

***Conclusion*:** The application of both UV and heat treatment is beneficial for the preservation of nutritional and quality characteristics of milk. UV treatment can be used as an alternative to heat treatment as it has a significant and much better impact on the properties of milk as compared to the heat treatment and is cost effective. UV intensity, its dose rate, stay time, turbulent or continuous apparatus are the important factors that must be considered for efficient results.

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