Comparative Analysis of UV Treatment and Heat Treatment on Fatty Acids Profile of Milk

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Research

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Abstract

**Background:** Application of UV radiation for ensuring the safety and quality status of liquid foods is of growing interest of food industry, as thermal pasteurization produces the qualitative and safety concerns in terms of fat oxidation of milk. Milk is an important part of human diet because of its balanced nutritional composition.

**Methods:** This study was planned to prevent the spoilage of milk because of fat oxidation and to ensure its quality and safety status towards human health by the application of UV. UV light does not promote the formation of free radicals thus it decreases the chances of fat oxidation and ultimately the formation of off flavored compounds. Eight different treatments were made in which milk was treated with one thermal treatment and to check whether the UV light treatment disturbs the fatty acid profile, six samples were treated with two different intensities and 3 different stay times.

**Results:** Among the UV intensities, 1st Intensity (1780 µW/cm$^2$) gives more good results than that of 2nd intensity (2300 µW/cm$^2$). The average value of three different stay times of UV$^{1st}$, UV$^{2nd}$ and heat treatment for Oleic acid (C18:1) are 16.74mg/g, 18.07 mg/g and 18.87 mg/g respectively, Similarly for linoleic acid (C:18:2 *trans trans*) values are 0.15 mg/g, 0.19 mg/g and 1.45mg/g which shows that there is lesser amount of trans fatty acids after UV intensity 1st treatment than second UV intensity and heat. Physicochemical attributes of milk remain unchanged by UV application, minor changes occurred in fatty acids profile of milk, but those changes were negligible as compared to thermal treatment.

**Conclusions:** Based on results it was concluded that thermal treatment considerably affects the physicochemical as well as the fatty acids profile of milk.

Background

Pakistan is among the top three milk producing countries of Asia and pacific region. According to the Pakistan Economic survey 2016-17 estimated gross milk production was 56,080,000 tonnes [1]. Livestock is main subsector of agriculture by sharing 59% to agriculture and total 11.39% share to the GDP. In Pakistan about 8 million people from rural areas are involved in livestock rearing. Among the livestock rearing, cow milk is contributing in country’s total milk production is 42 million tons [2].

Milk is an important part of human diet. It is due to its balanced nutritional conformation and variety of products is made from milk. In Pakistan and India cow milk is the major contributor in total production of global milk [3]. Milk is considered as a complete food in nature. Milk not only provides the nutrients to the neonate of mammalian species, but it also plays major role in the nourishment of human adults and growth of children [4]. Worldwide over 264 million dairy cows every year produce 600 million tonnes. Global average milk production per cow is 2,200 liters. Largest producer of milk is India and followed by US, China, Pakistan and Brazil [5].

These days not only the nutritional value of milk attracts the interest of consumer but also the other physiological properties of its components. Cows’ milk comprises of 87 percent water, 4.6 percent lactose,
4.2 percent fat, 3.4 percent protein, 0.8 percent minerals, and 0.1 percent vitamins [6]. Consumers expect that dairy products ensure food safety and provide high nutritional value. Milk available in the market is produced in different farming systems. Cheapest milk sold in the market in large amount is produced in intensive production system. In these farms’ cows are fed with cereals, complete balanced feed comprising of preserved bulk feed and also with feed additives and kept all year in closed barns [7].

Mostly milk is pasteurized by thermal methods in which high temperature is applied to kill the microbes. Aftertaste had more sweet-related characteristics and less cooked flavors in higher fat milks as compared to lower fat milks [8]. Whey proteins are denatured and the interactions between whey proteins and caseins takes place on the surface of milk fat globules due to heat treatments such as UHT process [9].

Oxidation of milk lipids deteriorate the nutritional quality and also produce off flavor in return it will affect the acceptability of product and its shelf life [10]. In dairy products high content of unsaturated fatty acids leads to oxidation and in result stale, oily and metallic flavor is produced, especially after storage. Exposure to high temperature and oxygen increases the oxidation rate and thus lowers the acceptability of product by consumers and its nutritional value [11].

Pasteurization could affect the rumenic acid after 24 hours of treatment at 5 °C storage. Studies found that microwaving and low pasteurization of milk cause losses of \textit{trans} fatty acids while UHT and HTST processing decrease the conjugated linoleic acid content [12]. Application of heat treatment results in adverse effects such as change in milk color depending upon the intensity and duration of heat, decrease in nutritional value, increase in heat generated aroma compounds, deterioration of sensory qualities. To make milk safe from these kind of chemical changes non-thermal methods such as Ultrasound and Ultraviolet have been introduced as a substitute of heat treatment. These non-thermal techniques have no adverse effects on quality of milk [13].

Food safety is of supreme importance in food industry especially in dairy sector, it includes the quality and safety of milk and products made from milk such as cheese. Thermal and non-thermal treatments have not differently impacted the milk in terms of cheese production. Thermal treatment affects the vitamin and riboflavin content and denatures the protein of milk. For industrial significance UV treatment possesses different benefits over thermal treatment such as

- Low cost of maintenance and installation
- Lower production cost
- Reduction of carbon emission as compared to thermal pasteurization

Moreover, UV technology is beneficial for small scale producers of milk. Major limitations in the use of UV processing were its low penetration in opaque liquids. To resolve this problem Supreme Turbulator has been developed which will provide uniform penetration because of the features of swirl tube. This processing technology would be affordable and provide solutions to extend the shelf life of milk and improves the safety status and product end quality of secondary dairy products such as cheese [14]. European Food Safety Authority panel on Dietetic products, Nutrition and Allergies was requested to give opinion on UV processed milk usage as novel food. Milk was treated with UV after heat treatment, results in an increase in
vitamin D3. They concluded that UV treated milk does not cause lipid oxidation up to a level that cause quality or safety issue. UV processing is gaining importance as a substitute of thermal processing, because thermal pasteurization causes vitamin, carbohydrates degradation and offflavor [15].

Four subclasses of UV light are following:

- Vacuum UV range (100–200 nm)
- UV-C (200–280 nm)
- UV-B (280–315 nm)
- UV-A (315–400 nm)

A positive, customer reaction is growing towards the physical preservation of food by UV light. Among the food industries preservation by UV is also gaining popularity because of its low-cost operation. Recent research on UV light irradiation demonstrated that it is the best alternative to thermal processing of beverages and liquid foods [16].

**Methods**

Fresh raw cow milk was purchased from local milk vendor in sterilized and clean sample bottles. Milk sample was kept under refrigerated condition (4 °C) in lab during the analysis. T₀ sample is kept as control no treatment was given to it.

**Thermal treatment**

For thermal treatment water bath was used. Water bath temperature was set on 75 °C. T₁ sample was treated with thermal treatment.

**UV Application**

Two different UV apparatus was used to treat the milk samples, each of them consists of a low-pressure lamp possessing different intensities. One of them lamp possesses 30Watt power that imparts 1780 µW/cm² intensity (1st intensity) at 15 centimeters to the milk sample arranged horizontally encircled with quartz sleeve. UV intensity was measured by using radiometer. Milk was poured from inlet at the upper part of the UV apparatus. When milk settled in glass sleeve three different stay times were given to the sample that were 4, 8 and 12 minutes. UV dose can be measured by multiplying stay time with the intensity.

\[
\text{UV dose} = \text{intensity (µW/cm}^2\text{)} \times \text{stay time}
\]

T₂, T₃, T₄ were the samples that were treated by using 1780 µW/cm² intensity.

Another apparatus with the same configuration possesses 60 Watt that imparts 2300 µW/cm² intensity (2nd intensity) at 15 cm, was used to treat the remaining samples that were T₅, T₆, T₇. Sample was introduced
into the apparatus in the same manner and given three different stay time 4, 8 and 12. Before and after running the samples instrument was cleaned with the distilled water.

**Physicochemical analysis of milk**

Digital pH meter was used to measure the pH of milk samples. Calibration of pH meter was done by using Buffers of pH 4 and 7 each time. After calibration, in a beaker 20 ml of sample was taken and then electrode was dipped in the milk until constant reading was achieved [17]. Viscosity of milk samples was determined by viscometer according to the method described in AOAC [18]. Spindle number 1 was used with rotation of 60 rpm. Viscometer reading was taken in centipoises unit. Fat content is determined by Gerber method according to prescribed method [19]. Titratable Acidity was determined by using Titration method no. 947.05 of AOAC [18]. For this 10 ml of milk sample was taken in a beaker. As an indicator, 1–2 drops of phenolphthalein solution were added, and then it is titrated against 0.1N NaOH until a faint pink color appeared as an end point. Total soluble solids of milk were determined according to the AOAC [18].

**Sensory Evaluation**

Milk was analyzed by panel of University students. Sensory evaluation was completed by using 9-point hedonic scale. Color, flavor and aroma were analyzed as sensory attribute of milk. Analysis were performed according to the method described by Reinemann *et al.* [20].

**Fatty acid analysis**

Fatty acids profile of milk was evaluated by using Gas Chromatography as described in Elgersma *et al.* [21]. Fatty acids especially butyric acid, stearic acid, oleic and linoleic acid were analyzed. Fat was extracted through centrifugation as described by Conte *et al.* [22] with some alterations. Milk samples were taken in conical plastic tube of 15 ml and centrifuged at 2000 rpm speed for 20 minutes at 4 °C. Fat cake layer was transferred in a clean test tube.

**FAME preparation**

Before the analysis fatty acids were converted into methyl esters. Pasteur pipettes were used to transfer the 100µg ± 5 µg of fat samples into test tubes with sealing caps. To dissolve the lipids 5 ml of hexane was added in test tube and vortex concisely. 250 µL of sodium methoxide was added in test tube caped it and vortex for one minute and allow the vortex to collapse by pausing every 10 seconds. 5 mL of saturated NaCl was added in test tube, caped and shacked for 15 seconds and stand it for 10 min. Hexane layer was removed and transferred into a vial having small volume of sodium sulphate. Hexane layer remained in contact with sodium sulphate for at least 15 minutes before analysis. Then hexane layer was transferred into a vial for gas chromatography analysis.
Gas chromatography operating conditions

Fatty acid methyl esters were analyzed by using GC (Agilent 6890) equipped with Flame Ionization Detector (FID) as described by Wiking et al. [23]. GC analysis was performed on an Agilent 6890N Network GC system, under the following conditions: column, DB wax Capillary; 60.0m x 0.25mm x 0.25 m; oven temperature programmed: the column held initially at 60ºC for 3 min after injection, then increased to 185ºC with 10ºC/m in heating ramp for 1 min and increased to 200ºC with 5ºC/min heating ramp for 10 min. Then the final temperature was increased to 220ºC with 5ºC/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.

Statistical analysis

Statistical analysis was done at 95% significance level (α = 0.05) by using completely randomized design and two-way factorial design. CRD was used to check the impact of heat on milk. Then two way factorial was used to determine the impact of UV intensities and stay time, in which one parameter is dependent and other 2 parameters such as UV intensities (1 and 2) and stay time (4, 8 and 12 mints) were independent by the use of process defined by Mason et al. [24]. In last, means of all treatments were compared to evaluate which treatment has more significant impact.

Results

In the current research plan point of consideration was to minimize the fat oxidation in milk through non-thermal treatment without affecting its nutritional and physicochemical characteristics negatively. I bought fresh milk from the local market and applied non-thermal UV treatment to check and evaluate the influence of UV light on the fatty acid oxidation status of the milk. Additionally, physicochemical analysis of milk performed to check the effect of UV light on these attributes.

Physicochemical analysis

According to the results, pH of milk was not significantly affected by the application of UV light treatment as compared to thermal pasteurization. Mean values of thermal treatment is 6.7200 ± 0.01 and 6.7500 ± 0.01. My results are similar to the results of Batool et al. [25] they assessed the pasteurized and raw milk samples for pH and reported that the pH for raw milk ranges between 6.35 to 6.98 and pH for pasteurized milk ranges between 6.40 to 7.03. The pH of UV treated milk showed that there was non-significant relation among the means of treatments which means that non-thermal treatment has no influence on the pH of milk. Mean values of control sample and UV treated samples are 6.7200 ± 0.01, 6.8400 ± 0.01 and 6.7522 ± 0.01. These results are similar to the results of Orlowska et al. (2013) as these results showed that pH of milk was not changed by the UV treatment.

Thermal treatment showed significant impact on viscosity which means that application of heat altered the viscosity of milk. The mean values of viscosity of milk samples are 1.4500 ± 0.01 and 2.3700 ± 0.01. This study is closely related to the work of Kumbar and Nedomova [26] who demonstrated that the dynamic
viscosity of the milk increases with temperature. Results of UV treated milk had showed that UV do not alter the viscosity of milk. Mean values of viscosity of UV treated milk are $1.3500 \pm 0.01$, $1.5633 \pm 0.01$ and $1.4300 \pm 0.01$. My results are similar to the results of Orlowska et al. [27].

Results for acidity had showed significant impact of heat treatment on the acidity of milk. My results are according to Hassan et al. [28]. Mean values of my results are $0.1880 \pm 0.001$ and $0.4566 \pm 0.001$. This study showed that UV radiation did not affect the acidity. Mean values are $0.1990 \pm 0.001$, $0.1700 \pm 0.001$ and $0.1690 \pm 0.001$. Rossitto et al. [29] reported that titratable acidity did not exceed above 0.3%.

Study showed significant impact of thermal treatment on solid content of milk. Mean values for milk soluble solid content are $13.600 \pm 0.1$ and $15.400 \pm 0.1$. My results are similar to Hossain et al. [30] who reported that solid content of the UHT treated milk is greater than that of the raw milk. UV treatment has significant impact on solid content of milk. As demonstrated by Guneser and Yuceer [31] Ultra-violet light application significantly affect the solid content of milk. Mean values of my results are $13.600 \pm 0.1$, $14.207 \pm 0.1$ and $10.733 \pm 0.1$.

Milk fat was determined by Gerber method. Results showed significant impact of heat treatment on fat. Results are similar to the Bermudez-Aguirre et al. [32] who found a significant difference among the butter fat content of all samples, including raw, thermally treated and sonicated milk samples. Mean values for fat are $3.65 \pm 0.1$ to $3.75 \pm 0.1$. Results of fat of UV treated milk showed that UV rays have no significant impact on the fat content of the milk. The results are also confirmed by Elias-Argote [33] who sated that UV treatment do not affect the fat, lactose and protein content of milk. Mean values are $3.70 \pm 0.01$, $3.75 \pm 0.01$ and $3.81 \pm 0.01$.

**Sensory evaluation**

Milk is consumed by the children, adults and people from every age group on daily basis. Its color, flavor and aroma are the most influencing organoleptic characteristics. Hedonic scale with nine points was used by the university student panelist to score the milk treated with thermal and non-thermal UV technique.

Graphical representation of results pertaining to sensory attributes is presented in Graph.3. Results showed that milk treated with heat pasteurization have 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. This is because the denaturation of protein β-lactoglobulin as reported by Wolf et al. [3]. Aroma of milk was also affected up to little extent as shown by the results. Milk treated with two different UV intensities and three different stay times have shown no significant difference in terms of color, flavor and aroma. My results are in agreement with Engin and Yuceer [13] and Reinemann [20] who reported that UV treated milk is preferred than thermally treated milk. But UV dose and stay time should be considered. Milk treated with lower dose gives good results.

**Fatty acids profile of milk**
After procurement of milk from market one sample was kept as control with no preservation treatment. After fat extraction GC analysis was performed for fatty acid profile. The major fatty acids found in raw sample were myristic acid (C14:0) 10.23 percent, palmitic acid (C16:0) 27.23 percent, oleic acid (C18:1) 16.22 percent, stearic acid (C18:0) 9.12 percent, butyric acid (C4:0) 2.51 percent, capric acid (C10:0) 5.67 percent, lauric acid (C12:0) 4.11 percent, linoleic acid (C18:2) 3.77 percent, trans linoleic acid 0.10, and linolenic acid (C18:3) 0.14 percent. These results were according to Ceballos, et al. [34] who confirmed the same trend of fatty acids.

Conventionally milk is preserved by the application of heat. Milk sample is heated for 75°C for 15 seconds. Comparison of results of raw and heat treated milk showed that linoleic acid and linolenic acid content of milk reduced. Kaya [35] also reported loss of fatty acid content in milk butter when heated at 60, 70 and 80 °C. While Conjugated linoleic acid content of the thermally treated milk was higher than that of raw milk. CLA increased from 6.98 percent to 7.86 percent in processed milk reported by Rodriguez-Alcala et al. [36].

After UV rays exposure milk fat was analyzed by GC-FID. The results showed that three treatments T1, T2 and T3 are similar in terms of fatty acid profile. They were different in terms of stay time; no change in results confirmed that UV light stay time has no influence on the fatty acid content of milk. Major fatty acids in these three treatments (T1, T2 and T3) are palmitic acid (C16:0), oleic acid (C18:1), stearic acid (C18:0). Linolenic and linoleic acid are in lesser amount. These results are similar with Matak et al. [37] who analyzed the fatty acid profile of goat milk and found the same fatty acids in abundance. He also concluded that UV light does not increase the poly unsaturated fatty acids except the conjugated linoleic acid. There is a little increase in CLA content that may become the cause of oxidation. According to my results when CLA content of raw, thermally and UV treated milk sample was compared, there was a little increase in CLA content of UV treated milk as compared to raw but this increase was very less than that of thermally treated sample exhibits. These results are in agreement Cilliers et al.[14] who conclude that there is no effect of UV treatment on fatty acid profile.

Another UV intensity with higher penetration power was used to treat the samples in a same way as in UV intensity one, samples were separately treated with three different stay time to check the effective penetration of UV in combination with time. UV dose affect the oxidation process, lesser the dose lesser will be the oxidation. In terms of heat treatment miscellaneous fat constituents are increased in concentration than that of UV treatment as explained by Cilliers et al. [14].

**Discussion**

The pH of heat treated milk showed that thermal treatment had significant influence on the hydrogen ion concentration of milk. Previous studies presented that energy from the UV light source has no impact on the pH of the product. Application of three different stay times does not affect the pH of milk. This study suggested that there is no significant alteration in pH of milk before and after the application of UV treatment.

Viscosity of milk is defined as internal resistance of milk to shear in a definite environment. According to the results there was increase in viscosity by the increase in temperature, it is may be due to the precipitation of
proteins in milk. UV treated milk did not show the change in the viscosity of milk. Viscosity remains almost unchanged by the application of UV, but it may be affected by changing the UV lamp, different UV lamps differently influence the viscosity.

According to the results an increase in titratable acidity was observed in thermally treated milk. When milk is heated and stored, lactose is degraded and converted into acids that’s why titratable acidity value increases. UV treatment does not show any changes in milk acidity. Raw milk contains microbes that increase the acid content of milk as UV radiation kills the microbes so that is why there are less chances of increase in acidity after UV treatment.

Application of heat treatment negatively affects the moisture content of milk and increases the solid content of milk. UV treatment significantly affects the solid content of milk. This means that UV light energy considerably affect the TSS of turbid liquid foods. According to the results, impact of thermal treatment is more considerable than that of UV light treatment; this means that in comparison to thermal treatment impact of UV treatment is negligible.

Study show that thermal treatment significantly affects the fat content of milk. Thermal treatment may cause the breakage of fat globules and releases the triacylglycerol. Fat content of the milk was according to the standards of pure food laws (1965) of raw milk. UV treated milk showed that UV does not affect the fat content of the milk. This means energy from UV rays do not disturb the major constituents of milk.

Heat treated milk show significant change in color, flavor and aroma of milk. UV treated milk reports no effects in terms of flavor and aroma because it does not disturbs the volatile profile and constituents of milk such as fat and protein that play significant role in taste and aroma.

Thermal application can reduce or convert the fatty acid into isomers or other compounds. Results showed no significant difference among the saturated, monounsaturated and content of milk. Almost amount of fatty acids in both raw and thermally treated fatty acids remained unchanged. However, there was a considerable difference exist among the conjugated linoleic acid content. CLA content of pasteurized milk was higher than that of raw milk. Linoleic acid can isomerize into C18:2 t9t11 and 18:2 t10t12 and in milk butter after heating oleic acid isomerized into trans fatty acids. These kinds of reactions are oxidative in nature. Thus according to my results as isomerized fatty acids increases by processing it will provide substrate for oxidation reactions.

UV treatment results exhibit no negative impact of on fatty acids, so fatty acid profile remained unaffected by UV rays exposure. CLA content increased but this increase is comparable with the raw milk. Isomerization of polyunsaturated fatty acids is less in UV treated milk as compared to thermal treatment. But in terms of UV treatment UV dose or intensity must be considered. Lesser UV dose does not promote the oxidation as it does not convert the polyunsaturated fatty acids into their trans isomers which is a kind of oxidation and does not increase the substrate up to that level that can cause the oxidation.

**Conclusion**
The results reveal the fact that physicochemical attributes of milk does not affect by the UV light exposure. Fatty acid profile of the samples revealed the fact that heat affects the fatty acids. It increases the isomerization in the fatty acids. Polyunsaturated fatty acids converted into trans isomers which is a kind of oxidation because the substrate are increased in concentration for the oxidation. Increase in CLA content of heat treated sample was greater than that of UV treated. UV treated sample was also exhibited the increase in PUFAs but that increase is comparable with raw milk. Milk treated with 1st UV intensity showed little change, while 2nd UV intensity showed more pronounced affect but less than that of heat treated. UV treatment can be used as an alternative of heat treatment but some factors must be considered while using it. UV intensity, its dose rate, stay time, turbulent or continuous apparatus are the important factors that must be considered for efficient results. UV treatment is advantageous over pasteurization treatment as it is cost effective.

Declarations

DECLARATION STATEMENTS:

All authors declare that the data is not published in any journal, book or anywhere.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

N/A

CONSENT FOR PUBLICATION:

Corresponding Author is authorized to submit the manuscript for Publication.

AVAILABILITY OF DATA AND MATERIAL:

All the data and material will be available on demand

COMPETING INTERESTS:

Authors declare that they have no competing interest.

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AUTHORS' CONTRIBUTIONS:
This data is the Ph.D. work of Raa Mubeen, Ali Hassan, Zonia Rashid and Sahar un Nisa are the members of supervisory Committee. Farhan Saeed & Muhammad Afzaal Have helped in conducting all the research trials. Faqir Muhammad Anjum is an external member, co supervisor and corresponding Author. Tabussam Tufail has proof read the manuscript and helped in formatting of the manuscript.

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**Tables**

Table 1. Effect of thermal treatment on physicochemical attributes of milk

| Treatment | Heat   | pH         | Viscosity | Acidity     | TSS           | Fat         |
|-----------|--------|------------|-----------|-------------|---------------|-------------|
| T0        | 0      | 6.7200±0.01b | 1.4500±0.01b | 0.1880±0.001a | 13.600±0.1b  | 3.65±0.01b  |
| T1        | 75°C   | 6.7500±0.01a | 2.3700±0.01a | 0.4566±0.001b | 15.400±0.1a  | 3.75±0.01a  |

T0= Control sample   T1= Thermally treated milk
Table 2. Effect of UV treatment on physicochemical attributes of milk

| Treatment | Intensity | pH     | Viscosity | Acidity | TSS     | Fat     |
|-----------|-----------|--------|-----------|---------|---------|---------|
| T₀        | 0         | 6.720±0.01<sup>a</sup> | 1.350±0.01<sup>a</sup> | 0.199±0.001<sup>a</sup> | 13.600±0.1<sup>a</sup> | 3.70±0.01<sup>a</sup> |
| T<sub>24</sub> | 1         | 6.840±0.01<sup>a</sup> | 1.563±0.01<sup>a</sup> | 0.170±0.001<sup>a</sup> | 14.207±0.1<sup>a</sup> | 3.75±0.01<sup>a</sup> |
| T<sub>57</sub> | 2         | 6.752±0.01<sup>a</sup> | 1.430±0.01<sup>a</sup> | 0.169±0.001<sup>a</sup> | 10.733±0.1<sup>b</sup> | 3.81±0.01<sup>a</sup> |

T₀= Control sample  
T<sub>57</sub>= Mean of T5, T6 and T7  
T<sub>24</sub>= Mean of T2, T3 and T4

Table 3. Fatty acid profile of milk

| Sr.No | Fatty acids | Carbon No | Raw milk (mg/g) | Heat treated milk (mg/g) | Milk treated with 1<sup>st</sup> UV intensity (mg/g) | Milk treated with 2<sup>nd</sup> UV intensity (mg/g) |
|-------|-------------|-----------|----------------|--------------------------|------------------------------------------------------|------------------------------------------------------|
|       |             |           | Raw milk (mg/g) | Heat treated milk (mg/g) | T<sub>2</sub> | T<sub>3</sub> | T<sub>4</sub> | T<sub>5</sub> | T<sub>6</sub> | T<sub>7</sub> |
| 1     | Butyric acid | C:4:0     | 2.51           | 2.33                     | 1.83 | 1.23 | 1.79 | 2.11 | 1.44 | 1.56 |
| 2     | Capric acid  | C:10:0    | 5.67           | 4.87                     | 9.56 | 9.12 | 8.23 | 10.23 | 12.29 | 11.55 |
| 3     | Lauric acid  | C:12:0    | 4.11           | 3.42                     | 6.12 | 5.56 | 7.34 | 5.56 | 6.67 | 5.76 |
| 4     | Myristic acid | C:14:0  | 10.23          | 12.60                    | 9.33 | 8.57 | 8.45 | 11.33 | 10.34 | 8.43 |
| 5     | Palmitic acid | C:16:0 | 27.23          | 31.22                    | 23.52 | 21.98 | 22.11 | 26.22 | 27.23 | 29.55 |
| 6     | Stearic acid | C:18:0   | 9.12           | 8.25                     | 9.57 | 9.11 | 8.99 | 10.67 | 11.34 | 11.72 |
| 7     | oleic acid | C18:1     | 16.22          | 18.87                    | 17.55 | 16.55 | 16.12 | 17.33 | 18.66 | 18.22 |
| 8     | Linoleic acid | C:18:2 | 3.77           | 2.11                     | 3.23 | 3.45 | 2.89 | 3.23 | 3.89 | 2.45 |
| 9     | Linoleic acid | C:18:2 | 0.10           | 1.45                     | 0.14 | 0.19 | 0.11 | 0.22 | 0.15 | 0.21 |
| 10    | Linolenic acid | C:18:3 | 0.14           | 0.07                     | 0.13 | 0.09 | 0.06 | 0.08 | 0.06 | 0.09 |
Figure 2

Graph No. 2. Effect of UV treatment on physicochemical attributes of milk
Figure 3

Graph No.3. Sensory Evaluation of color, flavor and aroma of milk T0= Control sample T1= 75°C for 15 sec T2= UV intensity 1 at 4 mint. stay time T3= UV intensity 1 at 8 mint. stay time T4= UV intensity 1 at 12 mint. stay time T5= UV intensity 2 at 4 mint. stay time T6= UV intensity 2 at 8 mint. stay time T7= UV intensity 2 at 12mint. stay time
Figure 3

Graph No.3. Sensory Evaluation of color, flavor and aroma of milk T0= Control sample T1= 75°C for 15 sec T2= UV intensity 1 at 4 mint. stay time T3= UV intensity 1 at 8 mint. stay time T4= UV intensity 1 at 12 mint. stay time T5= UV intensity 2 at 4 mint. stay time T6= UV intensity 2 at 8 mint. stay time T7= UV intensity 2 at 12mint. stay time