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Comparison of the Effects of Laser Pasteurization and Heat Pasteurization on The Cow's Milk

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Abstract: The main objective of this work was to investigate the cow's milk ingredients percentage after pasteurized using laser and heat treatment in order to compared them with untreated milk. In this work, fresh cow's milk sample (360 ml) were obtained from farms of Sudan University of Science and Technology, the sample was divided into three parts, the first part pasteurized by Nd: YAG laser with output power of 50 watts for two minutes, the second part pasteurized by heating to a temperature of 72°C for 15 seconds the third part was control sample used as obtained. Moisture content, crude protein content, crude fat, ash content, total solid (TS) content, lactose content, pH of the milk samples and titratable acidity were analyzed for the three samples. The obtained results revealed that the ingredients percentage reduced in all heat-based pasteurized milk components compared to laser-based pasteurized milk components.

Keywords: Bovine milk; Food Irradiation; Laser milk interaction; Laser-based pasteurized; Spoilage bacteria.

INTRODUCTION

If we want to drink pasteurized milk, we have to understand at least what Pasteurization means. It set out to accomplish two things: Destruction of certain disease carrying germs and the prevention of souring milk. These results are obtained by keeping the milk at a temperature of 145 degrees to 150 degrees F. for half an hour, at least, and then reducing the temperature to not more than 55 degrees F. A vat pasteurizer consists of a temperature controlled, closed vat. Milk bacteria like acid producers, Gas producers, ropy or stingy fermentation, proteolytic and lipolytic bacteria which are killed by process of pasteurization [1].

The original method of pasteurization was vat pasteurization, which heat milk or other liquid ingredients in a large tank for a at least 30 minutes. It is now used primarily in the dairy industry for preparing milk for making starter cultures in the processing of cheese, yogurt, buttermilk and for pasteurizing some ice cream mixes. There are four common types of milk pasteurization that vary with temperature and time the milk is held at that temperature. Vat Pasteurization: This is the type typically used by farmers for their own consumption, and is the least harmful to the milk's nutrients. The milk is heated to 145° F and held at that temperature for 30 minutes. Such milk is used to prepare milk for culturing (cheese, yogurt, etc), as it is the least destructive to milk's proteins. Average shelf life is 7 - 10 days. High Temperature/Short Time (HTST): The milk is heated to 161° F and held at that temperature for 15 seconds. This is the most common method of regular pasteurization used by local dairies, with about the same shelf life as vat process. Ultra-pasteurization (UP): The milk is heated to 280° F for 2 seconds. Note this is above boiling, which means that high pressure must be applied to the milk to achieve this temperature, and is destructive to its nutritional quality. This method is used because it extends the refrigerated shelf-life of the milk to 60 - 90 days, and is the method of choice for national or regional milk brands because it allows time for warehousing and shipment of milk. Ultra-High-Temperature (UHT): The milk is heated to 280° to 302°F for 1 or 2 seconds followed by packaging in airtight containers. It allows storage without refrigeration for up to 90 days. Again, high pressure is required to reach this high temperature [2-5].

Pasteurization of milk can be accomplished using microwaves [6], dynamic high pressure (DHP) [7] and laser beam [8-11].

MATERIALS AND METHODS

Procedures

Milk samples-1

Fresh milk samples were obtained from Sudan University of Science and Technology farms in Bahri city and kept in ice container then transferred directly to

the animal's products department-National Food Research Center (NFRC). Chemicals and reagents used were obtained from the store of the NFRC, Ministry of Higher Education, Sudan. All the chemicals and reagents were of analytical grades.

Bacterial Isolates and Inoculations -2

Salmonella spp, Escherichia coli and Pseudomonas aeruginosa were used to inoculate raw milk prior to Nd: YAG laser exposure. To dilute milk samples, 10 fold peptone water medium was used.

Laser Exposure and Bacterial Recovery-3

Milk sample was divided into two parts; one of them pasteurized by continuous Nd: YAG laser (DORNIER med Tech Medilas 5100 fibertom GlassI) with wavelength of 1064 nm and output power of 60 Watts for two minutes and that based on a previous studies (Marouf and Sara, 2017), the second sample was pasteurized by heating to a temperature of 72 ° C for 15 seconds the third sample was control sample as obtained.

For counting bacteria numbers; all samples were inoculated into tryptic soy agar plates. Bacteria were incubated in (35-37) °c for 2 days. Three types of bacteria were targeted following the analysis; *Salmonella spp, Escherichia coli and Pseudomonas aeruginosa*. For *Salmonella spp* xylose lysine deoxycholate agar medium was used and MacConkey agar medium for *E.coli* and cetrimide agar medium for *P.aeruginosa*, these media work as selective differential media. Milk samples were cultured into those media and incubated in (35.37)°c for 3days , and for *E.coli* detection the samples were inoculated into tubes of MacConkey broth medium and incubated in 43°c for 24 hours and after that cultured into plates of MacConkey agar medium. Results were expressed as CFU/ml.

DATA ANALYSIS

Moisture content-1

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists [12].and it was as follow:

Procedure

A sample of 5 ml was weighed into a pre-dried and tarred dish. Then, the sample was placed into an oven (Kat-NR.2851, Elektrohelios, Sweden) and left to dry at 105±1C° until a constant weight was reached. After drying, the covered sample was transferred to a desiccators and cooled to room temperature before reweighing. Triplicate sample was used.

$$\text{Moisture content [\%]} = \frac{[m2-m3]}{[m2-m1]} \times 100$$

Where:

m1 = mass of dish + cover

m2 = mass of dish + cover + sample before drying

m3 = mass of dish + cover + sample after drying

Crude protein -2

The crude protein content was determined in all samples by micro-Kjeldahl method using a copper sulphate or sodium sulphate catalyst according to the Official Method of the AOAC [12].

Procedure

0.5 ml of sample was accurately weighed and transferred together with 2-3 glass pellets, kjeldahl catalyst (No 33064, BDH, England) and 20ml concentrated sulphuric acid (No 18474420, Mark AG, Germany) into kjeldahl digestion flask. After that, the flask was placed into a kjeldahl digestion unit (Tecator, Sweden) for about 3hours, until a colorless digest was obtained. Following, the flask was left to cool to room temperature. The distillation of ammonia was carried out in 30 ml boric acid (2 %) by using 40 ml distilled water and 60 ml sodium hydroxide solution (33 %). Finally, the distillate was titrated with standard solution of 0.1N HCL in the presence of 2-3 drops of indicator (Bromocreasol green and methyl red) until a brown reddish color was observed.

Calculation:

Nitrogen (%) = T × 0.1 x 0.014 × 100/ Weight of sample

Protein (%) = Nitrogen % × 6.38

Protein conversion factor = 6.38%

Fat content-3

The crude fat in the product was determined according to the standard analytical method of A.O.A.C, (2003).

Procedure

Ten ml sulfuric acid (density 1.815 gm/ml at 20°C) was poured into a clean Gerber tube, followed by the addition 10 ml of sample then 1 ml of amyl alcohol was added to the tube followed by addition of distilled water. The tubes was then thoroughly mixed till no white particles were see, centrifuged at 1100 revolution per minute (rpm) and transferred to a water bath at 65°C for 3 minutes. The columns of the fat was then recorded immediately

Ash content-4

The standard analytical method of A.O.A.C, [12] was used for determination of ash content in the samples.

Procedure

Two ml of the sample was weighed into a pre-heated, cooled weighed and tarred porcelain crucible. Before ashing, the sample was pre-washed on an electrical pre-asher and placed into a muffle furnace (Carbolite, Sheffeild, England) at 525 to 600 C °until a

constant weight was obtained. The weight of the residue after ashing was defined as ash content and expressed as a percentage based on the dry matter content in the ground sample.
Calculation:

Ash content = W_1 / W_0 X 100
Where
W_1= Weight of ash
W_0= Weight of sample

Total solids (TS)-5

Total solid (TS) content was determined according to AOAC (1995)[12].A clean aluminum dishes were dried at 105ºC for 3hrs.Five grams of the sample were weighed in dry clean flat bottomed aluminum dish and heated on a steam bath for 15 minutes. The dishes were placed into a forced draft oven at 100ºC for 3 hrs. Then cooled in a desiccators and weighed quick .Weighing was repeated until the difference between the two reading was <0.1mg.The total solids (T.S.) content were calculate as follows:
T.S.(%) = **w**1/**w**2 X100
Where:
W_1 =Weight of sample after drying
W_2 =Weight of sample before drying

Lactose content-6

The lactose content determined by An throne Method [13].One ml milk was pipette in a 500 milliliters volumetric flask and diluted to 500 milliliters was transferred in a boiling test tube (in Triplicate) the samples were placed in ice bath, and shacked while adding 10 ml of ice cod an throne reagent, the tubes contents were mixed and then placed in a boiling water bath for 6min , then transferred back to the ice bath for 30 min ,the optical density of the colored solution was then read at 625min. A blank consisting of distilled water 0.5 milliners and anthron reagent andstandard containing 100mg/ml of lactose and anthron reagent were included in each batch of analysis. The percentage of lactose was then calculated using the following formula:

$$\text{Lactose content} = \frac{\text{O.D of sample- O.D of blank X 4.75}}{\text{S.D of stander-O.D of blank}}$$

=g/1000ml
OD: Optical density.
S: Sample.
SD: stander.
B: blank.

pH-value-7

The pH of the milk samples was measured by using a recalibrated pH meter model (HI 8521 microprocessor bench pH/ MV/ Cº meter). This was calibrated with two standard buffers (PH6.8 and 4.0).

Titratable acidity -8

This test was carried out according to method described by A.O.A.C [12].Ten grams of samples were weighed in to a small beaker, the sample was mixed well, 2-3 drops of phenolphthalein were added, and the sample was titrated against 0.1N NaOH till a faint pink color. The titration figure divided by ten to get the percentage of lactic acid (1 millitres of 0.1N NaOH sodium hydroxide = 0.009gm of lactic acid).

RESULTS AND DISCUSSION

Estimation the Number of Viable Bacteria Cells

The results showed that the population of total bacterial load in the milk samples was (0×10^5 CFU/ml) due to the interaction of laser and heat with the bacterial cells.

Estimation of Milk Components

Table 1 shows the effect of the irradiation of Nd: YAG laser and heat treatment (72°c/15 s) on the milk components. The statistical analysis (Table 1) showed that there is no significant ($P<0.05$) variations were found in the chemical composition of the milk samples in all treatments, figure 1. However, slight decrease in the, moisture content of milk samples pasteurized at 72 ˚C/15 s was observed while the higher moisture was in the raw milk sample. The raw milk samples showed increase in fat content. Almost the protein contents of the milk samples treated with lazer and the raw one is the sample while slight decrease in the protein content was observed in the pasteurized milk sample with 72 ˚C/15 s.

The ash contents of the milk samples showed the same trend of the protein. The lactose was not found to be significantly different in all the milk samples. Therefore the high total solids were found in the raw milk samples while the lower one was in the heat treated samples.

The pH and the acidity of the milk samples were not significantly different in all treatments

The summary of the three experimental milk samples listed in table one , there were no statistical differences in basic compositions among the pH and acidity (lactic acid) for the milk pasteurized by laser and heat. while the moisture increase up to 88.6 (May be because a tarred dish is not dry) and dropped to 88.4 for the milk pasteurized by heat . But the protein, fat, ash and lactose remain the same in the milk pasteurized by laser and dropped down in the milk pasteurized by heat. Analyzing the data shows there is no significant difference between the milk components that pasteurized by laser and the one pasteurized by heat.

Table-1: Effect of pasteurization by laser and heat treatment on the cow's milk components.

Parameters %	Pasteurized milk by heat at72°c for 15sec	Pasteurized milk by Laser for 2 min	Control Sample	Level of significant
Moisture	88.413±0.44	88.69±0.055	88.58±0.13	NS
Protein	4.03±0.20	4.10±0.20	4.16±0.15	NS
Fat	3.13±0.15	3.20±0.10	3.23±0.15	NS
Ash	0.83±0.03	0.84±0.026	0.84±0.025	NS
Lactose	3.06±0.11	3.16±0.115	3.16±0.115	NS
Total solids	11.06±0.11	11.30±0.55	11.41±0.136	NS
pH	6.16±0.02	6.20±0.005	6.33±0.047	NS
Acidity (lactic acid)	0.19±0.005	0.20±0.000	0.19±0.000	NS

NS means Not Significantly (P<0.05) different

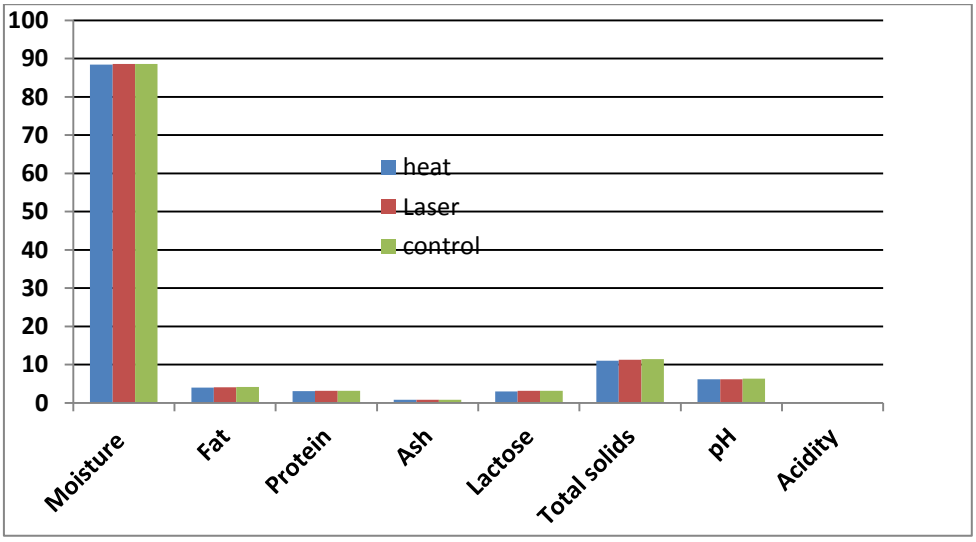

Fig-1: Comparative of characteristics of tow pasteurized samples (heat & laser) according to control sample

CONCLUSION

In conclusion, to save the value of the most milk components, it was found the milk that pasteurized by laser better in protein and fat than the milk pasteurized by heat .The irradiation process leads to the pasteurized the milk of milk. This technique keeps the protein and fat of the milk. In the future further studies could possibly be done.

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