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Evaluation of Laser Pasteurization on Production of Yogurt

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Abstract: *This work was undertaken to compare yogurt produced from unpasteurized milk with laser-pasteurized milk and thermal conductive heating pasteurized milk. Milk samples were obtained from SUST farm, Shambat, North Khartoum, Sudan. Nd: YAG laser used to pasteurize the first sample, the second sample pasteurized by heat and the third one was left as obtained to be control sample. Yogurt is produced by bacterial fermentation of milk. Chemical analysis were perfumed to the two kinds of pasteurized yogurt, and then flowed by statistical analysis. The results showed that the use of laser in pasteurization is not differ from heat pasteurization, while the production of yogurt from laser pasteurized milk is slightly better than that of heat pasteurized milk.*

Keywords: *Cold pasteurization, Laser milk interaction, Milk, Yogurt.*

1. INTRODUCTION

Sudan ranks the top place among the countries of Middle East and second in Africa regarding the animal wealth. It has been estimated that 2.9 million tons of milk is produced, of which 2.5 million tons (82%) were cow's milk, the bulk of which is in the hands of the nomadic tribes (AOAD, 2012). The ratio for the use of significantly milk products in the human diet devised many ways to kill the microbes that attack the milk during times the conservation and these processors or roads is heating normal heat in traditional ways or advanced. Yoghurt is one of the more milk products used in human food, so in addition to the use of heat to kill germs and microbes we use laser rays effective in disinfection and sterilization and genocide microbes of food product of various kinds. Electromagnetic radiation in general has long been known been used against germs live and harmful microorganisms to humans, has been used in a very large to sterilize drinking water and an example of its ozone and ultraviolet radiation, which to them Avery strong affect in killing germs. Nowadays; lasers used in most industrial and medical fields, as well as the food industry and draw a trademark on them. Pasteurization of milk by heat decrease its nutritional value (Tamime *et al.*, 1999). In 2015Tubasa Nakata, *et al* quantitatively evaluated the effect of far-infrared (FIR) irradiation pasteurization on fungi and compared it with the effect of thermal conductive heating. They found that for the same bulk temperatures, pasteurization by FIR heating was more effective than thermal conductive heating. The activation energy for the death of fungi by FIR irradiation was slightly lower than thermal conductive heating, indicating differences in the mechanism of action (Tubasa Nakata, *et al.*, 2015). Water and organic materials easily absorb infrared (IR) radiation. IR heating is used widely for the drying, dehydration, blanching, thawing and pasteurization (Rosenthal, *et al*, 1996), (Rosenthal, *et al*, 1996) , (Paakkonen, et, 1999) , Mongpraneet, *et al*, 2002), (Krishnamurthy, *et al*, 2008), (Khurana, Soojin, *et al*, 2007), (Rastogi, 2012), as well as for medical treatment (Hatayama, *et al*, 2008), (Tuchina, *et al*, 2014). The importance of microbial decontamination is increasing owing to

outbreaks of food poisoning and the emergence of drug-resistant bacteria. As well as providing clean working areas, IR heating can save space because no heat- transfer medium is needed. Although the IR radiation cannot penetrate deep and heats up only a few millimeters below the surface of the sample, the main effect of IR is due to heating of a thin layer of food material on the surface (Rastogi, 2012). The IR heating process improves the shelf life of foodstuffs (Ha, *et al*, 2o15), (Wang, *et al*, 2014) and is a promising method for the efficient inactivation of microbes (James, *et al*, 2002), (Ansari, *et al*, 2003), (Hebbar, *et al*, 2003). During IR heating operations such as drying, blanching, roasting frying and cooking of food products, the pasteurization has progressed at the same time. Previous studies have reported the use of IR, especially far-infrared (FIR), for pasteurization (Hashimoto, *et al*, 1991), (Hashimoto, *et al*, 1992), (Hashimoto, *et al*, 1993), (Sawai, *et al*, 1995), (Sawai, *et al*, 1997), (Sawai, *et al*, 2000), (Sawai, *et al*, 2003), (Sawai, *et al*, 2006). Com-pared with thermal conductive heating, FIR irradiation was found to be more effective in pasteurizing vegetative bacterial cells (Hashimoto, *et al*, 1991), (Sawai, *et al*, 1995), (Sawai, *et al*, 2006). Furthermore, FIR irradiation caused heat activation and death of Bacillus subtilis spores in a temperature range where spore viability was not affected by thermal conductive heating (Sawai, *et al*, 1997). Hamanaka *et al* also reported heat activation and the inactivation of bacterial spores by FIR irradiation (Hamanaka, *et al*., 2003). The pasteurization effects of FIR may be attributed to the absorption of radiative energy by the bacterial suspension in a very thin layer near the surface and an increase in the bulk temperature of the suspension (Hashimoto, *et al*., 1992), (Sawai, *et al*., 2000). Although the effectiveness and validity of IR heating were confirmed in these studies, evaluation of the IR pasteurization of laser pasteurization on production of yogurt was not performed and elucidated. In the present study, a comparison of laser pasteurization with heat pasteurization affecting on producing yoghurt was done, to study laser interaction with food components of milk, and to investigate the effect of the laser pasteurization on the nutritional components of yoghurt.

2. SYSTEM MODEL

2.1. Milk

Fresh cow's milk was obtained from the farm of College of Agriculture and Animal Production, Department of Animal Production, Sudan University of Science and Technology, Shambat, North Khartoum, Sudan. Milk was divided into three samples every sample containing two pounds of fresh cow's milk and quoted two of the three samples chilled in 4 ± 1 °C. The skimmed milk powder obtained from the local market in the North Khartoum city. The chemicals and reagents used in this step obtained from the Central Laboratory of the National Center for Food Research shop (NFRC). The irradiation process was done in the Institute of Laser, Sudan University of Science and Technology. Then transferred to the Department of Animal Products (National Center for Food Research NFRC) for testing them. A water path used to keep water at a consistent temperature for incubating samples in a laboratory.

2.2. Method

Nd: YAG laser with a wavelength of 1064 nm, and output power 60 Watt (DORNIER med Tech Medilas 5100 fiber tom Glass I, UK), used in the pasteurization process by exposing milk with the continuous mode for 2 minutes in sterilized beaker under magnetic stirring. Hot plate magnetic stirrer device with speed from 60 to 1500 pm (Model L M S -1003 Scott science UK) used to make homogenous solution by mixing the milk compound during Nd: YAG laser irradiation.

Yogurt been produced according to scheme in figure 3:

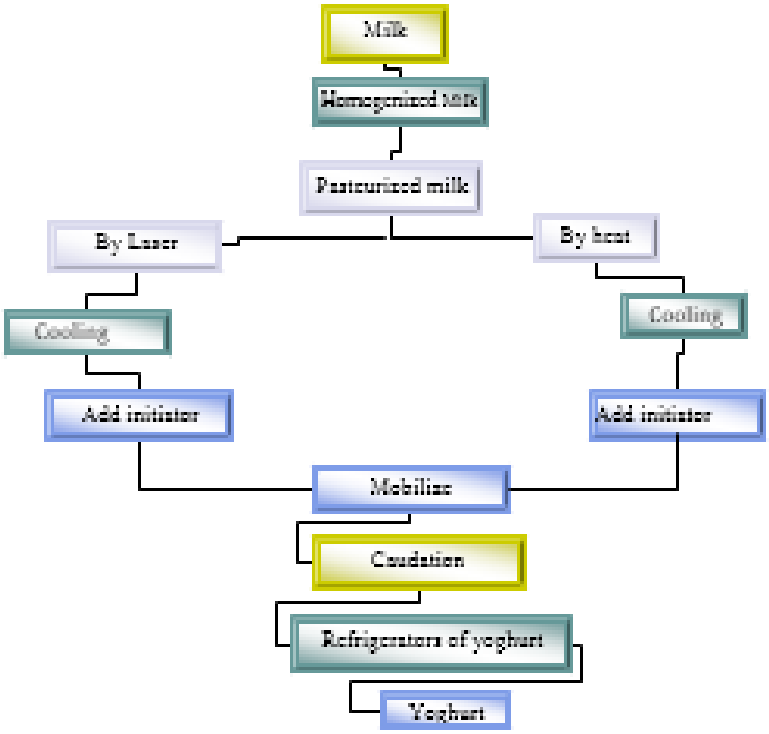

Fig1. *Diagram of Yoghurt Production*

2.3. Chemical Analysis

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 2003). 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,2003), fat in the product was determined according to the standard analytical method of A.O.A.C, (2003). The standard analytical method of A.O.A.C, (2003) and total solids of the samples calculated and expressed as a percentage (AOAC, 2003).

Lactose = Total solids- (fat+ protein+ ash), Solids-not-fat = Total solids-fat

2.3.1. Moisture Content

The moisture content in a weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105± 1C°. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

2.3.1.1. Procedure

A sample of 5 ml ± 1 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 obtained. After drying, the covered sample was transferred to desiccators, and cooled to room temperature before reweighing. Triplicate results were obtained for each sample and the mean value was reported to two decimal points according to the following formula:

2.3.1.2. Calculation

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

Where:

m1 = mass of dish + cover

m2 = mass of dish + cover + sample before drying

m3 = mass of dish + cover + sample after drying

2.3.2. Crude Protein Determination

The principle of method consists of sample oxidation and conversion of nitrogen to ammonia, which reacts with the excess amount of sulphuric acid forming ammonium sulphate. The solution is made alkaline and the ammonia is distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex, which is titrated against a standard solution of HCL (0.1N). Accordingly, the crude protein content is calculated by multiplying the total N percentage by 6.25 as a conversion factor for protein.

2.3.2.1. Procedure

10 ml ± 1ml sample was accurately weighed and transferred together with 2-3 glass pellets, kjeldahl catalyst (No 33064, BDH, England) and 25 ml 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 3 hours, until a colorless digest was obtained. Following, the flask was left to cool to room temperature, and then deleted by distilled water; the distillation of ammonia was carried out in 10 ml boric acid (2 %) and 15 ml sodium hydroxide solution (40 %). 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.

2.3.2.2. Calculation

Crude protein

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

Protein (%) = Nitrogen % × 6.3

Where:

T = Titration figure.

0.1 =Normality of HCl.

0.14 = Atomic weight of Nitrogen.

Crude protein:

Protein (%) = Nitrogen % × 6.38

Protein conversion factor = 6.38Fat content

Ten ml sulfuric acid (density 1.815 gm/ml at 20oC) were 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 were then thoroughly mixed until no white particles were see, centrifuged at 1100 revolution per minute (rpm) and transferred to a water bath at 65oC for 3 minutes. The columns of the fat were then recorded immediately.

2.3.3. Ash Content

Was used for determination of ash content in the sample, The inorganic materials which are varying in concentration and composition are customary determined as a residue after being ignited at a specified heat degree.

2.3.3.1. Procedure

2ml 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, Sheffield, England) at 525 to 600 C ºuntil a constant weight was obtained. The weight of the residue after ashing was defined as ash.

2.3.3.2. Content Calculation

The ash content was calculated as follow:

Ash (%) = W1 / W0 X 100

Where

W1= Weight of ash

W0= Weight of sample

2.3.4. Total solids T.S

Two grams (2ml) of yoghurt was weighed into each of three previously washed, dried and weighed glass crucibles. The crucibles with the samples were then placed in a thermostatically controlled oven at 105^0C for 5 hours until a constant weight of solid material was obtained. The crucibles were then removed and cooled in a desiccator and then weighed, Used to dry oven the samples after pasteurization and also for drying foodstuffs after the sort of milk and yoghurt.

Then total solids content was calculated from the flowing equation:

Total solids (%) = W1/W0 × 100

Where

W1 = Weight of sample after drying

W0= Weight of sample before drying

2.3.5. The pH Measurement

The PH of the mixture was measured by using a recalibrated pH meter model (HI 8521 microprocessor bench pH / MV / C˚ meter). This has been calibrated with two standard buffers (6.8 and 4.0).

2.3.6. Titratable Acidity Measurement

This test was carried out according to method described by A.O.A.C (2003) 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.

2.4. Statistical Analysis

The statistical analysis was done as per Steel and Torrie (1980), using Completely Randomized Design (CRD). Analysis of variance test was done to find out the statistical difference within the quality of the three types of cow milk.

3. Experimental Results

3.1. Nutrition Value of Milk

Table 1 shows the nutrition value of the milk samples as obtained (control sample) and pasteurized milk with heat and with laser. The results shows significant changes in pH value and acidity, while there are no significant changes in the other properties.

Table1. *Results of the Natural Value of Milk*

		Paired Differences					t	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
					Lower	Upper		
Pair 1	Control - Pasteurize Milk Average	.075	.2053	.0726	-.097	.247	1.033	.336
Pair 2	Control - Irradiation Milk Average	.050	.2268	.0802	-.140	.240	.624	.553

3.2. Statistical Analysis for Milk Samples

Table2. *Descriptive Statistics for milk samples*

S. No.	Parameter	Control	Pasteurize Milk Average	Irradiation Milk Average
1.	Moisture	85.5	85.3	85.5
2.	Protein	5.0	4.8	4.9
3.	Fat	3.5	3.9	3.9
4.	Ash	1.5	1.3	1.1
5.	Lactose	4.7	4.6	4.6
6.	T.S	14.7	14.5	14.5
7.	pH	6.6	6.6	6.6
8.	Acidity	1.2	1.1	1.2

Table3. *Paired Samples Test for milk samples*

Property	N	Minimum	Maximum	Mean	Variance
Heat Pasteurize Milk Average	8	1.1	85.3	15.263	818.380
Laser pasteurized Milk Average	8	1.1	85.5	15.287	822.490

The statistical analyses show significance value of 0.33, when comparing the control sample with the heat pasteurized sample, which is greater than 0.05 I.e. sig > 0.05, and mean of 0.075. Whereas a significance value of 0.553 when comparing the control sample with the laser pasteurized sample which is greater than 0.05 I.e. sig > 0.05 and mean of 0.050. Which is mean that there is no significant change in using heat or laser in pasteurization process, with a preference for heat pasteurization.

3.3. Time of Producing Yoghurt

Time needed to convert milk to yogurt from the control sample was five hours and twenty minutes, while yogurt produced from laser pasteurized milk was three hours and forty five minutes and yogurt produced from heat pasteurized milk was three and minutes.

3.4. Nutrition Value of Yoghurt

Table 4 shows the nutrition value of the yoghurt samples as obtained (control sample) and pasteurized milk with heat and with laser. The results shows significant changes in Ash value while there are no significant changes in the other properties.

Table4. *Results Nutrition Value of Yoghurt*

Parameter	Control Average	Pasteurize Average	Irradiation Average
Moisture	86.1	86.53	85.92
Protein	5.26	5.53	5.68
Fat	4.59	4.12	4.18
Ash	1.99	1.7	1.88
Lactose	2.40	2.15	2.37
T.S	13.90	13.47	14.08
pH	4.45	4.36	4.54
Acidity	0.99	1.12	1.20

3.5. Statistical Analysis for Yogurt Samples

Table5. *Descriptive Statistics for yoghurt samples*

	N	Minimum	Maximum	Mean	Variance
Heat Pasteurize yoghurt Average	8	1.1	86.5	14.873	853.526
Laser pasteurized yoghurt Average	8	1.2	85.9	14.981	837.990

Table6. *Paired Samples Test for yoghurt samples*

		Paired Differences					t	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
					Lower	Upper		
Pair 1	Control - Pasteurize	.087	.3325	.1176	-.190	.365	.744	.481

	yogurt Average							
Pair 2	Control - Irradiation yogurt Average	-.021	.2594	.0917	-.238	.196	-.232	.823

The statistical analyses show significance value of 0.481 when comparing the control yogurt sample with the heat pasteurized yogurt sample, which is greater than 0.05 I.e. sig > 0.05 and mean of 0.087. Whereas a significance value of 0.823 when comparing the control yogurt sample with the laser pasteurized yogurt sample which is greater than 0.05 I.e. sig > 0.05 and mean of 0.021, which is mean that there is no significant change in using heat or laser in pasteurization process, with a preference for laser pasteurization.

4. Conclusion

It is noted that the pasteurized milk by heat turns into Yogurt with a time of 3 hours and 10 minutes, while laser pasteurized milk needs to 3 hours and 45minutes for switching to Yogurt. The use of laser in pasteurization is not differ from heat pasteurization, while the production of yogurt from laser pasteurized milk is slightly better than that of heat-pasteurized milk. Yogurt output of the laser-pasteurized milk contains a large proportion of protein.

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