

Effect of Using Microwave Radiation in Milk Pasteurization

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Abstract

The aim of the present study is to modify a microwave device to be used as a continuous pasteurization device and to study the ability of the device to inhibit microorganisms, and to improve the thermo-physical and chemical properties of the pasteurized milk.

The buffalo milk was pasteurized by microwave at 72° C for a time ranging between 20 -400 seconds, then a sudden cooling was introduced in the refrigerator at a temperature of 5° C and stored on this degree for a period of 15 days. The microbial and chemical analysis were performed, Each milk sample was divided into four groups: A, B, C and D, where group (A) represents the milk control sample, group (B) represents the milk subjected to radiation intensity of 800W with flow rates of 75, 150 and 225 ml/20 – 40 – 80 seconds respectively, group (C) represents the milk subjected to radiation intensity of 480W with flow rates of 75, 150 and 225 ml/ 40 – 80- 160 seconds respectively and group (D) represents the milk subjected to radiation intensity of 160 W with flow rates of 75, 150 and 225 ml / 100 – 200 – 400 seconds respectively, keeping the coil length of 200 cm constant for all the previous treatments. The device productivity reached 13.5 liters/hour and heating rate was 3.6°C/second.

Results showed that chemical properties of milk were as follows: pH, fat, protein, lactose, ash values of group (B) was significantly higher than control sample ($P < 0.05$), followed by group (C) and group (D), while the titratable acidity, moisture values was significantly less than the control sample ($P < 0.05$).

Microbiological tests before treatment included the total number of microbes, coliform group. After microwave treatment, the thermo-physical properties of milk included density, thermal conductivity, viscosity, and specific heat at different temperatures were also calculated. The results were: (1031.146 - 1012.792 kg/m³). (0.566191 - 0.644071w/m.k). (0.000858 - 0.0006901 Pa.s).(3855 - 3939 J/kg.k) respectively. The results were seriously significantly increased by increasing the heating time compared to the control samples ($p < 0.05$), whereas the viscosity of milk and its intensity were significantly decreased by increasing the heating time in comparison to the control sample ($p < 0.05$).

Results had been improved that after pasteurization where the total number of microbes, chloroform group, tuberculosis, Lysteria microbes and alkaline phosphatase had been eliminated in the pasteurized milk.

Keywords: Milk pasteurization, Thermo-physical properties, Milk pasteurization by microwave oven.

Introduction

In order to reduce the chances of spoilage in liquid foods especially milk, it is necessary to apply various preservation methods to extend the shelf life and to make it safe for consumers.

Heat treatment is one of the most common preservation methods applied to milk to extend the shelf life as well as, to improve the quality of the products by reducing microbial load thus minimizing the risk of food contamination *McKinnon, et al., (2009)*.

Enter the **U.S.A.** Food and Health Office, the time required for flash pasteurization of milk, Pasteurization at 95.6 ° C needs 0.05 seconds either at 100° C needs 0.01 seconds.

Sun, et al., (2007), indicated that the short time pasteurization by microwave radiation keeps the milk from being damaged compared to conventional heat treatment.

Sieber, et al., (1996), indicated that compared to milk pasteurization using the traditional method and using microwave radiation at 72° C for 15 seconds, it was found that a large percentage of free amino acids were lost by the traditional method compared to the microwave method, and also it was found that using microwave radiation leads to a decrease in the total number of bacteria and alkaline phosphates compared to the traditional method of milk pasteurization.

The current study aimed to modify a microwave device to be used as continuous pasteurization of buffalo milk and to study the ability of this device to inhibit microorganisms and to improve the thermo-physical and chemical properties of the pasteurized buffalo milk at a temperature of 72° C for 20- 400 seconds in the microwave.

Materials and Methods

Raw Milk:

The buffalo raw milk was purchased from the dairy factory of Food Technology Research Institute – Agricultural Research Center – Giza, with the following specification: (Moisture 84.55%, PH value 6.39, Acidity 0.19 %) and Percentage of total solids (Fat 5.5%,) total protein 3.69%, Lactose 4.79 % , Ash 0.78 %).

Microwave Oven:

A (LG) Microwave Oven model (MS 3043 BARS) of a capacity 30 litre, power 800 W, Dimension (W×H×D) 34×27×50 cm shown in Figure (1) was used.

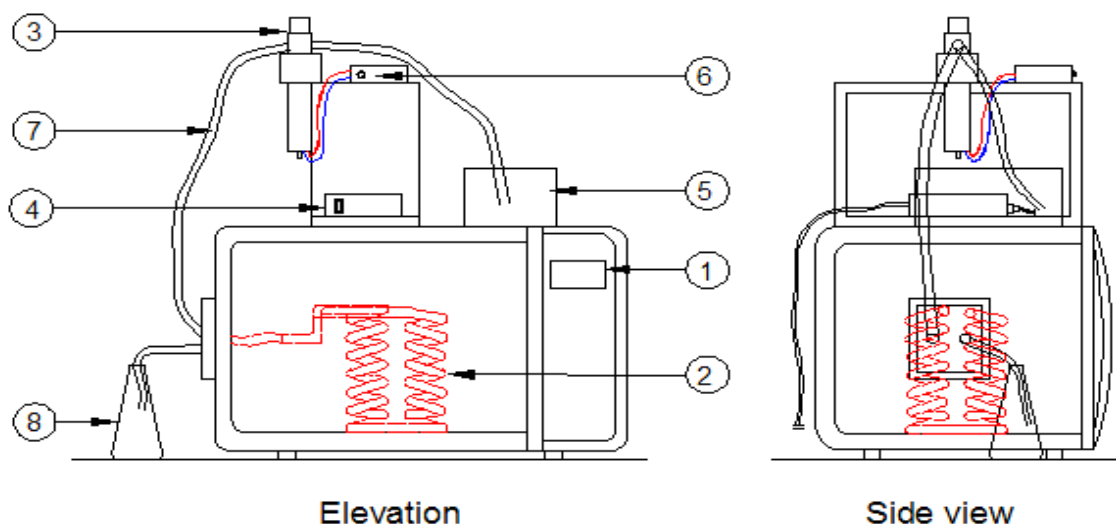


Figure (1): the Microwave

- | | | | |
|---|-------------------------|---|------------------------|
| 1 | Microwave control unit | 5 | Raw milk tank |
| 2 | a spiral of Pyrex glass | 6 | Dimmer |
| 3 | Pump | 7 | Hose |
| 4 | Electrical transformer | 8 | Pasteurized milk flask |

The intensity of the emitted light from the magnetron (Electromagnetic Valve) could be controlled by control unit to produce (800 – 640 – 480 – 320 – 160 W).

Figure (1) shows the modify microwave to become a continuous milk pasteurization unit by adding: a thermostat, a spiral of Pyrex glass, a pump, a pump – rate controller, a tank for raw milk, two holes were drilled in diameter 1.25 cm in one aspect of the microwave one of them to enter the milk in spiral and the other to exit the milk from the other side of the spiral to the pasteurized milk reception flask, 4 spirals with a diameter of 4 cm, length 50 cm / each spiral give a total length of 2 m were used. The diameter of the glass tube is 1 cm connected to thermo–silicon food-grade spiral exit with a diameter of 1 cm to deliver pasteurized milk to a flask.

The magnetron was connected to thermostat so that the magnetrons stop when the milk temperature reaches 72°C, and when milk temperature drops below 72°C magnetrons return back again to transmit microwave radiation, the flow rate of the milk from the pump was controlled by a control unit where the raw milk was withdrawn from the milk tank and pushed to the spiral installed inside the microwave, milk is exposed to a microwave radiation, three levels of radiation were selected (800 – 480 – 160 W), three flow rates were used for the milk (75 – 150 – 225 ml) with the constant serpentine length of 200 cm for all the tests.

The initial temperature of the raw milk was 12° C. The film was exposed from the milk pumped in a vortex of the pyrex glass to the microwave radiation, until the milk was heated to 72° C. Then the pump was stopped for a second by a thermostat until the milk was kept at a temperature 72° C for a second. The temperature was measured by a digital device and the pasteurized milk reception flask was placed, the highest microwave output was 13.5 l/h using radiation intensity 800 W/h and flow rate 75 ml/20 sec. Once the bottle is filled with hot milk, the bottle is closed and the milk is kept at 5° C for 15 days.

Digital temperature stick:

A digital temperature stick was used to measure air temperature, with the following technical data:

Model: test 905-T I.

Sensor: Thermocouple type k.

Measurement range: -50 to + 350° C.

Accuracy referred to calibration temperature of + 1°C.

The quantities of pasteurized milk in each experiment were (75 ml -150 ml- 225 ml).

The Heating rate was estimated according to **Asaad,et al.,(2013):**

$$Hr = T/ t \dots\dots\dots(1)$$

Where: (Hr) Heating rate, (T) temperature (°C), (t) Time.

Thermo physical properties for milk:

Specific heat could be obtained according to **Asaad,et al.,(2013):**

$$Cp=1.68T + 3864.2 \dots\dots\dots(2)$$

The viscosity of milk was determined according to **Asaad,et al.,(2013):**

$$\mu= (- 0.00445T + 0.947) \times 10^{-3} \dots\dots\dots(3)$$

Thermal conductivity was calculated according to **Asaad,et al.,(2013):**

$$\lambda = 0.00133T + 0.539911 \dots\dots\dots(4)$$

The milk density was calculated according to **Asaad,et al.,(2013):**

$$\rho = 0.00133 T + 0.2308T - 0.00246T^2 \dots\dots\dots(5)$$

Chemical analysis:

Moisture, fat, ash, protein and total solids (T.S) were determined as described by **AOAC (2000)**.

The Milk titratable acidity and pH were determined according to **Case et al. (1985)**.

Analysis of Lactose content were determined according to **Barnett,andTawab, (1957)**.

Microbiological examinations:

Total bacterial:

Total counts, yeast and molds counts (CFU x 10⁻²/ g) were determined using standard plate, count Media and potato Dextrose agar media, according to the American public Health Association **APHA,(1978)**.

Determination of Listeria microbes:

Listeria microbes were estimated according to **Harvey, and Gilmour, (1992)**.

Determination of Tuberculosis microbe:

Tuberculosis microbe were estimated according to **Grange, and yates, (1994)**.

Determination of Coliform group (E.coli):

Coliform group (*E. coli*) was estimated according to **Hossain, et al., (2010)**.

Determination of Phosphatase:

Phosphatase determination activity was determined according to **Murthy, et al., (1979)**.

Thermo physical properties:

Thermo physical properties for milk: (the density, the viscosity, the specific heat, the Thermal conductivity and the Heating rate) were determined according to **Asaad,et al., (2013)**.

Sensory evaluation of milk samples:

The sensory evaluation was performed by the scaling method using a 5-point scale for quality attributes: appearance, odour, consistency and taste.

A verification test (Ranking test) had been implemented at Food and Agro Industries Technology Center (FAITC) on October 21st, 2017 between ten samples of milk that different processing to verify the results obtained from the panelists that were selected from staff members of Food and Agro -Industries Technology center (FAITC) and Food Technology Research institute (FTRI) who had the various attributes according to screening methods ISO3972:1991 Sensory Analysis/ methodology (Method of investigating sensitivity of taste and confirm differences in the score card) according to **E. Larmond, Laboratory Methods for Sensory Evaluation of Foods. (1977)**.

Statistical analysis:

Statistical analysis of all results are the mean of three replicates. Data were analysed by ANOVA within a completely randomized design. LSD tests were used for mean discrimination (5% level of probability, using the SPSS).

Results and Discussion

Effect of microwave intensity treatment on physical properties of milk:

1- Influence of microwave radiation abilities on milk pasteurization time:

The milk heating curves by microwave and cooling are Shown in Figures (2,3,4).

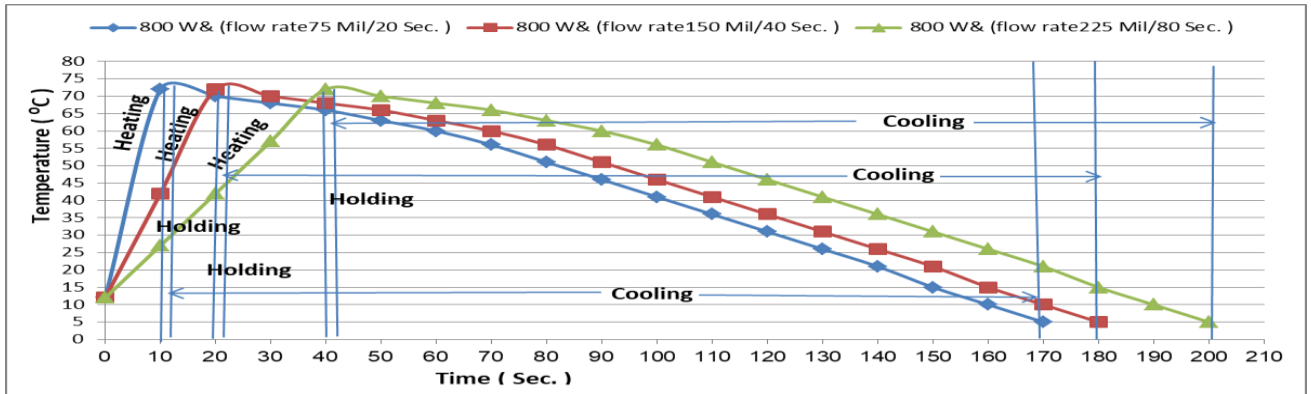


Figure (2): Milk heating curve by microwave and cooling for group (B).

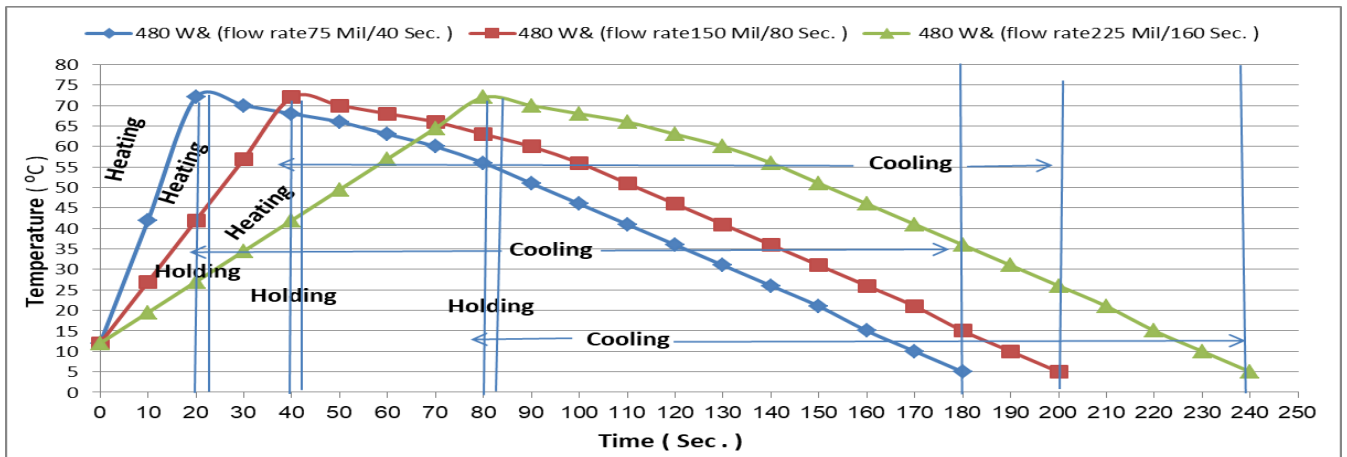


Figure (3): Milk heating curve by microwave and cooling for group (C).

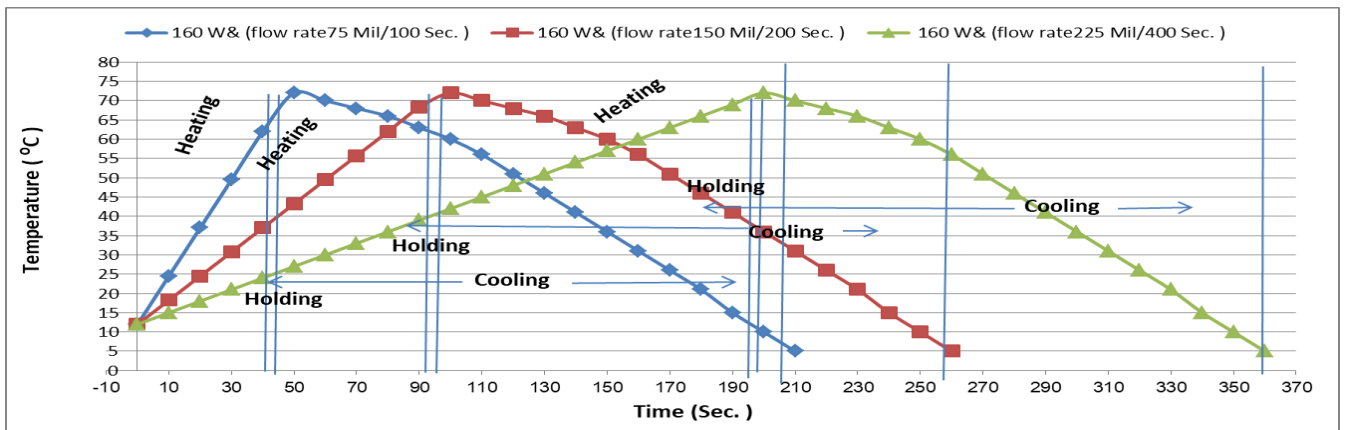


Figure (4): Milk heating curve by microwave and cooling for group (D).

As shown in this Figures the temperature is significantly increased with increasing time ($p < 0.05$). The required time to up rise milk temperature from 12 to 72°C is 20 seconds – 400 seconds (heating stage).

In the holding stage milk was stayed for 1 second. at 72 °C.

Third stage is the cooling stage, which requires 2.7 minutes to reach the milk to a temperature of 5° C. Heating at 72°C for 1 second caused an increasing in pasteurization speed, decrease in time and destroyed all microbes. Pasteurization stages depend on three stages: heating, holding and cooling. The heating stage reduces the level of bacteria in the milk when the temperature exceeds 55 ° C

Halleux, et al., (2005).

2 - Effect of microwave intensity treatment on specific heat and the thermal conductivity values of milk:

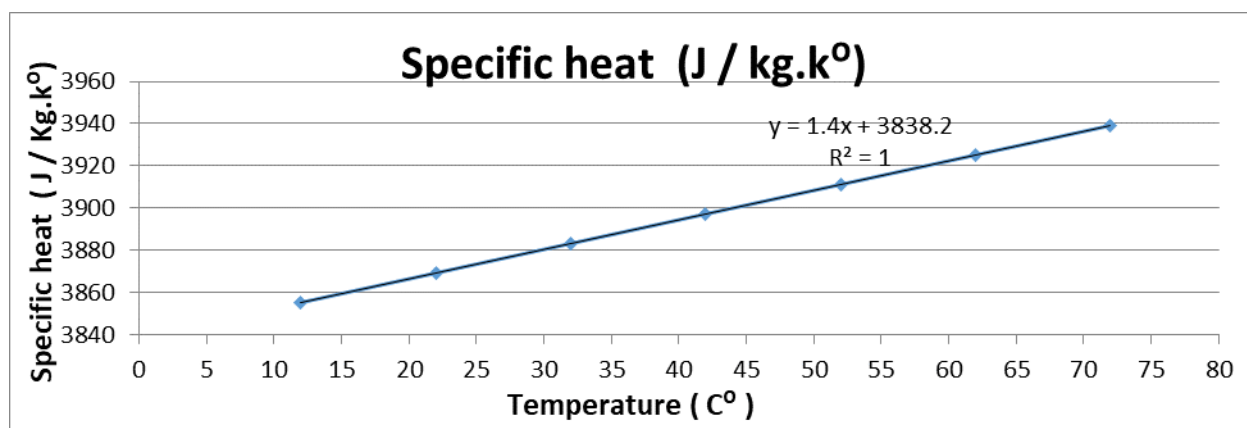


Figure (5): Effect of temperature on the specific heat of milk.

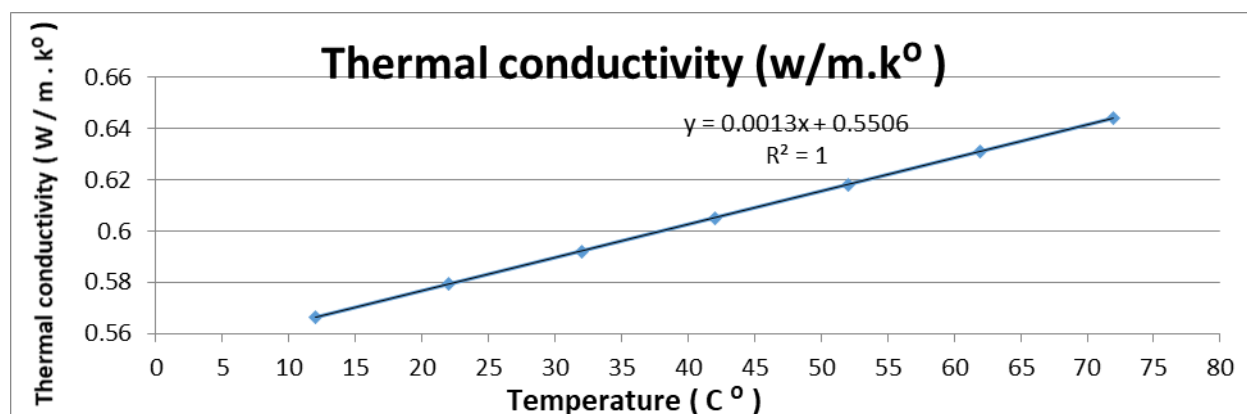


Figure (6): Effect of temperature on the thermal conductivity of milk.

Figures (5 and 6) showed the effect of temperature on thermal conductivity and specific heat . Both of the thermal conductivity and specific heat increased with increasing temperature since the initial temperature for the milk was 12 ° C, the specific heat and thermal conductivity of the milk was 3855 J / Kg.K, 0.566191w / m.k respectively and when the milk temperature reached 72 ° C, the specific heat and thermal conductivity of the milk reached to 3939 J / Kg.K, 0.644071 w / m.k respectively. These results are consistent with **Asaad,et al., (2013).**

3-Effect of microwave intensity treatment on viscosity and density values of milk:

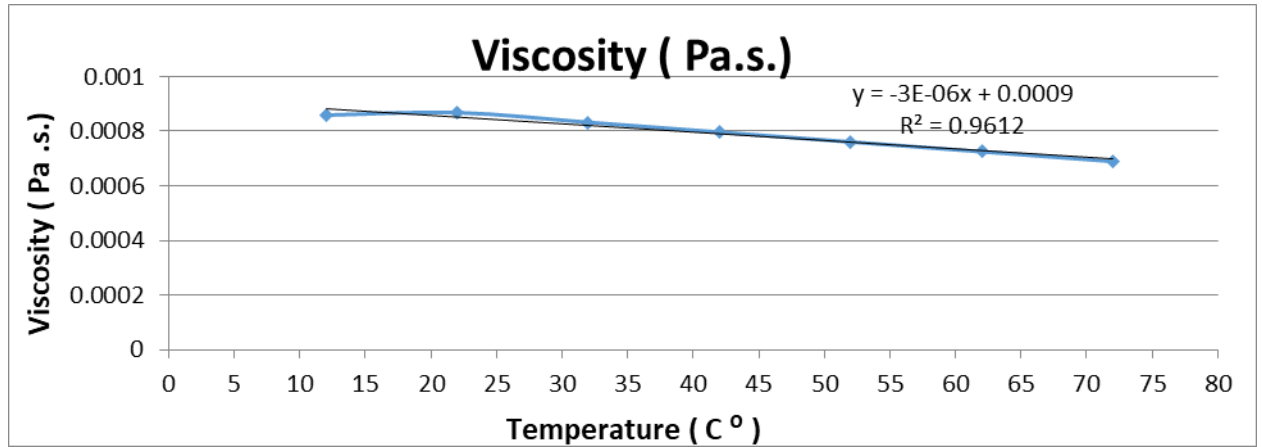


Figure (7): Effect of temperature on viscosity of milk.

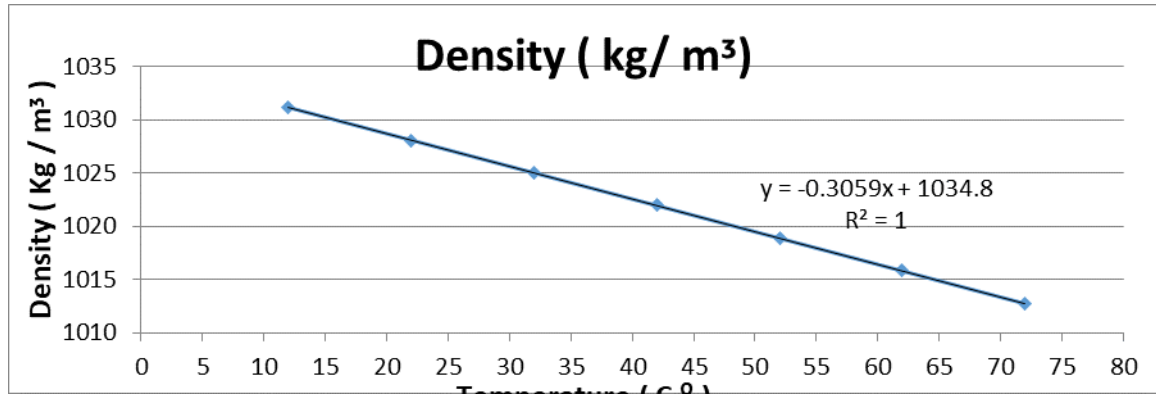


Figure (8): Effect of temperature on density of milk.

Figures (7 and 8) Showed the viscosity and density decreased with increasing temperature. Both the viscosity and density decreased with increasing temperature since the initial temperature for the milk was 12 ° C, density and viscosity of the milk was 1031.146, 0.000858 pa.s Kg / m³ respectively and when the milk temperature reached 72 ° C, the viscosity and density of the milk reached to 0.0006901 pa.s , 1012.792 Kg / m³ respectively. These results are consistent with **Asaad,et al.,(2013)**. The highest microwave productivity was 13.5 l/h at 800 W intensity and flow rate of 75 ml / 20 sec and heating rate 3.6 ° C / second.

3 -Effect of microwave intensity treatment on moisture content values of milk:

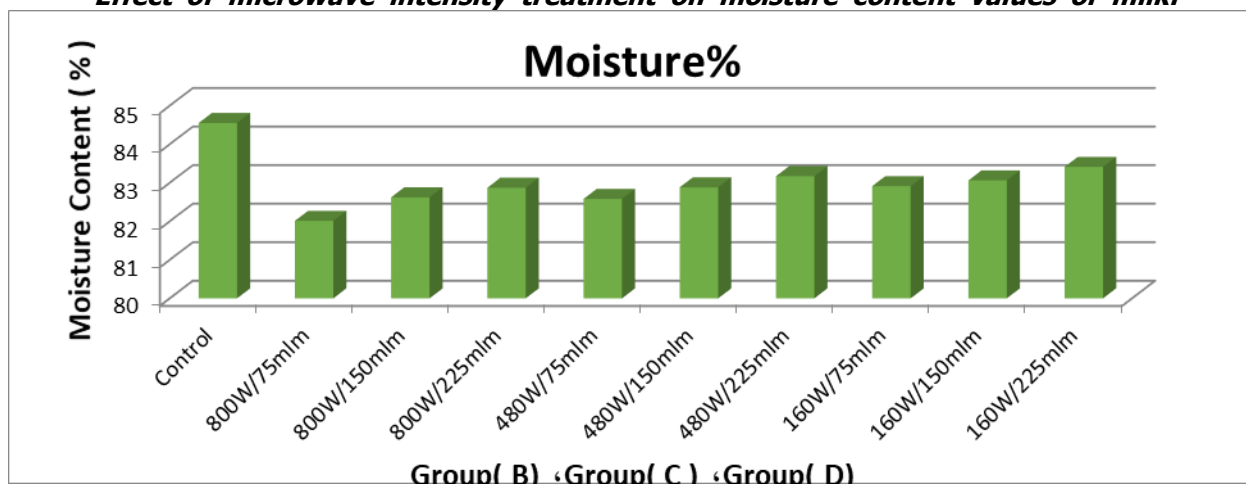


Figure (9): Effect of the microwave radiation intensity in groups (B), (C) and (D) compared to group (A) on the moisture content (%) of the milk.

4. Effect of radiation intensity treatments on moisture values of milk:

Results in Figure (9) showed that moisture values of milk decreases with increased intensity of microwave radiation and Increased by increasing milk flow rate at the same radiation intensity. Where the moisture values of group (A) 84.55, while it was in a range of 82.01% to 82.87 % in group B, 82.58 % to 83.17 % in group C and 82.91 to 83.66 in group D. Moisture content values were in group (B) Less affected comparatively with that of group (C) and group (D). The moisture content values of milk (group B; 82.5 ± 1.091) were remarkably less ($P < 0.05$) compared to that of milk (group C; 82.87 ± 1.095) and milk (group D; 83.21 ± 0.945). Moisture content values of all radiation intensity treated samples were significantly ($P < 0.05$) less than that of un-treated or control milk sample (group A; 84.55 ± 1.119).

It is noted that the moisture content of milk in treatment (B) decreases significantly from the rest of the treatments due to increased radiation intensity and low flow rate of milk. It is clear that moisture content decreased significantly when using 800 watts at a flow rate of 75 ml / 20 seconds it was 82.01%. This is due to the increase in the quantity of evaporated water in this group B compared to the treatment of 160 watts at a flow rate of 225 ml / 400 sec belonging to group (D) where the moisture content (83.66%) was approaching the untreated group (84.55% Due to the low amount of vaporized water . These results are consistent with **Nangraj, (2011)**. observations, which led to an increase in the temperature at which some moisture evaporated, resulting in reduced moisture content in processed milk compared to control group.

5 - Effect of radiation intensity treatments on fat and protein content values of milk:

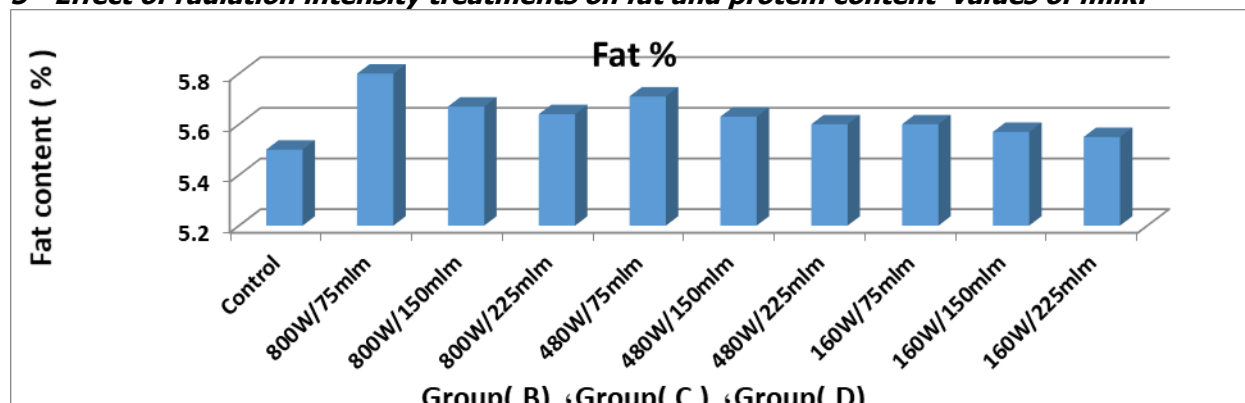


Figure (10): Effect of the microwave Radiation intensity in groups (B), (C) and (D) compared to group (A) on the fat content (%) of the milk.

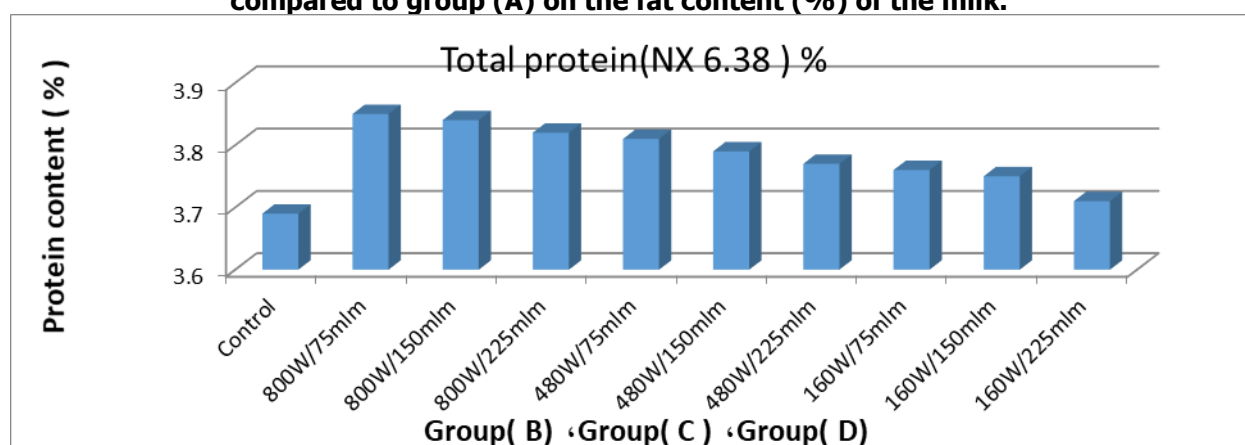


Figure (11): Effect of the microwave radiation intensity in group (B), (C) and (D) compared to group (A) on the protein content (%) of the milk.

6. Effect of radiation intensity treatments on fat values of milk:

As shown in Figure (10) it is clear that the fat content values of milk increases with increased intensity of microwave radiation and decreases by increasing milk flow rate at the same radiation intensity. Where the fat content values of group (A) 5.5 while it was in a range of 5.8 to 5.64 in group B, 5.71 to 5.6 in group C and 5.6 to 5.55 in group (D). Fat content values were in group (B) higher affected comparatively with to that of group (C) and group (D).

The fat content values of milk (group B; 5.7 ± 0.077) were remarkably higher ($P < 0.05$). compared to that of milk (group C; 5.6 ± 0.075) and milk (group D; 5.57 ± 0.043). Fat values of all radiation intensity treated samples were significantly ($P < 0.05$) higher than that of un-treated or control milk sample (group A; 5.5 ± 0.073). The results showed that increase in Radiation intensity slightly increased the fat content of milk samples. These findings are in agreement to the results by **Nangraj, (2011)**. Who reported that increase in temperature, resulted in slight increase in fat content.

7. Effect of radiation intensity treatments on protein content values of milk:

As shown in Figure (11), protein content values of milk increases with increased intensity of microwave radiation and decreases by increasing milk flow rate at the same radiation intensity. Where the protein content values of group (A) 3.6 while it was in a range of 3.85% to 3.82% in group B, 3.81% to 3.77 % in group C and 3.76 to 3.71 in group D. Protein content values were in group (B) higher affected comparatively with to that of group (C) and group (D). The protein content values of milk (group B; 3.83 ± 0.050) at were remarkably higher ($P < 0.05$) compared to that of milk (group C;

3.79±0.050) and milk (group D; 3.74±0.029). Protein content values of all radiation intensity treated samples were significantly ($P<0.05$) higher than that of un-treated or control milk sample (group A; 3.6±0.049). It is noted that the protein content of milk in treatment (B) increased significantly from the rest of the treatments due to increased radiation intensity and low flow rate of milk. It was observed that protein content increased with radiation intensity increase in group B and C. These results support the results of **Nangraj, (2011)** which also noted an increase in protein content of pasteurized milk.

8 -Effect of radiation intensity treatments on lactose and ash content values of milk:

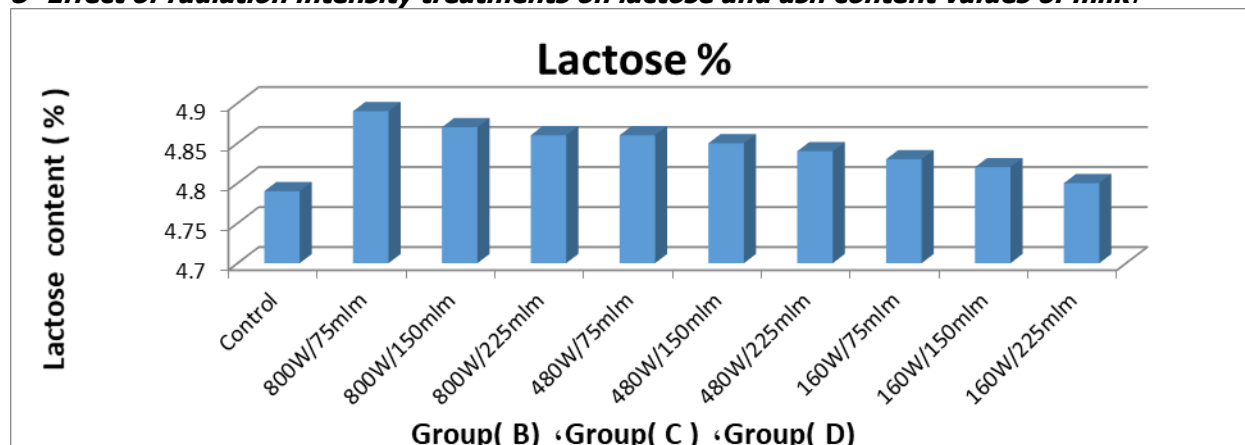


Figure (12): Effect of the microwave radiation intensity in group (B), (C) and (D) compared to group (A) on the lactose content (%) of the milk.

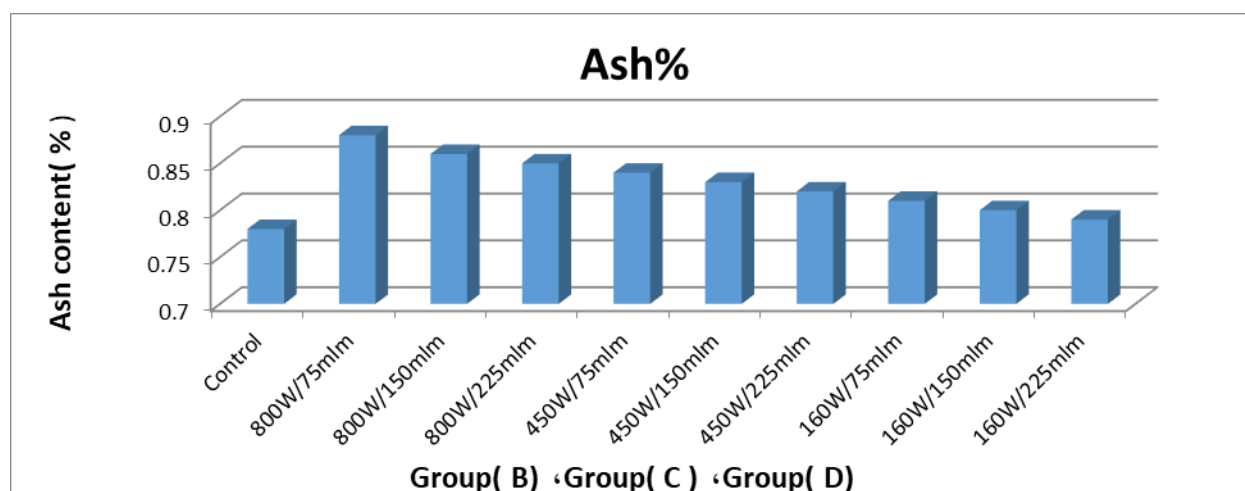


Figure (13): Effect of the microwave radiation intensity in group (B), (C), (D) compared to group (A) on the ash content (%) of the milk.

9. Effect of radiation intensity treatments on lactose content values of milk:

Results in Figure (12), showd that lactose content values of milk increases with increased intensity of microwave radiation and decreases by increasing milk flow rate at the same radiation intensity. Where the lactose content values of group (A) was 4.79 while it was in a range of 4.89% to 4.86% in group (B), 4.86% to 4.84 % in group (C) and 4.83 to 4.80 in group (D). Lactose content values were in group (B) higher affected comparatively with to that of group (C) and group (D).

The lactose content values of milk (group B; 4.87 ± 0.064) at were remarkably higher ($P < 0.05$) compared to that of milk (group C; 4.85 ± 0.064) and milk (group D; 4.81 ± 0.037). Lactose content values of all radiation intensity treated samples were significantly ($P < 0.05$) higher than that of un-treated or control milk sample (group A; 4.79 ± 0.063). These results were consistent with the results of **Hussain, (2011)**.

Indicated that at low temperatures the lactose content increased slightly from the control sample.

10. Effect of radiation intensity treatments on ash content values of milk:

Results shown in Figure (13), ash content values of milk Increases with increased intensity of microwave radiation and decreases by increasing milk flow rate at the same radiation intensity. Where the ash content values of group (A) 0.7 while it was in a range of 0.88% to 0.85% in group B, 0.84% to 0.82 % in group C and 0.81 to 0.79 in group D. ash content values were In group (B) higher affected comparatively with to that of group (C) and group (D). The ash content values of milk (group B; 0.86 ± 0.012) at were remarkably higher ($P < 0.05$) compared to that of milk (group C; 0.83 ± 0.011) and milk (group D; 0.80 ± 0.006). Ash content values of all radiation intensity treated samples were significantly ($P < 0.05$) higher than that of un-treated or control milk sample (group A; 0.7 ± 0.011). It is noted that the ash content of milk in treatment (B) increased significantly from the rest of the treatments due to increased radiation intensity and low flow rate of milk. Ash is increased slightly with increased intensity of microwave radiation. In the current study The findings support the findings of **Hussain, (2011)**. Who found that heating the skimmed milk samples resulted in increased ash content.

11. Effect of microwave intensity treatment on pH and titratable acidity values of milk:

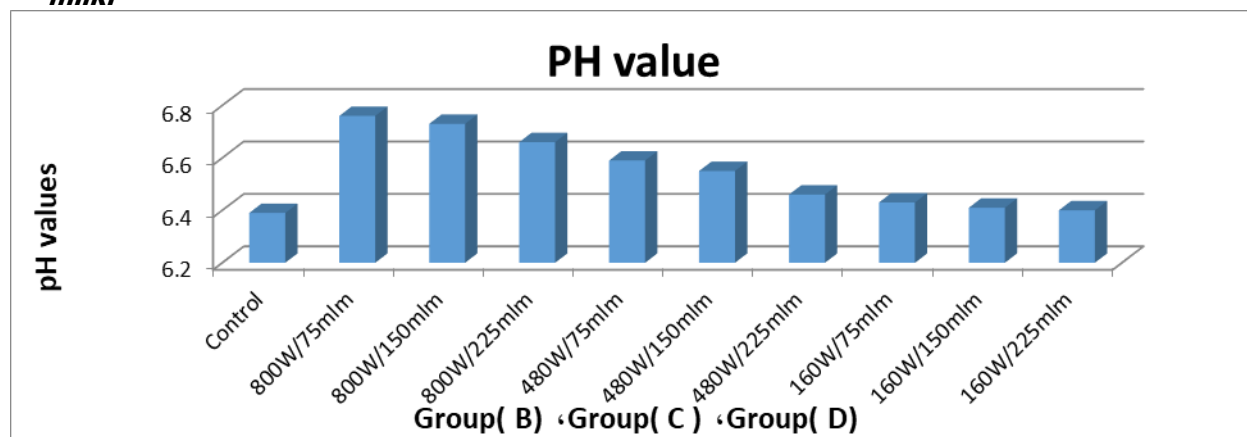


Figure (14): Effect of the microwave Radiation intensity in group (B), (C) and (D) compared to group (A) on the pH of the milk.

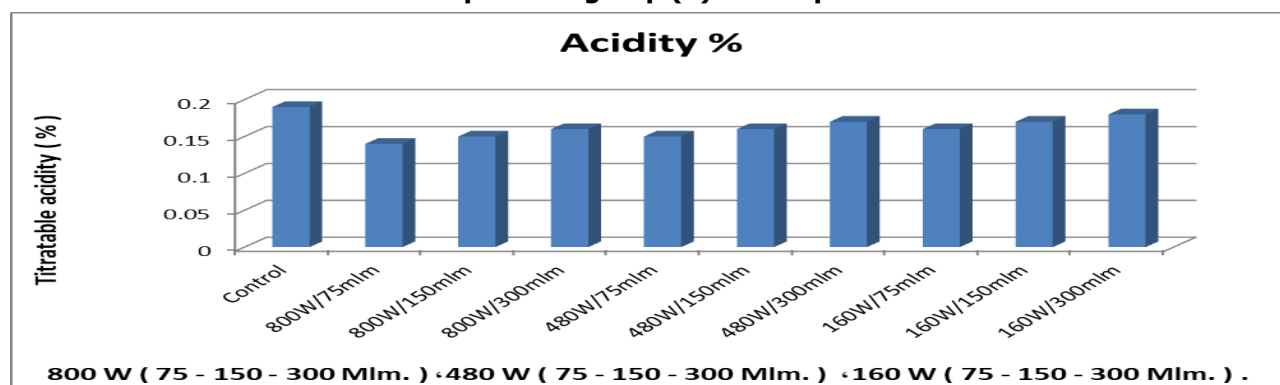


Figure (15): Effect of the microwave radiation intensity in group (B), (C), (D) compared to group (A) on the titratable acidity of the milk.

12. Effect of radiation intensity treatments on pH values of milk:

Figure (14) shows that pH values of milk increases with increased intensity of microwave radiation and decreases by increasing milk flow rate at the same radiation intensity. Where the pH values of group (A) 6.39 , while it was in a range of 6.76 to 6.66 in group B, 6.59 to 6.46 in group C and 6.43 to 6.40 in group D. pH values were In group (D) less affected comparatively with to that of group (C) and group (B). The pH values of milk (group B; 6.71 ± 0.089) at were remarkably higher ($P < 0.05$) compared to that of milk (group C; 6.53 ± 0.049) and milk (group D; 6.41 ± 0.085). pH values of all Radiation intensity treated samples were significantly ($P < 0.05$) higher than that of un-treated or control milk sample (group A; 6.39 ± 0.085). These finding are in agreement with results reported by **Molina, et al., (2005); Nagla, et al., (2009).** and **Hussain, (2011).** who also found that increase in temperature results in increasing the pH of milk samples. Whereas, **Walstra, et al., (2006); Erdam, and Yuksel, (2005).** Reported that heat treatment causes some possible physico-chemical changes that results in decreasing the pH of milk due to increase in concentration of lactic acid produced from degradation of lactose content. They also reported that changes in Calcium phosphate is also responsible for decreasing the pH and thus increases the acidity of milk samples.

13. Effect of radiation intensity treatments on titratable acidity values of milk

Results in Figure (15) shows that titratable acidity values of milk decreases with increased intensity of microwave radiation and increases by increasing milk flow rate at the same radiation intensity. Where the titratable acidity values of group (A) 0.19 , while it was in a range of 0.14 to 0.16 in group B, 0.15 to 0.17 in group C and 0.16 to 0.18 in group D. titratable acidity values were In group (B) higher affected comparatively with to that of group (D) and group (C). The titratable acidity values of milk (group B; 0.15 ± 0.003) at were remarkably higher ($P < 0.05$) compared to that of milk (group C 0.16 ± 0.002) and milk (group D; 0.17 ± 0.002). Titratable acidity values of all Radiation intensity treated samples were significantly ($P < 0.05$) higher than that of un-treated or control milk sample (group A; 0.19 ± 0.003). In present study results revealed that increase in i intensity of microwave radiation significantly decreases ($P < 0.05$) the titratable acidity of milk. These finding are in agreement with results reported by **Nagla, et al., (2009); Kang, et al., (2007) and Hussain, (2011).** that increase in temperature results in decreasing the acidity of milk. While findings disagreed with findings by **Erdam, and Yuksel, (2005).** who reported that heat treatment results in increasing the acidity of milk due to increase in concentration of lactic acid produced from degradation of lactose content.

Table (1): Effect of radiation intensity treatments on heating rate and productivity for the microwave.

the group	The amount of pasteurized milk per hour (kg / hr)	Heating rate (°C/sec.)
(B) 800 w (75 ,150 , 225) ml	13.5 , 13.5 , 10.12	3.6 , 1.8 , 0.9
(C) 480 w (75, 150 , 225) ml	6.75 , 6.75 , 5	1.8 , 0.9 , 0.45
(D) 160 w (75, 150 , 225) ml	2.7 , 2.7 , 2	0.72 , 0.36 , 0.18

It is noted from Table (1) that the best heating rate was 3.6 °c /sec at Group (B), using 800 watts and flow rate of 75 ml/ 20 sec. and the highest productivity for the microwave was 13.5 kg/hour. These results are consistent with **Asaad, et al., (2013).**

14 - Effect of microwave intensity and flow rate on microbial growth:**Table (2): Effect of microwave treatment (pasteurization) on microbial content of raw milk.**

Microorganisms of whole milk samples										
Microorganisms	Before pasteurization	After pasteurization								
		Group (A)	Group (B)			Group (C)			Group (D)	
	Control	800W/ 75 Mlm	800W/ 150 Mlm	800 W/ 225 Mlm	480W / 75 Mlm	480W / 150 Mlm	480W / 225M lm	160W / 75 Mlm	160W/ 150 Mlm	160 W / 225 Mlm
Total count (CFU x 10⁻²/ g)	17×10 ²	ND	ND	ND	ND	ND	ND	ND	ND	ND
yeast and molds counts (cfu x 10⁻²/ g)	8 ×10 ²	ND	ND	ND	ND	ND	ND	ND	ND	ND
Coliform group	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphatase	+Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve
Tuberculosis test	+Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve
Lysteria test	+Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve	-Ve

The results of the microbiological evaluation of pasteurized milk samples at 72 ° C (Table 2) showed a negative presence of bacteria. This indicates that the microwave radiation penetrates the milk from all sides and leads to the destruction of the wall of bacterial cells, leading to the disappearance of microbes, especially the tuberculosis and lesteria In addition to the tests conducted on pasteurized milk, there is a negative for coliform group in all test samples. These results are in full agreement with the results of *Solre,et al.,(1995)*. Alkaline phosphate disappeared in pasteurized milk.

This result was less than the minimum Egyptian standard specification, which stated that the total count bacteria in pasteurized milk of good quality are 10000 CFU/ml (4 log CFU/ml) and 50000 CFU/ml (4.698 log CFU/ml) with acceptable quality milk. Microwave flash pasteurized milk are significantly ($p < 0.05$) less than control treatments (without microwave flash milk pasteurization) at 5 °C at all storage times.

15- Sensory evaluation:

The samples were characterized by appropriate appearance without quality defects. Their color was evaluated as typical, white with a little cream shade with little difference between all the samples analyzed. The smell of milk was typical, sweet and creamy. The consistency of the tested milk was also highly evaluated - all samples were considered fluid and smooth. Regarding the taste of milk, the milky tone dominates, accompanied by sweet and greasy taste.

Table 3: illustrates Sensory evaluation of milk by scaling method using a 5-point scale number of samples used.

Samples		Appearance	Odour	Consistency	Taste
groups: A		5.00	5.00	4.8	4.7
groups: B	radiation intensity of 800 W with 75ml/10 s.	5.00	5.00	5.00	5.00
	radiation intensity of 800 W with 150ml/20 s.	5.00	5.00	5.00	5.00
	radiation intensity of 800 W with 300ml/40 s.	5.00	5.00	5.00	5.00
groups: C	radiation intensity of 480 W with 75ml/20 s.	4.8	4.6	4.5	4.6
	radiation intensity of 480 W with 150ml/40 s.	4.8	4.6	4.5	4.6
	radiation intensity of 480 W with 300ml/80 s.	4.8	4.6	4.5	4.6
groups: D	radiation intensity of 160 W with 75ml/20 s.	4.5	4.2	4.2	4.3
	radiation intensity of 160 W with 150ml/40 s.	4.5	4.2	4.2	4.3
	radiation intensity of 160 W with 300ml/80 s.	4.5	4.2	4.2	4.3

16- Economic feasibility study:**Table 4: Economic feasibility: (Calculate the cost of operating a Pasteurized liter-of milk by microwave compared to traditional pasteurization:**

Items comparison	Pasteurization by Microwave	Pasteurization by container Pasteurization
Electrical Energy used	Electrical Energy used in magnetron 800 W/hr	Productivity 500 liters of milk / 6 hr = 83 liters /hr, has 5heater (electrical capacity for one heater 2kw/hr) total 10 kw/hr
	Electrical Energy used to operate the raw milk extraction pump 150 w/hr	Electrical Energy used in motor flipping the raw milk 750 w/hr
	Total Consumption of Electrical Energy used in microwave to product 13.5 liter of milk is 950 w/hr	Total Consumption of Electrical Energy used in container to product 83 liter /hr is 10.750 kw
Production per hour	The maximum productivity of the microwave used in the research 13.5 liters/hour	83 liters of milk liter / hr
Electrical Energy used to product kg of pasteurized milk	Pasteurized liter of raw milk need to 70 W approximately	Pasteurized liter of raw milk need to 129 W approximately
The cost of electricity consumption required for pasteurization of kg of raw milk, price of consumption of kw/hr electricity in factories is 1.34 pound.	The cost of liter of pasteurized milk using a microwave 0.1 pound.	The cost of liters of pasteurized milk using a container 0.2 pound.

The results of the economic feasibility study in Table (4) indicate that the cost of electrical energy needed to pasteurize a liter of milk in the microwave provides 50% of the cost of electrical energy used in the traditional method. Therefore, it is preferable to use the microwave for continuous pasteurization in milk pasteurization factories, in order to save on the electricity bill and also to ensure access to high quality pasteurized and sterilized milk. These results are consistent with the results of **Lau and Tang,(2002)**, where he indicated that the use of microwaves in milk pasteurization reduces the consumption of electrical energy by half compared to pasteurization with a water bath.

Conclusions:

Continuous pasteurization at 72°C by microwave gave a good quality of pasteurized milk in terms of sensory evaluation and led to the elimination of microbial count, coliform bacteria, tuberculosis microbes and lysteria. Phosphatase enzyme disappeared in all treatments. Chemical properties improved with high efficiency occurred at 800 Watt and flow rate of 75 milliliters / 20 sec where the value of fat content and protein content as well as lactose content of milk increased and acidity decreased while acid value increased.

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تأثير استخدام أشعة الميكروويف فى بسترة الألبان

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الهدف من هذه الدراسة هو تطوير جهاز ميكروويف يلائم البسترة المستمرة للحليب لدراسة قدرة الجهاز على تثبيط الكائنات الحية الدقيقة، وتحسين الخواص الحرارية والفيزيائية والكيميائية للحليب المبستر. وقد شملت الدراسة بسترة الحليب الجاموسي عن طريق الميكروويف عند 72 درجة مئوية لمدة تتراوح بين 10 - 200 ثانية. وشملت الاختبارات الكيميائية تقدير الرطوبة والدهون واللاكتوز والرماد والبروتين. وشملت الاختبارات الميكروبيولوجية تقدير العدد الكلى للميكروبات، بكتريا القولون، ميكروب السل، ميكروب الليستيريا والفوسفاتيزالقلوية. شملت الخواص الحرارية الفيزيائية للحليب الحرارة النوعية، الزوجة، التوصيل الحرارى، الكثافة في درجات حرارة مختلفة. حيث تم تقسيم عينة الحليب إلى أربع مجموعات A، B، C، D حيث تمثل المجموعة (A) عينة اللبن الغير معاملة (كنترول)، وتمثل المجموعة (B) اللبن المعرض لشدة أشعة 800 واط مع معدلات تدفق 75 و 150 و 225 مل / 10 - 20 - 40 ثانية، وتمثل المجموعة (C) اللبن المعرض لشدة أشعة 480 واط مع معدلات تدفق 75 و 150 و 225 مل / 20 - 40 - 80 ثانية. والمجموعة (D) تمثل اللبن المعرض لشدة أشعة 160 واط مع معدلات تدفق 75 و 150 و 225 مل / 50 - 100 - 200 ثانية، مع ثبات طول الحلزوني ثابتا 200 سم لجميع المعاملات.

وصلت إنتاجية الجهاز إلى 13.5 لترًا في الساعة ومعدل التسخين 3.6 درجة مئوية / ثانية. وأظهرت النتائج أن الخصائص الميكروبيولوجية قد تحسنت بعد البسترة من خلال القضاء على الميكروبات وبكتيريا القولون والسل والليستيريا والفوسفاتيز القلوى في اللبن المبستر. كما أظهرت النتائج أن الخواص الحرارية الفيزيائية للحليب كانت كما يلي: تزداد الحرارة النوعية والموصلية الحرارية في اللبن المبستر بالميكروويف بشكل ملحوظ ($p > 0.05$) مقارنة بعينة اللبن الغير معاملة مع زيادة وقت التسخين، في حين انخفضت لزوجة الحليب وكثافته بدرجة ملحوظة ($p > 0.05$) مقارنة بعينة اللبن الغير معاملة مع زيادة وقت التسخين. وأظهرت النتائج أن الخواص الكيميائية للحليب تحسنت علي النحو التالي: قيم الرقم الهيدروجيني، والدهون، والبروتين، واللاكتوز، والرماد في مجموعة الحليب (B) كانت أعلى بدرجة ملحوظة ($p > 0.05$) مقارنة بعينة اللبن الغير معاملة، يليها المجموعة (C) والمجموعة (D)، بينما كانت قيمة الحموضة المعايرة والرطوبة أقل بدرجة ملحوظة ($p > 0.05$) مقارنة بعينة اللبن الغير معاملة.