

EFFECT OF MICROWAVE AND SOME TREATMENTS ON MICROBIAL INACTIVATION RATE OF MILK

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ABSTRACT

The aim of the present work is to study the effect of three different microwave power levels of 285, 385 and 470 W and alternating mixed treatments (20 seconds in microwave and 20 seconds sudden cooling) repeated one, two and three times on the total microbial counts (CFU/g) of milk . It was found that as the microwave power increases the total microbial counts decreases from 3.6×10^{10} to 2.4×10^4 CFU/g. Insignificant differences were found between 385 and 470 W for the pure microwave treatments. The decimal reduction time were 10.36 s, 7.87 and 7.49 s for the three power levels respectively. For the mixed alternating treatments the power level of 470 gives the least total bacterial count of 3.3×10^3 CFU/g compared to 3.5×10^3 for the power level of 385W at 2450 MHz. The decimal reduction times were 39.23 and 38.90 s for 385 and 470 W for the three times treatments respectively. Semi-logarithmic models were satisfied for the pure microwave and alternating mixed treatments with coefficient of determination of 0.98.

INTRODUCTION

Dessel et al. (1960) compared the effectiveness of conventional heating versus microwave power in killing several bacterial species. This was done by heating inoculated eggs and custard. The results showed no significant differences. In particular, they noted that both methods failed to destroy spores of *Bacillus Cereus*. Lechowich et al. (1969) studied the effect of 2450 MHz on both *Streptococcus Faecalis* and *Scchoromyces Cerevisiae*. This study also concluded that thermal effect could be detected in these systems. Mullin (1995) observed that there is no substantiated mechanism for the interaction of microwaves with microorganisms other than volumetric heating. The literature on microbial interactions can be divided into two chronological

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sections. A great deal of work was performed in 1940's to mid 1950's when the consensus was there were no thermal effects. With the increased use of microwave and radio frequency in 1960's, more work was undertaken in the area of health exposure effects, but also on microbial effects. Parbahanjan (1995) observed that a power level of 50 % (rated power 600 W) caused burning of the product in microwave. Chen (2004) reported that input electrical power level or the output microwave power governs the quality of final products, which has led many researchers to study the relationship between them. Toledo (1991) reported that when a suspension of microorganisms is heated at a constant temperature, the decrease in number of viable organisms follows the first order reaction.

MATERIALS AND METHODS

This work was carried out in the Agricultural Engineering Department and Dairy Science Department Faculty of Agriculture Al-Azhar University Nacr City for studying the effect of pure microwave treatment of three different power output levels: 285, 385 and 470 W at 2450 MHz, and also alternating mixed treatments for 385 and 470 W at 2450 MHz on microbial inactivation rate of milk.

Materials:

1. **Fresh buffaloe's** was obtained from the herd of Mostorod experimental farm , Faculty of Agriculture Al-Azhar University.
2. **Microwave:** Microwave oven 220-230V, 2450MHz , model N. SMB177KEB-P00C Made in Germany.
3. **Microbial count :**Total bacterial count of milk in colony forming units per gram (CFU/g) was evaluated according to the American Public Health Association (1987).

Measuring instrumentations:

1 Thermocouples:Temperature were measured using type-K thermocouples. The output device includes a large 4-digits temperature reading display and electronic circuitry, the specifications of thermocouples are U.S.A manufactured, model 8528-40, full accuracy 18-28°C and useful range 4-45 °C

2 Stopwatch: for evaluating the residence time in seconds, made in USA, model 7425N.

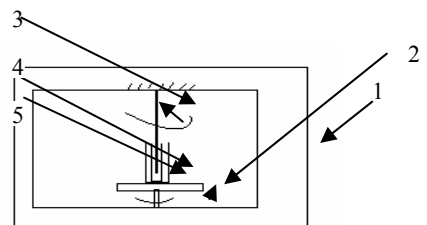
3-Pitchino switch for controlling residence time for treatments.

4-Electrical balance: Made in Japan, Sartorius type, accuracy 0.0001 g.

Experimental apparatus:

The experimental apparatus as shown in Fig.(1) is consists of a microwave oven, mixer, glass vessel 3 mm thick and test tube for holding the milk sample during treatment. Sample of 15 g milk was used for each treatment. For alternating mixed treatments, sample was put in microwave for 20 seconds and then cooled for 20 seconds using water at zero °C. This process was repeated one, two and three times.

- 1. Microwave oven.
- 2. Rotating disc.
- 3. Mixer.
- 4. Test tube
- 5. Glass vessel.



Fig(1)Experimental Apparatus.

METHODS

1 Evaluation of microwave output power.

The microwave output power in Watts was evaluated according to the operational manual of the microwave using one litter (1kg) of distilled water at 10 °C as follows:

$$\text{Microwave power} = (m C_{p_{\text{water}}} \Delta T)/t$$

Where:

$$C_{p_{\text{water}}} = 4187 \text{ J/kg.}^\circ\text{C}$$

ΔT : is the temperature rise of water above 10 °C.

t : is the time in seconds.

2 Evaluation of Decimal reduction time:

It was evaluated according to Toledo (1991), linear semi-logarithmic plot of N against t is used:

$$2.303 \log \frac{N}{N_0} = -kt$$

$$\log \frac{N}{N_0} = \frac{-kt}{2.303} \qquad \log \frac{N}{N_0} = -\left(\frac{t}{D}\right)$$

Where :

N_0 : is the initial microbial count,

N : is microbial count at any time t ; $\left(\frac{2.303}{k}\right)$, the time required to reduce viable population by a factor 10.

3-Experimental procedure:

The following treatments were evaluated:

- 1- Pure microwave treatment for three different power levels of 285, 385 and 470W at 2450 MHz.
- 2- Alternating mixed treatments (20 seconds in microwave followed by 20 seconds sudden cooling) repeated as follows:
 - One time,
 - Two times;
 - Three times respectively.

The Total bacterial count of milk was evaluated in (CFU/g) for all experiments.

RESULTS AND DISCUSSIONS

Table (1) shows total bacterial count as affected by pure microwave treatment of 285, 385 and 470 W and 2450 MHz. It is clear that residence time of 20 seconds in microwave gives 7.4×10^5 (CFU/g) at 285 W compared to 3.20 and 2.4×10^4 (CFU/g) for 385 and 470 W respectively. Treatments of 385 and 470 W were the least in the total bacterial counts respectively. The decimal reduction time was 10.36 s of 285W compared to 7.87 and 7.49 s for the power levels of 385 and 470W respectively. Insignificant differences were found between 385 and 470 W for the pure microwave treatments. Fig.(3) shows relationship between the number of survivors and residence time on semi-logarithmic plot, linear forms were satisfied for the three power treatments as follows:

For 285 W $\log N = -0.222t + 10.556$ $R^2 = 0.95$

For 385 W $\log N = -0.299t + 10.556$ $R^2 = 0.98$

For 470 W $\log N = -0.3077t + 10.556$ $R^2 = 0.98$

Fig.(2) and Table (2) shows the effect of alternating mixed (20 seconds in microwave and 20 seconds sudden cooling) of one, two and three times treatments on microbial inactivation rate for 385 and 470 W and 2450 MHz. It is clear that the number of survivors were 3.5×10^3 for 385 W compared to 3.4×10^3 at 470 W for the three times treatments. The decimal reduction times were 39.23 and 38.90 s for 385 and 470 W for the three times treatments respectively. Fig.(4) shows the relationships between the number of survivors as affected by residence time at 385 and 470 W for the three times treatments respectively. Semi-logarithmic relations were also satisfied as follows:

For 385 W $\log N = -0.0587t + 10.556$ $R^2 = 0.98$

For 470 W $\log N = -0.0592t + 10.556$ $R^2 = 0.98$

Table(1) Total bacterial count (CFU/g) of milk as affected by residence time in pure microwave treatments for 285, 385 and 470 W and 2450MHz.

Time	285 W	385 W	470 W
0	3.6×10^{10}	3.6×10^{10}	3.6×10^{10}
5	8.6×10^9	4.6×10^9	3.1×10^9
10	8.8×10^8	8.9×10^7	8.6×10^7
15	9.5×10^6	4.5×10^5	3.3×10^5
20	7.4×10^5	3.2×10^4	2.4×10^4
D	10.36	7.87	7.49

SUMMARY AND CONCLUSION

In the present work the effect of three different microwave levels and alternating mixed treatments (20 seconds in microwave followed by 20 seconds sudden cooling) repeated one, two and three times on the total microbial counts (CFU/g) of milk were studied. From the present study we can concluded that:

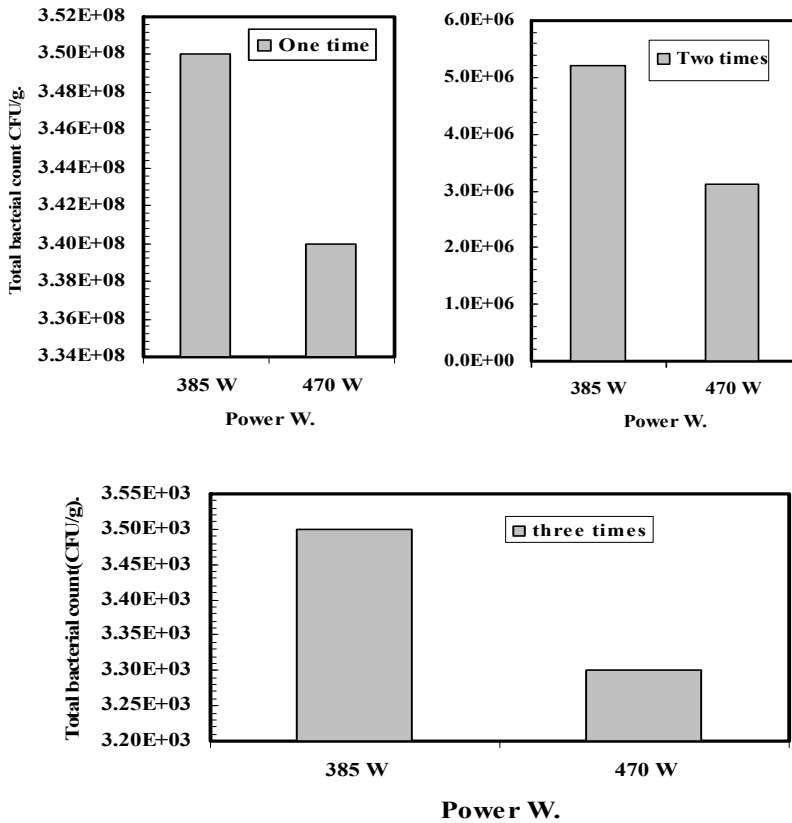


Fig.(2) Effect of alternating mixed process(20 s in microwave and 20 s sudden cooling) repeated one, two and three times on total microbial count of milk at 285, 385 and 470 W and 2450 MHz.

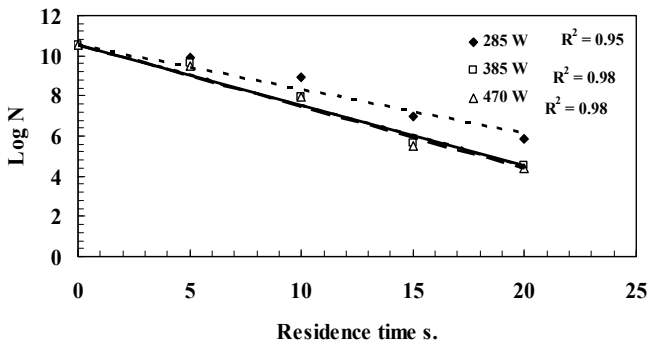


Fig.(3) Relationship between logarithms of microbial count and residence time at the three tested power levels of the microwave power and 2450MHz.

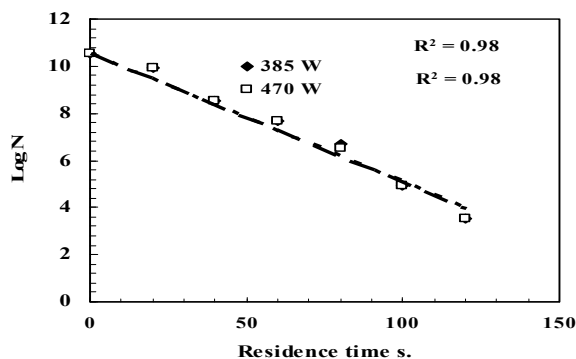


Fig.(4) Relationship between logarithms of microbial count and residence time at the 385 and 470 W of microwave power and 2450MHz.

Table(2) Effect of alternating mixed treatment three times (20 s microwave-20 s sudden cooling) on bacterial inactivation rate at 385 , 470 W and 2450MHz.

Time	385 W	470 W
0	3.6×10^{10}	3.6×10^{10}
20	8.6×10^9	8.5×10^9
40	3.5×10^8	3.4×10^8
60	4.8×10^7	4.6×10^7
80	5.2×10^6	3.12×10^6
100	8.6×10^4	8.5×10^4
120	3.5×10^3	3.3×10^3
D	39.23	38.90

1 As the microwave power increases the total microbial counts decreases from 3.6×10^{10} to 2.4×10^4 CFU/g. Insignificant differences were found between 385 and 470 W for the pure microwave treatments. The decimal reduction time were 10.36 s, 7.87 and 7.49 s for the three power levels respectively

2 For the mixed alternating treatments the power level of 470 gives the least total bacterial count of 3.3×10^3 compared to 3.5×10^3 CFU/g for the power level of 385W and 2450 MHz. The decimal reduction times were 39.23 and 38.90 s for 385 and 470 W for the three times treatments respectively.

3 Semi-logarithmic models were satisfied for the pure microwave treatments and alternating mixed treatments with coefficients of determinations ranged between 0.95-0.98 of the form:

$$\text{Log } N = -A t + B$$

Where A and B are constants varied with treatment.

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الملخص العربي

تأثير الميكرويف و بعض المعاملات على معدل التثبيط الميكروبي للبن

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يهدف البحث الى دراسة تأثير استخدام الميكرويف عند ثلاث مستويات للطاقة 285 و 385 و 470 وات و كذلك تأثير تبادل استخدام الميكرويف -20 ثانية ثم التبريد المفاجئ 20 ثانية- وتكرار تلك المعاملة مرة ثم مرتان ثم ثلاث مرات على العد الميكروبي للبن. ومما سبق يمكننا استخلاص الأتي:

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1. بزيادة طاقة الميكرويف يقل العد الميكروبي للبن من 10×3.6 الى 4×3.6 (CFU/g). كما لوحظ ان الاختلاف بين المعاملة 385 و 470 وات غير معنوية عند استخدام الميكرويف فقط. وقد كان زمن الانخفاض العشري للعد الميكروبي 10.36 و 7.87 و 7.49 ثانية لمستويات الطاقة على الترتيب.

2. في المعاملات المتبادلة (تسخين-تبريد) تبين أن المعاملة 470 وات كانت الأقل في العد الميكروبي 3.3×10^3 (CFU/g) بالمقارنة بالمعاملة 385 وات حيث كان العد 3.5×10^3 (CFU/g) عند تردد 2450 ميغا هرتز للميكرويف. وقد كان زمن الانخفاض العشري للعد الميكروبي 39.23 و 38.90 ثانية للمعاملة المتبادلة ثلاث مرات على الترتيب.

3. تبين أن العلاقة بين العد الميكروبي والزمن هي علاقة شبة لوغاريتمية خطية على الصورة:

$$\text{Log } N = -A t + B$$

حيث كل من (A) و (B) ثوابت تتغير تبعا لمستوى الطاقة او المعاملة.