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The effect of magnetic field treatment on the characteristics and yield of Iraqi local white cheese

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Abstract: *The study focused on the design and manufacture of a device to magnetize milk that used to make cheese and study the net percentage of its qualities when using a fixed magnetic field with an intensity of 0.3Tesla. Results showed the presence of the influence of magnetic field on the chemical qualities of milk, especially moisture content that significantly increased with increasing magnetic field exposure time. The results also showed a significant increase in titrated acidity and significant decrease in total bacteria count and quantity of cheese produced from magnetize milk. Organoleptic evaluation showed that cheese produced from magnetic milk was significantly better than that produced from heated pasteurize milk.*
Key words: *magnetic field, milk, pasteurization*

I. Introduction

In spite of milk is being sterilized inside the udder, it could be contaminated by various types of bacteria during and after milking, like mastitis caused by bacteria such as Staphylococcus aureus, Streptococcus uberis and Coliform spp.(Mahmoud and Ghaly, 2004; Meng-xiang et al,2004; Meng –xiang et al, 2005).Usually milkis preserved either bythermaltreatment likecooking, smoking, salting, freezingordrying.Currently othermodernmethods were used, such as a microwave, radiation(UV) andmagnetic fields (Coughlan and Hall. 1990; Pothakamury et al., 1993; Lipiec et al., 2004). Recently, magnetic fields are used as a good method to get rid of microorganisms, asthemagnetic fields inhibit microorganismsthat causefood spoilageFrankel and Liburdy(1995). This method was used to treat milk resulting reduction in the bacterial counts from 25000 to 970 CFU/ml at 12 field intensity of 12 Tesla, besides magnetic milk gives power and liveliness to exhausted people(Maes et al, 2000). Magnetization of milk by steady method is done by fixing a magnetic in a container which contains milk for 4-6 hours. The resulted magnified milk is useful to cure sick people, increase sexuality, preserve food quality by decrease thermal damage and enhance milk properties (Hileman,1993;Reminick,2000;Mahjob ,2002;Miyakoshi, 2005;). The aim of the present study was todesign and manufactureadevice to magnetizemilk by a magnetic field to eliminate microorganisms, prolonged milk shelf life and to study the effect of this treatment on the resulted cheese characteristics and yield.

II. Materials and Methods

Raw cow milk was obtained from the Agricultural Station, College of Agriculture, University of Basrah during spring 2015.

Milk magnetic device:

Milk magnetic device was designed and produced at the Laboratory of Food Industry Engineering/ Food Sciences Department/ Basrah University.Figured 1 and 2 showed a diagram of the device which consisted of a frame (body) (5) made of wood and two fixed magnetic (8), each of them has an intensity of 0.365 Tesla,with a distance of 0.5cm in between them.Northern polar was located in the front of the southern polar and with the presence of a transparence, (1cm in diameter) plastic pipe (2) provided with reciprocatingpump12 v which discharge (10L/min) siphoned off milk from the bottom of the 5L tank (3) and pushed it against the magnetic (8) to expose to magnetic energy and return back to the tank again. The system was provided with a battery of 90Ah capacity which provides 12 v. A pipe (4) provided with a valve (14) wasused to discharge the magnetic milk.

Device mechanism:

When tank (3) was filled with milk and the valve (14) was closed, the electricity key (7) was put on, the current goes through the pump (12), start pumping milk from tank bottom (3), pushed it through the plastic pipe (10), milk would go through the two magnetic polar (8), through pipe (2) to tank (3), the milk which was passed through the system became magnetic. This recirculation on process was repeated several times to let the milk take required explosion to magnetic field for longer time.

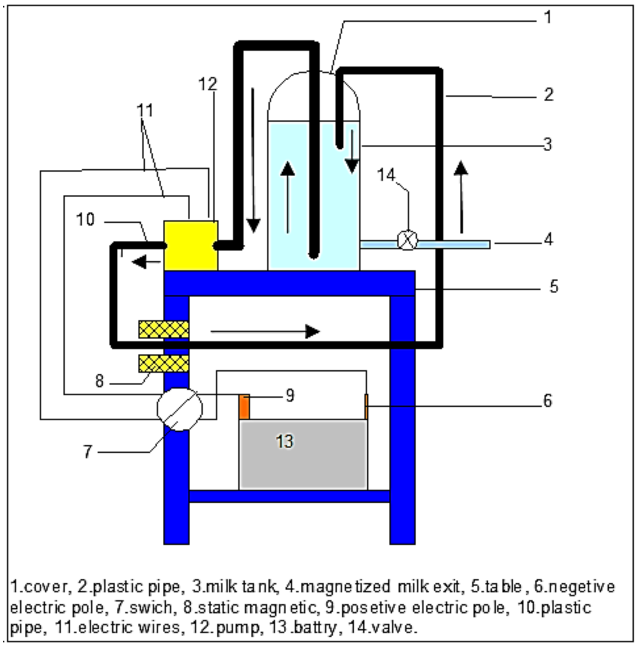

Figure 1: Locally produced milk magnetizer.

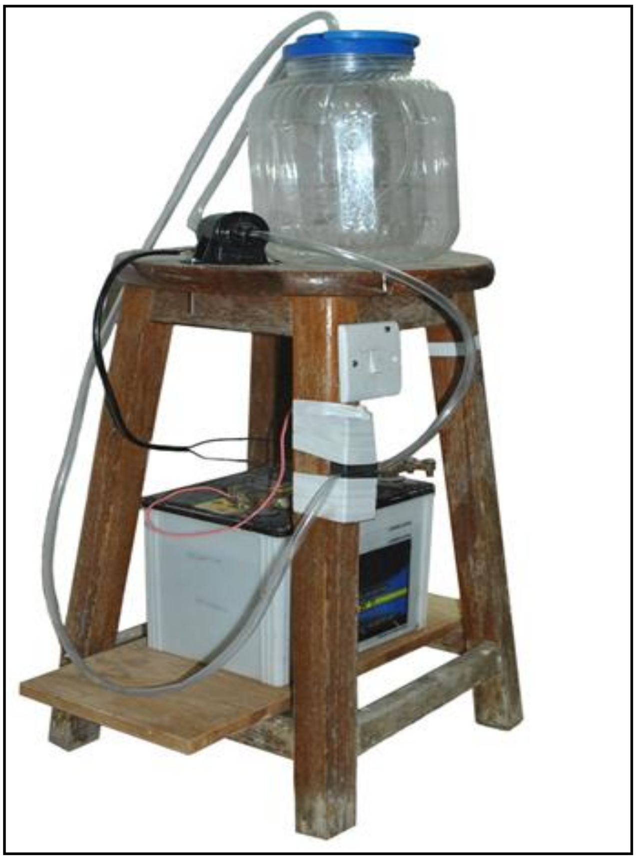

Figure 2:Image Locally produced milk magnetizer.

Measurement of magnetic intensity:

A Gauges and Tesla meter produced by Nvis Technology Pvt. Ltd., India was used to measure magnetic intensity by Telsa unit type Nv621.

Cheese making:

Dutch dry microbial rennet manufactured by Green Wings Co. was used. Fresh white milk cheese was made either from magnetic field exposed or not exposed milk. Temperature was elevated to 35°C, rennet was added according the supplier, curd was obtained after 35-45 min., and curd was cut, left for 5 min. and transferred to a sieve covered by cheese filtering cloth (Al-Tikrity and Al- Khal, 1984). During this stage salt was added, the three corners of the cloth was gathered and the fourth corner was used to make sag which contains the resultant curd and a heavy weight was put on to give the curd its shape in a traditional template. The resultant cheese was cut into 10 X 10 cm cubes for further testes.

Chemical, organoleptic and microbial tests:

Moisture and ash were measured according to A. O. A. C (1990), fat by Gerber method (Newlander and Atherton, 1977) and protein by Kjeldahl method (Ling, 1963). Milkclotting ability was determined and cheesewas weighted to calculate yield percentage (Ismail and Abdul-Salam, 1971). Pour-plate method was used to count total microbes, E. coli, Staphylococcus, yeasts and fungi (APHA, 1978).
Organoleptic evaluation was done according to method revealed by Hassan et al., (1983).

Ratio of survival microorganisms to total (C/CT):

Ratio of survival microorganisms to total (C/CT) was calculated by the following equation (Ferna'ndez-molina et al., 2001):

$$\left(\frac{C}{CT}\right) = \exp(k\,\Lambda_r\ \frac{t}{w}) \qquad 1$$

Where, Λ_r is a volume of treatment chamber (m^3), k is a constant, t, is the time (sec.) and W is the discharge (m^3/sec.).
The mathematical modeling was used to calculation (k) by using solver program in excel 2010.

D-value

D-value was calculated from the following equation:

$$D = \frac{t_2 - t_1}{\log N_{oj} - \log N_j} \qquad 2$$

Where N_{oj} and N_j (CFU/ml.) represent the survivor counts following magnetic for t1 and t2 (min), respectively. D is the time needed to destroy 90% of the microorganisms (to reduce their numbers by a factor of 10) is referred to as the decimal reduction time.

Data was statistically analyzed by using Complete Randomized Design (Al-Rawi and Khalfallah, 2000). Means were compared by Least Significant Difference test at 0.05 significant levels.

III. Results and Discussion

Table (1) showed the milk chemical compositions after being exposed to a magnetic field for different periods of time. Moisture was increased when milk was exposed for longer time. It was 88.97% at zero time and increased to 90.26% after 60 min of exposure. The reason behind that was that few nucleus center in the water of milk which causes inhibition of the ability of water molecules association, their magnetic power was very weak, finally they cracks and became free and scattered. This process inhibited crystal formation on pipes walls. Therefore, magnetic field cracks foreign materials found in water and increases ions movements (Al-Hilphy, 2011). However, fatshowed slight decrease in percentage, as it was decreased from 3.14% at zero time to 2.69% after 60 minutes of treatment. The reason was due to the adhesion of some fat molecules on the pipes walls of magnetic device. Since milk went through pipes at room temperature (25°C), fat molecules were solid and due to the fact that milk was not homogenizes.Milk protein showed slight decreases in percent from2.92% at zero time to 2.69% after 60 min. This may be due to association of protein withfatprecipitated on pipes walls(Korolenko et al, 1995).

Ash percentwas decreased from 0.55% at zero time to 0.5% after 60 minutes of treatment which may be due to the association of some minerals with fat and protein precipitated on the pipesSingh, (2001).
Lactose concentrate was decreased from 4.42% at zero time to 4.07% after 60 minutes of treatment. Thisdecrease was clear due to the small volume of milk used under the present study but on factory scale these changes would not be of importance. Homogenization of milk during large scale production will also decrease the importance of these changes.

Freezing pointwas changed from -0.509 at zero time to -0.468 after 60 minutes of treatment due to the decrease in lactose and minerals which are the main factors affecting the freezing point of milk.

Table (1). Chemical composition of milk before and after magnetizing exposure for different periods of time.

Magnetize field exposure time	Fat%	Protein%	Ash%	Moisture%	Lactose%	Freezing point C
0 min	3.14	2.92	0.55	88.97	4.42	-0.509
20 min	2.51	2.89	0.51	89.81	4.28	-0.475
40 min	2.50	2.73	0.51	90.13	4.13	-0.469
60 min	2.48	2.69	0.50	90.26	4.07	-0.468

Microbial content of magnetize milk were decreased ($P<0.05$) after different exposure periods (Table 2). It decreased from $250x10^4$ at zero time to $29x10^2$after 60 minutes of exposure by using magnetic field. Magnetic field causes a transfer of energy into ions which produce stream of ions which hit in highvelocity (Hofmann, 1985). Ions like calcium which possibly go through cell membrane frequently since reaction sites are influenced by magnetic field. The movement of ions due to the effect of magnetic field treatment may affect the cell membrane and the ability of transference through the cell walls (Moore, 1979). As well as magnetic fieldworks ondisengagementbetweenions andproteinsthat are connected to the cell wall and leadsto the weakening ofthe bacterial cell membrane, leading to their deathby damagingofDNAand the elimination ofthe number of microbes. Magnetic field treatment resulted in complete destruction ofE. coli,Yeastandmolds (Kimball, 1937; Van Nostran et al, 1967; Scaiono et al., 1994).On the other hand, the following empirical equations used to calculation of log total count of Bactria and count of staphylococcus are produced from practical data.

$$\log(y)_{\text{Totalcountofbactria}} = -0.05\, t + 6.3179 \qquad R^2=0.986 \tag{3}$$

$$\log(y)_{\text{staphylococcus}} = -0.0069\, t + 1.9601 \qquad R^2=0.969 \tag{4}$$

Where t is the magnetic time (min.) and y is the total count.

Table (2) Microbial content of milk before andaftermagnetic field treatment for differentperiod's exposure time

	Total bacterial count	E. coli	Staphylococcus	Yeast & molds
0 min	$250x10^4$	absent	86	absent
20 min	$200x10^3$	absent	70	absent
40 min	$13x10^3$	absent	52	absent
60 min	$29x10^2$	absent	33	absent

Figure 3 showed that the calculated and experimental ratio of survived to total counts of microorganisms (C/CT) in milk had been decreased with increasing time of exposure of magnetic field. The results also showed there is substantial convergence between the experimental and the calculated results and the coefficient of correlation R^2 and RMSE 0.999, 0.000451, respectively. Also, the k value has been calculated by using mathematical modeling (k=-0.53671) and the equation 1 becomes as follows:

$$\left(\frac{C}{CT}\right) = \exp(-0.53671\Lambda_r \frac{t}{w}) \tag{5}$$

Figure 4 shows the change of D-values with increasing exposure time of magnetic field. Although, changes were not significant, but it may of importance after storage of milk. The D-values of microorganisms in milk treated by the magnetic field were less than the traditional pasteurization. The decline of D-value refers to increasing speed of destruction of microorganisms.

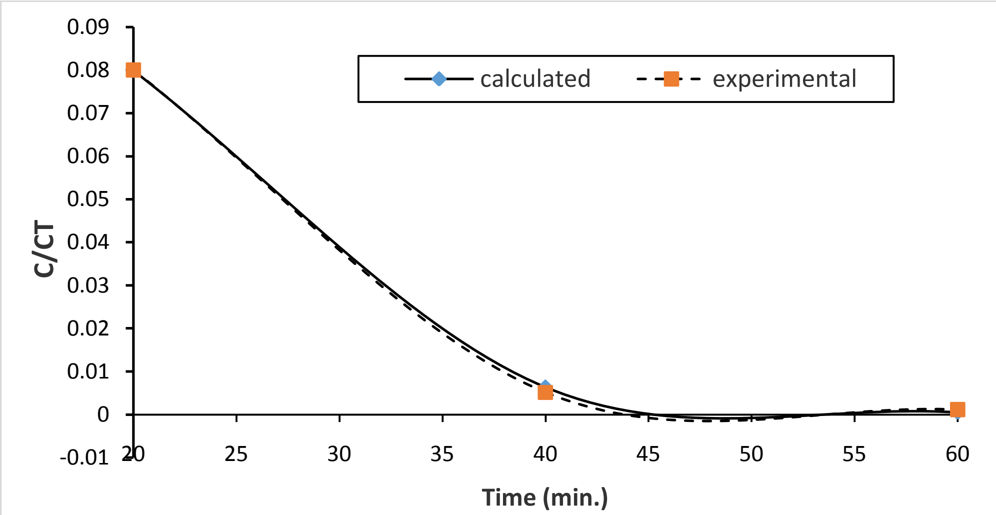

Figure 3. Calculated and experimental ratio of survival microorganisms to total (C/CT) in milk treated by magnetic field.

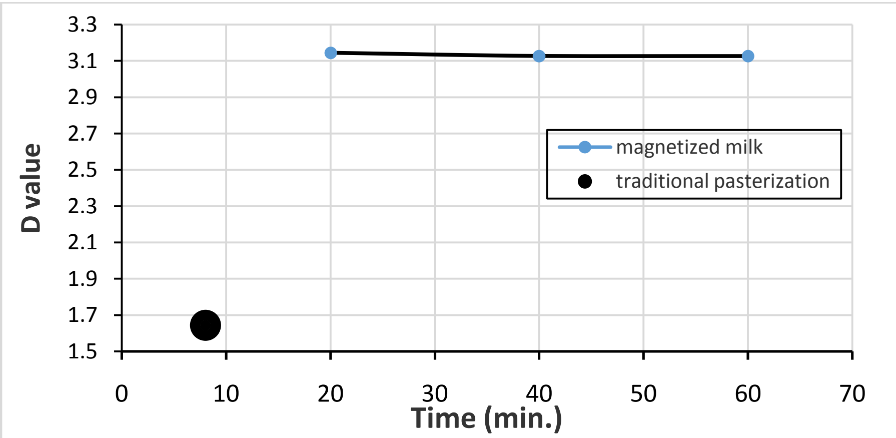

Figure 4. The D-values of microorganisms in milk treated by magnetic field and by traditional pasteurization.

Table (3) shows the chemical composition ofcheeseproduced from either milk treated by fast pasteurized milk (70°C for 15 Sec.) or after exposure to magnetic field treatment. The differences in the moistures contents in both types of cheeses were not significant. Cheese making changes the distribution of moisture within the structure of cheese as compared to that of milk components. These results were in agreement with that revealed by Kanka et al., (1989).Thermal treatments denatured whey proteinsslightly and may be associated with casein. Retention of whey proteins increased water holding capacity. As moisture percent elevated due to whey protein association with casein play fundamental role in increasing cheese yield from thermally treated milk (Quintanilla and Pena, 1991).Results also showed that cheese produced from magnetic field treated milk did not differ significantly from cheese produced from milk treated with 72°C for 15 sec. However, significant ($P<0.05$) decrease in fat% when milk treated thermally due to loosing part of milk fat with the whey, this is agreed with Ghosh et al., (1999). The table also showed insignificance differences in ash% of the resultant cheese. Cheese pH non-significantly decreased, while titrated acidity increased significantly ($P<0.05$) due to the dissolved CO_2 and to the development of acidity during magnetic field treatments. These results are in agreement with the results of Abd El-Salam et al., (1992) and Elein et al., (1999). Thermally treated milk may cause lowering pH, increasing calcium phosphate precipitation and whey protein denaturation which interact with caseins, Millard reaction, caseins modification and increase overall hydrolysis (Robinson, 1994).These changes depend on the severity of heat treatments.

Table (3) Chemical composition ofCheese produced from pasteurized milk and milk exposed to magnetic field

	Moisture%	Protein%	Fat%	Ash%	pH	Titrated Acidity
Cheese produced from milkpasteurized at 72°/15 sec	**60.3 a**	**19.3 a**	**17.4 a**	**2.8 a**	**6.45 a**	**0.15 a**
Cheese produced from magnetic milk	**60.26 a**	**19.9 a**	**17.4 a**	**2.7 a**	**6.59a**	**0.14 b**

Table (4) showed the microbial content of fresh white cheese produced from pasteurized milk fast method at 72°c for 15 sec and magnetic milk. Both type of cheeses were free of microbes, which improves cheese shelf life. As for the noteE. ColiandStaphylococcus and Yeast&molds the absence of anygrowth forthembecause of the influence of magnetic field on them. These resultsagreed with those ofTsuchiya et al., 1996;Rahman et al., (2000); Johnson (2001) ;Ray (2001); Carlos (2002).

Table (4) Microbial content of white soft cheese

	Bacteria total count	E. coli	Staphylococcus	Yeast & molds
Cheese produced from Pasteurized milk at 72°/15sec	180	absent	absent	absent
Cheese produced from magnetic milk	120	absent	absent	absent

Table (5) revealed cheese yield produced by after milk pasteurization at 72°c for 15 sec and magnetic milk. The yields were 17.8% and 18.7%, respectively. This result reflected the economic importance of magnetizingmilk. Retention of milk components should be at its optimum particularly due to the lackofmilk production in Iraq where anydrops of it should not be lost. During cheese manufacturing, whey proteins, fat, lactose and minerals are usually lost during running of whey. In Iraq this whey goes into the drain causing several ecological problems. Cheese overall quality produced by magnetic method also showed better net production. These results agreed with those of Law (Salaih and Al-Omar, 1984). Magnetic field caused increase inions movements such as calcium as an important salt in milk protein association and lead into higher yield production. When measuring thestrengthof rennet it became clear when usingmilkexposed tomagnetic field milk rennet curdstrengthwas up to8765Unitwhile it was for curd produced from pasteurized milkat72 ° Cfor 15 seconds7765 Unit.

Table (5) Cheese yield from pasteurized or magnetized milk

Type of milk that used in making cheese	Yield
Cheese produced from Pasteurized milk at 72°/15 sec	17.8
Cheese produced from magnetized milk	18.7

Organoleptic evaluation tests of different types of cheese are shown in table (6). Cheese produced from magnetized milk was better organoleptically ($P<0.05$) than cheese produced from pasteurized milk. These results are in agreement with those ofMenendes et al., (2003).

Table (6) Organoleptic evaluation of cheese produced from pasteurized and magnetized milk

	Taste 40	Texture 35	Color 15	Total acceptance 10	Total
Cheese produced from Pasteurized milk at 72°/15 sec	35 a	29 a	13 a	8 b	85 a
Cheese produced from magnetized milk	37 a	32 b	13 a	8 b	90 b

Conclusion

In conclusion magnetic field destroyed microbes and resulted in higher cheese yield. Further studies are required on microstructures of milk and cheese treated by magnetic field and on the distribution of moisture within milk and cheese. Nature and type of interaction between protein, fat and minerals resulted from magnetic fields treatments.

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