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THE MICROWAVES EFFECTS ON LIQUID FOODS

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Abstract

The microorganisms present in food could be beneficial (for example in the fermentation's process) or could cause human health risk. For this reason, is necessary a good control of microorganisms in food. There are two kinds of factors that affect growth and survive of pathogenic microorganisms in food:

1) *intrinsic factors such as: acidity, pH, water activity, redox potential, the presence of nutrience;*
2) *extrinsic factors: storage conditions (temperature, time and humidity) and the type of processing and packaging.*

In our days, the traditional thermal process used for pasteurization of liquid foods is replaced with new methods: electronic pasteurization, high-pressure processing, and pulsed electric field technology.

In this paper we present a report about the microwaves field on different microorganisms from liquid foods (fresh milk). It was used a microwave source with 2.4 GHz frequency and max. 1500 W power, for different exposure times. It was determined the total number of germs per ml, from every samples and compared with the standard. It remarks that the microwaves effects on microorganisms depend on electric fields strength, the treatment time and the shape of the pulse wave.

Keywords: *microwave, milk, microorganisms.*

INTRODUCTION

Food microbiology has been an interesting science to mankind for centuries and continues to deepen its roots in recent years. Microorganisms in foods continue to be a problem both to the safety and quality of food products, and hence food safety continues to be an important issue for the industry. There are several factors affecting the survival and growth of microorganisms in foods, and understanding these factors will aid in controlling microorganisms in foods. Detecting microorganisms in foods is an important issue, and there are several methods available.The industry is continuing to develop rapid methods for better detection. There are several technologies (physical, chemical, and biological) used to control or reduce microorganisms in foods. Apart from the traditional processes such as thermal processing, novel technologies such as high-pressure processing, pulsed electric field processing, irradiation, and others are also being developed.Using appropriate detection and control methods, the industry should be able toproduce a safe food supply for the current consumer (Ravishankar and Maks, 2007).

Milk is a complete and complex food, with high nutritional value. In the same time, it represents a good environment for the development of all organisms. The raw milk will always contain a lower or higher number of bacteria, according to animal health and the compliance with the hygiene rules. Microorganisms in milk causes degradation of key components: lactose, protein and fat.

The quality and quantity content of microbiota from milk differs depending on the source of contamination and is conditioned mainly by the conditions of hygiene laid down in legislation and primary treatment applied to milk. The normal microbiota of milk contains: lactic bacteria, propionic bacteria and typical yeasts.

The thermal treatment like: thermization, low temperature for long time,high temperature for short time, ultra high temperature or sterilizationareclassical methods used in our days; they can produce distortion of milk proteins or could have adverse effects on appearance, taste and nutritional value of milk.

The high temperatures offers the advantage of rapid inactivation of microorganisms and enzymes, and short exposure time provides less undesirable changes in milk quality. The conventional antibacterial treatment applied to milk should not modify sensory and physico-chemical properties of milk.

The unconventional antibacterial treatments applied on milk are: sterilization by ionizing radiation, ultrasound treatment, electropasteurization, the used of microwave etc.

By irradiating milk, besides bactericidal effect occur a number of changes in milk components: the destruction of vitamins A, E, C, B12, PP, fat oxidation (rancid and bitter taste occurs), lactose and proteins undergo modifications.

The ultrasound treatment is a method of hygienisation the milk, which does not lead to complete destruction of microorganisms. If ultrasound intensity increases, increase the destruction of bacteria, but appear negative influences on milk components.

The advantage of electropasteurization is that this hygienisation system can treat milk after packaging. The main disadvantage is the high cost of treatment that greatly limiting its application on an industrial scale.

Microwaves are nonionizing radiation, with varying electromagnetic waves of radiant energy with frequencies ranging from 300 MHz to 300 GHz. Domestic ovens operate at 2.450 MHz.

In food heating operations, microwave heating offers several distinct advantages when are compared to conventional heating methods. The advantages include speed of heating, energy saving, precise process control, and faster start-up and shutdown times. Other advantages include higher quality product in terms of taste, texture, and nutritional content.

There are two main mechanisms by which microwaves product heat in dielectric materials: ionic polarization and dipole rotation. Ionic polarization occurs when ions in solution move in response to an electric field. Kinetic energy is given up to the ions by the electric field. These ions collide withother ions, converting kinetic energy into heat. When the electric field is rotating at $2.45 x 10^9$ Hz, numerous collisions occur, generating a great deal of heat. However, thedipole rotation mechanism is more important. It is dependent on the existence of polar molecules. The most common polar material found in foods is water.Water molecules are randomly oriented under normal conditions. In the presence of an electric field, the polar molecules line up with the field. As mentioned above, the electric field of a microwave system alternates at 2.45×10^9 Hz, so that while the molecules try to align themselves with this changing field, heat is generated. When the field is removed, the molecules return to their random orientation.

The dielectric property is most important in the microwave heating of foods. The dielectric properties of foods at microwave frequencies are related to their chemical composition. They are also highly dependent on the frequency of the applied electric field, the moisture content, temperature, and bulk density (Decareau, 1985).

Sterilization refers to the complete destruction of microbial organisms. Commercially, sterility means that all pathogenic, toxic-producing organisms and spoilage organisms have been destroyed or reduced to safe levels. Microwave sterilization operates in the temperature range of 110–130°C. Pasteurization is a gentle heat treatment usually at temperatures between 60 and 82°C. Microwave sterilization/ pasteurization has been applied to several foods including fresh pasta, bread, granola, milk, and prepared meals. The main advantage of microwave sterilization or pasteurization is the effective reduction in the time required for the heat to penetrate to the food center (Tewari, 2007).

The microwave heating of food is directly influenced by food properties regardless of their nature. Thus, density, surface area its exterior shape, size, salt content and moisture, thermal and electrical conductivity, initial temperature, heat capacity and dielectric properties form a sum of factors that determine the rate of heating, heat transfer and penetration depth of microwaves (Albert et al., 2009).

The dielectric properties of foods and their dependence on temperature, frequency and composition have a great influence on the temperature distribution developed during microwave sterilization (Ohlson and Bengtsson, 1975).

Milk as colloidal material has electrical charges likely to move under the influence of electric

field of the microwaves. The heating generated by microwave can significantly reduce the time required for pasteurization and sterilization comparative with the classic methods. As an immediate result of this, the quality for pasteurized or sterilized food by microwave increase significantly (Constantin, 2011).
The milk pasteurization by continuous microwave proved to be an effective method to achieve a satisfactory product quality in microbial and sensorial terms, free from damage caused by thermal effect (Da-Wen, 2005).

MATERIALS AND METHODS

In this paper we made preliminary tests of microwave treatment for milk samples, to relieve the effects of unconventional methods on milk microbiota.
For milk treatment, we realized an experiment with a microwave source, defined by power 1500 W and frequency 2.4 GHz. The mean value of irradiance was 250 mW/cm^2 and the mean intensity of electric field was 15 V/m. Both of these operational factors were invariable during the experiment.
The time of exposure was 15, 30, 60, 90 and 120 seconds for 1 to 5 variants (V1 to V5).
The fresh cow milk sample was from Ciupa farm, Arges County. The samples were tested for chemical properties with Lactosar device and the microbiological properties were established by inoculating on nutrient media. These two kinds of tests were realized both before and after microwave exposure.
The determined chemical properties were fats, proteins, lactose and dry matter. Also, we established the freezing point before microwave exposure and after that.
The microbial categories were: yeasts and moulds (YM), determined on Compact Dry YM medium; total number of viable bacterial cells (TVC) determined on Compact Dry TC medium, lactic acid bacteria (L), determined on Lafon Lafourcade medium.
The samples were diluted from 10^{-1} to 10^{-3} and 1 ml of each appropriate dilution was inoculated on the adequate medium in three repetitions. The inoculated media were incubated at 37°C for 24 h (L) and 48 h (TVC), at 30°C for three to five days for yeasts and moulds.
The number of colonies was counted with Funke Gerber colony counter and for each sample was established the number of colony forming units per ml (CFU/ml) in terms of yeast and moulds, total viable aerobic bacteria and lactic acid bacteria.

RESULTS AND DISCUSSIONS

The results of chemical tests are presented in Table 1. The values before exposure were in normal range for fresh cow milk. After exposure, all the samples had almost the same values. No significant differences between the milk samples before and after microwave exposure were observed.

Table 1. The chemical properties of milk samples

	Fats (%)	Proteins (%)	Lactose (%)	Dry matter (%)	Freezing point (°C)
Before exposure	4,0	3,5	5,1	9,35	-0,599
After exposure					
V1 (15′)	3,85	3,53	4,9	9,14	-0,582
V2 (30′)	3,94	3,53	4,9	9,14	-0,582
V3 (60′)	3,94	3,53	4,9	9,14	-0,582
V4 (90′)	3,94	3,53	4,9	9,14	-0,582
V5 (120′)	3,94	3,53	4,9	9,14	-0,582

Some minor differences may be registered because of irregular blending of samples, but the microwave treatment does not decrease the amount of important substances from milk.
The results of microbiological tests for fresh milk sample are presented in next figures.
In Figure 1 are presented the number of CFU/ml for yeasts and moulds (YM), on the Compact dry YM medium. The untreated sample (UT) had 600 CFU/ml of milk and V1 (after microwave irradiation over 15 seconds) had 200 CFU/ml, whereas the other variants (V2 – V5) were lack of yeasts and moulds.
The total number of viable aerobic bacterial cells (TVC) for untreated sample (UT) and microwave irradiated samples (V1 - V5) are presented in Figure 2. The number of viable cells decreased from untreated sample and V1 to other variants. The decrease was significant for V2 variant (after microwave irradiation over 30 seconds), while V3 and V4 had similar values for total bacterial cells. The smallest

value was registered for V5 variant, just 150 CFU/ml.

The lactic acid bacteria were determined on Lafon Lafourcade medium and the number of viable cells (CFU/ml) decreased significant after 30 second of irradiation (Figure 3). The values for V3, V4 and V5 registered an easy decline.

In Figure 4 are presented bacterial colonies on Compact Dry TC medium, for the untreated sample.

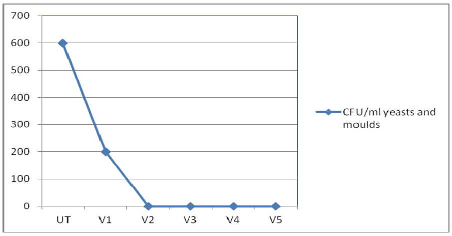

Figure 1. Yeasts and moulds in milk samples

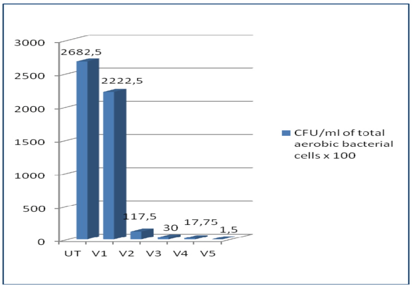

Figure 2. Total viable bacterial cells in milk samples

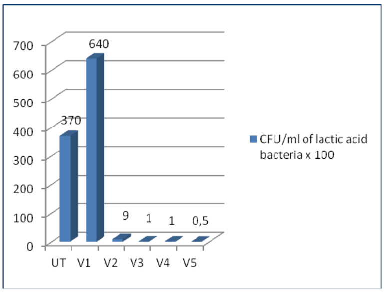

Figure 3. Lactic acid bacteria in milk samples

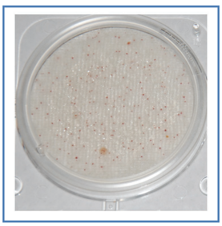

Figure 4. Bacterial colonies on Compact Dry TC

CONCLUSIONS

The microwave irradiation may be use as unconventional method of milk sterilization.

This treatment does not produce significant alteration of chemical properties under 250 mW/cm^2 (irradiance) and 15 V/m (electric field intensity).

The effect of microwave irradiation on milk microbiota is obvious, in terms of decrease the number of yeasts, mould, total viable bacterial cells and lactic acid bacteria. The most significant differences were registered over 30 seconds of irradiation.For exposure time longer than 30 seconds, neither yeast nor mould cells were viable in the milk samples. The colony forming units for total bacteria decreased from $2682.5x10^2$ for untreated sample to $30x10^2$ or less for exposure time longer than 30 seconds. The decrease was registered for lactic acid bacteria too, in the same manner, for exposure time 30 seconds or more the colony forming units were 100-fold less than untreated sample.

The additional experiments with microwave irradiation are needed for the fresh milk at different time exposure, in order to obtain the sterile samples.

Considering these results, we intend to continue research with microwave irradiation for other liquid food (such grape juice).

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