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RESEARCH ON THE INFLUENCE OF MICROWAVE TREATMENT ON MILK COMPOSITION

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Abstract: *A quality milk product has to fulfill various quality demands. Milk must be a qualitative product and also must be preserved a long time without any changes in the chemical or physical structure. This paper presents the permanent connection between preservation and milk compounds and also presents the physical and chemical changes taking place when milk is treated at high temperature with microwave energy.*

Key words: *milk quality, microwave, treatment.*

1. Introduction

The safety and also the quality of the liquid food products are the two main factors that influence the customers' choice. Conventional methods used for liquid food preservation and sterilization often have as result a number of undesired changes in foods like loss of smell, color, flavour, texture and losses of nutritional value. So, conventional preservation method used in liquid food case increase the safety and the life time of the product but decreases the freshness and the final product quality [3].

For the customers the most important food characteristics are the sensory characteristics like flavor, color, smell, texture etc. In most cases all these characteristics trigger the choice made by customers. Maybe today most important challenge for the food producers is how to be able to store food from time of plenty to time of need or how to transport food over long distances and to keep negative changes in quality to a minimum. A goal of food manufactures is to develop new methods used in processing technologies that retain or create desirable sensory qualities or reduce undesirable changes in food due to processing [1].

2. Milk Composition and Properties

Milk can be considered a fat emulsion in an aqueous solution containing many other substances, some in colloidal form (protein substances) and other in dissolved state (lactose, minerals, water soluble vitamins, enzymes).

Quantitatively, the predominant component of milk is water (approx. 87.5%) and total dry matter (total dry extract) is approx. 12.5% which is the nutritious milk. If one liter of milk is heated at 100 °C until all water evaporates it will remain a yellow-brown residue, (dry weight), with a weight ranging from 110-140 g/L.

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The chemical composition of milk varies according to animal species and other factors: breed, diet, age etc. As qualitatively different types of milk composition is the same, only proportions of various constituents are different (Table 1).

Fat is one of the most important components of milk. It is on the form of finely dispersed spherical cell diameter of 0.5... 20 µm.

Milk fat is secreted from mammary epithelial cells as fat globules which are primarily composed of a globule of triglyceride surrounded by a lipid bilayer membrane similar to the apical membrane of the epithelial cells (discussed in more detail in the Lesson on Milk Fat Synthesis). This fat globule membrane helps to stabilize the fat globules in an emulsion within the aqueous environment of milk (remember that cow milk is about 87% water). Lipid has a lower buoyant density than water, so when raw milk is centrifuged the fat rises to the top resulting in the cream layer.

Different milk content Table 1

Indicator	**Milk types:**		
	Cow	***Buffalo***	***Sheep***
Water [%]	87.7	82.8	82
Fat content [%]	3.4	7.7	7.2
Proteins [%]	3.3	4.0	5.6
Lactose [%]	4.9	4.8	4.3
Mineral salt (ash) [%]	0.7	0.7	0.9

In general, the gross composition of cow's milk is 87.7% water, 4.9% lactose (carbohydrate), 3.4% fat, 3.3% protein, and 0.7% minerals (referred to as ash) (Figure 1). Milk composition varies depending on the species (cow, goat and sheep), breed (Holstein, Jersey), the animal's feed, and the stage of lactation.

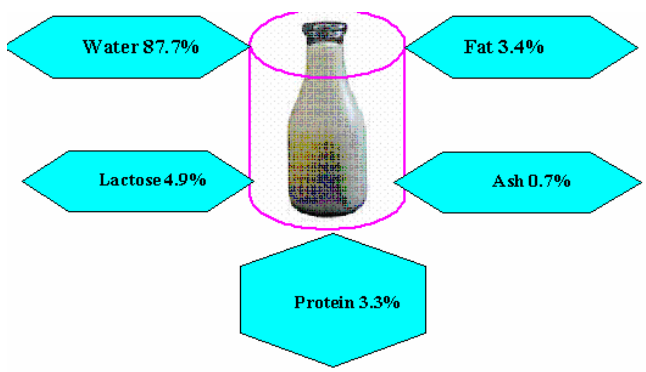

Fig. 1. *Cow milk composition*

3. Milk Chemical Deterioration

Proteins can be degraded by enzyme action or by exposure to light. The predominant cause of protein degradation is through enzymes called proteases. Milk proteases come from several sources: the native milk, airborne bacterial contamination, bacteria that are added intentionally for fermentation, or somatic cells present in milk. The action of proteases can be desirable, as in the case of yogurt and cheese manufacture, so, for these processes, bacteria with desirable proteolytic properties are added to the milk. Undesirable degradation (proteolysis) results in milk with off-flavors and poor quality [2].

3.1. Influence of Heat Treatment on Milk Proteins

The caseins are stable to heat treatment. Typical high temperature short time (HTST) pasteurization conditions will not affect the functional and nutritional properties of the casein proteins.

The whey proteins are more sensitive to heat than the caseins. HTST pasteurization will not affect the nutritional and functional properties of the whey proteins. Higher heat treatments may cause denaturation of ß-lactoglobulin, which is an advantage in the production of some foods (yogurt) and ingredients because of the ability of the proteins to bind more water. Denaturation causes a change in the physical structure of proteins, but generally does not affect the amino acid composition and thus the nutritional properties. Severe heat treatments such as ultra high pasteurization may cause some damage to heat sensitive amino acids and slightly decrease the nutritional content of the milk. The whey protein α-lactalbumin, however, is very heat stable [2].

3.2. Influence of Heat Treatments on Milk Fat

Milk fat has a wide melting range, and is fully melted at 104 °F (40 °C). Typical high temperature short time (HTST) pasteurization conditions do not affect the functional and nutritional properties of milk fat. Higher heat treatments may stimulate oxidation reactions and cause fat deterioration and off-flavors. High heat treatments such as ultra high temperature (UHT) pasteurization can disrupt the milk fat globule membrane proteins and destabilize the globules, resulting in their coagulation.

3.3. Effects of Heat Treatments on the Vitamin and Mineral Content in Milk

The mild heat treatment used in the typical high temperature short time (HTST) pasteurization of fluid milk does not appreciably affect the vitamin content. However, the higher heat treatment used in ultra high temperature (UHT) pasteurization for extended shelf combined with the increased storage life of these products does cause losses of some water-soluble vitamins. Thiamin is reduced from 0.45 to 0.42 mg/L, vitamin B 12 is reduced from 3.0 to 2.7 μg/L, and vitamin C is reduced from 2.0 to 1.8 mg/L. Riboflavin is a heat stable vitamin and is not affected by severe heat treatments [2].

4. Materials and Method

Microwave heating system used, as can be seen from Figure 2, is composed of a single mode resonant cavity and two waveguides carrying electromagnetic waves and distribute evenly inside cavity. Two sources of excitements (magnetron) that have a cumulative power of 1700 W are arranged on top of the waveguides. Liquid, in this case milk, flows through silicone helical pipes center located inside a treatment room.

Cow milk was exposed in continuous flux to microwave treatment in order to obtain sterilized milk. The maximum temperature 100.4 ^{0}C was obtained using all the 1700 W power.

The temperature of the system was controlled by using 4 thermistors located in the key points of the heating system, inlet and

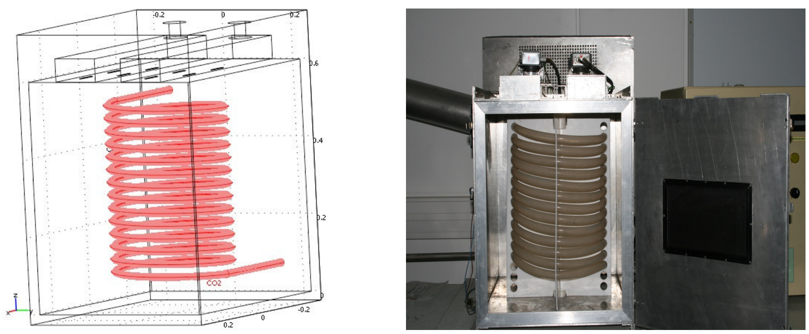

Fig. 2. *Experimental setup*

outlet. Also a thermo vision camera was used to measure the radiant surface temperature as can be seen in Figure 3.

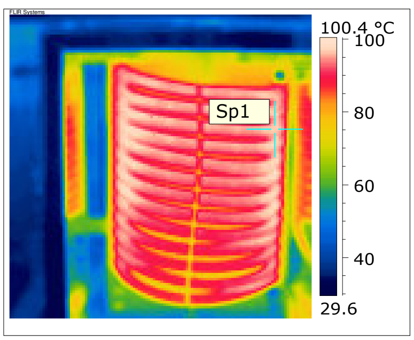

Fig. 3. *Termo vision capture*

The milk studied and subjected to high microwave temperature was also analyzed from the physical and chemical point of view before and after going under microwave field using Lactostar analyzer as it can be seen in Figure 3. A sample of 20 mL of milk was analyzed at different temperature reached in microwave oven. Treated milk was cooled to the maximum temperature of 35 °C which is accepted by the lactostar analyzer.

5. Results and Discussions

A total of 4 samples were analyzed (see Table 2). First sample was collected from the initial milk which was not processed. Sample 2, 3, 4 where collected at different temperature reached in microwave field. As it can be send in Table 2.

Sample encoding Table 2

Sample 1	Initial milk
Sample 2	Milk at 92 °C, 5 s
Sample 3	Milk at 98 °C, 3 s
Sample 4	Milk at 99 °C, 2 s

After analysis the four samples these results were obtained, Figure 4. It can be seen that where not significant denaturation of the protein and lactose content. Protein content was affected with a 0.05 percentage and lactose decreased with 0.06%.

The FP value of heat-treated milk depends on the FP value of raw milk and on changes in the milk FP in the process of heat treatment. Heat treatment causes an increase in the FP of pasteurized milk ranging from 0.001 to 0.009 °C as opposed to the FP values of raw milk ascribed the increase in milk FP to a change in the calcium phosphate complex and to a change in the pressure of carbon dioxide.

This shift is represented by approximately 0.002 °C depending on the temperature and duration of heat treatment. The following influences can also come into action: milk adulteration e.g. with residual water, loss of salts caused e.g. by the formation of milk stone deposits, changes in milk acidity e.g. due to the formation of lactic acid while

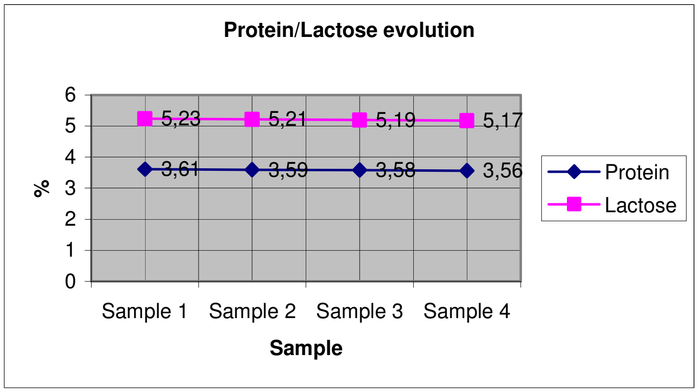

Fig. 4. *Protein/Lactose evolution*

fermenting lactose and gas content in milk.

During the production, handling and processing of milk, small quantities of water may adulterate milk. This may result from washing and sterilizing procedures or from careless practices. Therefore it is of practical importance to know the extent of variations in freezing point results and the upper tolerance limit for determination of extraneous water.

The freezing point of the milk increased during this experiment as the literature said with only 0.007% (Figure 5). Different reasons could be responsible for this increase of the freezing point as high temperature used for the heat treatment and also the time exposure of the milk at this high temperature.

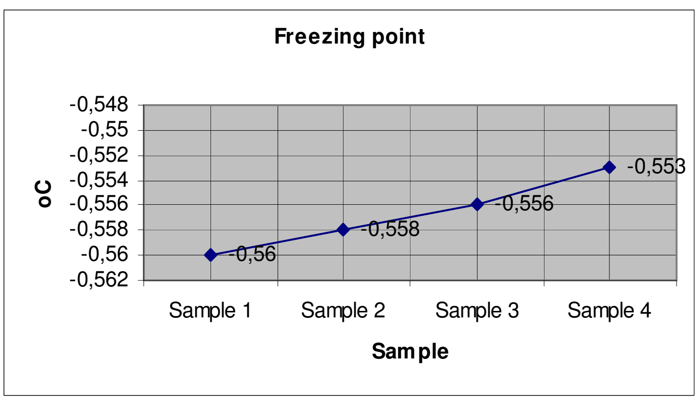

Fig. 5. *Freezing point evolution*

6. Conclusions

- The safety and also the quality of the liquid food products are the two main factors that influence the customers' choice.
- Conventional methods used for liquid food preservation and sterilization often have as result a number of undesired changes in foods like loss of smell, color, flavour, texture and, maybe most importantly, generate losses of nutritional value. So, conventional preservation method used in

liquid food case increases the safety and the life time of the product but decreases the freshness and the final product quality [1].

• Maybe today the most important challenge for the food manufacturers is how to be able to store food from time of plenty to time of need or how to transport food over long distances and to keep negative changes in quality to a minimum. A goal of food manufactures is to develop new methods used in processing technologies that retain or create desirable sensory qualities or reduce undesirable changes in food due to processing [3].

• After this experiment it could be said that there are not significant modification in the chemical structure of the cow milk treated with microwave power at high temperature. The changes are visible only at the third decimal for the milk freezing point and the second decimal for the protein and lactose composition.

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