Bulgarian Chemical Communications, Volume 46, Special issue B (pp. 142 – 145) 2014

Effect of active packaging material on milk quality

M. Galikhanov, A. Guzhova*, A. Borisova

Kazan National Research Technological University, 68 Karl Marx Str., 420015 Kazan, Russian Federation.

Submitted August 6, 2014; accepted December 10,.2014

Effect of active electret package on milk quality was studied. Electric charge of electret package was shown to reduce milk acidity growth by 2 °T a day in average and to elongate milk shelf life by half. Electric field of the package affects milk composition: lactose content in milk decreases, density grows, while protein content remains unchanged. Milk particle micellization model in electric field of the package was suggested.

Keywords. Milk, active package, electret.

INTRODUCTION

Role of packaging in food quality preservation is known worldwide. Basic function of packaging is protection from climatic factors (oxygen, moisture, light and temperature), transportation and storage damages and biological factors (microorganisms, insects, etc) [1]. However, many food products contain microorganisms that cause food spoilage when stored. Milk and dairy products are generally very rich in nutrients which provide an ideal growth environment for many microorganisms. Milk, for example, contains *Lactobacillus, Pediococcus, Lactococcus, Streptococcus,* etc.

Dairy products are exposed to different treatment at milk processing factory. Bactofugation, pasteurization, sterilization and ionization are the most common techniques used to reduce microorganism content in milk products [2]. Their combination eliminates up to 99 % bacteria [2]. Pasteurization process involves heating milk for 15 – 20 s at 90 – 92°C; during sterilization milk is heated above 100 °C under pressure. Such thermal treatment efficiently kills many forms of microbial life initially contained in milk, but it leads to destruction of vitamins and nutrients. Ionization radiation treatment is advanced technique used to elongate shelf life of products sensitive to high temperatures.

However, the objective is not only to delete undesired microorganisms in raw milk but to exclude new bacteria and prevent resurgence of the remained ones. Preserving agents are not always used as they can have negative health affect since a lot of nutrient additives may cause digestive disorder and skin problems being allergen or carcinogen. For this reason manufacturers are looking for advanced packaging that enables to preserve nutrients as long as possible. The challenge to extend shelf life of a product due to packaging specific physical properties is up to date in both economic and environment protection aspects.

Materials with targeted active action on packed products are classified as active packaging. They replace gradually traditional materials that perform mechanical and barrier properties. Production technologies of these materials are manufacturer's know-how [1]. These technologies include application of electric field produced by the packaging material as sterilant. Such kind of materials that have constant electric field is known as electrets. They are used in radio electronics, mechanical engineering and medicine [3-5]. It would be interesting to study their effect on packed products.

The corona poling of polyethylene packaging films results in a decrease in the total migration of different compounds from the film into food products[6]. The decrease in the amount of the migrant transferred from the poled polyethylene films into different solvents is due to the effect of their electric field on the wetting, dissolution, and diffusion processes.

In this paper we have studied application of electrets material as active packaging for milk. The objective of the paper is to determine effect of packaging material electric field on biochemical and biological processes that occur in milk during storage.

EXPERIMENTAL

At the first stage active packaging material was manufactured by LDPE film corona poling [3]. Samples were charged in the field of negative

* To whom all correspondence should be sent.
E-mail: alina_guzhova@mail.ru

corona discharge after being heated at 90 °C for 10 min. Corona treatment unit is shown in Figure 1. Corona electrode consists of 196 needles equally spaced on 49 cm^2 area. The gap between corona electrode and the sample was 20 mm, polarization time was 30 s, polarization voltage – 30 kV.

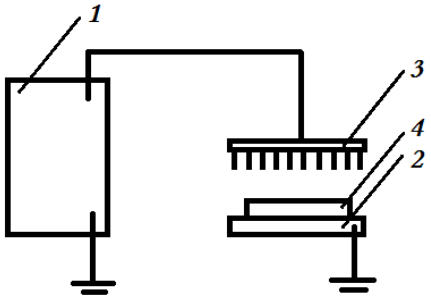

Fig. 1. Corona discharge system: 1 – high voltage source, 2 – grounded electrode, 3 – corona electrode, 4 – sample.

Corona electret characteristics were following: surface potential (~ 1500 V), efficient surface charge density (~ 0.85 μC/m^2), electric field strength (~ 60 kV/m).

Packages for milk were made of electret material and industrial PE film using thermal impulse sealer IS - 600. Quality changes of milk packed according to GOST 13277-79 (Russian Standard) was studied. It was examined for bacterial number (total bacteria number per volume unit), number of Escherichia coli (coli-titer), organoleptic characteristics and acidity (GOST 13264-88).

RESULTS AND DISCUSSION

Over time, off-flavor appears in milk that is not specific to fresh product (greasiness, rust and etc.). This disadvantage can appear due to accumulation of free fatty acids resulting from life activity of microorganisms and lactose fermentation to form lactic acid. Electric field was shown [8] to reduce respiratory rate, heat production and other energy parameters of bacteria. It indicates retarded metabolic process i.e. electric field inhibits bacterial activity.

Research performed showed that milk packed in electret film preserved initial organoleptic characteristics for a longer time. Electret package elongated milk shelf life by half. Figure 2 shows organoleptic evaluation of milk stored in active (curve 1) and traditional (curve 2) packages.

Electric charge of electret package reduced acidity growth by 2 °T a day in average i.e. it inhibited microorganism life activity. Acidity level decay (Turner degree) is given in Figure 3.

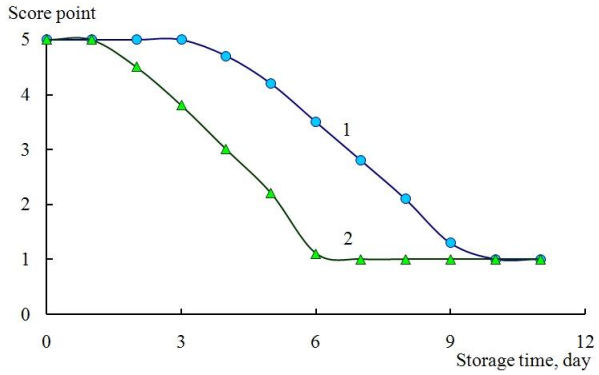

Fig. 2. Organoleptic evaluation of milk in electret (1) and industrial (2) package.

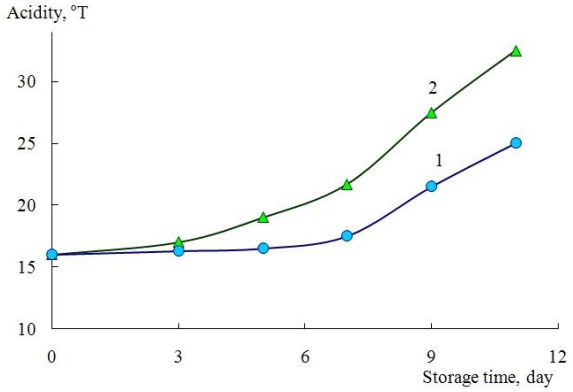

Fig. 3. Milk acidity when stored in electret (1) and industrial (2) package.

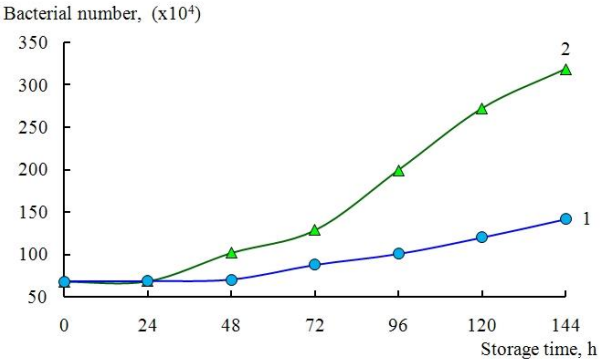

Fig. 4. Total bacterial content in milk packed in electret (1) and industrial (2) film.

Microbiological analysis data also point to the fact of bacterial activity inhibition. When industrial polyethylene film was used as packaging, number of mesophilic microorganisms in milk in two hours was higher compared to active package. Figure 4 illustrates that total bacterial content in milk packed in industrial film (curve 2) almost two and a half times exceeded total bacterial content in milk packed in active package (curve 1) by the sixth day. There were no Escherichia coli found in both raw and packed milk.

Besides, electric field of the package was revealed to affect dairy products composition (Table 1).

Table 1. Milk composition changes during storage.

Milk parameter	industrial PE film			electret PE film		
	0	**24 h**	**48 h**	**0**	**24 h**	**48 h**
Milk density, kg/dm^3	1026	1035	1066	1026	1031	1047
Protein weight fraction, %	3.427					
Lactose content, %	3.01	2.9	2.4	3.01	2.95	2.8

Lactose content in milk decreased, while density grew that represents microorganism life activity processes. At the same time protein content remains unchanged. These data correlate with changes of organoleptic, physical and chemical values.

Milk nutritional content associated with bioactive substances slightly decreased. However, when electret package was used, this process was slowed down significantly. It occurs due to the presence of electric-field sensitive substances in bacteria cells (e.g. coenzyme A) that determine, in particular, cell respiration system activity [7].

Milk is complex disperse system that includes components in different aggregate state: molecules and ions (some salts, lactose, water-soluble vitamins, etc.) and charged (mainly negative) colloid particles (casein, whey proteins, calcium phosphate and butterfat). There is a strong interaction between specific disperse phases i.e. single equilibrium system is formed. Any change in content and state of milk dispersion components under different factors (temperature, pH and etc.) may result in disequilibrium and system stability loss [2].

Colloid particle stability in milk is determined by electric charge. For example, casein micelles have negative surface charge. There are attractive and repulsive forces between colloid particles. If interparticle repulsive forces prevail, then the whole system is stable. As repulsive forces decline and attractive forces increase, system stability gets broken with coagulation and agglomeration of colloid particles. Visually it corresponds to cream layer formation on a milk surface. This process is accompanied by casein negative charge decay.

Electric field of active package effects colloid system stability. In this case more uniform emulsion particle distribution is observed.

In this regard, premature coagulation of casein and other milk components can be prevented due to package negative charge distribution in milk.

Milk is bad electric conductor. Its conductivity is associated with Cl^-, Na^+, K^+, H^+, Ca^{2+}, Mg^{2+} and other ions. Although casein, whey proteins and fat globules have electric charge on surface, they move slowly owing to large size and increase viscosity of the solution and in practice reduce electric conductivity. Calcium phosphates are of the most interest. One part of them is molecular solution, another one is colloid and equilibrium is established between them. Equilibrium stability is affected by milk acidity. Milk acidity is increased due to growth of microorganisms that ferment lactose to form milk acid. It decreases negative charge of protein particles and disrupt the balance between calcium salts i.e. some colloid calcium salts are transformed into ionic-molecular state.

This process can be presented by the following model (Figure 5).

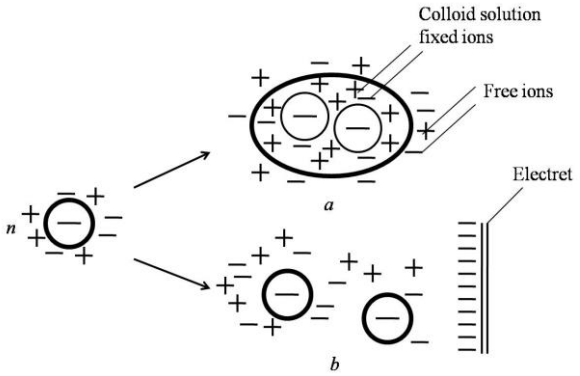

Fig. 5. Milk particle micellization model: a – micelle coagulation when attraction forces prevail during storage; b – micelles in solution exposed to negative electric field of the corona electret.

Typically, equilibrium is shifted to excess of calcium and magnesium ions with the phosphorous and citric acid distribution breaking [8-10]. As milk acidity grows, electric conductivity and number of coagulated particles (Figure 5a) increase as well. Milk in active package shows another pattern (Figure 5b). Electric field is seen to affect colloid system equilibrium in dairy products –more uniform distribution of emulsion particles is observed.

Hence, application of electret material as active package has following peculiarities. On the one hand cumulated electric charge affects microorganisms; on the other hand it stimulates initial equilibrium state of milk dispersive system. Moreover, electric field - that has negative charge – improves milk keeping qualities. More uniform emulsion particle distribution was observed for milk packed in electret films.

Based on obtained results one may state that active package with negative electric field enables to extend shelf life, preserve milk organoleptic and physical characteristics.

REFERENCES

1. O. G. Piringer, A. L. Baner Plastics packaging Materials for food. Barrier function, mass transport, quality assurance, and legislation, Wiley-VCH (2000).
2. Hand Book of Milk Processing, Dairy Products and Packaging Technol., Engineers India Research Inc. (2007).
3. G. Sessler (Ed.). Electrets, Springer, Berlin (1987).
4. V. N. Kestelman, L. S. Pinchuk, V. A. Goldade. Kluwer Acad. Publ., Boston, Dordrecht, London (2000).
5. T. Yovcheva. New York: Nova Sci. Publ. Inc. (2010).
6. M. F. Galikhanov, A. N. Borisova, R. Ya Deberdeev. *Polymer Sci., Ser*. A, **48**, 133 (2006).
7. A. V. Makarevich, L. S. Pinchuk, V. A. Goldade. IMMS NANB, Gomel (1998). (in Russian)
8. L. V. Chekulaeva, K. K. Poljanskij, L. V. Golubeva.Moscow: DeLi print (2002). (in Russian)
9. A. T. Andrews, J. R. Varley, Biochemistry of Milk Products, Woodhead Publ. (1994).
10. P. F. Fox , A. L. Kelly. Chemistry and Biochemistry of Milk Constituents (Food Biochemistry and Food Processing), Blackwell Publ. (2007).

ВЛИЯНИЕ НА АКТИВНИТЕ ОПАКОВЪЧНИ МАТЕРИАЛИ ВЪРХУ КАЧЕСТВОТО НА МЛЯКОТО

М.Ф. Галиханов, А.А. Гужова, А.Н. Борисова

Казански национален изследователски технологичен университет, ул. „Карл Маркс“ № 68, 420015, Казан, Руска федерация

Постъпила на 6 август, 2014 г.; приета на 10 декември, 2014 г.

(Резюме)

Изследвано е влиянието на активни електретни опаковки върху качеството на млякото. Показано е, че електричният заряд на електретните опаковки намалява нарастването на млечната киселинност средно с 2°T на ден и увеличава срокът на годност на млякото с 50 %. Установено е, че електричното поле на опаковката влияе на състава на млякото: съдържанието на лактоза в млякото намалява, плътността расте, докато съдържанието на протеини остава непроменено. Предложен е модел на мицелизиране на млечни частици в електричното поле на опаковката.