Effects of osmotic pressure environments lethal effects on the level of microorganisms in the conditions of evacuation

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Abstract

Introduction. The article deals with the possibility of osmotic pressure environment to act as a factor that, in certain quantities causes bacteriostatic effects and provides information about the strength of cell membranes and mechanisms of interaction with the environment. Experimental studies to determine the action of osmotic pressure environment at the level of lethal effects on different physical interactions.

Materials and methods. Research performed at chamber vacuum packing machine Easy PACK (Germany). The temperature environments in all cases were kept with the restriction on the maximum value $t \leq 38$ °C, which excluded lethal effects on this indicator. Vacuum pump composed laboratory facility provided residual pressure in the vacuum chamber at 0,002-0,004 MPa, corresponding to boiling temperature range environments ~ 20 ... 30 °C. Therefore, the initial ambient temperature $t_{(in)} \leq 15$ °C boiling point not taken place, and the transition to the initial ambient temperature of $20 < t_{(in)} \leq 38$ °C provided the boiling adiabatic mode.

Results. It is known that exposure of yeast in the water accompanied by increased physical pressure in the cells at the osmotic pressure of the cell sap. Transferring in osmotically active yeast solution leads to a reduction of physical pressure, which should be appropriately reflected by vacuuming. Increasing the osmotic pressure of the solution reduces the level of lethal effects of vacuuming, but nevertheless a significant impact on the achievement of the organization lethal effects adiabatic boiling environments. The influence of the level of lethal effects on microorganisms indicators such as exposure time environment and the dynamics of change of pressure in the vacuum chamber, the amount of solids in the environment and the importance of temperature conditions, and the presence or absence of boiling adiabatic environment under vacuuming.

Conclusions. Vacuuming biological environment by reducing the constant saturation gas liquid phase creates limitations in the mass transfer between microbiological cells and environment, and level of limits depends on the osmotic pressure of the solution. Achieved possibility of lethal effects on microorganisms accompanying the food environment, due to the aggregate impact of osmotic pressure and vacuuming.

Introduction

A large number of food and drink to some extent be attributed to the solutions. Last importance of the existence of biological systems, since power transfer biological objects made food components in solution.

The main properties of solutions based on experimental studies and focuses on the phenomenon of osmosis – the penetration of the solvent into the solution through a semipermeable barrier (membrane), impermeable to solute, the solution when it is separated from the pure solvent [1-4].

Osmosis phenomena play an important role in the life of flora and microorganisms, because cell membranes are easily permeable to water and almost impermeable to substances that are part of the cell sap. Penetrating into the cell water creates increased pressure in their shell and stretches, keeping them in a state of stress.

The typical protoplasmic cells derived from bags, that are filled with aqueous solutions of various substances (cell sap). The magnitude of the osmotic pressure determined by the equation Van't – Hofa

$$P_{\hat{\imath}sm} = \frac{n}{V} RT, \tag{1}$$

where n – number of moles of solute in a volume V of the solution; R – universal gas constant; T – absolute temperature.

Osmotic pressure of the cell sap on the border of the water is between 0,4 – 2 MPa. In solution with a high osmotic pressure of the cell loses water protoplasmic sac. This phenomenon is called plasmolysis and in this state is achieved bacteriostatic effects.

As the osmotic pressure acts as a factor which, in certain quantities causes bacteriostatic effects, it is advisable to stay on the strength of information on the mechanisms of cell membranes and interactions with the environment.

Among the microorganisms that accompany microbiological and food production include yeast, mold, actinomycetes and bacteria. The dimensions of the cells typically 0.5 – 10 microns. In general, the construction of cells of animals, plants and microorganisms are the same and the environment protected cell membrane.

The cell wall of yeast, for example, is about 15% of the mass of the cell and its thickness of 400 nm. The structure of the cell membrane are protein-polysaccharide complexes and lipids. Approximately 70% of the dry weight of the cell membrane of yeast polysaccharides mankan up and glucan. It polysaccharides play an important role in maintaining its mechanical strength.

The effects of osmotic pressure on microorganisms recorded in different technologies and therefore made some adjustments in manufacturing processes. Thus, the increase in osmotic pressure of the solution leads to increased levels of molecular diffusion of water from the microbial cells or vice versa, which eventually leads to equilibrium at a new level.

Therefore, it is logical for research to determine the action of osmotic pressure on the media level for lethal effects of different physical effects.

Materials and methods

Among the planned vacuuming was attributed liquid media (water, beer, wort, sugar solutions) with microorganisms. This was provided for the possibility of vacuuming without boiling environment and adiabatic mode boil. The temperature environments in all cases were kept with the restriction on the maximum value t ≤ 38 °C, which excluded lethal effects on this indicator.

Organization experiments without boiling and boiling media carried out by different initial temperature environments. Vacuum pump composed laboratory facility provided residual pressure in the vacuum chamber at 0,002-0,004 MPa, corresponding to boiling temperature range environments ~ 20 ... 30 °C. Therefore, the initial ambient temperature $t_{(in)}$ ≤ 15 °C boiling point not taken place, and the transition to the initial ambient temperature of 20 <$t_{(in)}$ ≤ 38 °C provided the boiling adiabatic mode.

Results and discussion

It is known that exposure of yeast in the water accompanied by increased physical pressure in the cells at the cellular osmotic sap. Transferring in osmotically active yeast solution leads to a reduction of physical pressure, which should be appropriately reflected by vacuuming.

Generalized experimental results are presented in table. 1.

The table shows that increasing the osmotic pressure of the solution reduces the level of lethal effects of the evacuation, which in this group of experiments continued for 10 minutes. However, a significant impact on the achievement of the organization lethal effects adiabatic boiling environments.

Studies have shown that the level of lethal effects influenced by such factors as exposure time environment in a vacuum chamber and dynamics of change of pressure in the vacuum chamber of the maximum to minimum values. Summary data of this series of studies given in the table. 2.

Table 1

The results of studies to assess the lethal effects of vacuum

Environment	The initial temperature environment, °C	The vacuum in the vacuum chamber, МПа	The level of the lethal effects , %	The initial temperature environment, °C	The vacuum in the vacuum chamber, МПа	The level of the lethal effects, %
	Without boiling adiabatic			With adiabatic boiling		
Water +yeast	15	0,002	75	38	0,002	90
15 % sugar solution in water + yeast	15	0,002	50	38	0,002	70
20 % sugar solution in water + yeast	15	0,002	30	38	0,002	60

Table 2

Impact assessment and evacuation time dynamics pressure changes in the level of lethal effects

Environment	The initial temperature environment, °C	Time pressure reduction, c	Dwell time in a vacuum chamber, c	The level of the lethal effects, %
Water +yeast	8	90	60	20
Water +yeast	8	90	120	30
Water +yeast	8	90	1200	100
Water +yeast	8	15	10	95
Water +yeast	8	15	30	100
Water +yeast	8	15	60	100

Stabilized at 8 °C reference temperature environments provided no adiabatic boiling. However, from the table 2 shows a significant effect of reducing the rate of pressure from the start of vacuuming until its completion at the level of lethal effects.

The following table 1 and 2 summarizes the results of studies make it possible to assess the impact of the choice of parameters. This does not exclude the presence of mutual influences of factors and the transition to a comprehensive assessment advisable to look towards multivariate experiment.

The list of important factors and the lower and upper levels shown in the table. 3. Matrix plan that complies presented in table. 4.

Table 3

Parameter	Unit of measurement	Code	levels			The interval of variation
			lower	null	upper	
The initial temperature environment, t	°C	z_1	8	23	38	15
Concentration of solids	%	z_2	0	7,5	15	7,5
Dwell time in a vacuum chamber, τ	C	z_3	10	605	1200	595
The rate of change of pressure in the vacuum chamber, dP/dt	MPa/s	z_4	0,0001	0,0003	0,0005	0,0002

Research performed at chamber vacuum packaging machine Easy PACK firm WEBOMATIC (Germany), and the results determine the levels of lethal effects are presented in table 4.

Mathematical processing of experimental results presented in the form of equation (2). Data processing research based on methods of mathematical statistics, the use of which is possible under the assumption that the results have a normal distribution.

$$\begin{aligned}\bar{y} = 64,812 + 7,937z_1 - 7,687z_2 + 17,312z_3 - 0,187z_4 + \\ +2,9375z_1z_2 + 2,3125z_1z_3 + 4,1875z_1z_4 - 7,6875z_2z_3 + \\ +3,5625z_2z_4 + 2,3125z_3z_4 + 2,9375z_1z_2z_3 + 1,6875z_1z_3z_4 - \\ -1,4375z_2z_3z_4 + 2,9375z_1z_2z_4 + 2,937z_1z_2z_3z_4\end{aligned} \quad (2)$$

Table 4

№	z_1	z_2	z_3	z_4	z_0	The level of the lethal effects, %
1	-	-	-	-	+	50
2	+	-	-	-	+	60
3	-	+	-	-	+	40
4	+	+	-	-	+	50
5	-	-	+	-	+	95
6	+	-	+	-	+	100
7	-	+	+	-	+	60
8	+	+	+	-	+	65
9	-	-	-	+	+	30
10	+	-	-	+	+	50
11	-	+	-	+	+	40
12	+	+	-	+	+	60
13	-	-	+	+	+	95
14	+	-	+	+	+	100
15	-	+	+	+	+	45
16	+	+	+	+	+	97

Equation (2) shows that the most effective towards achieving the lethal effects of a factor z_3 – exposure time biological system in a vacuum chamber after reaching the final pressure. At that time exposure in the vacuum chamber is the most effective factor indicates a correlation coefficient of z_3 (equal to +17.312). The physical nature of the impact of this factor explains the complex causes, among which include the change in the rates of mass transfer processes, especially CO_2.

In connection with the above it must be concluded that the decrease in osmotic and physical pressure of cell sap should lead to a decrease in lethal effects, ceteris paribus. To achieve these pressure reducing cell sap possible by increasing the osmotic pressure of the solution. In table 4 can be seen that the double effect of osmotic pressure of the sugar solution (factor z_2) largely eliminates the effect given by the violation rate mass transfer processes.

This is underlined by the fact that in all the experiments in which the concentration of sugar is highest, lethal effects are significantly reduced, which also corresponds to a correlation coefficient of z_2, even -7.687.

Only in those experiments where a combination of the maximum and minimum factor z_3 z_2 lethal effects close to 100%.

Assessment on the impact factor z_3 leads to the conclusion that increasing the osmotic pressure of the environment in which microorganisms are, creates a barrier to achieving lethal effects.

Another factor influencing the intensity towards achieving lethal effects in experiments determined the initial temperature environment (factor z_1). The correlation coefficient of this factor amounts to +7.937. Turn to steam experiments (table 4), which differ only in the upper and lower levels of the factor z_1 (experiments 1–2; 3–4; 5–6 ...). At a time when there is adiabatic boiling, increment of lethal effects is about 10%.

The results for the aggregate impact of these factors enable prediction and delineation of areas obtained using scientific information.

Vacuum packaging of food products is carried out by the relevant standards parameters and generally such factors as the osmotic pressure of the solution is stabilized. Among the parameters controlled with the related temperature, level of residual pressure vacuuming and the exposure time vacuumed environment.

Information obtained in experiments gives reason to explain instability results in the lethal effects for vacuum processing, such as drinking water. The vacuum and the delay time so stabilized system should be well-defined. However, one should not neglect the opportunity to organize adiabatic boiling the treated environment.

In experiments conducted by the time determined initial boiling adiabatic energy potential of the medium, which was largely temperature. Similar conditions occur and when the vacuum packaging products.

Definitely increase the level of state aseptic products meet increasing initial temperature. However, this figure for each product in some way regulated.

As for the vacuum aseptic water treatment exists conditional restrictions related to energy consumption for a given initial temperature.

The share impact of adiabatic boiling point as compared to the vacuuming and the exposure time can be increased by external supply of heat to the treated environment and continued so time point.

Using vacuum processing to achieve aseptic condition in some way limited production capacity given packaging for products, but in terms of technological processing of these limitations are removed.

Adiabatic boiling in conjunction with vacuuming relate to purely physical factors that rightfully belong to environmentally friendly technologies.

It is on this basis must find a way to microbiological purity of drinking water as a general and special software. Other points of application of vacuum technology with elements of adiabatic boiling is the production of beverages, juices, compotes.

The results of experimental studies clearly indicate a reduction of lethal effects with increased osmotic pressure environments. This is a strengthening effect the transition to a medium boil adiabatic regime that derives its vacuuming. The explanation of these factors needs to develop relevant hypotheses.

Painting intracellular structures in a solution of methylene blue indicates that there is a destruction of cytoplasmic and cell membranes. It could happen for two groups of factors, which include internal and external influences. Among the outer include pressure, temperature, cavitation modes adiabatic boil and even geometry volume, which are located environment. The latter is due to the fact that the residual pressure in the vacuum chamber and the height of the column with the environment can be commensurate and the resulting destabilized adiabatic boiling in full.

Adiabatic boiling is active displays on the various components of the solution are, however, cells of microorganisms thermodynamic parameters of the medium is not achieved. This is due to the fact that physical pressure cell sap equal to its difference in osmotic pressure and the osmotic pressure of the medium can far exceed the physical pressure in the vacuum chamber. The latter leads to the conclusion that in such circumstances the establishment of the solvent vapor phase in the middle of the cell is impossible.

But with the approach of osmotic pressure and cell sap environment is expected to reduce the physical pressure in the cells. Thus we can say that with the decrease of osmotic pressure environment (down to zero for distilled water), the possibility of the formation of vapor phase reduced, and in some limiting value π_2 vapor phase formation becomes impossible.

But are among the factors operating in the cell sap dissolved gases. Liquid environment saturated with dissolved gases, among which include nitrogen and carbon dioxide. The level of saturation with the law meets Henry.

Active reduce the pressure in the vacuum chamber reduces physical pressure in microbiological cell so disturbed equilibrium. This should lead to rapid selection of the gas phase, enhance mass transfer for CO_2 and additional internal pressure in the cells.

These internal factors, such as creating a vapor phase and the allocation of dissolved gases may occur in parallel or the first may be missing. Therefore, a relatively small osmotic pressure environments involving increased physical pressure in microbial cells predominant influence of dissolved gases.

Thus, by dissolving gases (most convenient CO_2) significantly expands the range of variation of pressure and physical phenomena that accompany them.

Conclusions

1. Vacuuming biological environment by reducing the constant saturation gas liquid phase creates limitations in the mass transfer between microbiological cells and environment.
2. Level restrictions mass transfer processes and state of microbial cells depends on the osmotic pressure of the solution.
3. Limitation of metabolic processes in cells and in the "cell-environment" due to osmotic pressure in the last, leads to an increase protective function and bacteriostatic effects. Due to the increase in osmotic pressure of the solution and the migration of water from the cell sap physical pressure in the cells decreases and decreases the solubility of gases in the sap. The result is a restriction of lethal effects.

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