REGULARITIES OF CHANGES IN OSMOTIC PRESSURES, MATERIAL AND ENERGY TRANSFORMATIONS IN FERMENTATION MEDIUM

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Abstract

The paper deals with the features associated with changes in osmotic pressure in connection with the transformations and destructions of sugars in the processes of anaerobic fermentation with the formation of ethyl alcohol and carbon dioxide. The possibility of influence on osmotic pressure by temperature and desaturation modes is shown.

Analytical dependences for their definition are proposed, including such on the basis of the laws of Van-Hoff, Gay-Lussac and Henry. Regularities concerning osmotic pressure were determined based on the principle of superposition. An important direction of the variation of osmotic pressures is an option of influence due to the variable solubility of CO_2 in connection with the alternating pressures in gas-liquid media. Another option concerns the ability to stabilize the concentration of alcohol at acceptable levels.

It is shown that decomposition of sucrose on glucose and fructose increases osmotic pressure almost twice. The complexity of the flow of microbiological processes of fermentation, even in cases of accurate determination of concentrations and molecular masses of the input streams and the final result, leaves open the question of the flowing value of osmotic pressure. For example, there information about the particularities of the digestion of circulating mixtures in the production of champagne wines is shown.

According to the Wan-Hoff law and the material balance, there is a direct proportional relationship between changes in the osmotic pressure of dissolved substances from the values of equalizing coefficients, and even the number of molecular structures in solutions. Physical pressure does not have a direct effect on the osmotic pressure, but there are manifestations mediated through the solubility of carbon dioxide (Henry's law). Due to the last property of changes in physical pressures, it is possible to restore the saturation properties of the medium with a decrease in osmotic pressure with the exclusion of systems beyond the limits of bacteriostatic states.

Key words: *Osmotic pressure, Energy transformations, Temperature, Alcohol, Sugar, Carbon dioxide, Mass transfer.*

1. Introduction

The industrial processes of fermentation, on which the synthesis of organic products is carried out, are important components of the processes of transformation of cyclic energy-mass flows. The importance of such technologies is associated with the production of biomass of baking or fodder yeast, the synthesis of beverages, new sources of food, fuel, etc.

At the core of the energy supply of these technologies is the synthesis of sugars, starch or other biopolymers, which are the result of the interaction of the famous triad - water, carbon dioxide and sunlight. The continuous circle of the named components with the participation of other substances provides the synthesis of organic compounds, the final decomposition of which ends with the formation of carbon dioxide and water. Fermentative anaerobic and aerobic technologies are an important part of the general circle, although partly unfinished with a beneficial effect for humans, because fermentation ends with the production of target substances which are characteristic for the production of: bread, wine, beer, kvass, etc., which provide the appropriate energy, taste facilities and interactions when consumed.

An indicator of the dynamics of the transformation of such system is the change of the concentration of sugar, accumulated ethanol and carbon dioxide.

Changes in the ratio of these substances correspond to the Gay-Lussac equation, which allows to determine the efficiency of the used technologies. These ratios apply to all anaerobic fermentation technologies and indicate the presence of losses (Glinka [1], Lavrenchenko and Kopytin [2, 3]):

$$C_6H_{12}O_6 = 2C_2H_5OH + 2CC_2 \qquad (1)$$

If neglecting the losses associated with the synthesis of yeast biomass, then carbon losses make up one third of the amount of input material flow. In most of the fermentation technologies, these carbon dioxide losses are really losses, except those parts that provide saturation of beer, kvass or work of carbon dioxide shops. The only technology from the number of fermentation technologies, in which the loss of CO_2 is liquidated, is the production of champagne wines.

The absence of production losses of CO_2 in this case is related to the exact addition of sugars at the stage of secondary fermentation, when the concentration of CO_2 in the finished drink is a standard value of 10 g/L.

Monitoring of the dynamics of fermentation of sugar-containing substances, synthesis and the formation of a dispersed gas phase for the limiting savings of CO_2 reveals the prospects of intensifying technological processes and increasing their productivity.

The purpose of the paper is to evaluate the patterns of changes of osmotic pressures and the corresponding material and energy transformations in the fermentation media.

2. Materials and Methods

Materials and methods of research are related to the peculiarities of material transformations of digestible media on the basis of the laws of: Gay-Lussac, Van-Hoff, Raoul and Henry.

Regularities concerning osmotic pressure were determined on the basis of the principle of superposition. An important direction of osmotic pressure variation is the variant of influence due to the variability of CO_2 in connection with the alternating pressures in gas-containing media. Another option concerns the ability to stabilize the concentration of alcohol at acceptable levels.

The presence of transformations in the form of material balance is the base of the processes of anaerobic fermentation, and phenomenological considerations provide the logic for constructing calculations and predicting that it is the change in pressure and gas-specific ingenious fraction that allows to do regulatory influences on the concentration of dissolved carbon dioxide and osmotic pressure. The analysis of the received numerical ratios of osmotic pressure has the prospect of establishing their bonds, it has a perspective to establish their links with the structure of material balances using equalization coefficients in the corresponding equations.

3. Results and Discussion

Changes in the culture medium in the processes of fermentation are associated with the decomposition of each molecule of sugar into two molecules of ethyl alcohol and two molecules of carbon dioxide. This means that there is a sharp increase of the osmotic pressure of solutions due to the decreasing molecular masses of new substances in almost the established mass material balance of dissolved substances.

Fulfilment of fermentation processes in microbiological and food technologies is carried out in dilute solutions based on osmosis phenomena. Osmosis and osmoregulation are present in physical-chemical and physiological processes, which provide the relative stability of the osmotic pressure of the internal medium inside the cells. As a result, osmosis regulates mass exchange, feeding the metabolism substances, as well as their delay and the term of withdrawal from the body.

The term "dilute solution" refers to a mixture of several substances, when the amount of one of them is dominated over others. The main substance is a solvent, while others are dissolved substances. If the solubilized substance is divided into separate molecules (molecular variability of the substance), then a molecular true solution is formed. In cases of true ionic solutions decomposition of substances into ions occurs. In addition, there are colloidal solutions, in which there are curds of substances.

The amount of dissolved substance is determined by its concentration. When the molecules of substances completely dissociate strong electrolytes are formed in the associated solvent. The interaction of the formed ions with molecules of the solvent leads to the phenomenon of hydration.

In dilute solutions there is a chaotic motion of molecules of a dissolved substance similar to the gas molecules. However, for dissolved molecules, Maxwell's velocity distributions do not correspond as well as the law of distribution of free rides and other gas-kinetic laws. As the result of the preferred motion of solvent molecules in the direction of the solution the equilibrium in the solvent-membrane system is supported by the osmotic pressure of the dissolved substance in the solution, which is determined by the Van-Hoff equation (Glinka, [1]):

$$\pi_{osm} = nRT/V \qquad (2)$$

Where:
n - a number of moles of the dissolved substance in volume V of the solution; R - universal gas constant; T - absolute temperature.

The equilibrium concentration of the dilute solution resulting from the dissolution of gas in the liquid or solid substance is proportional to the gas pressure and does not depend on the nature of gas and the condensed phase (Henry's solubility law). This tightening corresponds to the condition of the absence of chemisorption. The saturation vapor pressure above the dilute solution is less than above the pure liquid. The relative pressure drop of the vapor is proportional to the concentration of the solution and does not depend on the nature of the dissolved substance (Raul's law).

The presence of the molecules of the dissolved substance in the solvent raises the boiling temperature and reduces the temperature of the transition to the solid state (freezing) by the amount proportional to the concentration of the solution and does not depend on the chemical nature of the dissolved substance (Raul's law).

By changes in the concentrations of substances by the reaction of the medium is a change in osmotic pressure and they are determined on the basis of the principle of superposition. For an example, let's go to the law (1), which reflects the law of Gay-Lussac. Here the molecular mass of glucose is 180 units, and the molecular masses of the starting substances are 46 and 44 units. In this regard, in accordance with the Want-Hoff law, and taking into account the equation of the material balance (Glinka [1]):

$$m_s = m_{al} + m_{CO_2} \uparrow \qquad (3)$$

Where:
m_s, m_{al} and m_{CO_2} – the mass of sugar, alcohol and carbon dioxide respectively.

The initial osmotic pressure of the sugar solution for the molecular weight M_s is:

$$\pi_{s(i)} = \frac{m_s RT}{M_s V} \qquad (4)$$

Condition (3) is performed only for a certain period of time, when it reaches the saturation of the medium with carbon dioxide, it will start to isolate in the form of gas bubbles.

Formula (4) is written for the beginning of the process, when only the dissolved sugar is present in the medium, and from the beginning of fermentation, the amount of sugar remaining in the dissolved state decreases and then $m_s = m_s(t)$ Accordingly, we determine the total osmotic pressure of the medium on the basis of the superposition principle in the form:

$$\pi_{med} = \left(\frac{m_s(t)}{M_s} + \frac{m_{al}(t)}{M_{al}} + \frac{m_{CO_2}(t)}{M_{CO_2}} \right) \frac{RT}{V} \qquad (5)$$

Where:
$m_s(t)$, $m_{al}(t)$ and $m_{CO_2}(t)$ – the mass of matter as a function of time.

Since sugar digestion regimes are regulated, the dynamics of accumulation in the media of ethyl alcohol, carbon dioxide and biomass of yeast are the same.

At the end of fermentation, we obtain the final value $m_s(t)_{(fin)} = 0$ and the final osmotic pressure is determined by the dependence:

$$\pi_{med(fin)} = \left(\frac{m_{al}(t)_{(fin)}}{M_{al}} + \frac{M_{CO_2}(t)_{(fin)}}{M_{CO_2}} \right) \frac{RT}{V} \qquad (6)$$

Where:
$M_{CO_2}(t)_{(fin)}$- the final value of the mass of dissolved carbon dioxide, which shows the state of saturation of the medium.

Provided that the sugar is added to the fold in the technological process, the decrease of its concentration will vary from maximum to zero, and the concentration of ethyl alcohol and carbon dioxide increases from zero to maximal values. According to them, osmotic pressure also changes. Biochemical reactions in culture media approach to the reactions of the first order by their structure and their flow is reflected by the dynamics of digestion, which is influenced by the natural properties of microorganisms. In general case, the graphical interpretation reflects the components of osmotic pressure changes on the Figure 1.

In existing technology of fermentation of ethanol production, its maximum concentrations are only approaching 12%, since bacteriostatic effects appear at these concentrations and fermentation is stopped. In this regard, the initial concentrations of sugars should be consistent with the critical concentration of ethyl alcohol, along with the component of osmotic pressure of CO_2, although in the predicted estimates of this indicator in most cases, the concentration of alcohol is called so. It is possible that this situation may be explained by different magnitudes of influence of CO_2 and C_2H_5OH, since the validity of alcohol in water is not limited, while Henry's law imposes a tight limit on the solubility of carbon dioxide. For comparison, we give some correlations that relate to osmotic pressure.

Let's calculate the osmotic pressure of a 12% solution of ethyl alcohol at a temperature of 30 °C and determine the volume of this solution, which dissolves 1 g/mole of this substance.

1 g/mole of ethyl alcohol C_2H_5OH is 46 g. With some error we will assume that a 12% solution of alcohol is a solution 1 litre of which contains 120 g of alcohol. Then we have the ratio: 1 L - 120 g, V - 46.

$$V = \frac{46 \cdot 1}{120} = 0.383$$

and thus osmotic pressure is

$$\pi = \frac{8.314 \cdot 10^3 \cdot (273 + 30)10^{-6}}{0.383} = 6.58 \text{ MPa} \qquad (7)$$

The value of the absolute temperature of the medium is taken to be T = 303 K (30 °C), which corresponds to the optimal temperature of the culture medium (Plevako, [4], Kunts, [5], and Pirog, [6]).

Decrease of temperature of culture media is accompanied by a decrease of osmotic pressure. Thus at t = 20 °C π = 6.36 MPa, at t = 10 °C π = 6.14 MPa, and at t = 2 °C π = 5.96 MPa.

Although in modern technologies the fermentation temperature is not included as a factor of influence, but in the brewing industry stages of digestion with a decrease of temperature to 0 ... 2 °C are foreseen.

We evaluate the osmotic pressure produced by carbon dioxide.

It is known that solubility of CO_2 in culture media depends on partial pressure of the gas phase, temperature and physical-chemical properties of media (Sokolenko et al., [7, 8, and 9]). The formation of the dispersed gas phase takes place in the full volume of the medium, therefore, the hydrostatic pressure in them also influence on the solubility, which in the approximate calculations is defined as mediated and stabilized at the limit of maximum solubility. For the estimation of the level effects the calculations we will perform for such concentrations of carbon dioxide: 5, 10 and 20 g/L.

1 g/mole equals 44 g, and for this indicator we define the parameter V for the indicated gas solubilities:

$$
\begin{array}{ccc}
1\,L \rightarrow 5\,g & 1\,L \rightarrow 10\,g & 1\,L \rightarrow 20\,g \\
V \rightarrow 44\,g & V \rightarrow 44\,g & V \rightarrow 44\,g \\
\hline
V = 8.8\,L & V = 4.4\,L & V = 2.2\,L
\end{array}
\qquad (8)
$$

In accordance with these indicators, osmotic pressure was determined at the temperature - t = 30 °C:

$$\pi = 0.286\,MPa \qquad \pi = 0.583\,MPa \qquad \pi = 1.139\,MPa \qquad (9)$$

and at the temperature - t = 10 °C

$$\pi = 0.267\,MPa \qquad \pi = 0.534\,MPa \qquad \pi = 1.066\,MPa \qquad (10)$$

From the given data it follows that, in other equal conditions, osmotic pressure of alcohol solutions are dominated by osmotic solutions of CO_2 almost in a row. The first grow continuously until the fermentation is complete, and the pressure from dioxide is stabilized at saturation level (Figure 1).

The dynamics of changes of the osmotic pressure of sugar solutions is equivalent to a decrease of concentrations of glucose, sucrose and other mono- and disaccharides.

The concentration of sugars at the beginning of the process is the greatest and monosaccharides glucose and fructose and disaccharide sucrose may be in their
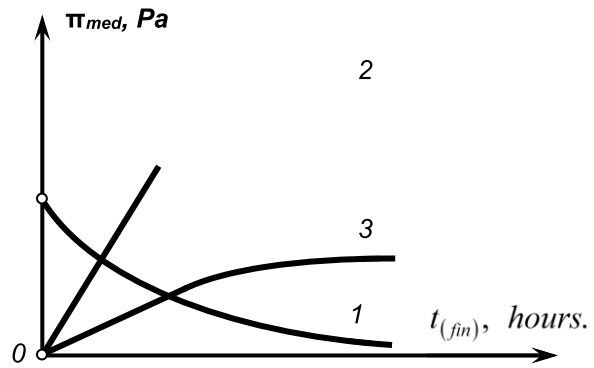

Figure 1. Graph of osmotic pressure changes due to the solutions' components: 1 - Sugar; 2 Ethyl alcohol; 3 - Carbon dioxide

composition. Sucrose breaks down with the formation of glucose and fructose molecules by hydrolysis. Obviously, the level of hydrolysis of disaccharides some way determines the osmotic pressure of the solution.

Let's show this, taking into account different concentrations of sucrose and monosaccharides. Let's assume that there is sucrose in the incoming stream and it is not hydrolysed. We find its quantity from the condition that 4 molecules of alcohol are synthesized from one molecule of $C_{12}H_{22}O_{11}$. Then, at the mass concentration of alcohol 12%, it is necessary to have glucose and fructose in the amount of $m_{gl} = \dfrac{180 \cdot 120}{92} = 234$ g, and recalculation on sucrose is determined by the ratio:

$$
\begin{array}{ccc}
342 & & 360 \\
\text{sucrose} & - & \text{glucose+fructose} \\
\hline
m_{fr} & - & 234 \\
\end{array}
$$

$$m_{fr} = \frac{342 \cdot 234}{360} = 222.3 \text{ g} \qquad (11)$$

Recalculation on the volume of the medium leads to the result:

$$
\begin{array}{c}
1\,L - 222.3\,g \\
V - 342\,g \\
\hline
V = \dfrac{342 \cdot 1}{222.3} = 1.538 \text{ L}
\end{array}
\qquad (12)
$$

which corresponds to the osmotic pressure:

$$\pi = \frac{8.314 \cdot 10^3 \cdot (273 + 30) 10^{-6}}{1.538} = 1.637 \text{ MPa} \qquad (13)$$

Since the osmotic pressure of the medium is determined by the mass concentration and molecular mass in the ratio m/M, then for the hydrolysis of sucrose in the form:

$$C_{12}H_{22}O_{11} \;+\; H_2O \;=\; \underset{glucose}{C_6H_{12}O_6} \;+\; \underset{fructose}{C_6H_{12}O_6} \qquad (14)$$

it is growing. If we assume that during the fermentation transformation of glucose and fructose are equivalent and their total mass corresponds to the mass of sucrose, the result of the calculation of osmotic pressure is reduced to the following:

$$1 \text{ L} - 222.3 \text{ g}$$

$$V - 180 \text{ g}$$

$$V = \frac{180 \cdot 1}{222.3} = 0.81 \text{ L} \tag{15}$$

and osmotic pressure of the solution:

$$\pi = \frac{8.314 \cdot 10^3 (273 + 30) 10^{-6}}{0.81} = 3.11 \text{ MPa} \tag{16}$$

Thus, the decomposition of sucrose on glucose and fructose increases osmotic pressure almost twice. Such transformation is practically obligatory, since yeast directly does not absorb sucrose. Sucrose is decomposed into glucose and fructose under the influence of the enzyme saccharase, which transform into ethyl alcohol and carbon dioxide by the action of the yeast cells, and maltose is decomposed into two molecules of glucose by the maltase enzyme. The presence of maltose in culture media is associated with the enzymatic hydrolysis of starch by amylolytic enzymes.

The list of nutrient components of digestible media is far from complete, which is not reflected in the osmotic pressures. However, the most important fermentation factors are the presence of sugars, ethyl alcohol, carbon dioxide in the media and yeast concentration. Processes occurring during fermentation can only be conditionally divided into parts of the main fermentation and digestion, but they form an integral complex.

The Table 1 and the Figure 2 show the estimated data relating to the initial concentrations of sugar in the pools, based on the final concentration of alcohol, the initial and final values of osmotic pressure. It is clear from the given data that the difference between the final and the initial osmotic pressure increases with the increase of the final concentrations of C_2H_5OH. In this analysis, the algorithm of calculations assumed the following sequence.

Table 1. Initial, final concentrations of sugar and alcohol and osmotic pressure in the media

Initial concentration of sugar, kg/m³	Initial osmotic pressure, MPa	Final alcohol concentration, % wt.	Final osmotic pressure, MPa
156.5	1.152	8	4.373
176.09	1.298	9	4.92
195.65	1,44	10	5.468
215.22	1.374	11	6.01
234.78	1.725	12	6.56
254.34	1.873	13	7.12
273.9	2.02	14	7.66

Graphic representation of dependences on Figure *2* allows getting their mathematic formalization in the form of linear functions.

The initial concentration of sugar, depending on the final concentration of alcohol in the barrel, is given to the form:

$$c_{s(i)} = 19.56\ c_{al(\%)}\ \text{kg/m}^3 \tag{17}$$

Similarly, we obtain for the initial osmotic pressure:

$$\pi_{(i)} = 0.1447\ c_{al(\%)}\ \text{MPa} \tag{18}$$

and for final osmotic pressure:

$$\pi_{(fin)} = 0.546\ c_{al(\%)}\ \text{MPA} \tag{19}$$

Where:
$c_{al(\%)}$ - the final concentration of alcohol in the barrel,%.

The linear nature of the resulting dependences leads to a conclusion about their compliance with the laws of Raoul and Van-Hoff and the logic of the growth of the initial and final osmotic pressure of solutions and the difference between them. It is obvious that this conclusion corresponds to the phenomenological analysis of the processes in the technologies of sugar fermentation, and the peculiarities of material transformations are reflected by the graphs of changes in the parameters of the system (Figure 2).

The transition from media with specific components and dry matter concentrations to food technologies media means a significant increase of the level of complexity in determining osmotic pressures. Even in the cases of a clear determination of the concentrations and molecular masses of the input streams and the final result of their transformations, the question remains open because the transition itself is accompanied by the synthesis and the presence of substances of transient processes.

To evaluate the degree of complexity of the solution of problems in determining the magnitude of osmotic pressure, let's consider an example of the technology in which the transition of the transient characteristics is clearly represented. It may be the process of champagnization of wine in its classical representation, which consists of the following stages:
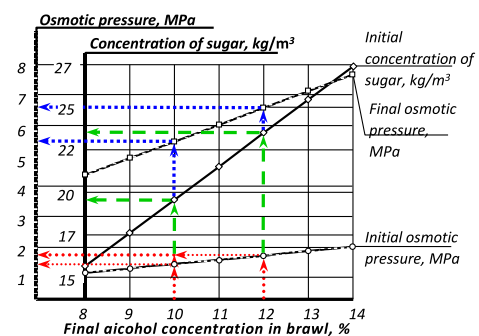

Figure 2. Graphic dependences of initial and final osmotic pressure and initial concentration of sugar from the final alcohol concentration

- Preparation of mixture by mixing blended wine-materials with a circulation liqueur, sugar;
- Mixing of the mixture with the dilution of pure yeast culture and with the materials of pasteurization;
- Packing of the mixture into bottles and sealing of bottles with samples and metal brackets;
- Placing bottles into stacks in a horizontal position for secondary fermentation at a temperature of 10 - 15 ^{0}C and three years of aging;
- Transfer of bottles and mixing media to complete the processes of biochemical transformation.

According to the requirements of microbiological support, in each bottle there are from 5 to 50 billion yeast cells, corresponding to a level up to 20 m^2 of cell mass exchange space with the medium.

The biochemical waking process is divided into 4 periods:

1 period: Active fermentation, propagation and growth of biomass (up to 15 days).

2 period: Dying of cells and transfer of enzymes and biologically active substances in a bottle medium (up to 100 days).

3 period: Active development of enzymatic processes (up to 350 days).

4 period: Inactivation of enzymes and attenuation of all biochemical processes.

Due to the interests of determining the dynamics of osmotic pressure, a course of the transformation of substances is significant. The main components of osmotic pressure at the beginning of the process are represented by the presence of sugar and alcohol. In this case, the concentration of sugar is calculated due to the possibility of obtaining the final concentration of CO_2 in wine in the amount of 10 g/L. Osmotic pressure of dissolved sugar is supplemented by the osmotic pressure of ethyl alcohol. The results of biochemical transformations are represented by dependence:

$$\frac{C_6H_{12}O_6}{180} = \frac{2C_2H_5OH}{92} + \frac{2CO_2}{88} \quad (20)$$
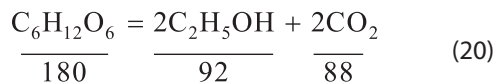
which is supplemented by mass ratios.

It follows that in order to obtain 10 g/L concentration of carbon dioxide in wine, it is necessary to disperse glucose in quantities:

$$m_{gl} = \frac{180 \cdot 10}{88} = 20.45g$$

In this case, the amount of synthesized alcohol will be:

$$m_{al} = \frac{180 \cdot 92}{180} = 10.45g$$

Since the mentioned masses of alcohol and glucose are attributed to 1 litre of wine, this means that the

alcohol content will increase by 1.045%. In this case, the mass of carbon dioxide will be:

$$m_{CO_2} = \frac{20.45 \cdot 88}{180} = 10g$$

Let's determine the volumes of liquid phases that correspond to the solution of 1 g/mole of substance:

1 L - 20.45 g of glucose V - 180 g	1 L - 10.45 g of C_2H_5OH V - 146 g
$V_{gl} = \dfrac{180}{20.45} = 8.8L$	$V_{al} = \dfrac{46}{10.45} = 4.45L$

1 L - 10 g of CO_2
V - 44 g

$$V_{CO_2} = \frac{44}{10} = 4.4L$$

At the temperature T = 293 K (20 C) osmotic pressure of glucose at the beginning of the process is:

$$P_{osmgl} = \frac{RT}{V} = \frac{8.3144 \cdot 10^3 \cdot 293 \cdot 10^{-6}}{8.8} = 0.427683 \text{ MPA} \quad (21)$$

Osmotic pressure of synthesized C_2H_5OH and carbon dioxide, respectively:

$$P_{osmal} = \frac{RT}{V} = \frac{8.3144 \cdot 10^3 \cdot 293 \cdot 10^{\;6}}{4.4} = 0.553663 \text{ MPa} \quad (22)$$

$$P_{osmCO_2} = \frac{RT}{V} = \frac{8.3144 \cdot 10^3 \cdot 293 \cdot 10^{-6}}{4.4} = 0.553663 \text{ MPa} \quad (23)$$

Total change of osmotic pressure of substances in the ratio:

$$\frac{P_{osmal} + P_{osmCO_2}}{P_{osmgl}} = \frac{0.553663 + 0.553663}{0.27683} = 4 \quad (24)$$

means the possibility to formulate the following rule based on the laws of the equivalents of masses and Van-Hoff: Osmotic pressure of solutions of substances that interact in chemical or biochemical reactions are directly proportional to the equation coefficients in the corresponding equations. At the same time it is possible to come to another conclusion, evaluating the results about changes of osmotic pressure and the number of molecules of dissolved substances. After all, each molecule of glucose is transformed into two molecules of alcohol and two molecules of carbon dioxide. Hence a different conclusion, which concerns the generalization of the physical basis of the phenomenon of osmotic pressure: Changes of osmotic pressure are directly proportional to changes of the quantities of molecular structures in solutions.

In other words, the nature of osmotic pressure is determined by the formation of the molecules on the molecular levels.

The calculated changes of osmotic pressure reflecting the processes of champagnization should be

considered at the level of the first approximation, since there is an unaccounted potential of molecular structures associated with the destruction of yeast cells, the development of fermentation processes with inactivation of enzymes. Obviously, these final points of champagnization increase the magnitude of osmotic pressure of the system. However, the theoretical possibilities for this additional number of molecular structures are practically exhausted, and therefore further steps in determining osmotic pressures should be associated with experimental measurements.

4. Conclusions

- Changes of the concentrations of substances in solutions of fermented media reflect the dynamics of changes of osmotic pressure, the direction of which is due to the increase of the number of molecules of new synthesized substances. In accordance with Van-Hoff laws and the material balance, there is a direct proportional relationship between the changes of the osmotic pressure of the dissolved substances and the number of equalizing coefficients, and even the number of molecular structures in the solutions.

- The growth of osmotic pressure in microbiological degradation systems of organic substances in conditions of self-governing processes leads to bacteriostatic blockages of these processes.

- In accordance with Van-Hoff law among the factors influencing on the osmotic pressure there are the temperature of the solution medium and the number of moles of the dissolved substance in the volume of the solution. Physical pressure does not have a direct effect on osmotic pressure, but its manifestations are mediated, not directly due to the solubility of carbon dioxide (Henry's law). Due to the last quality of the changes of physical pressures, it is possible to restore the saturation power of the medium with a decrease of osmotic pressure with the exclusion of systems beyond the boundary of bacteriostatic states.

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