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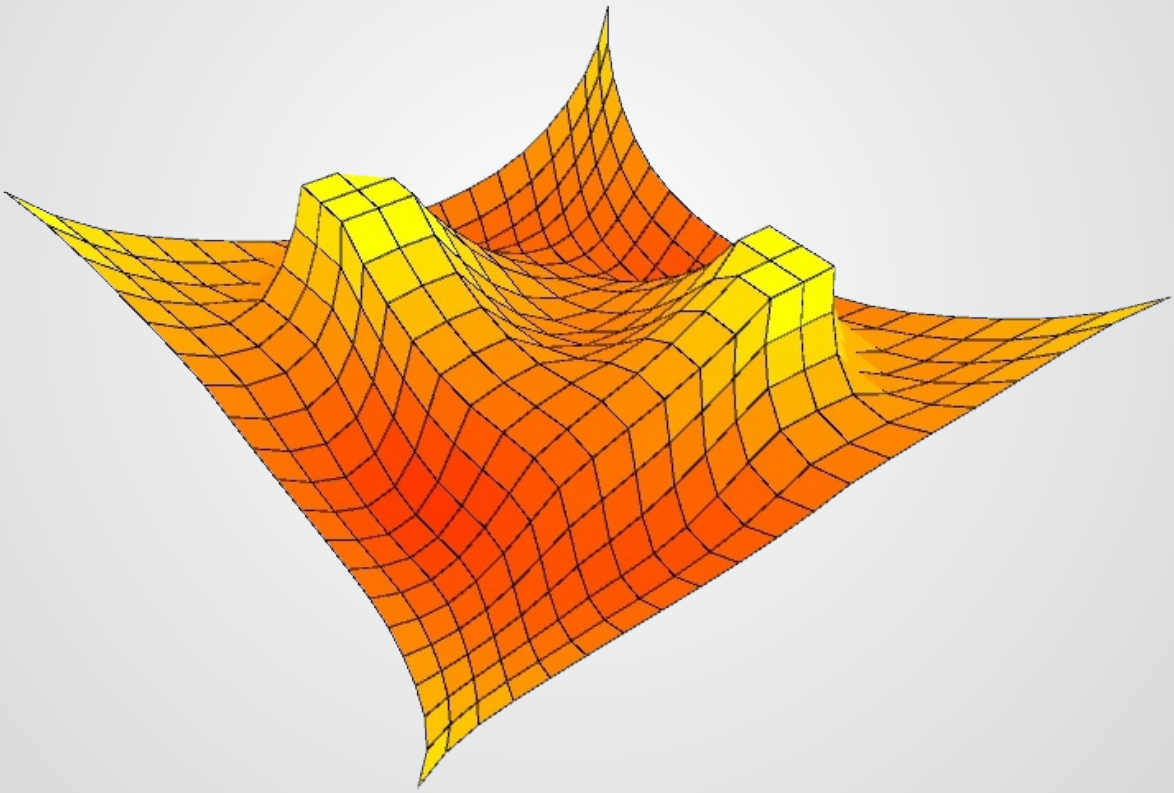

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CONTENTS

Characterization of walnut (*Juglans regia* L.) green husk extract obtained by supercritical carbon dioxide fluid extraction

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Abstract. *In this contribution, the performance of supercritical fluid extraction (SFE) procedure towards the extraction of bioactive compounds from walnut (Juglans regia L.) green husk is presented. The husks were extracted with non-toxic solvent, namely carbon dioxide (CO_2). Some extraction conditions including temperatures, times and pressures have been studied. The produced walnut green husk extract has been characterized in terms of extraction yields, antioxidant activity (using DPPH$^{\bullet}$ stable free radical), total phenols (using Folin-Ciocalteu reagent). Besides, the extract has been chemically characterized using UV/Vis spectra. This method allowed the determination of the main compounds present in walnut green husks, including phenolic acids, flavonoids, carotenoids and chlorophyll. The results obtained in this study show that SFE using carbon dioxide was able to produce the extract with good antioxidant activity and yield. Nevertheless, in this work, the potential of the walnut green husk as an economical source of antioxidant compounds is demonstrated.*

Key Words: supercritical fluid extraction, walnut green husk, antioxidant activity

I. Introduction

Walnut green husk is an agro-forest waste generated in the walnut (*Juglans regia* L.) harvest that could be valued as a source of natural compounds with antioxidant and antimicrobial properties [2]. Different works demonstrated the potential antioxidant of walnut products, especially fruits, leaves and liquers which produced by green fruits [6, 7, 13].

Stampar *et al*. (2006) identified thirteen phenolic compounds in walnut green husks: chlorogenic acid, caffeic acid, ferulic acid, sinapic acid, gallic acid, ellagic acid, protocatehuic acid, syringic acid, vanillic acid, catechin, epicatechin, myricetin, and juglone. Oliveira *et al.* (2008) determined that walnut green husk can be used as an easily accessible source of compounds with health protective potential and antimicrobial activity.

In the food industry, synthetic antioxidants, such as butylated hydroxyanizole (BHA) and butylated hydroxytoluene (BHT), have long been widely used as antioxidant additives to preserve and stabilize the freshness, nutritive value, flavor and color of foods, and animal feed products. However, at least one study has revealed that BHT could be toxic, especially at high doses [11].

Nowadays, there is an increasing interest in the substitution of synthetic food antioxidants by natural ones. The antioxidant compounds from waste products of food industry could be used for protecting the oxidative damage in living systems by scavenging oxygen free radicals, and also for increasing the stability of foods by preventing lipid peroxidation [4]. Special attention is focused on their extraction from inexpensive or residual sources coming from agricultural industries.

Regarding the extraction of antioxidants, supercritical fluid extraction (SFE) with CO_2 is an alternative method for replacing organic solvents and, recently, it has received considerable attention. The major advantages of SFE lie in the rapid equilibration, therefore resulting in faster and more efficient extraction of analytes than liquid solvent-based extraction, and the ease with which the contaminants can be separated from supercritical fluids, thus, allowing the reuse of fluids [10]. Carbon dioxide is abundant, inert, non-toxic, environmentally friendly solvent and acceptable in the food industry. The extracts obtained by supercritical fluid extraction technique are of outstanding quality and the yields are comparable with those of organic solvent extraction methods. SFE extracts were generally recognized as safe to be used in food products. Therefore, SFE can serve as a promising technology in food and pharmaceutical processing [3, 8].

The objectives of this study were (*i*) to explore applicability of supercritical fluid extraction process for effective extraction of bioactive compounds from walnut green husks, (*ii*) to examine bioactive compounds composition of walnut green husk extract using UV/Vis spectra, (*iii*) to determine the reaction kinetics of DPPH$^{\bullet}$ free radical with walnut

green husk extract and its scavenging activity, (*iv*) to establish reducing power (EC_{50}) of the walnut green husk extracts.

II. Materials and methods

2.1. Plant material

Walnut (*Juglans regia* L.) healthy green husks were manually collected in October 2011 in Chisinau, Central Moldova. The husks were dried at room temperature, powdered, packed and stored in order to protect them from the light. Voucher specimens were transported to the Minimal Processing Lab., Faculty of Food Science and Engineering, ″Dunarea de Jos″ University of Galati, Romania.

2.2. Chemical and reagents

1,1-Diphenyl-2-picrylhydrazyl ($DPPH^{\cdot}$) as free radical form (95%), Folin-Ciocalteu's phenolic reagent, sodium carbonate were supplied by Sigma-Aldrich. 3,4,5-trihydroxybenzoic acid were obtained from Alfa Aesar. Methanol (99.8%) and ethanol (96%) were provided by Eco-Chimie (Chisinau, Moldova).

Carbon dioxide gas (99.92%) was supplied by Technic Gaz (Buzau, Romania) and delivered in cylinders with siphon tube for feeding with liquid solvent the working tank of the extraction plant.

2.3. Supercritical fluid extraction

Equipment used for supercritical fluid extraction (Figure 1) of walnut dried green husks was designed and supplied by Natex Prozesstechnologie GembH (Ternitz, Austria).

Figure 1. *Experimental plant for supercritical fluid extraction of walnut green husk*

The pressure level was set at 200 bar and was above the critical pressure of the CO2 solvent (73.8 bar), and as suggested by previous workers for extraction of phenolic compounds from plant material. Temperature of 50°C is above the critical temperature for CO2 (respectively 31.06°C) and this temperature is generally used in the extraction of plant materials by SC-CO2. The selected value of the temperature (50°C) was low enough to avoid the damage of heat sensitive compounds.

2.4. UV/Vis spectra and calculation of extraction factors

The UV/Vis spectra were recorded following the process described by Zavoi S. *et al*. (2011) with small modifications [14]. Walnut green husk extract was dissolved in chloroform to obtain the concentration 1 mg/ml of tested extract. UV/Vis spectra were measured in UV/Vis spectrophotometer HACH-LANGE DR-5000 (Germany) in the range of 200 - 700 nm using quartz tubes 10×10 mm. There were identified the maxima wavelengths specific for different compounds.

The Extraction Factors of bioactive molecules from the extract were calculated, considering the absorption values ($A_{\lambda max}$) recorded for each λ_{max}, multiplied with the dilution factor (d). The formula applied was:

$$EF = A_{\lambda max} \times d.$$

The results were expressed as mean values of two samples per extract from walnut green husk.

2.5. Total polyphenol content measurement

For quantification of total polyphenol content, the Folin-Ciocalteu's method was used [12]. A volume of 0.5 ml of Folin-Ciocalteu's reagent was added to a dark flask, containing 0.5 ml of the each extract sample and 10 ml of distilled water. After 5 min, 8 ml of a 7.5% aqueous sodium carbonate solution was added to the mixture and the content was mixed thoroughly. The samples were kept in dark for 2h and then the absorbance was measured at 765 nm with HACH LANGE DR-5000 UV/vis spectrophotometer. Three parallel samples were analyzed.

Gallic acid was used for constructing the standard curve, obtained in advance. Concentration range of gallic acid was of 0.05-0.5 mg/ml. The results of total polyphenol content were expressed as mg of gallic acid equivalents per ml of extract (mg GAE/ml).

2.6. Determination of DPPH radical scavenging activity

The antioxidant activity of walnut green husk extracts as well as the kinetics of inhibition of free radicals were studied in terms of radical scavenging ability using the stable $DPPH^{\bullet}$ method [1]. 0.1 ml of

the extract sample was added to 3.9 ml of 60 μM solution of DPPH$^{\bullet}$ in methanol. The reaction was carried in dark conditions and the absorbance was recorded at 515 nm to determine the concentration of remaining DPPH$^{\bullet}$. Methanol as instead of DPPH$^{\bullet}$ solution was used as blank solution. The values of $[DPPH^{\bullet}]_t$ at each reaction time were calculated according to the calibration curve (in the concentration range of 0.38-38 μg/ml): $A_{515\ nm}$ = 0.0293 $[DPPH^{\bullet}]_t$ – 0.0072, where the concentration $[DPPH^{\bullet}]_t$ is expressed in μg/ml. The coefficient of linear correlation of the above relation is R = 0.9999. The radical scavenging activity (RSA) was calculated using the equation [9]:

$$RSA = 100\% \bullet ([DPPH^{\bullet}]_0 - [DPPH^{\bullet}]_{30})/ [DPPH^{\bullet}]_0$$

where: $[DPPH^{\bullet}]_0$ is the concentration of the DPPH$^{\bullet}$ solution (without sample) at t=0 min and $[DPPH^{\bullet}]_{30}$ is the remained DPPH$^{\bullet}$ concentration at t=30 min. Lower $[DPPH^{\bullet}]_t$ in the reaction mixture indicates higher free radical scavenging activity.

2.7. Statistical analysis

Variance analysis of the results was carried out by least square method with application of coefficient Student and Microsoft Office Excel program version 2007. Differences were considered statistically significant if probability was greater than 95% (p-value <0.05). All assays were performed by triplicate at room temperature 20 ± 1 ^{0}C. Experimental results are expressed as average ± SD (standard deviation).

III. Results and discussion

Walnut green husks are inedible by-products in walnut (*Juglans regia* L.) plantations, which may be a potent source of antioxidants, and have a potential as a value-added ingredients for functional foods.

Supercritical fluid extraction technique was applied to extract biologically active compounds from walnut green husks. Knowledge of the behavior of the factors influencing the process conditions is necessary to enhance the optimization extraction efficient for any bioactive compound.

Previous findings have reported the influence of many independent variables, such as extraction method, solvent composition, pH, temperature, pressure and extraction time on the yields of bioactive compounds which can be extracted from diverse natural products. The positive or negative role of each factor in the mass transfer of the process is not always clear; the chemical characteristics of the solvent and the diverse structures and compositions of the natural products mean that each material-solvent system has a different behavior, which cannot be predicted.

In this study, the UV/Vis spectra of walnut green husk extract were analyzed, chloroform was considered as a reference solvent. The maximum absorption (λ_{max}) of the extract and extraction factors (EF) were calculated (Table 1).

Table 1. *The maximum absorption (λ_{max}) of walnut green husk extract and extraction factors (EF)*

Compounds	λ_{max} [nm]	Absorption	EF
Phenolic acids	237	0.672	67.2
	290	0.333	33.3
Total phenolic acids	-	-	**10.5**
Flavonoids	333	0.292	**29.2**
Carotenoids	417	1,039	103,9
	457	0,593	59.3
	484	0,497	47.7
	538	0,9	90
Total carotenoids	-	-	**302.9**
Chlorophyll	611	0.07	7
	668	0.355	35.5
Total chlorophyll	-	-	**42.5**

To have an integrated image of the bioactive compounds composition and the differences between their concentrations, the UV/Vis spectra of walnut green husk extract dissolved in chloroform were analyzed in the wavelength range 200 - 710 nm (Figure 2).

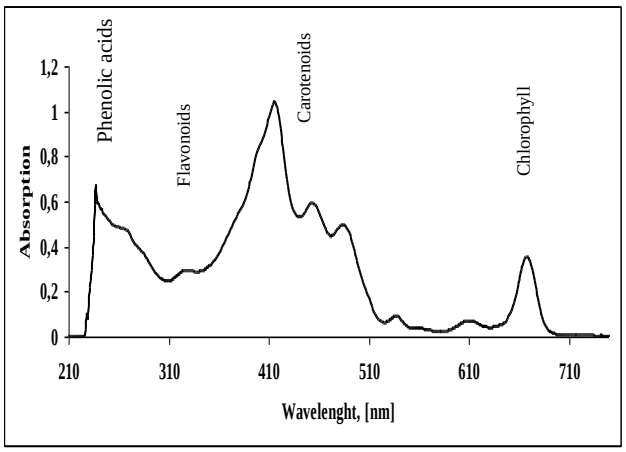

Figure 2. *UV/Vis spectra of walnut green husk supercritical fluid extract*

From identification of bioactive compounds by UV/Vis spectra, it clearly revealed that studied extract contain phenolic acids (237 and 290 nm), flavonoids (333 nm) and carotenoids (417, 457, 484 and 538 nm). The highest extraction factor value was registered for carotenoid compounds. The total phenolic content (by Folin-Ciocalteu assay) was 477.59 mg/g in walnut green husk extract.

The knowledge of the kinetics of atom transfer is important because free radicals in the organism are short-lived species, what implies that the impact of a substance as an antioxidant depends on its fast reactivity towards free radicals.

In this study the antioxidant capacity of the walnut green husk extracts were analyzed as the kinetics of inhibition of free radicals (the percentage of DPPH• remaining at steady state). The work concentrations of the walnut green husk extracts were between 0,1 and 10 mg/ml. Reaction kinetics of DPPH· free radical with walnut green husk extracts are shown in figure 3.

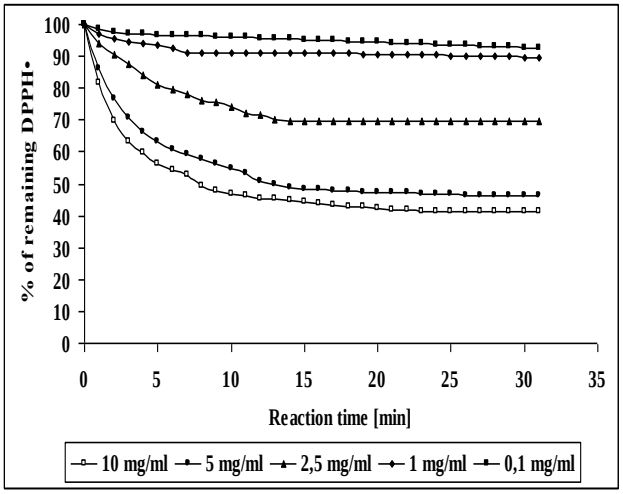

Figure 3. *Reaction kinetics of DPPH· free radical with different concentration of green husk extract*

It is well known that the absorbance decreases as a result of a colour change from purple to yellow when the radical is scavenged by antioxidants through donation of hydrogen to form the stable DPPH-H molecule. A more rapid decrease of the absorbance means more potent antiradical activity, expressed in terms of hydrogen donating ability of the compounds.

Walnut green husk extract obtained by SFE possess good amounts of bioactive compounds and a significant radical scavenging activity towards stable DPPH free radical (Figure 4).

The antioxidant activity analyses were performed with the walnut green husk extracts of different concentration in chloroform. The antioxidant activity value of tested extracts was expressed as radical scavenging activity and this parameter was in the range of 7.42 – 58,83%.

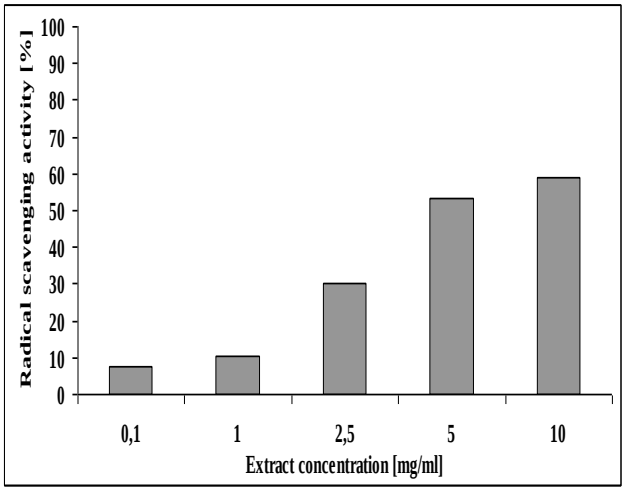

Figure 4. *Scavenging activity of walnut green husk extracts on the DPPH· free radical*

The amount of extract needed to decrease the initial DPPH· concentration by 50% is usually used for antioxidant activity appreciation of studied extract. In this study EC50 for walnut green husk extract was also determined. Thus value was 4.69 mg/ml for walnut green husk extract (Figure 5).

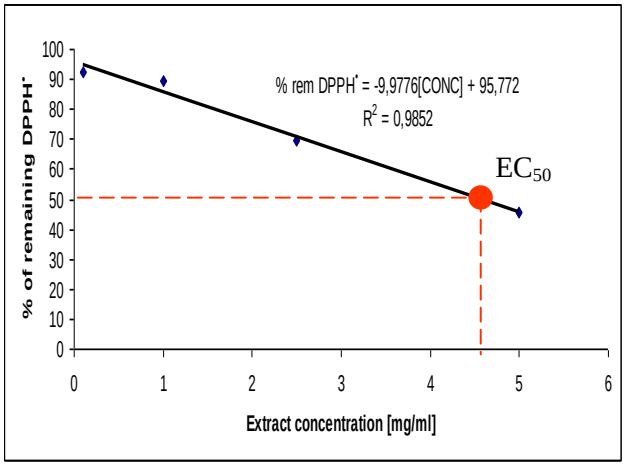

Figure 5. *Reducing power (EC_{50}) of the walnut green husk extracts towards DPPH· free radical*

IV. Conclusions

Walnut green husk extracts obtained by supercritical fluid extraction showed the polar properties, chloroform as a solvent was used to analyze the antioxidant potential and content of biologically active compounds. From identification of bioactive compounds by UV/Vis spectra in this study, it clearly revealed that extracts contain

phenolic acids (237 and 290 nm), flavonoids (333 nm) and carotenoids (417, 457, 484 and 537 nm).

The total phenolic content (by Folin-Ciocalteu assay) was 477.59 mg/g in walnut green husks extracts. The extraction yield was 5.29 % for walnut green husks. To increase the extraction efficiency, and consequently, reduce the extraction time of biologically active compounds and extraction yields from walnut green husks it can be proposed to increase the polarity of carbon dioxide solvent by addition of small amount of liquid co-solvent (modifier). Ethanol is more preferable as a co-solvent in supercritical fluid extraction because of it lower toxicity.

Walnut green husk extracts obtained by SFE possess considerable amounts of carotenoids, phenolic compounds and a significant radical scavenging activity towards stable DPPH free radical. Using supercritical carbon dioxide extraction method, the EC_{50} for walnut green husks extracts was 4.69 mg/ml.

Acknowledgments

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Experimental research of malt roasting process for production of dark beers

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Abstract. *In the conditions of the market competition producers of beer are compelled to increase the range of let-out production. Increase in the range possibly at the expense of release of dark grades of beer in which structure along with light grades of malt are added specially. In this regard by production of dark grades of beer the need for high-quality special grades of malt (caramel and roasted) increases. One of the key processes in the production of caramel and roasted malt is the process of heat treatment, resulting in the product getting a unique color and flavor. [1]*

Key words: supercritical fluid extraction, walnut green husk, antioxidant activity.

I. Introduction

In the conditions of the market competition producers of beer are compelled to increase the range of let-out production. Increase in the range possibly at the expense of release of dark grades of beer in which structure along with light grades of malt are added specially. In this regard by production of dark grades of beer the need for high-quality special grades of malt (caramel and roasted) increases. One of the key processes in the production of caramel and roasted malt is the process of heat treatment, resulting in the product getting a unique color and flavor [1].

At present, the Republic of Belarus uses imported special malt. One of the main reasons is the lack of domestic equipment for their production. In this regard, the development of domestic high-technology equipment for the production of caramel and roasted malt is a very urgent problem in the state program of import substitution.

II. Materials and methods

Caramel malt - is strongly colored aromatic product obtained from fresh sprouted pale malt which issugared and roasted. It is prepared as follows: light malt fresh sprout in multiple irrigation water moistened to 50-60% and loaded into a drum roaster for 2/3 of its capacity. When drum speed 30 min per second, malt is heated to 70 ^{o}C, kept 40-50 minutes, then heated to 130-180 ^{o}C, allowing the malt at this time to dry, and stir fry until the desired color for 2.5-4.0 h. quality malts, including caramel, is regulated by GOVT 29294-92 [2], according to which the caramel malt must meet the requirements specified in Table 1.

Table 1. *Physiochemical characteristics of caramel malt according to GOST 29294-92*

Description	Standard for caramel malt	
	I Class	I Class
Mass fraction of moisture (humidity), max%	6,0	6,0
Mass fraction of the extract in dry matter of malt,%	75,0	70,0
Number of caramel grains,%	93,0	25,0
Mass share of trash,%	0,5	0,5
Color (value of Lintner-Lee)	20,0	20,0

Assessing the readiness of malt and, consequently the quality in the process of heat treatment is carried out using the method and sensory methods to GOST 29294-92. Even on-time fryer with a system of automatic control, time and temperature of roasting each batch of malt established empirically based, primarily on the initial moisture content of the feedstock. For rejection of the initial moisture content of the malt is allowed up to 2.5-3% of the standard. Despite the set time roasting program, control product readiness at the end of the process is still carried out by means of organoleptic. Color grading of malt is conducted in accordance with GOST 29294-92 for color extract. Methods for determination of dry matter extract for roasted and caramel malt is conducted in accordance with (GOST 29294-92 with a refractometer to control the determination of dry matter. The use of these indicators provides a timely opportunity to regulate the process of roasting and simultaneously reduce waste in the form of a dry weight basis, which increases the yield and improves the quality of the finished product. However, for these methods to assess the quality of the finished product

requires a series of experiments in which they would otherwise have time and roasting temperature.

A number of studies [1, 3] proposed roasting time and temperature regimes for the same sorts of different malts, which points to a variety of methods to assess readiness of the product at the end of the heat treatment and the lack of a unified approach. In order to develop highly efficient fryer needs to develop a generalized methodology for evaluating the quality of the finished product at the end of frying and determine the optimal parameters of heat treatment of malt.

For experimental studies of the process of roasting malt in the department "Technology and technical support for the processing and storage of agricultural products" UO BSATU designed and assembled experimental stand, the circuit is shown in Figure 1. And Figure 2 is a perspective view of the stand.

Experimental facility is based on a fryer designed with a fundamentally new design solutions [4 5]. The cylindrical surface of the perforated drum roaster 18, heated air heating elements 14 (heating elements). The rotary shaft 16 is designed as a screw fixed to the shaft of the drum roaster 18 with runners on the inner surface in the form of helical lines with opposite direction of the screw turns, which ensures highmixing efficiency of malt during operation. A distinctive feature of the developed fryer is the presence of a perforated hollow shaft 16 which is connected by steam line 17 to the steam generator 2. This allows processing of barley, steam medium roasting drum 18, which not only intensifies the heat process, but at the same time improves the quality of the finished (roasted) product by getting proper color scheme, as well as removal of volatile components ("burnt" flavor and bitterness) .

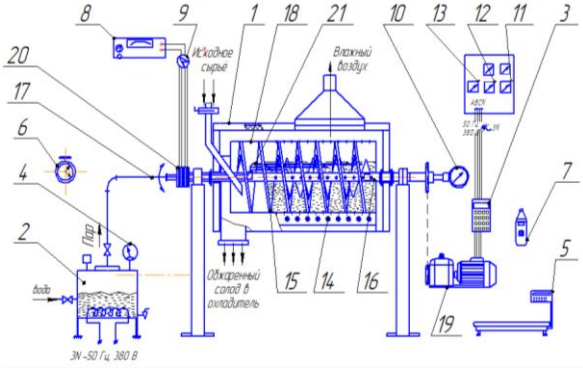

Figure1. *Scheme of the experimental stand: 1 – fryer, 2 – steam generator, 3 – inverter E2-8300-007N, 4 – manometer, 5 – electronic scales SC 4010, 6 – stopwatch, 7 – optical pyrometer AKIP 9303, 8 – millivolt 9 – selector switch; 10 – tachometer, 11 – voltmeter, 12 – ammeter, 13 – watt meter, 14 – heaters, 15 – screw, 16 – perforated shaft, 17 – steam pipe, 18 – roasting drum with screw guide, 19 – drive, 20 – contact group 21 – thermo-steam.*

Design laboratory fryer allows you to adjust the following regime-design parameters of the process of roasting malt: the speed of the screw, the temperature inside the chamber, the flow rate and temperature of the heating steam, period of roasting.

Figure 2. *General view of the experimental stand 1 – fryer, 2 – steam generator, 3 – control equipment 4 – personal laptop ASUS 1005 PX.*

One of the factors that have a significant impact on the quality characteristics of the finished product is the mixing efficiency of malt during the heat treatment.

Mixing efficiency is considered as stochasticity (random) process and determined based on the statistical characteristics of the mixture. This feature is usually a coefficient variation of the distribution of a key component in the mixture.

The coefficient of variation is given by:

$$V = \frac{100}{X}\sqrt{\frac{\sum_{i=1}^{n}(X_i - X)^2}{n-1}}, \qquad (1)$$

where: X – the average content of a key component in the mixture%; X_i – a key component of the content in each of the samples,%; n – number of samples analyzed.

The lower coefficient of variation, the more evenly distributed component in the mixture. In an ideal distribution of the components in the mixture of coefficient of variation tends to zero. An important role in quantifying the quality of the mixture is the mass of samples to be taken. Analyzed samples should have the mass at which the random deviations of control components are not obscured in the overall picture of its distribution in the amount of the investigated mixture.

Determination of homogeneity of the mixture is reduced to the following. Malt taken several batches each with a defined set of core components (colored

barley). The more samples taken, the more accurately can be defined homogeneous mixture. The number of selected portions depends on many factors, which are difficult to take into account. In practice it takes away at least 10 ... 15 batches of 100 g each. In our work, we can confine ourselves to simplify 5 ... 8.

The data characterizing the mixing efficiency in the fryer proposed design shown in Figure 3.

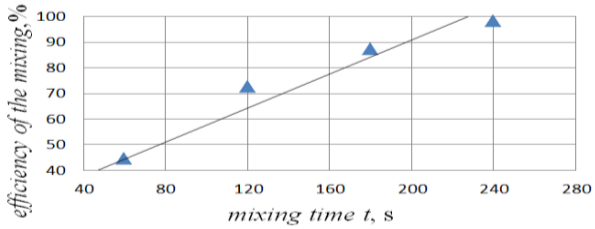

Figure 3. *Dependence of the efficiency of the mixing time*

As can be seen from the data presented in the table, the product reaches almost homogeneous mixing after 240 drum rotation. Since cooking malt last much longer, we assume that during the roasting malt evenly mixed and this factor can be eliminated from the parameters Multivariate experiment.

One of the most energy-intensive processes for the preparation of caramel malt is roasting beans, and the quality of roasting largely determines the final physiochemical and sensory characteristics of caramel malt. Figure4, malt before and after roasted in roasting drum with the developed new design.

Figure 4. *Malt before and after roasted in roasting drum with the developed new design.*

Figure 5 and 6, shows the experimental data to determine the effect of the duration of roasting (II phase) on the physiochemical characteristics of caramel malt.

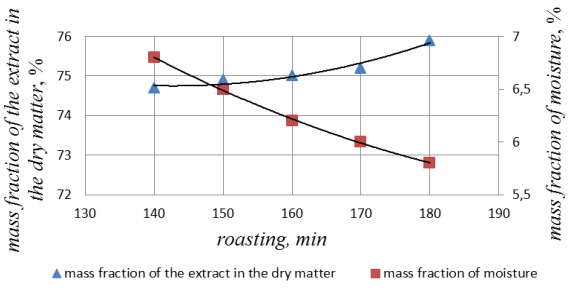

Figure 5. *Effect of roasting (II phase) on the mass fraction of the extract in the dry matter and the mass fraction of moisture*

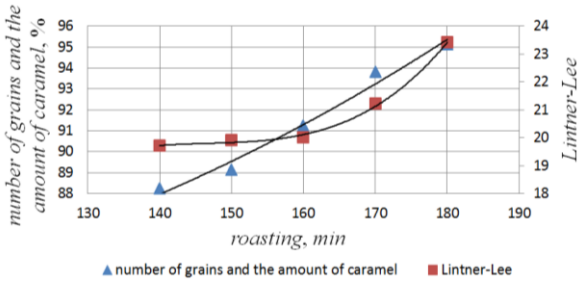

Figure 6. *Effect of roasting (II stage) by the number of grains and the amount of caramel Lintner-Lee*

As can be seen from the above data, the duration of roasting 165 min is optimal in terms of achieving the desired organoleptic and physiochemical parameters, Reducing the duration of roasting leads to unsatisfactory organoleptic and physiochemical parameters, and increasing the time of roasting results in increased numbers of charred grains, which affects the quality of the finished beer (deterioration of color and flavor).

The quality of the finished malt significantly affected temperature in the oven fryer. In order to intensify the process of thermal treatment of the product in the cooking chamber roaster drum fed wet saturated steam, which is produced in the steam generator and the steam line is fed into the interior of the shaft and go through the perforations in the work area to form a vapor environment. Steam-air medium than air has a higher heat transfer coefficient, and water vapor is in a superheated state absorbs and re-emits radiant energy, which as a whole tends to raise the thermal efficiency of the fryer. Intensification of the process of roasting malt contributes to the perforated surface of the drum roaster (through perforations air heated by heating coils, heavily circulated in the area of the oven).

To determine the effect of the temperature of the second stage of roasting on the physio-chemical and organoleptic parameters of caramel malt a series of experiments at constant duration of roasting - 165 min. Effect of temperature roasting (II phase) on sensory characteristics of caramel malt presented in Table. 2.

Table 2. *Effect of roasting (II phase) on sensory characteristics of caramel malt*

Name	**Температура, ^{0}C**				
	140	**150**	**160**	**170**	**180**
Appearance	Homogeneous grain weight does not contain moldy grains and grain pests.				

Color	Light yellow	Light yellow	Light yellow	from brown to light yellow	brown
Smell	malt	malt	malt	malt	burnt
Taste	sweet	sweet	sweet	sweet	sweetish
Kind of grain on a cut	Baked brown mass	Baked brown mass	Baked brown mass	Baked brown mass	Baked brown mass

The Effect of temperature roasting (II phase) on the physiochemical characteristics of caramel malt (Fig. 7 and 8).

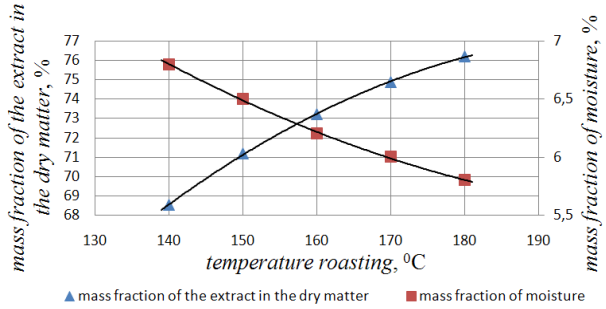

Figure 6. *Effect of temperature roasting (II phase) on the mass fraction of the extract in the dry matter and the mass fraction of moisture*

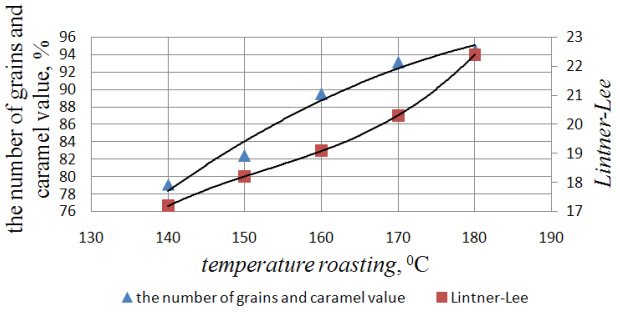

Figure 7. *Effect of temperature roasting (II stage) by the number of grains and caramel value Lintner-Lee*

Analysis of experimental data suggests that, to obtain the necessary sensory and physiochemical properties of caramel malt, the cabinet temperature fryer must be between 160-170 ^{o}C. With further increase in temperature leads to a deterioration of quality indicators of caramel malt and reducesenergy efficiency of a whole fryer.

III. Results and discussion

Based on analysis of published data in the design of devices for heat treatment of malt, new design of the fryer with a fundamental new technical solutions Designed and made laboratory apparatus for experimental studies. The basic technological parameters of malt change during the heat treatment and describing its quality.

The experimental data have allowed identification of the main factors affecting the efficiency in the process of roasting malt, and their range of variation:

- Speed of the screw – (20-30 min^{-1});
- The temperature inside the chamber – 160-180 ^{0}C;
- Before roasting – 140-180 min.

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The mathematical description and the analysis of interaction of grain weight with gravity separator's constructive elements

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Abstract. *The article defines the conditions of moving particles on the surface of the vibrating mesh cage depending on impacts to a single particle. Based on these studies the mathematical relationship that allows you to define the specific theoretical performance of vibratory separator for separating the grain mass density, describes the design of the developed vibratory separator with fundamental new design solutions to enhance the cleaning of the crop from hard-separable impurities and reduce the loss of suitable grain.*

Key Words: vibratory separator, grain hard- separable impurities.

I. Introduction

According to most researchers, making mathematical model of the vibrating separation is only possible for a single particle and the material for the given parameters of the oscillations. In the theoretical framework of displacement of the crop on the gridded surface, developed in studies of authors [1.2] does not take into account all the factors affecting the process. Moreover, in these studies considered cleaning the grain mass of mineral impurities hard- separable whose density is much greater than the density of grain and the main mineral admixture percentages to the total mass of purified grain is relatively small (less than 1%). Hard- separable density of impurities and the bulk grains differ by 10-15%, and the geometric parameters are very close, which can't effectively allocate data impurity on the existing equipment. The possibility of application of our previous findings for the cleaning of the grain from hard- separable impurities requires additional theoretical and experimental studies.

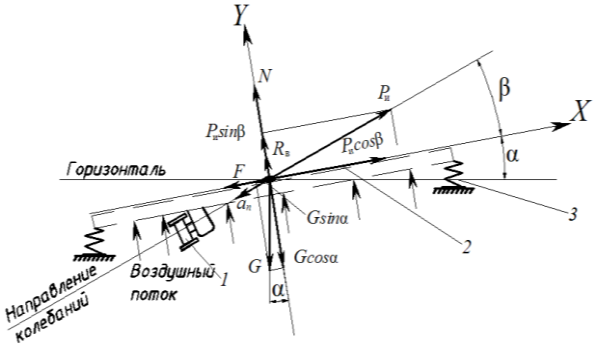
II. Materials and methods

One of the reasons the average directional movement on an inclined surface with vibration excitation asymmetry is by tilting the plane of oscillation. The force of friction in the case of the positive direction of the horizontal projection, the inertial forces in the mobile traffic (driving force) is reduced by reducing the normal pressure. The opposite direction of this projection and the friction force is increased.

During vibration separation movement of the grain on the gridded surface vibratory separator performs translational oscillations whose disclosure forms with the surface angle β, is due to the action of the additional force, a role that performs inertial force in the mobile movement:

$$P_{II} = ma_{II}, \qquad (1)$$

where: m – the mass of the particle, a_{II} – portable acceleration.



1 – electric vibrator, 2 – mesh surface, 3 – anti-vibration mountings

Figure 1. *Scheme of forces at vibrating movement of particles in case of inclined harmonious fluctuations.*

The theoretical studies suggest that the most appropriate to describe the behavior of the grains on the gridded surface vibratory separator used method of replacing a single grain stream of material particles. After reception of mathematical dependence, a single material particle must be based on additional experimental studies to make the correction factors that allow it take into account the

effect, is not accounted for in the mathematical model of factors.

Figure 2 shows a diagram of the forces acting on the material particles on the surface of the vibrating mesh surface.

The following forces act on the particle:

- Force of gravity in particles- $G = mg$;
- overall reaction deck, a deviation from the normal to the surface at an angle of friction - N;
- Force of inertia in portable movement -P_u;
- Reaction of an ascending air stream – $P_в$, operating normally to a surface decks

Given that the surface vibration separator performs translational periodic oscillations, which obey the harmonic law, P_u is given by:

$$P_И = mA\omega^2 \sin(\omega \cdot t + \varphi), \qquad (2)$$

where: A – the amplitude mesh decks, m; ω - angular frequency of oscillation, s^{-1}; t – time, s; φ – the initial phase of the oscillations.

For the given scheme of forces the differential equations of relative movement of a particle can be written as:

$$\left.\begin{aligned} m\frac{d^2x}{dt^2} &= P_И \cos\beta - G\sin\alpha - F \\ m\frac{d^2y}{dt^2} &= P_И \sin\beta - G\cos\alpha + N + R_B \end{aligned}\right\} \qquad (3)$$

Considering that, $G = mg$, $F = ma$ the system of the equations (3) can be rewritten as:

$$\left.\begin{aligned} m\frac{d^2x}{dt^2} &= mA\omega^2 \sin\omega t\cos\beta - mg\sin\alpha - fN \\ m\frac{d^2y}{dt^2} &= mA\omega^2 \sin\omega t\sin\beta - mg\cos\alpha + N + R_B \end{aligned}\right\} (4)$$

For movement without tossing, $\frac{d^2y}{dt^2} = 0$, that allows (4) to express normal reaction N from the equation.

$$N = mg\cos\alpha - mA\omega^2 \sin\omega t\sin\beta - R_B, \qquad (5)$$

Using the equation (5) it is possible to define theoretically a condition of continuous movement of a particle (grain weight) on a mesh surface. The mode of continuous movement is characterized by that for the entire period of fluctuation of T, normal reaction of N keeps positive value, т.е. N >0, even when $\sin\omega \cdot t = 1$. Then for performance of a condition of continuous movement inequality observance is necessary:

$$mg\cos\alpha - mA\omega^2 \sin\omega t\sin\beta - R_B > 0. \qquad (6)$$

After elementary transformations we receive:

$$\frac{m(g\cos\alpha - A\omega^2 \sin\beta)}{R_B} > 1. \qquad (7)$$

To determine the response of the rising air flow on the particle by the author [1] proposed to use the Newton's formula:

$$R_B = k_\beta \rho_B F_M (v_1 - v_2)^2, \qquad (8)$$

where: k_β -factor of resistance; ρ_B – density of air, kg/m^3; F_M – midsection m^2; v_1 – air velocity

m/s; v_2 – the speed of the particle, m/s.

Author [3] the notion of "speed wool particles in cramped conditions." Then (8) reduces to:

$$R_B = mg\frac{(v_1 - v_2)^2}{C_S^2}, \qquad (9)$$

where: C_S – wool speed particles in cramped conditions.

This rate is given by:

$$C_S = \sqrt{\frac{4}{3}\cdot\frac{gd_Э(\rho_Ч - \rho_B)^2}{\rho_B k_\beta}}, \qquad (10)$$

where $d_Э$ – the equivalent diameter of the particle, m; $\rho_Ч$ – particle density, kg/m^3; ρ_B – air density, kg/m^3 .

Then (7) can be written as:

$$\frac{4d_Э(\rho_Ч - \rho_B)^2(g\cos\alpha - A\omega^2\sin\beta)}{3\rho_B k_\beta (v_1 - v_2)^2} > 1. \qquad (11)$$

Thus, if the inequality (11), particle moves on a mesh surface continuously. The system of equations (4) must be substituted into the upper equation of the normal reaction N defined by equation (5). Then the upper equation in (4) becomes:

$$\frac{d^2x}{dt^2} = A\omega^2(\cos\beta + f\sin\beta) - g(\sin\alpha + f\cos\alpha) \quad (12)$$

Given that $f = tg\rho$ formula (12) is reduced to:

$$\frac{d^2x}{dt^2} = A\omega^2\frac{\cos(\beta-\rho)}{\cos\rho}\left[\sin\omega t - \frac{g}{A\omega^2}\frac{\sin(\alpha+\rho)}{\cos(\beta-\rho)}\right]\cdot \quad (13)$$

Equation (13) corresponds to the positive direction of the velocity of the particle. In the case of the opposite direction of the particle, this equation becomes:

$$\frac{d^2x}{dt^2} = A\omega^2\frac{\cos(\beta+\rho)}{\cos\rho}\left[\sin\omega t - \frac{g}{A\omega^2}\frac{\sin(\alpha-\rho)}{\cos(\beta+\rho)}\right] \quad (14)$$

The average speed of the particle is considered as the sum of the particle movements up and down in one period of oscillation attributed to the time of data movement and is given by:

$$v_ч = \frac{S_B + S_H}{T_O} = \frac{n}{60}(S_B + S_H), \quad (15)$$

where: S_B – the particles move up in one period of change in the force F, m; S_H – move the particles down in one period of change in the force F, m; T_O – period changes in the force F, s; n – number of periods of change in the force F for 1 min.

For solving systems of equations, in previous studies conducted, the average speed was defined particle located on a slope, performing harmonic oscillations:

$$v_ч = A\omega\cos\beta\cos\varepsilon\sqrt{1-\left(\frac{\varepsilon z}{\sin\varepsilon}\right)^2}\left[\frac{2}{\pi}ftg\beta\left(tg\varepsilon - \varepsilon + \frac{\pi}{2}\right) - 1\right] \quad (16)$$

where: z – a coefficient determined by the formula:

$$z_{\pm} = \frac{g}{A\omega^2}\frac{\sin(\alpha \mp \rho)}{\cos(\beta \mp \rho)}. \quad (17)$$

In (17) the upper signs ρ correspond to the positive direction of motion of the particle (x> 0), lower - the negative direction (x <0).

Coefficient is given by:

$$\varepsilon = \frac{\delta_{2+} - \delta_{1+}}{2}, \quad (18)$$

where: $\delta = \omega \cdot t$ -the phase angle

In this case δ_{1+} the phase angle, at which the relative sliding of the particle in a positive direction $(\frac{d_2x}{dt^2} \geq 0)$ a δ_{2+} - the phase angle at which the movement ends in a positive direction.

Expression (16) doesn't consider influence of ascending air streams and interaction with constructive elements of a vibrating separator therefore the theoretical speed determined by expression (16) doesn't correspond to the valid speed of moving of a particle on a mesh surface of the developed vibrating separator. From the practical point of view the greatest interest represents determination of theoretical productivity, as one of indicators of efficiency of its work.

Proceeding from a condition of contiguity of a grain stream, on a mesh surface it is possible to determine average speed of moving of grain weight by a formula:

$$v_{ср} = \frac{Q}{B \cdot h_{дин} \cdot \rho_н}, \quad (19)$$

where: $v_{ср}$ – the average speed of the crop on the gridded surface, m / s; Q – load on the working body (deck), kg / s; B – channel width, m; $\rho_н$ – the bulk density of the grain mass, kg/m^3, $h_{дин}$ – bed height in dynamics, m.

When working in vibratory separator load mesh deck is performance, because during the height of the separation of the product layer, mesh surface remains constant. The bed height in the dynamics $h_{дин}$ considering design features equal to the height outlet. Then the formula (19) with respect to specific performance can be written as:

$$Q = 36 \cdot v_{ср} \cdot \rho_н \cdot h, \quad (20)$$

where h - height of the gap between the lower edge of the sliding door stop plate and the mesh deck, m;

Then, taking into account the correction factors to the high speed of the grain mass is equal to the average velocity of a single particle. The specific theoretical performance of vibratory separator is given by:

$$Q = 36 \cdot k \cdot \rho_H \cdot h \cdot \left[A\omega \cos\beta \cos\varepsilon \sqrt{1 - \left(\frac{\varepsilon z}{\sin\varepsilon}\right)^2} \left[\frac{2}{\pi} f tg\beta \left(tg\varepsilon - \varepsilon + \frac{\pi}{2} \right) - 1 \right] \right], \quad (21)$$

where: k – the dimensionless factor considering changes of a tilt angle of mesh decks and increase in volume of grain weight under the influence of ascending streams of air. To investigate the process of separation of the crop on the efficiency of allocation division, experimental facility was created (Figure 2).

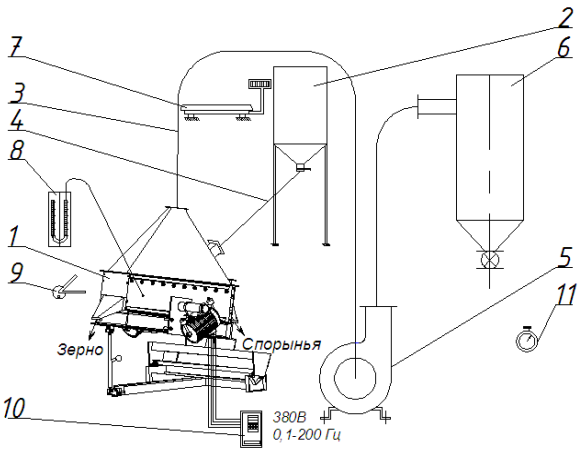


Figure 2. *Scheme of the experimental stand*

1 – vibratory separator, 2 – hopper 3 – air line, 4 – material line, 5 – fan VCP-3, 6 – cyclone BTSSH-3, 7 – electronic scales VTNt-15, 8 – micromanometer MMN, 9 – protractor optical OAM -3, 10 – frequency converter VFD-B; 11 – stopwatch

Figure 3 shows a general view of the laboratory vibration separator.

Based on the experimental studies of the process determined the coefficient:

$$k = -523{,}316 - 240{,}576 \cdot \alpha + 4{,}045 \cdot H - 12{,}597 \cdot \alpha^2 + 0{,}775 \cdot \alpha \cdot H - 0{,}0074 \cdot H^2, \quad (22)$$

where:

H – pressure in the chamber vibratory separator, Pa.

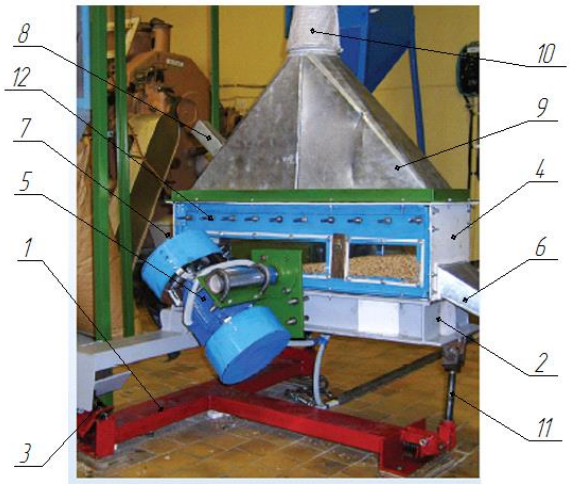


Figure 3. *Laboratory vibratory separator*

1 – frame, 2 – mesh surface, 3 – anti-vibration mountings, 4 – case, 5 – electric vibrator, 6 – suitable outlet for grain 7 - outlet for ergot, 8 - feeding tube, 9 – confuse, 10 – Duct, 11 – mechanism for the tilt mesh deck, 12 – airflow control dampers

Analyzing the expression, (21) can be concluded that an explicit performance vibratory separator depends on the amplitude of oscillation mesh deck. The analysis of the influence of other kinematic and structural factors requires additional experimental studies.

The theoretical research have developed vibratory separator for cleaning of the grain from hard-separable impurities with adjustable kinematic design parameters and performance of up to 4 t/h. Figure 4 is a perspective view of an industrial design of vibratory separator.

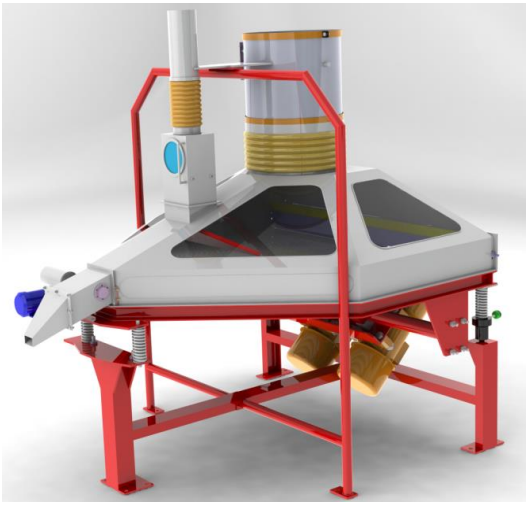


Figure 4 *Vibrating separator for cleaning grain weight of hard-separable impurities.*

Created vibratory separator for the cleaning of grains of hard-separable impurities with fundamental new design solutions suitable for use in grain processing plants, grain elevators, feed mills, as well as seed plants and farms

III. Results and discussion

Conditions of emergence of moving of a particle on a mesh surface of a vibrating separator depending on power impact on a separate particle are defined.

On the basis of the carried-out researches the mathematical model describing change of productivity of a vibrating separator for division of loose products depending on amplitude, frequency and the direction of fluctuations mesh decks, its tilt angle and pressure in the working chamber of the developed vibrating separator is received.

The design of a vibrating separator with essentially new constructive decisions allowing considerably increase factor of cleaning of grain weight from hard- separable impurity is described and thus to reduce losses of good grain.

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Mathematical modeling of the capacity of roller grain crusher

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Abstract. *The article present results of theoretical research of the capacity of roller grain crusher with the same pairs of roll diameter and angular velocity. According to the research, the dependences to calculate the capacity of crusher are received at various frequencies of rotation and diameters of rollers, and also in between gap and friction coefficient of the roller weevil.*

Key words: crusher, roller, grains.

Introduction

The crushing technology with simultaneous conservation of damp grains is one of the most economic and productive at preparation of the concentrated forage. It allows grain cleaning in a stage of wax ripeness at humidity of 35-40 % depending on technical possibilities of harvest combines. During this period grain contains the maximum quantity of nutrients. While harvesting begins 10 -15 days earlier than normal, Weather conditions do not have a decisive importance for harvesting. Conditioning does not require pre-treatment after the combine. Does not require drying of grain for fodder purposes, it saves energy consumption. No need to break up the grain after drying i.e. eliminated one of the stages of preparation of feed. Rolled grains are fully assimilated by animals which increases their productivity [1]. As a rule, the operation of crushing grain is performed with the roller crusher. In the practice of engineering and design, roller crusher simulation of crushing grain is important. Therefore, the aim of this work is to simulate the process of grain crushing in order to conduct a theoretical analysis of the influence of designed parameters of crusher and speed of roller on the capacity of crushing process.

Research methods: used methods of mathematical modeling.

Results and discussion, From the analysis of theoretical results and experimental studies presented in [2, 3, 4, 5, 6,] follows that at productivity and capacity definition of roller crushers, it is necessary to consider grain sliding on a surface of rollers.

Using the results of the studies described in [2, 3, 6, 10] we can assume that there is an arc of rolled grains on the surface of each drum within which weevil experiencing strain and glides over the surface of the drum.

Then all the way l_{AC} $(l_{A`C`})$, traced weevil on rollers, can be divided by the length of the two arcs: arc deformation l_{AB} $(l_{A`B`})$, by a deformation angle α_1 $(\alpha`_1)$ and lengths of an arch of sliding $l_{BC}$ $(l_{B`C`})$, limited to a corner of sliding $\alpha_2(\alpha`_2)$, which it will take place, accordingly, in time t_1 and t_2. If the length of an arch of deformation l_{AB} $(l_{A`B`})$ is almost uniquely determined by the size and physio-mechanical properties of the grains, the gap between the rollers b_3, the length of the arc sliding l_{BC} $(l_{B`C`})$ will have a much more complex relationship.

To find the specified dependences we will make the settlement scheme for the most typical crusher design with identical diameters of rollers D and frequencies of their rotation n=n ` (fig. 1). Thus we will designate all forces operating on grains, an axis t-t which will direct on a tangent to a forming circle of rollers in a contact point of grains with rollers, an axis p-p – perpendicularly tangent in a point of contact with the roller.

In determining the power going to the roller crusher drive, consider the two main components:

1. Capacity of a sliding friction of a surface of rollers on grains, depending at most friction and lengths of an arch of sliding
2. 2. Power deformation grains, depending on the strength (physical and mechanical) properties of the grains;

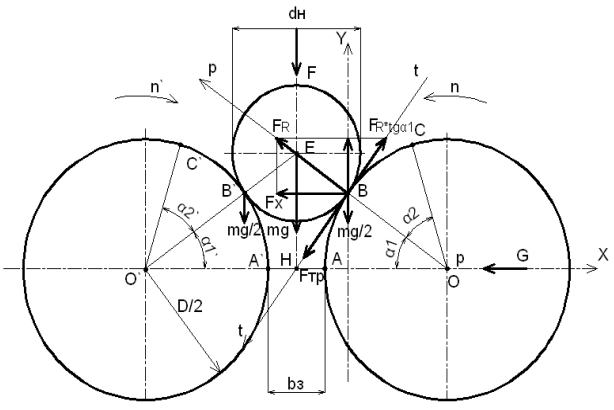

Figure1. *The design scheme for determination of the forces acting on the roller crusher*

From the calculation sketch (Figure 1), shows that at the caryopsis have an additional external force *F*, as well as roll after capturing weevil click on it with force *G*, created by the clamping roller device. Expand this force on equally effective F_R pressure on grains are uncertain until an angle to an angle deformation α_1, as well as the vertical force

$F_Y = F_R \cdot \sin\alpha_1$, horizontal

$$F_X = F_R \cdot \cos\alpha_1 \quad (1)$$

and on a tangent to the rollers

$$F_R \cdot tg\alpha_1 = \frac{F_Y}{\cos\alpha_1} = \frac{F_R \cdot \sin\alpha_1}{\cos\alpha_1}. \quad (2)$$

Under the influence of F_R on the drum circle as it rotates develops friction $F_{mp} = f \cdot F_R$, which must be greater than or equal to the tangential force $F_R \cdot tg\alpha_1$.

The force of friction F_{mp}, arising from the interaction with the surface of grains roll on an arc sliding l_{BC}, we find the formula:

$$F_{mp} = \frac{f(mg+F)}{\cos\alpha_1}, \quad (3)$$

where:

m – mass of grains, kg;

g – acceleration of gravity, m/s^2.

Sliding path increment ds find as:

$$ds = \frac{d\alpha_2 D}{2}, \quad (4)$$

where:

α_2 – slip angle, rad;

D – diameter of the drum, m.

Then capacity of a sliding friction on two rollers:

$$P_{mp.c} = \frac{f(mg+F)}{\cos\alpha_1} \cdot \frac{d\alpha_2 D}{dt_2}. \quad (5)$$

Given that, $\frac{d\alpha_2}{dt_2} = \frac{\pi n}{30}$.

Then

$$P_{mp.c} = \frac{f(mg+F)}{\cos\alpha_1} \cdot \frac{\pi n D}{60} = \frac{\pi}{60} \cdot \frac{f(mg+F)nD}{\cos\alpha_1} \quad (6)$$

Capacity of deformation of grains found from the expression:

$$P_\partial = 2fF_R\upsilon_з, \quad (7)$$

where:

$\upsilon_з$ – the actual speed of the grain stream, m/s.

Since the action of F_R varies displacement angle α_1, then to determine the magnitude of the resultant force F_R belongs to the coordinate axes *YOX* drum circle, where the Y axis vertical axis passing tangent to the circumference of the drum as shown in figure 2, and the X axis runs horizontally through the center O.

We select the circle infinitesimal element ds under yet uncertain angle to the horizontal angle of deformation α_1.

Then

$$\cos\alpha_1 = \frac{dy}{ds}, \quad (8)$$

$$\sin\alpha_1 = \frac{dx}{ds}, \quad (9)$$

$$dF_R = pLds, \quad (10)$$

where: p - the resistance of compression per unit area, the variable across the arc AB, N/m^2.

According to Hooke's law compressive strength can be determined from:

$$p = E\frac{\frac{d_H \cdot \cos\alpha_1 - x_{\alpha_1}}{2}}{\frac{d_H \cdot \cos\alpha_1}{2}}, \quad (11)$$

where: *E* – modulus of elasticity, N/m^2;

$$\frac{x_{\alpha_1}}{2} = \frac{b_з}{2} + x, \quad (12)$$

Then

$$p = E\frac{\frac{d_H \cdot \cos\alpha_1 - b_з}{2} - x}{\frac{d_H \cdot \cos\alpha_1}{2}}. \quad (13)$$

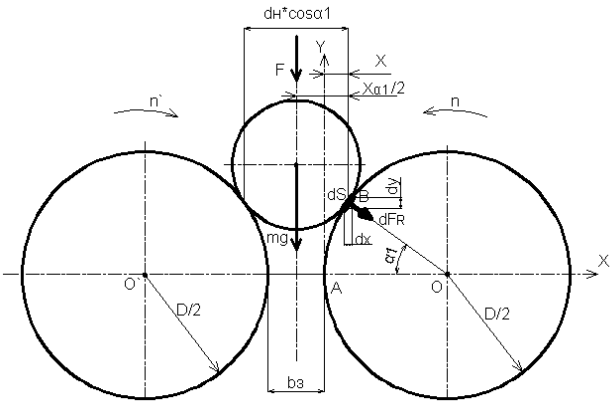

Figure 2. *The designed sketch for the determination of the resultant force F_R, acting on a roller crusher.*

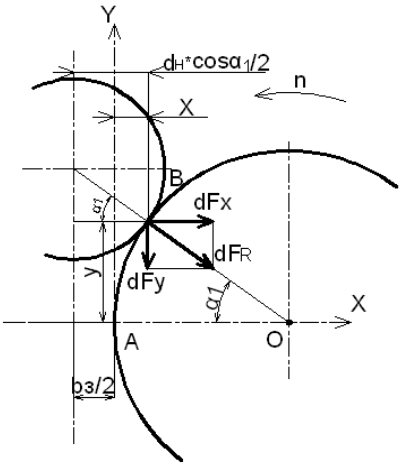

Figure 3. *Design scheme to determine vertical F_Y and horizontal F_X components of the resultant F_R*

Vertical component dF_Y equally effective force dF_R (Figure 3) can be define as

$$dF_Y = dF_R \sin\alpha_1 = Lpdx, \qquad (14)$$

then

$$F_Y = L\int_0^{\frac{d_н\cdot\cos\alpha_1 - b_з}{2}} pdx = E\frac{2L}{d_н}\int_0^{\frac{d_н\cdot\cos\alpha_1 - b_з}{2}} \left(\frac{d_H\cdot\cos\alpha_1 - b_з}{2} - x\right)dx \qquad (15)$$

Taking a continuous flow of grain and equalize the thickness of grains. $d_н\cdot\cos\alpha_1$. Integrating the equation (15) in the range of *0* to $\frac{d_H\cdot\cos\alpha_1 - b_з}{2}$ obtain:

$$F_Y = \frac{LE}{d_н\cdot\cos\alpha_1}\left(\frac{d_H\cdot\cos\alpha_1 - b_з}{2}\right)^2,$$

$$\text{or } F_Y = \frac{LE}{4}\frac{(d_н\cdot\cos\alpha_1 - b_з)^2}{d_н\cdot\cos\alpha_1}. \qquad (16)$$

Horizontal component dF_X equally effective force dF_R can be define as

$$dF_X = dF_R\cos\alpha_1 = Lpdy, \qquad (17)$$

Then

$$F_X = L\int_0^{\frac{D}{2}\sin\alpha_1} pdy = E\frac{2L}{d_H\cdot\cos\alpha_1}\int_0^{\frac{D}{2}\sin\alpha_1}\left(\frac{d_н\cdot\cos\alpha_1 - b_з}{2} - x\right)dy \qquad (18)$$

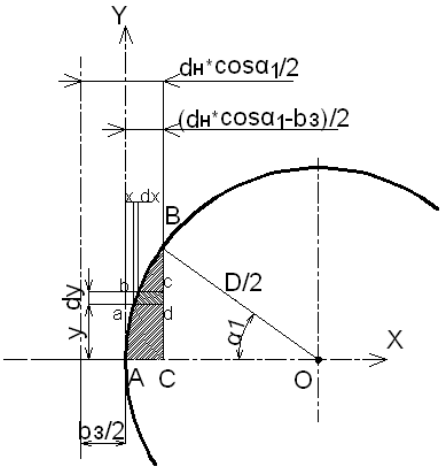

Figure 4. *Design scheme to determine the horizontal component of the resultant is FX FR.*

It is obvious that the integrand size is equal to elementary area;

S_{abcd} (Figure 4):

$$S_{abcd} = \left(\frac{d_н\cdot\cos\alpha_1 - b_з}{2} - x\right)dy, \qquad (19)$$

then

$$F_X = E\frac{2L}{d_н\cos\alpha_1}S_{ABC}. \qquad (20)$$

From Figure 4 it is visible that area S_{ABC} is equal to a difference of the areas of sector *ABO* and rectangular triangle *CBO*:

$$S_{ABC} = \frac{D^2\alpha_1}{8} - \frac{D^2\sin\alpha_1\cos\alpha_1}{8}. \qquad (21)$$

Then taking into account (21) the formula for determining F_X changes;

$$F_X = \frac{ELD^2}{4d_н\cos\alpha_1}\left(\alpha_1 - \sin\alpha_1\cos\alpha_1\right). \qquad (22)$$

Therefore

$$F_R = \sqrt{F_Y^2 + F_X^2} = \sqrt{\left(\frac{LE}{4}\frac{(d_H\cdot\cos\alpha_1 - b_з)^2}{d_H\cdot\cos\alpha_1}\right)^2 + \left(\frac{ELD^2}{4d_H\cos\alpha_1}\left(\alpha_1 - \sin\alpha_1\cos\alpha_1\right)\right)^2} = \frac{EL}{4d_H\cos\alpha_1}\sqrt{\left(d_H\cdot\cos\alpha_1 - b_з\right)^4 + D^4\left(\alpha_1 - \sin\alpha_1\cos\alpha_1\right)^2} \qquad (23)$$

Then, capacity of deformation of grains, according to equation (7), with the expression of the grain flow rate is obtained in work [10]

$$\upsilon_з = \frac{2fD}{\frac{D}{\upsilon} + \frac{\upsilon - \upsilon_0}{\alpha_1\left(g + \frac{F}{m}\right)(f\sqrt{1-\cos^2\alpha_1} + \cos\alpha_1)}} \quad (24)$$

$$P_д = \frac{2fD}{\frac{D}{\upsilon} + \frac{\upsilon - \upsilon_0}{\alpha_1\left(g + \frac{F}{m}\right)(f\sqrt{1-\cos^2\alpha_1} + \cos\alpha_1)}} \times \times \frac{EL}{4d_н\cos\alpha_1}\sqrt{\left(d_н \cdot \cos\alpha_1 - b_з\right)^4 + D^4\left(\alpha_1 - \sin\alpha_1\cos\alpha_1\right)^2} \quad (25)$$

Conclusions

- friction power of rollers surface sliding of caryopsis depends on the diameter and speed rollers frequency, roller friction coefficients of caryopsis, deformation angle of caryopsis and additional external forces effecting the caryopsis.

- caryopsis deformation power also depends on the rolls' diameter, roller friction coefficients of caryopsis, deformation angle of caryopsis and additional external forces effecting the caryopsis, and in addition, depends on the physical and mechanical properties of the caryopsis and the peripheral speed of the surfaces forming rolls.

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Research of hydrodynamics in the vacuum apparatus crystallization Massecuite with a view to intensifying

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Abstract: *The purpose of the study - increased efficiency in the production of sugar. Object - massecuite heating in a vacuum apparatus. Way - additional steam in massecuite.*

Keywords: massecuite, steam, intensity

Introduction

One of the main ways to improve crystallization technology is to maximize the removal of sucrose from beet with minimum energy consumption. Vacuum devices are the major consumers of energy in a sugar factory.

Research in the area of bulk crystallization of sucrose are traditional for the National University of Food Technologies, which carried out fundamental research on heat and mass transfer in boiling sugar massecuite, sugar crystallization kinetics and fluid dynamics in the vacuum apparatus.

The objective of our work is theoretical and experimental study of the recycling process in obtaining a sugar massecuite and study design factors on the process.

The purpose of research is to determine the impact of the introduction of water vapor from the outside in sugar solution and massecuite to intensify the process of bulk crystallization.

Mixing and circulation speeds up the process of crystallization. The most intensive growth of crystals is observed in the circulation rate of massecuite 0.5 ... 1,0 m/s. Achieving this rate of circulation throughout the cooking, especially at the end of the process, the existing designs of vacuum pans with natural circulation is not possible. At the end of boiling massecuite circulation rate is significantly reduced, and may reach 0,02 ... 0,043 m/s.

In the case of forced circulation of the massecuite in vacuum pans increases the overall heat transfer

coefficient and reduces the boiling massecuite. This improves the quality of crystal sugar.

Experimentally [1] that the growth of crystals in boiling affect the frequency of recycling. The crystal

growth rate is proportional to the frequency of recycling massecuite.

Hydrodynamic methods of intensifying the process of crystallization of sucrose different input methods of steam or gas [2].

One method to intensify the process of recycling mass, which crystallizes in the vacuum apparatus is the introduction from the outside in massecuite boiling steam. The introduction of steam improved hydrodynamic properties of massecuite, and causes a redistribution of the solute between the unit cells of massecuite [3] as a result of recrystallization [4, 5].

Reducing the speed of circulation of the massecuite is accompanied by a reduction of heat transfer, the temperature increases in the heat transfer surface and the increase in the value of specific heat flux. This leads to a decrease in the driving force of natural circulation [1].

We have studied the bubble flow steam and massecuite mixtures typical of industrial vacuum apparatus. The data on the hydraulic characteristics of the flow of massecuite in forced circulation. We used a method of hydrodynamic intensification boiling massecuite by injecting steam into each tube apparatus [6]. Injected steam flow was maintained in the optimal range for each stage of boiling. [5].

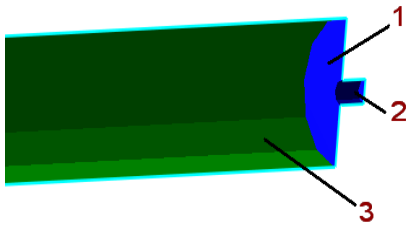

Figure 1. *The geometric model of a single tube heat transfer in a vacuum apparatus.*

It was first used to simulate the movement of the massecuite in vacuum apparatus using software system FlowVision. This complex is designed to simulate three-dimensional flows of liquid and gas in the technical and natural objects, as well as the visualization of these flows by computer graphics.

The proposed geometrical model shown in Fig 1.

In our case, we consider the problem of modeling of turbulent flow between two media with properties that are different in many times. Massecuite is fed to the main entrance to the canal, and steam is supplied from the auxiliary input in the center of the tube.

This task was chosen model of an incompressible fluid. In the calculation equations are solved Navier–Stokes equations for turbulent transfer functions and equations of convective-diffusive transport.

Analysis of simulation results

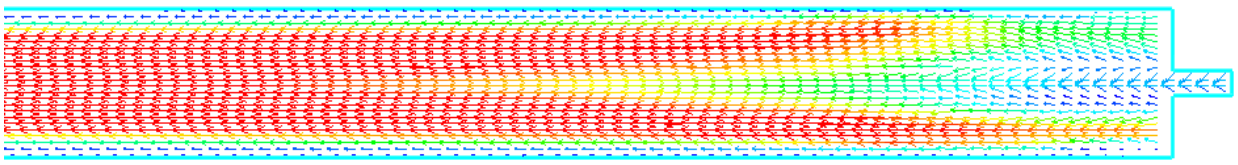

Figure .2. *Velocity vectors of the product*

From Figure 2 that massecuite moves through the pipe evenly. In the initial step of the way is the distribution steam massecuite. And then both products are moving through the pipe a common substance.

Concentration of the mixture of the massecuite and the pair gradually aligned (see Figure 3). Most of the steam remains in the center of the stream. This is a favorable factor, as the center of the heat from the hot walls of all comes later.

Figure 3. *Changing the concentration of vapor in the massecuite in their joint motion (direction from right to left).*

Process in Figure 4 allows us to assess the pattern of heat transfer in a pipe. The heat enters the system from two sources: from the outer walls of the pipes and steam.

In this case, significantly increases the efficiency of central heating layers massecuite.

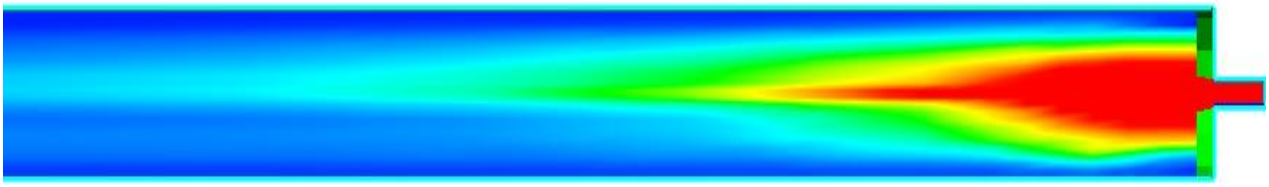

Figure 4. *Temperature change in the massecuite by simultaneous heat from the walls and from the steam*.

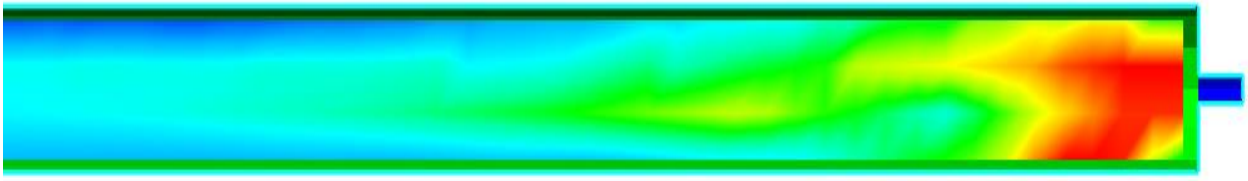

Figure 5. *Changing the flow of heat introduced into the system.*

After analyzing the data modeling made the following experiments and mathematical generalization.

Studies on the effects of water vapor introduced from outside into massecuite at the rate of crystallization of sugar massecuite last crystallization was carried out in the range of 80...220 kg/h (Fig. 6). This corresponds to 1,8...3,52% of injected steam to the total steam flow to the full cycle of the vacuum apparatus.

The analysis shows that the introduction of water vapor from the outside more than 3,52% did not give a significant intensification of the process of crystallization.

Influencing factors were selected: the number of additionally introduced from outside into the boiling sugar solution of water vapor as a percentage of total expenditure pair (Q) and the relative time of boiling (τ_i/τ_u).

The rate of crystallization of sugar last product viewed as a state variable.

Normalization was performed by independent factors dimensionless variables.

After confirming the adequacy of the mathematical model obtained a formula for practical calculations:

$$G = -0{,}62 + 5{,}26 \cdot \tau - 4{,}225 \cdot \tau^2 -$$

$$-0{,}181 \cdot \frac{Q^2}{2{,}56} + 0{,}138 \cdot \frac{\tau . Q}{0{,}64} + 0{,}29 \cdot Q$$

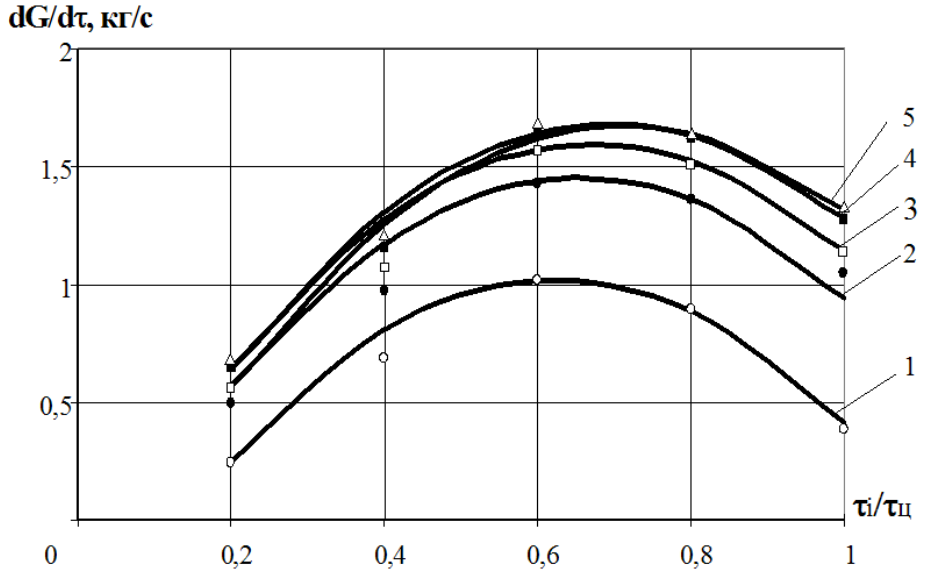

Figure 6. *Dependence of the rate of crystallization of sugar massecuite last crystallization from boiling time with the additional introduction of a couple: 1 - 0%, 2 - 1.28%, 3 - 2.0%, 4 - 2.28%, 5 - 3.52%*

Clarification of the optimal amount of steam injected conducted using the methods of mathematical planning of the experiment.

For the construction plan of the second order and the creation of the mathematical model used quadratic matrix of optimal planning of Boxing (Bn). This method of planning refers to D-optimal methods, the use of which guarantees a maximum amount of reliable information in a minimum number of experiments.

For finding the minimum of the response surface gradient method is applied.

Having the greatest speed crystallization of sugar at the maximum amount of steam injection (Q = 3,52%) in massecuite weight of the total cost for a pair of full cycle vacuum apparatus.

Based on the analysis of mathematical calculations proposed a new scheme for building a vacuum apparatus.

In Figure 7 is a vacuum apparatus with increased hydrodynamic circulation. Manifold runs between rows of water tubes close to the bottom of the tube sheet unit.

Vacuum apparatus has a housing 1, in which the two suspended heating chamber and trap separator 3. Heating chamber tube sheet is 4, which is located in the middle of the circulation pipe 5.

The steam in the heating chamber passes through the device 6. Between the body and the body of the

heating chamber apparatus has an annular space for the circulation of the massecuite.

To separate drops of the product being made secondary steam at the top of this unit is set trap separator 3, the bottom of which runs a baffle plate. Arrangements for additional steam injection 7 placed under heating chamber. At the bottom of the unit is set to walk down the massecuite discharge valve 8.

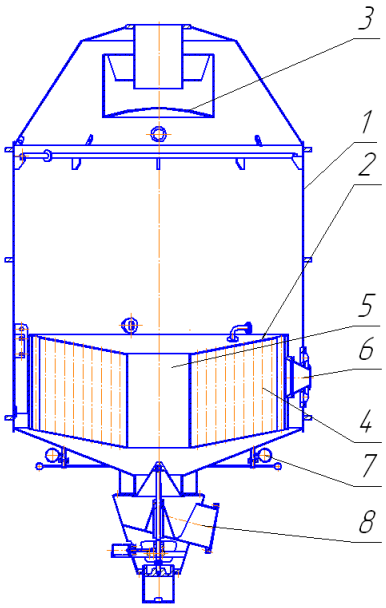

Figure 7. *Vacuum apparatus with provision for additional steam injection*

Conclusions

Computer simulation of motion of the massecuite in vacuum-tube device with additional steam injection allowed us to obtain quantitative and qualitative data on the process of heat transfer.

On the basis of studies of the process of heat transfer and hydrodynamics in a vacuum apparatus proposed upgrading unit batch. It is equipped with a device for amplification of hydrodynamic circulation in order to intensify the process.

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The study of phthalates migration from different materials contacting with food

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Abstract. *Today, in the modern, industrialized world is difficult to imagine life without materials that make our life more comfortable. Some of these are PVC and rubber, paints and varnishes, perfumes and cosmetics [1]. However, their application often make us to choose between health and comfort. Phthalates are one of the reasons for this search for a compromise. The use polymers, not intended for this purpose, in the food industry becomes the cause of food contamination by phthalates. In the winery and other alcoholic beverages industry situation is much more critical, because migration in the liquid phase occurs at a higher rate and the contact during storage that can last for years. In the research laboratory of National Center for Quality Testing of the Alcoholic Beverages (Chisinau, Moldova), the last two years there were monitored the wine industry products for the presence of phthalates. Also a wide range of materials and substances that contact with product during processing and storage was examined. The laboratory elaborated methods of studying the processes of migration of phthalates in alcoholic beverages. During this period, there was received a large amount of experimental data.*

Keywords: phthalates, migration, extraction, solvent, GC-MS.

1. Introduction

In modern, industrialized society people can hardly imagine life without home appliances, communication systems, a convenient plastic packaging, fragrance and cosmetics. Most of these and many other chemical products have their properties such as strength, ductility, durability, incombustibility, etc., owing to a number of synthetic organic chemicals. Phthalates are among the members of this series. Phthalates (esters of phthalic acid) are included in the compositions of almost all types of plastics, rubber, paints and varnishes, giving them elasticity and strength [2]. The most of the phthalates produced are used exactly as plasticizers, near 90%. EU prohibits the manufacture and importation into the Community of plastic materials and articles intended to come into contact with food which does not comply with restrictions and specifications for phthalates [3]. At perfume and cosmetic products phthalates mainly used as a solvent and vehicle for fragrance and cosmetic ingredients and subsequent skin contact [4, 5].

Humans always are surrounded by materials containing phthalates, such as linoleum, insulation of wires, pipes, plastic housings of domestic appliances, toys, varnishes and paints.

By the authors [6,7,8,9] provided that phthalates accumulate in the human body, which negatively affects its hormones, liver and kidneys may also become the causes of allergies, asthma and cancer, neurodevelopmental disorders and abnormalities in the development of children. Molecules of phthalates are not structural elements of the polymer chains and therefore easily stand out in the environment, getting into the human body through food, skin or by inhalation.

The annual production of phthalates was estimated by the World Health Organization (WHO) to approach 8 million tons (by data on 1992) [10] and 5 million tons by data on 2011[11]. Approximately 95% of the phthalates enters into the production of polymeric materials, in some of them phthalates' content reaches 50% by weight of the polymer.

In a number of investigated wine-products released by vendors it was detected the presence of phthalates. Special attention was given to the dibuthyl phthalate (DBP) and di-(2-ethylhexyl) phthalate (DEHP).

The problem of phthalates in food production is not new, but still remains relevant. Determination of the sources and causes of food contamination with phthalates is the key moments in the issue of product safety. A number of European laboratories investigated the migration of harmful substances from the polymer by acting on them with solutions simulating saliva, blood, milk, soft drinks, etc. Most of the procedures of the study of migration are described of existing publications and directives [3, 12, 13].

2. Expermental

2.1. Methods and Materials

Measuring of phthalates concentration is based on chromatographic separation on a capillary column, identify the retention time and mass spectrum, and quantify with the characteristic ions m/z. for determination and optimization of the extraction conditions of phthalates from the materials used in winemaking, various polymeric materials have been exposed to some solvents, including products and solutions simulating wine production. Alcoholic beverages such as vodka, brandy, grappa, eaux-de-vie, etc., were simulated by 50% v/v aqueous-alcoholic solution. Wine was simulated by aqueous solution of 15% ethanol and tartaric acid (6g/dm^3) (tartaric acid, supplied by Fluka, puriss. p.a. for ion chromatography) and carried to the pH 3.5 with 5M sodium hydroxide - wine simulant [14] (all material used were pre-tested for content of phthalates).

2.2. Instruments

a). SHIMADZU GCMS-QP-2010S (EI) with a COMBI PAL autosampler (CTC Analytics, Zwingen, Switzerland) equipped with capillary silica column RESTEK - Rtx-5MS (30m/0.25mm/0.25µm 5% diphenyl / 95% dimethylpolisiloxane phase) was used to perform injections and gas chromatographic analyses in an automated way.

b). Analytical balance SARTOGOSM (d=0.1mg).

c). Ultrasonic bath HYDROSONIC 25M (frequency 45 kHz, power output 100 W).

3. Results and discussion

Migration of phthalates has been studied on samples of rubber and plasticized PVC. For each series of experiments samples of polymers were taken with the same mass (5.0g of rubber, 1.0g of PVC) and surface area S=32,98см^2 and S=15,57см^2 respectively. The volumes of extractants are also the same for every series - 100ml. As the solvents there were investigated: water - as a basic component of alcoholic beverages (T=25,0^{o}C), solution of water/alcohol (1:1) for modeling strong alcoholic beverages (T=25,0^{o}C), wine simulant (T=25,0^{o}C), alcohol ethylic - as an essential component (T=0,0^{o}C, 25,0^{o}C, 50,0^{o}C, 75,0^{o}C), chloroform as alternative organic solvent (T=25,0^{o}C), alcohol ethylic (T=25,0^{o}C under the ultrasonic influence). All samples of polymers, completely immersed in the extractants, were kept for 7 hours at static conditions, except the case of ultrasonic extraction. One ml of every "samples" was taken for analysis every hour (all extractions were performed in two parallels). DBP and DEHP were detected in the investigated samples of PVC. As a result of GC-spectrometric analysis of the extracts there were constructed dependency of DBP concentration in the above-mentioned solution from the contact time with PVC - figure1. and the variation of the concentration of DEHP in the extracts from the same PVC – figure2.

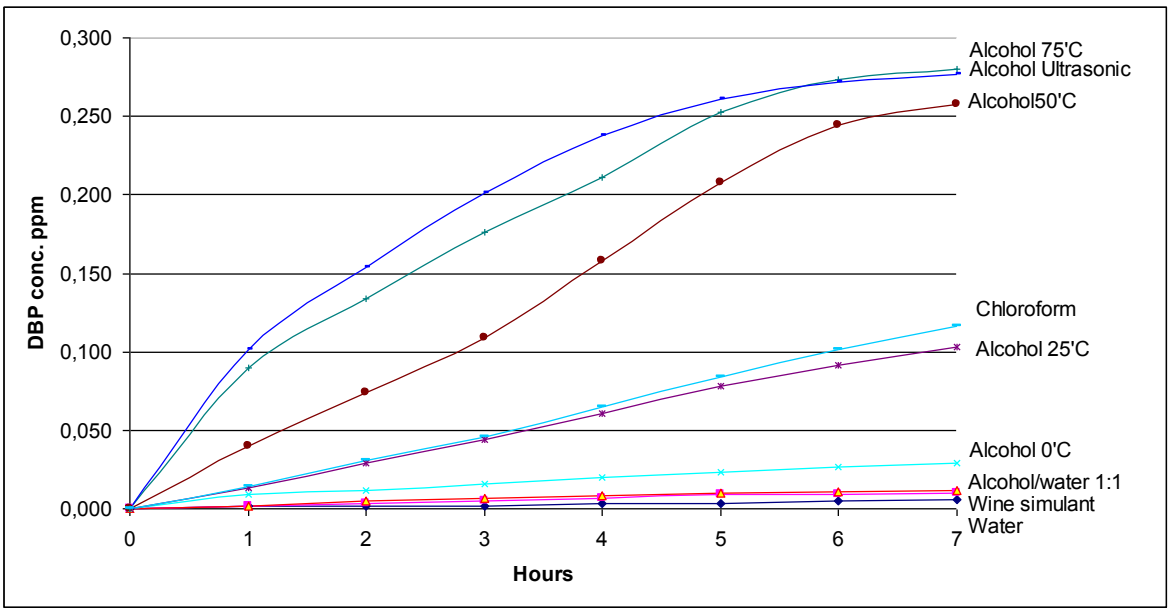

Figure 1. *Migration of DBP in various solvents from PVC.*

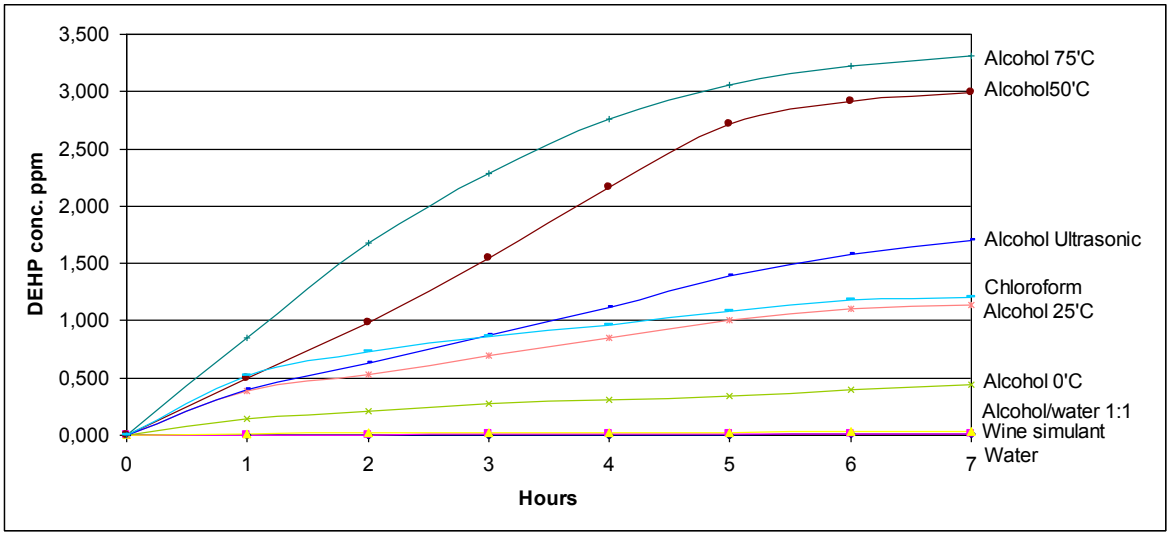

Figure 2. *Migration of DEHP in various solvents from PVC.*

The study of migration phthalates from the rubber was carried out similar to the same experiment with PVC. The volumes of extractants are also the same for each of the series - 100ml. As the solvents there were investigated: water (T=25,0°C, 50,0, 75,0°C), a solution of water/alcohol (1:1) for modeling strong alcoholic beverages (T=25,0°C), wine simulant (T=25,0°C), alcohol ethylic (T=0,0°C, 25,0°C, 50,0°C, 75,0°C). All samples of polymers, completely immersed in the extractants, were kept for 8 hours at static conditions. One ml of every "samples" was taken for analysis every hour (all extractions were performed in two parallels). Important research was focused on DBP and DEHP. As a result of GC-spectrometric analysis of the extracts there were constructed graphs of dependency of DBP concentration in the above-mentioned solution from the contact time with the tires – Figure 3. (chart scale to 14.0 ppm) and Fig.4. (chart scale to 0,14 ppm) and the variation of the concentration of DEHP in the extracts in the same condition - Figure5. (chart scale to 120,0 ppm) and Figure 6 (chart scale to 0,09 ppm).

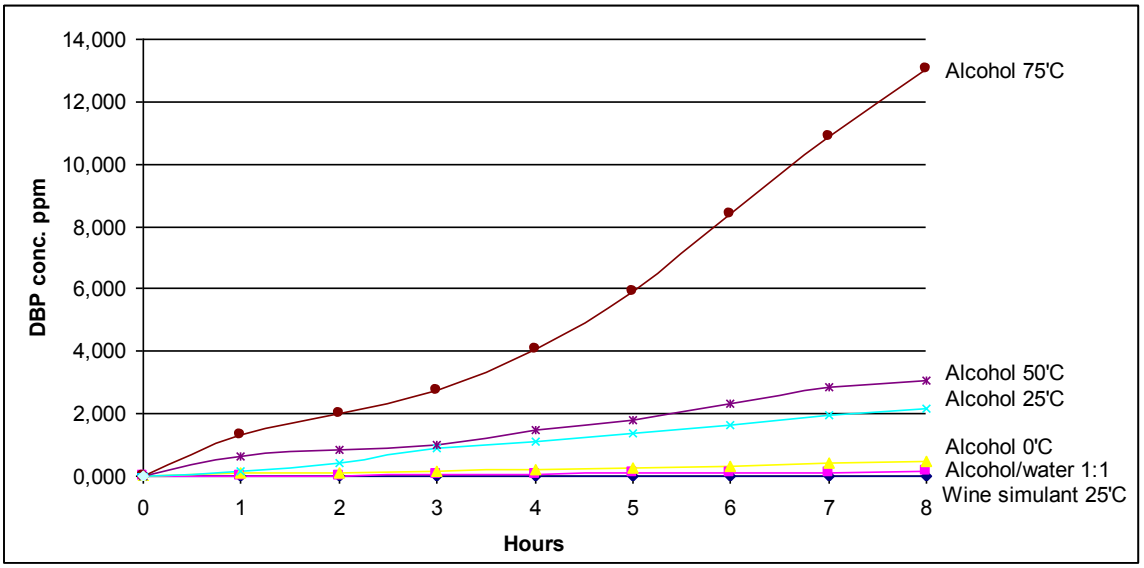

Figure 3. *Migration of DBP in alcohol and models from rubber (chart scale to 14,0 ppm).*

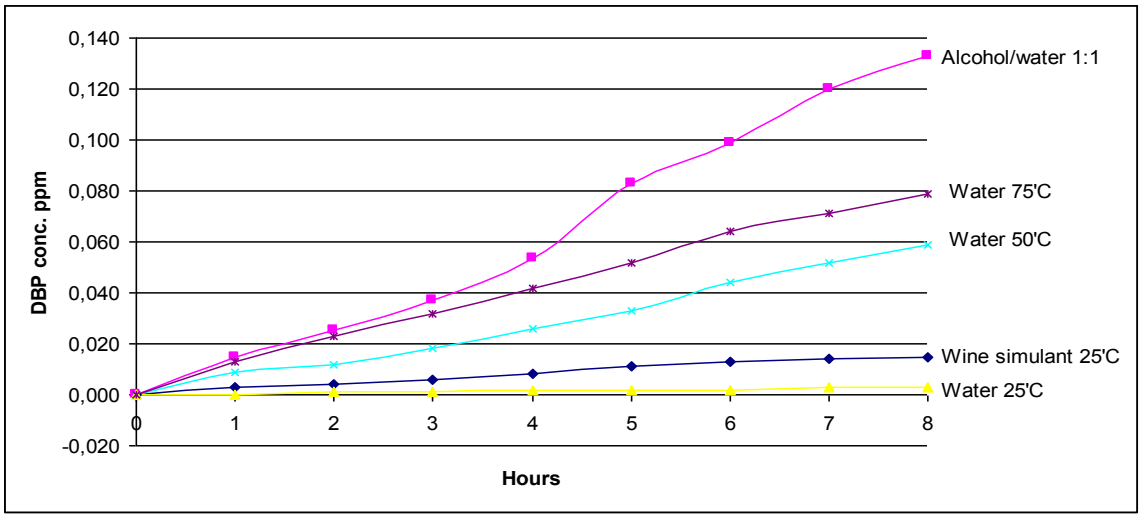

Figure 4. *Migration of DBP in water and models from rubber (chart scale to 0,14 ppm).*

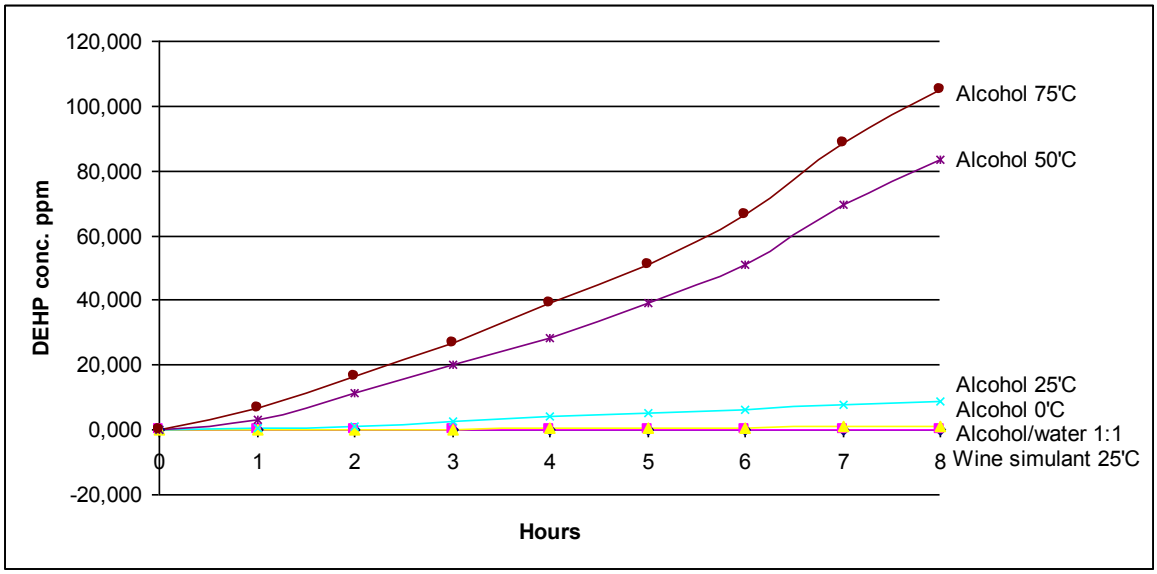

Figure 5. *Migration of DEHP in alcohol and models from rubber(chart scale to 120,0 ppm).*

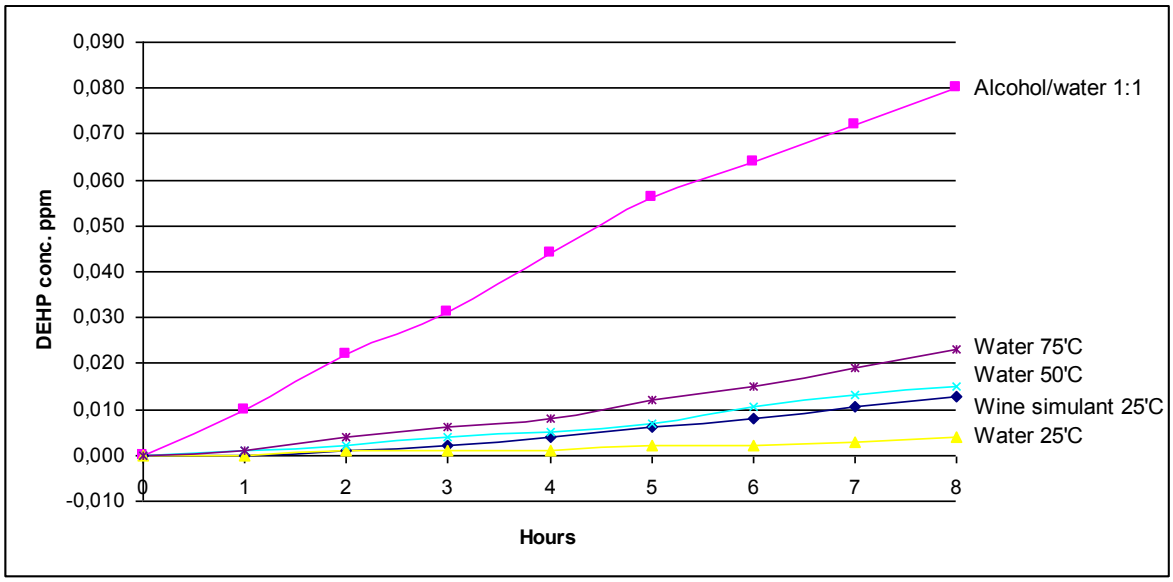

Figure.6. *Migration of DEHP in water and model solutions from rubber (chart scale to 0,09 ppm).*

According to the results we can conclude that the study of the migration of phthalates from polymer solutions by applying the model is ineffective. Use of non-toxic ethanol has the potential to increase the rate of extraction in one-two times. In addition to the rate of migration it can increase the completeness of recovery, reducing the analysis time of materials for the presence of phthalates. In addition, as it's shown on the figures 1, 2, 3 and 5, in the early hours of extraction in model solutions the concentration of phthalates does not very differ from zero, that allows you to doubt in possibility of a qualitative detection of contaminants in the objects with a low content of them. Carrying out the extraction at high temperature migration rate of phthalates from the solid material in the liquid increases. The rate of migration to the water increases in 1.5-2.5 times with increasing temperature by 10 degrees, and in 2,5-15 times to alcohol in similar temperature conditions. The use of ultrasonic bath (45k Hz, 100 W) for the study of the migration initially increases the rate of migration up to 6-10 times.

Based on these investigations by M. Katsitadze et al. [15] it can be concluded that a number of methods for the determination of phthalate migration from polymers should be modified.

Using this information, samples of materials in contact with wine / wine raw material at different stages of production were investigated. The samples for study, such as lining for containers, hoses, rubber and PVC pipe, etc. have been provided by some manufacturers to determine the availability for use in winery. Results of the phthalates migration in alcohol are given in tab.1. The data are expressed as mg (phthalate) per kg (of investigated material) – ppm. (25^{o}C, 1 hour).

Table 1. *Migration of phthalates in alcohol for 1 hour*

Name	DMP, ppm	DEP, ppm	DBP, ppm	DEHP, ppm
Paints	<LD	<LD	0 - 867,4	0 – 55,7
Lining for containers	<LD	<LD	0 - 94,6	0 – 34,44
Enamels	<LD	<LD	0 - 29,5	0 – 11,589
Varnish	<LD	<LD	63,7	13,15
Hardenger	<LD	<LD	33,2	<LD
Hoses	<LD	<LD	0 - 170,0	0 – 2478,5
Filter paper	<LD	<LD	0,052	0,042
Filter sheets	<LD	0 – 0,020	0,068 – 0,406	0,025 – 0,241
Perlite	<LD	<LD	0,000	0,000
Nutrient additions	<LD	<LD	0 – 0,019	0 – 1,016
Bentonite	<LD	<LD	0,023	0,000
Gelatine	<LD	<LD	0,000	0,000
Kieselguhr	0 - 0,082	0 - 0,104	0,05 - 4,204	0 - 0,067

Also 36 different samples of cork stoppers (for wine and brandy), 6 samples of polymer stoppers for sealing wines and more than 20 samples of caps, seals, dispensers bottle and other polymer elements, which can contact with bottled alcoholic beverages have been studied as a potential source of contamination. All the samples were crushed to accelerate the potential migration of phthalates in the model solution, in which further there was determined the content of phthalates. In some cases, migration of phthalates was determined from the surface of the products. As the model solutions there was used water-alcohol solution and acidic water-alcohol mixture simulating wine. As a result, it should be noted that DBP was detected in trace amounts only in four of the investigated samples. In these cases, the observed DBP was on the surface of cork, what is probably due to a violation of the conditions of capping material storage. Quantities of phthalates sufficient for essential change of them in beverages were found in no one of the studied samples of capping materials.

Conclusions

During investigation there was investigated migration of phthalates in various solutions from polymeric materials. A number of materials that might be potential sources of phthalates were studied. In addition influence of temperature on the rate and extent of extraction was carried out. As the result there was proposed some modifications of methods of analysis for materials contacting with food.

Acknowledgments

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Determination of nanofiltrated membrane mass transfer resistance after separation of whey

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Abstract. *This paper presents the results of experimental studies to determine the mass transfer resistance of the new nanofiltrated membrane OPMN-P (JSC STC "Vladipor", Russia), and its mass transfer resistance after whey separation at the pressure of 2.5 MPa. It is found out that the value of mass transfer resistance formed by the interaction of solutes with the membrane is 5 times bigger than the resistance of the new membrane.*

Key Words: nanofiltration, mass transfer resistance, whey

I. Introduction

Nanofiltration is a baromembrane process which is widely used in various industries, particularly in the food industry. If to compare it with reverse osmosis it is characterized by high performance, lower power consumption and, moreover, it allows separating monovalent ions of polyvalent and macromolecular compounds [1]. Such advantage is the main reason for development of new whey processing technologies by using nanofiltration [2, 3]. While concentrating solids partial demineralization of whey, first of all, reduces the amount of moisture evaporated in a vacuum evaporator, and with its further processing improves the crystallization of lactose [4], which, in turn, reduces energy consumption during its spray drying [5], and secondly, treating this whey on electrodialysis for deep demineralization is recommended [6], as it increases the electrical conductivity and decreases the liquid volume which requires a smaller pump that positively affects the power consumption of such treatment [7].

However, fouling of membrane during separation of liquid medias is unavoidable, this leads to growing of membrane mass transfer resistance and, consequently, to decreasing its effectiveness. The reason for this, in most cases, is the concentration polarization, adsorption, gelling, sealing or blocking of pores [8]. There is no data in the scientific literature concerning mass transfer resistance of nanofiltrated membrane OPMN-P (JSC STC "Vladipor", Russia) after separation of whey, which requires a special research.

II. Theory

It is believed [1, 8, 9] that the flow of pure (distilled) water through the membrane is directly proportional to the applied hydrostatic pressure and can be described by the equation (1):

$$J = \frac{\Delta P}{\mu \cdot R_m}, \qquad (1)$$

where: J – flux, $m^3/(m^2\ s)$; ΔP – pressure drop at both sides of the membrane, Pa; μ – dynamic viscosity, Pa·s; R_m – resistance of the membrane, m^{-1}.

Using equation (1) it is easy to calculate R_m:

$$R_m = \frac{\Delta P}{\mu \cdot J}. \qquad (2)$$

Membrane resistance, R_m, is a constant value and depends on membrane structural features. However, if the liquid contains dissolved substances they create additional resistance to mass transfer. Varieties of such resistance are shown on Figure 1. The mechanism of mass transfer and the formation of membrane fouling depend on the solutes properties, membranes surface and the interaction between the membrane surface and the solutes.

Taking into account the abovementioned, equation (1) can be rewritten as:

$$J = \frac{\Delta P}{\mu \cdot R_t} = \frac{\Delta P}{\mu \cdot (R_m + R_f)}, \qquad (3)$$

where: R_t – total mass transfer resistance, m^{-1}; R_f – resistance that is created by the solutes while interaction with the membrane, m^{-1}.

Hence, R_t and R_f can be found due to the following equations:

$$R_t = \frac{\Delta P}{\mu \cdot J} \quad (4)$$

$$R_f = \frac{\Delta P}{\mu \cdot J} - R_m. \quad (5)$$

Three main types of membranes fouling which increase mass transfer resistance, R_f, can be determined during whey separation:

- Protein compounds;
- Mineral salts;
- Lactose and milk fat

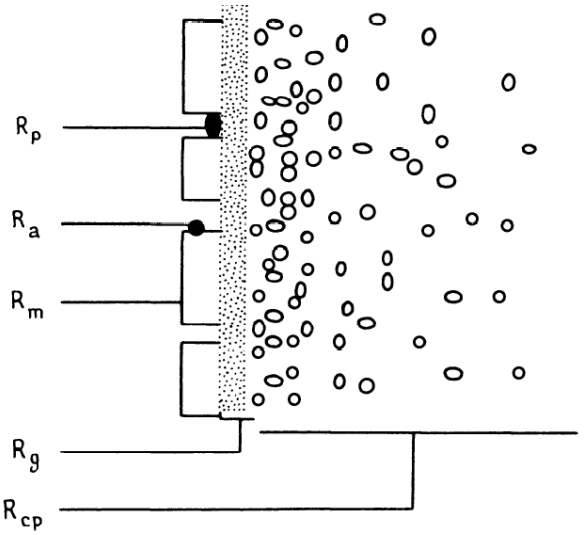

Figure 1. *Different types of membrane mass transfer resistance:*
R_p – fouling pores, R_a - adsorption, R_m - membrane, R_g - the formation of gel layer, R_{cp} - concentration polarization [8].

At high concentrations of proteins on the membranous layer there is a possibility for protein gels formation that strongly bind to the surface of the membrane and significantly reduce the flow of permeate. It is also believed that the main cause of membrane fouling by protein compounds is adsorption [10]. Morphology of protein contamination greatly depends on pH and electrolyte composition. They are able to absorb under various forces, namely ionic forces, Van Der Waals forces, hydrophobic forces, etc., depending on their chemical and structural properties [11, 12]. However, the degree of adsorption depends on the local concentration of the protein [13].

Sedimentation of minerals on the surface of nanofiltrated membrane is first of all caused by concentration polarization [1] when solution is saturated with soluble compounds on the membranous layer. It is determined [14-16] that among minerals that are crystallized while separation of milk and whey, the biggest amount is of calcium phosphates.

Milk fat is usually separated before nanofiltration because, as discovered by own researches, its contact with the membrane leads to almost twice reduction of whey flux. Lactose at high concentrations may be crystallized on the surface of the membrane, though the authors of works [15, 17], who studied composition of precipitate after nanofiltration of milk, did not mark this.

III. Materials and methods

Pretreatment of the new membrane OPMN-P (JSC STC "Vladipor", Russia) was by filtering distilled water at the operating pressure of 2.5 MPa to adjust a stable performance. Experiments were conducted on a laboratory unit shown on Fig. 2. The effective membrane area was $4{,}3 \cdot 10^{-3}$ m^2.

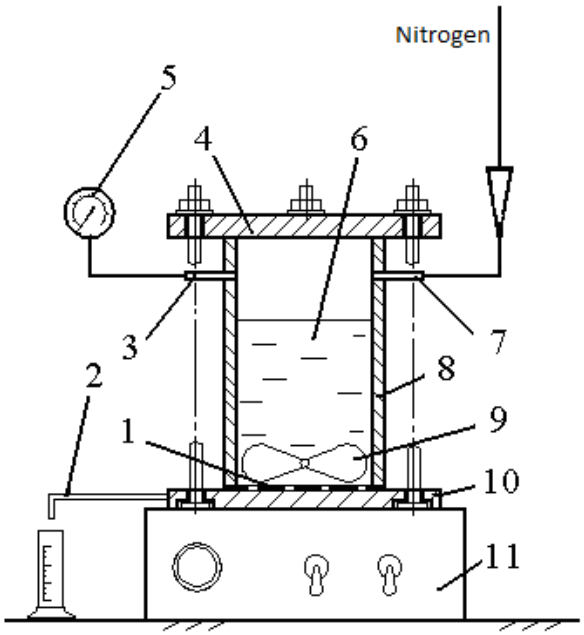

Figure 2. *Principal diagram of the laboratory unit of non-circulating type:*
1 – disc, 2 – permeate outlet, 3, 7 - fitting, 4, 10 - cover, 5 - pressure gauge, 6 - working chamber, 8 - cylindrical body, 9 - mixer, 11 - magnetic mixer.

Membrane (1) was placed on the bottom and pressed by metal cylinder (8). Membrane mixer (9) was put on top. Tightness of the modules was

achieved by tightening bolts and nuts pressing the cover (4) and (10) to the housing (8). Rubber gaskets were laid between these elements. When fittings (3) and (7) were opened, the solution was poured through one of them into the working chamber. Gauge (5) was attached to the fitting (3) for pressure control inside the module and Fitting (7) was connected to the gearbox which was mounted on the tank with an inert gas (not shown). Magnetic mixer (11) was switched on which started the mixer (9). The necessary pressure in the chamber was created by opening the valve on the tank with inert gas and the gearbox. The permeate was collected through the tube (2) Temperature of the solutions during experiments was 20 ± 3 ° C.

Cottage cheese whey used in the experiments was obtained at the dairy industry. It was filtered prior experiments by microfilter with pore size of 5 microns in order to separate residual milk fat and casein dust.

IV. Results and discussion

The distilled water flux of the new membrane at a pressure of 2.5 MPa was 190.24 $dm^3/(m^2h)$. Dynamic viscosity of water at 20°C was $1004 \cdot 10^{-6}$ Pa s. Resistance, R_m, was calculated by equation (2) which was $4{,}7 \cdot 10^{13}$ m^{-1} for membrane OPMN-P under the mention conditions. Then the whey was separated on this membrane. Fig. 3 shows the dependence of flux (point 1) on the concentration coefficient, k, which is calculated by the equation (6):

$$k = \frac{V_n}{V_k}, \qquad (6)$$

where: V_n, V_k – initial and final volume of the solution, accordingly, dm^3.

Fig. 3 shows that whey flux of the new membrane was lower; this can be explained by sorption of whey components and by active formation of dynamic membrane on it. After reaching a concentration factor value of 1.25 the flux started to decrease more slowly due to the established dynamic equilibrium in the system. After the experiment the unit was filled by distilled water and was left for 10 minutes with mixer on. The distilled water was refilled and the flux volume was determined. It was around 30.44 $dm^3/(m^2h)$ under those conditions. This value was slightly lower than the initial flux while whey separation. By equation (4) and (5) a general resistance, R_t, and mass transfer resistance, R_f, of adsorbed components of whey on membrane were calculated. Their values were $R_t = 29{,}5 \cdot 10^{13}$ m^{-1}, $R_f = 24{,}7 \cdot 10^{13}$ m^{-1}. As we can see, whey components had almost 5 times more resistance than membrane. Then this membrane was removed and washed, the surface was cleaned manually under running distilled water, and flux was tested again, on both distilled water and whey. Those procedures were repeated twice after which the active layer of membrane was damaged. The data are presented in Table 1 and Figure 3.

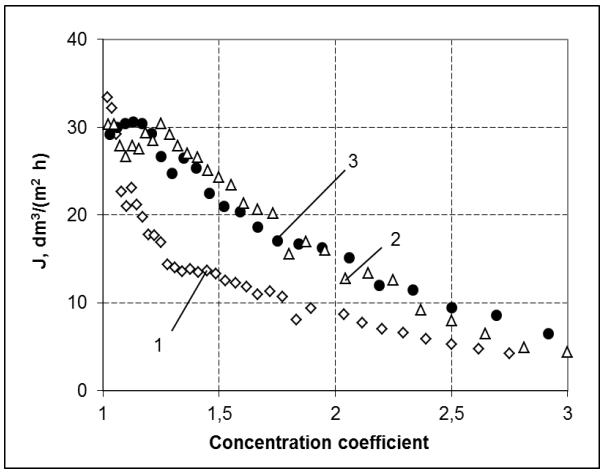

Figure 3. *Dependence of flux of nanofiltrated membrane OPMN-P on concentration coefficient during separation of whey. Pressure - of 2.5 MPa*
1 - new membrane, 2, 3 - membrane after the first and the second mechanical cleaning accordingly.

Based on the data achieved, we see that the flux of nanofiltrated membranes was considerably restored after mechanical cleaning. Obviously, most of the contaminants are adsorbed on the membrane surface and only a small portion enters into the pores. However, this assumption is not confirmed experimentally. During whey separation on the washed membrane we noticed that the flux was larger. It is obvious that the new membrane has a certain surface charge which leads to intense absorption of the dissolved components which in turn creates significant resistance of mass transfer. By mechanical cleaning we washed the fouling layer that was not in direct contact with the membrane surface; that affects the redistribution of the membrane surface charge and the subsequent intensity of the whey separation adsorption process. However, to confirm the above additional studies are needed to be conducted.

Repeated washing showed that Rf was increased almost three times (Table 1), although the flux of separating whey remained at the same level (Fig. 3). The authors [9] also noticed the increase in mass transfer resistance when ultrafiltrating coconut water by number of repeated experiments. Therefore, an important step in the developing industrial

technologies is a study of nanofiltrated membranes regeneration process by chemical reagents, for instance.

Table 1. *Specific membrane capacity and mass transfer resistance values*

	J, $dm^3/(m^2 h)$	R_t, m^{-1}	R_f, m^{-1}
New membrane	190,24	$4,7 \cdot 10^{13}$	0
After nanofiltration of whey	30,44	$29,4 \cdot 10^{13}$	$24,7 \cdot 10^{13}$
After nanofiltration of whey + mechanical cleaning	170,83	$5,2 \cdot 10^{13}$	$0,5 \cdot 10^{13}$
After 2 cycles of nanofiltration of whey + 2 cycles of mechanical cleaning	139,51	$6,4 \cdot 10^{13}$	$1,7 \cdot 10^{13}$
After 3 cycles of nanofiltration of whey + 3 cycles of mechanical cleaing	149,47*	$6,0 \cdot 10^{13}$	$1,3 \cdot 10^{13}$

*active layer of membrane was damaged

V. Conclusions

It was found out that mass transfer resistance of the new nanofiltrated membrane OPMN-P (JSC STC "Vladipor, Russia") at the pressure of 2.5 MPa is $R_m = 4,7 \cdot 10^{13}$ m^{-1}, however, this figure rises to 6.25 times after whey separation and the overall mass transfer resistance reaches $R_t = 29,4 \cdot 10^{13}$ m^{-1}. Mechanical cleaning of the membrane surface, though, restores the flux but leads to rapid membrane damage. The study of nanofiltrated membranes regeneration process after whey separation using chemical reagents is promising.

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Sweet products with grape anthocyanins extracts use as a natural food colorant

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Abstract. *Consumers are increasingly avoiding foods containing synthetic colourants, which lead food industries to replace them by natural pigments, such as carotenoids, betalains, anthocyanins and carminic acid. The objective of this research was to elucidate the influence of the substitution of synthetic colorants (carmoisine) with extracts of grape anthocyanes on the organoleptic, physico-chemical and antioxidant properties of some confectionery products (marmalade, jellies).*

Keywords: Antioxidants, natural colorants, grape seeds anthocyanins, confectionery products.

1. Introduction

One of the major hazards of this beginning of the millennium is the larger use of various synthetic food additives. Firstly, it includes synthetic colorants, which are present practically in most types of processed food. The danger is even greater when it comes to children who consume, having a small body weight, a mass of sweets, brightly colored, so the contribution of additives per kg of body weight is often dangerous to health, causing various allergic reactions.

Recently, natural plants have received much attention as sources of biologically active substances including antioxidants, antimutagens and anticancers [1]. Plant extracts obtained from some fruits and vegetables have been reported to be effective antioxidants. In most cases, phenols mediate their anticancer effects by inhibiting all stages of chemical carcinogenesis, initiation, promotion and progression as well as formation of carcinogens from dietary precursors.

Grape (*Vitis vinifera*) is one of the world's largest fruit crops, while grape seed is a complex matrix containing approximately 40% fiber, 16% oil, 11% proteins, and 7% complex phenols including tannins, in addition to sugars, mineral salts, etc. Proanthocyanidins of grape seed are a group of polyphenolic bioflavonoids, which are known to possess large pharmacological activities and therapeutic potentials [2,3]. Proanthocyanidins, the major polyphenols found in red wine and grape seeds, have been reported to show cardio protective effects against ischemic reperfusion injury. In addition, grape seeds are rich sources of monomeric phenolic compounds, such as (+)-catechins, (+)-epicatechin, (+)-epicatechin-3-o-gallate, and, dimeric, trimeric and tetrameric procyanidins, which have antimutagenic and antiviral effects. Recognition of such health benefits of catechins and procyanidins has facilitated the use of grape seed extract as a dietary supplement [4].

The objective of this research was to elucidate the influence of the substitution of synthetic colorants (cramoisy) with extracts of grape anthocyanes on the organoleptic, physical-chemical and antioxidant properties of some confectionery products (marmalade, jellies).

2. Materials and methods

Spectrophotometer measurements were performed by UV–Vis spectrophotometer **Pye *Unicam UV4-100 UV-Visible***. The study group was made a jelly quartz cell size of 10 x 10 mm (working volume of 4 ml), which was placed in the sink-holder device. The measuring process starts automatically after closing the sample compartment (546 nm).

The method of determining the ability of inhibiting oxidation activity of hydrogen peroxide (HPSA - hydrogen peroxide scavenging activity).

The ability to inhibit the activity of hydrogen peroxide oxidation (HPSA) is determined according to the method published in NAGULENDRAN et al., 2007 [5].

The principle of the method. The ability to recover hydrogen peroxide is determined by titration method of substitution (the test solution does not come into direct reaction so transformed into a chemical compound, which is then titrated with a solution of known concentration).

Reagents: hydrogen peroxide (0,1 mM), a solution of ammonium molybdate (3%), sulfuric acid(2M), sodium thiosulfate (5,09 mM), potassium iodide (1,8 M), concentrated nitric acid, distilled water [5].

3. Experimental results

Production of jelly products can not only be considered as a combination of the mechanical

action of raw materials. During cooking there is a series of very important physical and chemical changes, which to some extent affect the bioavailability of the raw materials used and the finished product. When cooking, always follow the technology and production conditions in order to get a finished product that meets the quality requirements specified in the regulations, and exhibits antioxidant properties.

Preservation of color - an important indicator of the quality of the product manufactured from natural dye. Change the color speaks of the destruction of natural dyes, which reduces the nutritional value of the product.

Given these conditions it has been determined the optimum pH at which the maximum intensity of the color is preserved and the optimum temperature at which the anthocyanins may be introduced into the product, avoiding their destruction. For marmalade optimum value is the range of pH 2.5-2.7, and the optimum temperature + 60 º C.

The measurements were performed using a spectrophotometer UV/vis "UNICAM", length 1 cm cuvette at wavelength = 546 nm. The results are presented in figure.1.

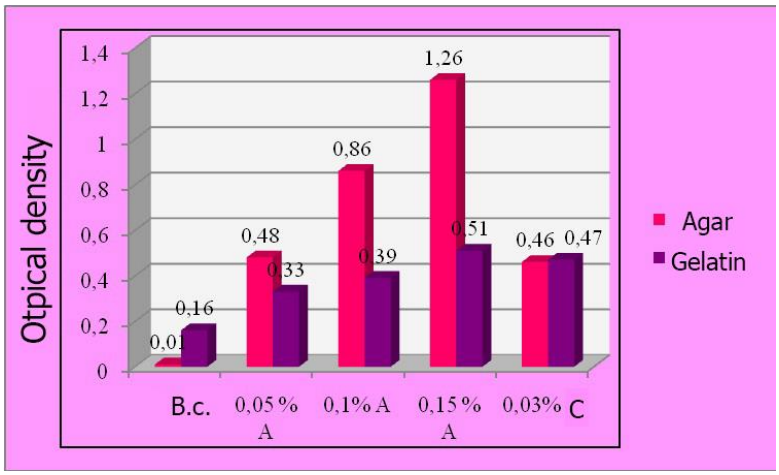

Figure 1. *The study of the intensity of staining jelly gelatin-based and agar, depending on the nature of the dye*

The study of intensity jelly products, depending on the nature of paint shows that gelatin products with natural paint color intensity is less than the intensity karmuazinom jam on synthetic gelatin. The intensity color by adding 0.05% anthocyanins equals 0.33 units and adding synthetic karmuazina intensity equal to 0.47 units. For the agar jelly also the color intensity of the product by adding 0.05% solution is

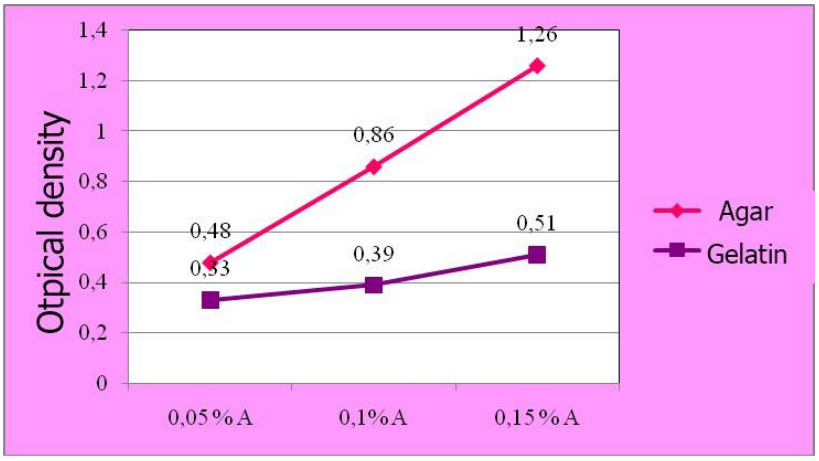

Figure 2. *The study of the intensity of the colors of jelly products depending on the concentration of anthocyanin that were added to the product.*

almost the natural dye intensity karmuazine sample (0.48 and 0.47, respectively). Thus, marmalade, made on agar with natural dye has a higher color intensity than jam on gelatin. When adding the synthetic dye to the color intensity of the two

samples is almost the same marmalade 0.46 and 0.47 units.

For the agar jelly, based on natural dye intensity range is between 0.48 1.26 units and for marmalade on gelatin - between 0.33 0.51 units depending on the number of added anthocyanin.

The concentration of anthocyanin affect color intensity can be considered on *figure 2.*

The intensity of the color of jelly products on gelatin and agar grows with increasing concentration of added anthocyanin. Maximum color intensity is observed when adding 0.15% anthocyanin - 0.51 units of samples on gelatin and 1.26 units of samples on agar. The intensity of the color of the samples on agar are 1.5-2.5 times higher than that of samples in gelatin. This can be explained by the fact that initially (even without dye) the marmalade on agar jelly is a colorless product but marmalade on gelatin has a yellowish color. Therefore, the addition of the dye to the samples on the basis of gelatin, dims out the color of marmalade, and the color intensity of the product falls.

The color intensity is a composite index, which depends on a combination of factors: the nature of the dye, natural ingredients and the concentration of the dye. In order to more accurately describe the intensity of the color of the product is necessary to consider the impact of each factor separately.

Study of changes in the color stability during storage

Anthocyanins - are plant pigments whose color depends on the acidity of the medium. At pH <6 anthocyanins are red variable intensity, more vivid and more dense at pH 1-2, at a pH of 6 - violet at a pH of 8 - blue at pH = 10 - green. Color intensity increases with decreasing pH, thus adding citric acid items increases color stability.

It was found that the acidity of the investigational product is pH = 2.5. In order to determine the color stability over time it has been defined the intensity of the colors of jelly products on the day of manufacture and after 15 days of storage. The measurements were performed in the laboratory on photocolorimeter at wavelength = 540nm. The results are presented in figure 3.

The intensity of the color jelly product within 15 days varies slightly. The color of jelly products based on synthetic dyes does not change.

More clearly it can be represented the change of the intensity of the color of jelly products in the diagrams. It can observe changing the the color stability over time, depending on the nature of the dye, the nature of ingredients and the qualiy of natural dyes.

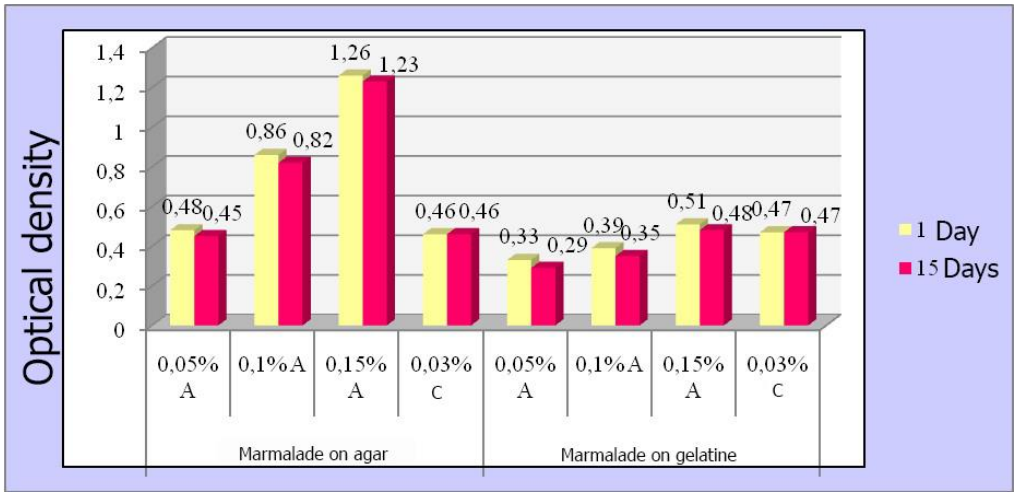

Figure 3. *Changing the color stability of jelly products in time depending on the nature of the dye and natural ingredients.*

Undesirable property of natural dyes is to reduce the color of the product during storage. Regardless of the nature of the ingredients in both cases, the products with natural dyes decrease the color intensity of the product for 15 days. But this reduction is not as significant. In the study jelly products reducing the intensity does not exceed 0.04-0.06 units.

If in samples with natural dyes color intensity decreases, then in the specimen with a synthetic dye color intensity of the product over time will not change at all. In jelly products prepared on the basis of gelatin it is observed the greatest decrease of the

intensity by 0.05 units (at 0.05% content of anthocyanin). The highest intensity of staining characteristic of agar jelly, where the color intensity equals 1.26 and in storage decreases by only 0.03 units.Thus, the products of synthetic dyes can be considered more stable. But the use of natural dyes is very important due to their many favorable properties. In addition, the charts data suggest that if a product is made of natural dyes concentration of 0.15% or higher, the intensity will decrease slightly.

Determination of the inhibition of oxidative activity of hydrogen peroxide. Many fans of sweet like jelly products (lemon drops, chewing marmalade). Jelly products (lemon drops, chewing marmalade) like many fans of sweet. Their unusual taste pleases kids and adults. Jam and jelly decorate cakes and desserts, ice cream and biscuits. It is very important that of all the sweets the marmalade is the most useful. The fact is that it includes nutrients such as agar-agar, pectin, gelatin and applesauce.

Agar-agar is a product of plant origin which improves liver. Pectin is a soluble dietary fiber, helps normalize the digestive tract. Marmalade is a low-fat confectionery product; it contains no fat, and therefore is considered a dietary product. It is also widely known that the marmalade is an excellent anti-depressant, as it helps to relieve stress and improve mood.

But most importantly, marmalade can be also an excellent antioxidant, for example, if it is composed of natural dye anthocyanin.

The antioxidant properties of marmalade from natural dye can be determined by the ability to inhibit the action of anthocyanin hydrogen peroxide.

The obtained data are recorded in Table 1.

Table 1. *The results of the study of antioxidant activity of jelly products*

Nr P.p.	Ingredients	The concentration of the dye,%	$\bar{V}_0$	$\bar{V}_1$	$HPSA(_{\%}H_2O_{2inhibat}) = \frac{V_0 - V_1}{V_0} \cdot 100$, %
1.	**Marmalade on agar**	Without dye	4,65	4,40	5,38
2		0,03% crimson	6,15	6,05	1,63
3.		0,05 % anthocyanin	5,20	4,80	7,69
4.		0,1% anthocyanin	5,65	4,90	13,27
5.		0,15 % anthocyanin	6,30	5,15	18, 25
6.	**Marmalade on gelatin**	Without dye	3,90	3,85	1,28
7.		0,03% crimson	5,10	5,00	1,96
8.		0,05 % anthocyanin	4,10	3,90	4,88
9.		0,1% anthocyanin	3,85	3,50	9,09
10.		0,15 % anthocyanin	4,80	4,25	11,46

The nature of the dye has a large effect on the antioxidant properties of the product. In both types of marmalade natural dye products, the antioxidant activity (AOA) of the finished product increases. The higher the concentration of the dye in the product, the higher the antioxidant activity is. Contrary, the synthetic dye may reduce or increase slightly the antioxidant activity depending on the nature of the ingredients.

In the marmalade on agar, not yet painted, initially there is a rather high content of antioxidants, so the addition of anthocyanins, the AOA of products increases significantly with 5.38% in the unpainted product and to 18.25% in the product, which contains 0.15% anthocyanins.

In the marmalade on gelatin the initial antioxidant content is very low only 1.28%, therefore the highest AOA rises to 11.46% in the richest anthocyanins sample.

Synthetic dyes have an undesirable effect on AOA of the product. The sample on agar synthetic dye reduced AOA by almost 3.5 times from 5.38% to 1.63%.

In this paper, it is important to understand and analyze how and how much natural dye - anthocyanin affected significantly on AOA of the product. To do this, consider the following diagram.

The AOA of the value marmalade products is directly proportional to the amount added to the in products in the gelatin. But regardless of that, marmalade on agar with anthocyanin concentration of 0.15% contains 1.5 times more antioxidants than marmalade on gelatin with the same concentration of anthocyanin. Because in the marmalade on agar initially there is a high level of antioxidants, it can be considered as its antioxidant properties lushimi and jellies more useful.

4. Conclusion

The addition of extracts of grape anthocyanes gave an excellent antioxidant effect on the marmalade compared with the effect of synthetic colorant. In addition, natural antioxidants are safe and impart health benefits to the consumer. Increased knowledge of their bioavailability and therapeutic effects will result in better adoption of anthocyanin-based products as functional foods.

product of anthocyanin. With increasing concentration of anthocyanin rises AOA of the product. In both types of jelly products AOA increases by 2.5 times from 7.69% to 18.25% in the products on the agar and 4.88% to 11.46%

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Analysis of energy consumption during work of breadcutting machine

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Abstract. *In scientific and reference books there are no designed procedures to determine the drive power of cutting and feeding mechanisms of bread-cutting machines, with a bundle of tape serrated knives.*

Laying on the assaying of the scientific literature, critical parameters of process of cutting of bread are defined such as: rate of cutting and feeding, structurally - mechanical properties, force of cutting, cutting mode. Based on this data an analyze was conducted on the power of mechanisms of the bread-cutting machines, and it was developed a designing procedure of drive power of cutting and transportation mechanisms. The mathematical dependences which were determined allowed us to calculate drive power at known force and rate of cutting, to analyze and optimize expenditures of energy in the machine.

Results of probes could be used in calculation of the cutting equipment and when making a choice on the optimal parameters of work.

Keywords: energy consumption, bread, cutting

1. Introduction.

During operation of the bread-cutting machine with a bundle of tape serrated knives (Figure 1), power is used for the following processes:

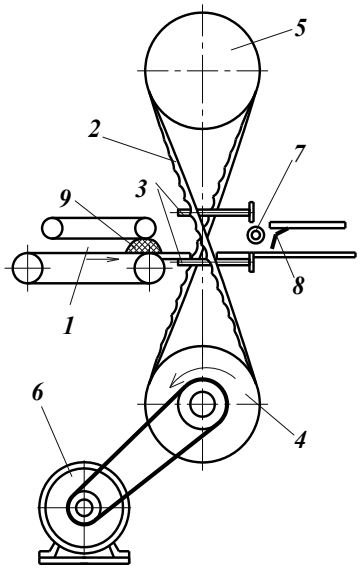

Figure 1. *Bread-cutting machine:*
1 - feeding mechanism; 2 - belt knives; 3 - guide rollers;, 4, 5 - drive and tensioning drums; 6 – drive; 7 – photosensor; 8 - moving mechanism sliced bread; 9 - bread.

1. Starting of a bundle of tape knives.
2. Starting of the conveyor for feeding of bread and pinch conveyor.
3. Starting auxiliary conveyors (the side pinch conveyors, the assign conveyor).

In the scientific and educational literature there are techniques which allow us to define capacity of drives of the bread-cutting machine and to analyze expenses of energy. However, number of modern scientific suggestions, allow us to define the expense of energy for work of the cutting machine. Among them it is necessary to note some results from the researches:

- data about structurally - mechanical properties of bread
- influence of speed of a knife on force of cutting of a grain crumb and crust.
- influence of speed of sliding of bread on lateral surfaces of a knife on a frictional force.
- rational speed of a knife at whom we will receive high quality of a cut under different conditions and modes of cutting

The purpose of the analytical research - analysis of energy costs in working cutting machine and development of methods for calculating bread cutting machines with toothed belt knives.

2. Materials and methods.

To define expenses of energy for work of the cutting machine results of scientific researches of process of cutting of bread are used [1, 2, 3, 4].

In developing the methodology for determining the power of the drive of cutting machine, data about the process of cutting bread was used, and power analysis was conducted for the individual elements of the cutting machine: feeding conveyor, clamping belts, cutting mechanism

To define the resistance to moving of conveyors and knives, moving between drum heads, the method for traction calculation and the theorem of Euler are used.

In order to analyze the friction between bread and a side face of knives data about the influence of the speed of the knife and the pressure of a friction is used. In case of movement of bread on a conveying tape at small speeds of sliding, it is accepted that a coefficient of friction is constant.

3. Results and discussion.

It is known that force of cutting of bread depends on the speed of the knife and the time of keeping of the bread after baking (figures 2, 3) [3]. By increasing the speed of an edge in a product, the force of cutting of a crumb increases. At speed about 5 m/s force of cutting reaches maximum (extremes on charts of the force of cutting), while at further increase of the speed force of cutting decreases. The greatest force of cutting of a crumb - when cutting bread right after baking.

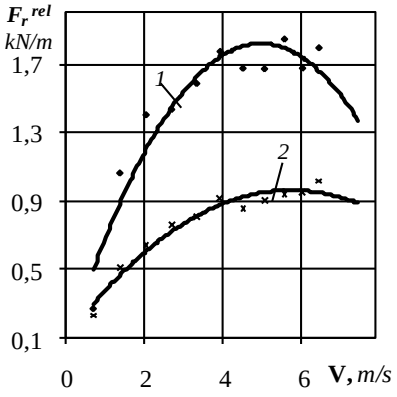

Figure 2. *Influence of the knife speed over the relative cutting effort of the bread core when time for stay of bread, h:*
1-0; 2-6.

Pressure of a friction between a side face of a knife and bread also depends on speed of the knife. With the increase of speed, the pressure of friction for bread crumb and crust increase. To define pressure of a friction *G, kPa*, it is possible to use the following equations [1].

For a crumb:

At 0 <τ<240 min:

$$G = 133 + 0.003\cdot\tau^2 - 0{,}97\cdot\tau - 4.1\cdot10^{-5}\cdot N^2 + 0.447\cdot N - 0.00104\cdot\tau\cdot N + 12.4\cdot V. \quad (1)$$

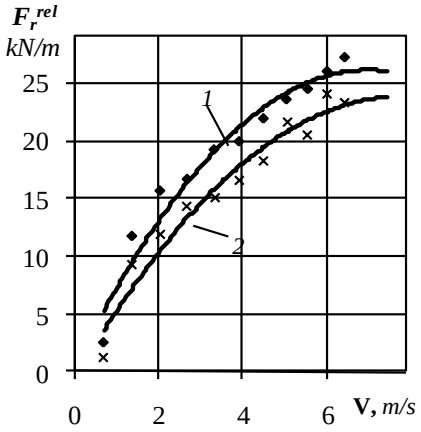

Figure 3. *Influence of the knife speed over the relative cutting effort of the bread cortex when time for preliminary stay of the bread,* ***h****:*
1-0; 3-from 6 to 48.

For a crust:

$$G = 98.56 - 0.0015\tau^2 + 0.60\tau + 0.14P + 31.9V, \quad (2)$$

where: τ - time of keeping of bread, minutes;

N - pressure of bread on the lateral area of a knife, *kPa*;

V - speed of sliding, *m/s*.

The equations is valid for such conditions:

range of speed V = 1-8 *m/s*;

pressure of bread on the side face of a knife of N = 400-2500 *Pa*;

time of keeping of bread τ = 0-240 *min*.

While calculating the pressure of a friction on a side face of a knife, it is necessary to know normal pressure of bread on a surface of a knife. It is determined using the formula:

$$N = Ex = E\frac{s}{B}, Pa, \quad (3)$$

where: E - an elastic modulus of a product, *Pa*; x - relative deformation of a product; s-thickness of a knife, *mm*; B - a thickness of a piece of a product, *mm*.

It is necessary to know the elastic modulus as crumb, and crust.

Using of formula (3) is possible provided that in the product there is only elastic strain. Based on the literature it can be assumed that the elastic deformation occurs when the ratio of the thickness of the blade and a piece of the product is 1/10.

The coefficient of elasticity is defined according to the data [1] (Figure 4).

At the higher speeds of cutting, quality of the cut worsened: the cortex of bread is sanded smooth, and the crumb - crumbled. In work [1] the maximum speed was defined where there are no such types of defects. The speed is defined on Figure 5 depending on a normal surface load on the knife.

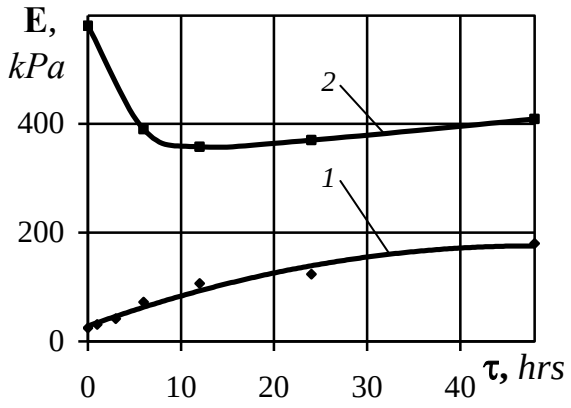

Figure 4. *Influence of time of keeping of bread on a coefficient of elasticity:*
1- bread crumb*; 2- bread cortex.*

As it had been specified, the load per unit area depends on a parity of thickness of a knife and a piece of the product.

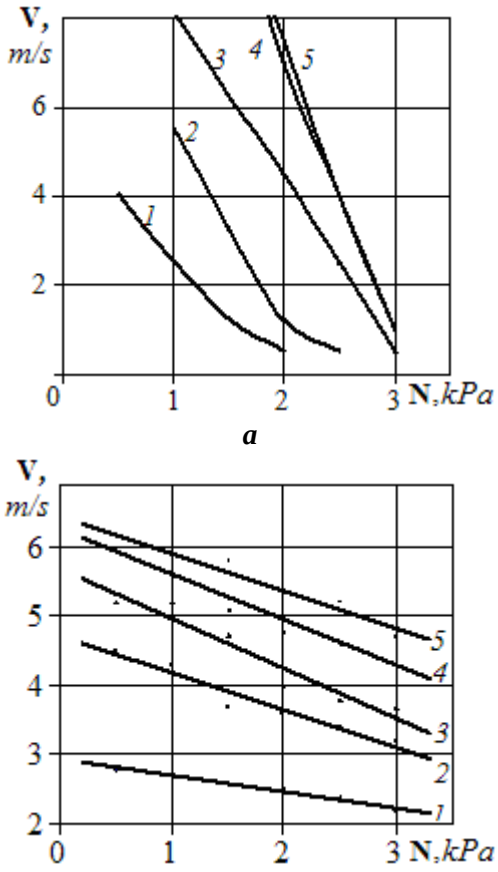

Figure 5. *Influence of specific batch on rate of a blade at whom quality of cutting decreased:*
a - the crumb crumble, b - the crust grind.
Time of keeping of bread, hour: 1-0; 2-1; 3-3; 4-6; 5-24.

Definition of force and capacity of cutting.

Force of cutting of bread by a tape gear knife is defined by the formula:

$$F = F_l^{rel} \cdot \frac{V_n}{V_t} \cdot H, \quad (4)$$

where: F_l^{rel} - specific force of cutting, N/m; V_n, V_t - rates of a knife and feeding of a product, *m/s*; H - height of a cut, *m.*

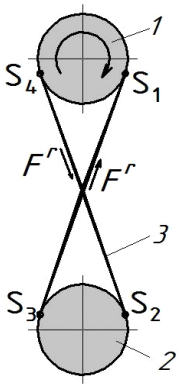

Figure 6. *The settlement scheme for definition of capacity of a drive of a package of tape knifes*
1, 2 - drive and tension drum heads; 3 - tape knife.

Definition of drive power of a bundle of tape knifes.

In order to define the capacity of a drive of pack of tape knives 3 (Figure 6) which move between drive (1) and tension (2) drum heads, we will make the settlement scheme and give on it characteristic points of contact with a tape knife.

Knowing force of cutting F, considering that the one tape knife cut a 2 pieces of bread, lets define a tension of a knife in characteristic points. We start with a point 1, in which tension of a knife is minimal. Let's designate a tension as S_1.

Tightness in a point 2:

$$S_2 = S_1 + F\,. \qquad (5)$$

Tension in a point 3:

$$S_3 = k \cdot S_2 = 1.06 \cdot (S_1 + F)\,, \qquad (6)$$

where k - coefficient of resistance for a tension drum head

Tension in a point 4:

$$S_4 = S_3 + F = 1.06 \cdot (S_1 + F) + F\ . \qquad (7)$$

The tension in a point 4 also can be defined using the theorem of Euler:

$$S_4 = S_1 \cdot e^{f\alpha}\,, \qquad (8)$$

where *f* - a coefficient of friction of a knife on a drum head; for a friction of a steel on a steel at a coarseness of surfaces of 0.8 *mkm, f=0.13.*

α - angle of wrap of a drum a knife, usually α = 240 hailstones = 4.2 *rad.*

Then:

$$S_4 = S_1 \cdot e^{f\alpha} = 1.65 S_1\ . \qquad (9)$$

Tension in a point 1 we will define from the equations (7) and (9):

$$1.06 \cdot (S_1 + F) + F = 1.65 S_1 \qquad (10)$$

$$S_1 = 3.49 \cdot F \qquad (11)$$

From the equation (9) and (11) we will define a tension in a point 4:

$$S_4 = 1.65 S_1 = 1.65 \cdot 3.49 \cdot F = 5.76 \cdot F \qquad (11)$$

Let's define traction effort for one knife:

$$W = S_4 - S_1 + k \cdot (S_4 + S_1) = 5.76 \cdot F -$$
$$- 3.9 \cdot F + 0.04 \cdot (5.76 \cdot F - 3.9 \cdot F) = 2.58 \cdot F \qquad (12)$$

Traction effort for a bundle of knifes:

$$W_\Sigma = n \cdot W = n \cdot 2.58 \cdot F \qquad (13)$$

Where n - number of working knives.

Capacity of a drive for a pack of knives:

$$Q = \frac{W_\Sigma \cdot V_n}{\eta} = \frac{n \cdot 2.58 \cdot F \cdot V_n}{\eta}\,, \quad W \qquad (14)$$

where: η - efficiency of a drive.

Definition of power mechanism of transportation bread to tape knives.

For definition of power of mechanism for transportation of bread to knives it is necessary to know resistance of bread to moving when cutting. Let's consider the scheme in Figure 7.

When cutting on bread, force of cutting F_Σ operated. It pressed bread to a bearer. Bread is being transported to the knife if force of feed of P is more than a frictional force of G.

Condition of feed of bread to a knife of a friction:

$$G = f \cdot F_\Sigma\ . \qquad (15)$$

Coefficient of friction between bread and a metal surface it is possible to accept *f* = 0.17.

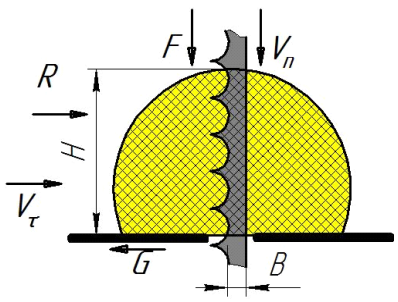

Figure 7.*The circuit of forces when cutting:*
F-force of cutting; G-friction force; R-force of feeding.
V_n - speed of a knife; V_τ - speed of feed

Bread is being transported because of the clamping pressure of the press conveyor 5 (Figure 8)

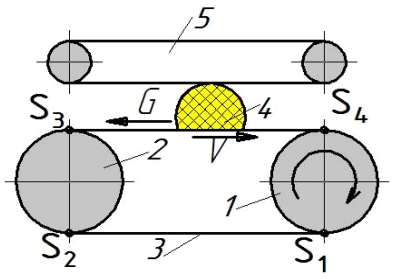

Figure 8.*The calculated circuit of the transporting conveyor.*
1, 2 - head and tension drums; 3 - ribbon; 4 - bread; 5 - pinch conveyor.

When driving the belt of feeding conveyor, we should note that there is force of resistance on the belt equal to the force of friction G.

Perform similar traction calculation.

$$S_2 \approx S_1 \quad (16)$$

$$S_3 = k \cdot S_1 \approx 1.06 \cdot S_1 \quad (17)$$

$$S_4 = S_3 + G = 1.06 \cdot S_1 + G \quad (18)$$

$$S_4 = S_1 \cdot e^{f\alpha} \quad (19)$$

f=0.17,

α - a corner of a grasp of a drum head a knife, α = 180 grad = 3.14 rad.

Then:

$$S_4 = S_1 \cdot e^{f\alpha} = 1.69 S_1 . \quad (20)$$

Tension in a point 1 we will define from the equations (19) and (20):

$$1.06 \cdot S_1 + G = 1.69 \cdot S_1 \quad (21)$$

$$S_1 = 1.58 \cdot G = 1.58 \cdot f \cdot F_\Sigma \quad (22)$$

From the equation (20), (22) and (15) we will define a tension in a point 4:

$$S_4 = 1.69 S_1 = 1.69 \cdot 1.58 \cdot 0.17 \cdot F_\Sigma = \\ = 2.68 \cdot G = 0.45 \cdot F_\Sigma \quad (23)$$

Let's define a tractive effort of a drum head:

$$W = S_4 - S_1 + k \cdot (S_4 + S_1) = 2.43 \cdot F_\Sigma . \quad (24)$$

Power of a drive for a package of knifes:

$$Q = \frac{W \cdot V}{\eta} = \frac{2.43 \cdot F_\Sigma \cdot V_\tau}{\eta} , \quad (26)$$

where: η - efficiency of a drive of the conveyor; V_τ - speed of transportation of bread, *m/s*.

Capacity of a drive of the clamping conveyor is equal to the capacity of a drive of the submit conveyor provided.

Procedure of payments of capacity of mechanisms of the cutting machine.

1. Determine the thickness of the crumb and crust
2. At the set speed of a knife and time of a seasoning define force of cutting of a crumb (Figure 2) and crusts (Figure 3).
3. On the formula 14 define power of a drive of the cutting mechanism.
4. On the formula 26 define power of a drive of mechanism of transportation

Example of use of results of researches.

Let's define capacity of drives of the cutting and transporting mechanisms of the cutting machine in the following circumstances:

Speed of a knife of V_n = 0.6 *m/s*.

Speed of mechanism of transportation of bread V_τ = 0.05 *m/s*

Quantity of working knifes - 11 (bread are cut on a 24 piece)

Dwell time after baking bread - 20 *min.*

Thickness of a crust - 3 *mm.*

Thickness of a crumb - 60 *mm.*

Force of cutting of a crumb - 1.8 *kN/m.*

Force of cutting of a crust - 25 *kN/m.*

Force of cutting for an one knife (the formula 4) F = 0.0028 *kN.*

Power of a drive of the cutting gear (the formula 14) - Q=530 *W.*

Power of a drive of the conveyor of feed (the formula 26) - Q=45 *W.*

Usually the power of a drive of the cutting gear is taken with factor of a stock 2-3. It is connected to the big frictional forces of bread and knives during start-up of the machine, and also for overcoming the forces of inertia at dispersal of a drum head.

Settlement power of a drive of mechanism of transportation is small compared to the cutting mechanism, and usually, considering power reserve, is considered within 200-300 W.

Conclusion

On the basis of the analysis of process of cutting of bread and the power analysis of mechanisms of breadcutting machine it is defined power of drives of cutting and transporting mechanisms.

The determined mathematical dependencies allowed to calculate capacity of a drive at known force and speed of cutting, to analyze and optimize expenses of energy in the machine.

The obtained results could be used during the designing of the cutting equipment, the analysis of expenses of energy and optimization of process of cutting.

The further research are demanded by the questions connected to a friction and a gripping power at cutting the corn by machines with a bundle of tape knives, and also the account of frictional forces when calculating the power.

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Hypotheses about the mechanisms of influence of input factors in tableting coffee on the output quality of a coffee drink

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Abstract. *Tableting of different materials: tea, coffee, spices, nutritional supplements, etc. increasingly finds an application in the food industry. The marketing of coffee in the form of tablets is widely disseminated, packed in filter paper – so-called "Coffee pods". In the scientific literature there are no data about any research of the process of creating of "coffee pods", as well as those for experiments aimed at managing the drink composition and its taste and quality, by affecting the input factors during the process of tableting. In this article we discuss the creation and development of "coffee pods", characteristics of the tableting process and their advantages. The input factors affecting the process of tableting are identified and classified and hypotheses about the mechanisms of their influence on the output qualities of the coffee drink are constructed.*

Keywords: coffee, "coffee pods", tableting, input factors, hypotheses

1. Introduction

Tableting /briquetting/ of different materials: sugar, concentrates, powders, tea, coffee, spices, nutritional supplements, etc. increasingly finds an application in the food industry. [1] Tableting / briquetting / is a mechanical process of obtaining products or semi-finished products in the form of small, in some form, tablets /briquettes/ from powdered materials. It is used mainly to improve the technological properties of food materials, to prevent adhesion, to allow the use of the material in small and equal portions, to improve hygiene and increase the duration of storage, to give products compactness and to facilitate the transportation.

Recently, marketing of coffee in the form of tablets, packed in filter paper – so-called "Coffee pods", increasingly gets spreading. The use of these tablets has a number of advantages: saving time in the preparation of coffee, it is easy and fast to clean the machine, it is offered absolutely accurately defined combinations of different types of coffee in one tablet with guaranteed repeatability of taste and content for subsequent use, the possibility of prolonged storing the product without changing the taste and quality components, easy to transport, reducing the total consumption of coffee and preventing the possibility of fraud in the sale dose in bars.

2. Development of "coffee pods" and the essence of the standard E.S.E.

The machines for this type of coffee were originally developed for use by the Italians in their workplaces in order the process of making espresso in the office to be quicker and cleaner. Later, these machines were adapted for use in restaurants to avoid the need of training staff to work with a traditional coffee – espresso machine. Using an espresso machine at home with tablets became popular after the creation of the so-called standard E.S.E in 1998. After creating this standard Illy company launched a successful campaign to impose this kind of machines at home, as a convenient way to make coffee.

The marking E.S.E. - Easy Serving Espresso (easy preparation of espresso) – can be found in coffee packaging. It means that products marked with this sign – coffee and coffee machines - refer to so-called System E.S.E., which consists of two parts:

- a coffee portion (cialda coffee, serving, pod), which contains approximately 7 grams roasted, ground, weighed and pressed coffee packed in a tablet form in filter paper;
- espresso - machinery, specialized for coffee in such a package.

The term E.S.E. is characteristic of Illy, and Saquella, for example, prefers the term Pod System (from the English pod, which means tablet).

Figure1. *A section of tablet, marking a sign of E.S.E. and a special machine*

In the scientific literature there are no data about researches of the process of creating "coffee pods", as well as those for experiments aimed at managing the composition of drink taste and quality, by affecting the input factors of a tableting process.

3. Compressible nature of the process in the version "coffee pods"

The tablets are produced by pressing the "clean" powders or mixtures containing secondary substances. In the food industry for mass production of tablets rotary machines are used having high productivity and providing better quality products. For productions with a lower volume eccentric and hydraulic machines are used.

Tableting process is performed in conditions of a multi-pressure in confinement. Depending on the nature of motion of different swages there are two types of pressing: with arrest and without arrest of the pressed nutritious material under pressure. Pressing retention provides favorable conditions for the removal of air from the pressed powder and leads to partial scatter / release / of internal tensions, which results in preventing the segregating of the tablets. There is unilateral and bilateral pressing. The first one is done by pressing one swage, moreover the most pressure is born by the material layer directly touching the swage. In the second one, the least pressure occurs in the layer located in the middle of the height of the tablet.

Figure 2 shows the working position of tableting coffee machine of the company (creator of the E.S.E. system) - Illy [2]. It consists of a pneumatic cylinder 1, piston – swage 2, bearing assembly 3, spring for automatic raising of the piston 4, unit for rotating the swage at the end of pressing 5, guide 6, strip guides of filter paper 7 and 8. With 9 and 10 the coffee tablet and filter paper are labeled accordingly. Due to the need to close the tablet by filter paper, the pressing process is unilateral as to expel air an additional spin is used.

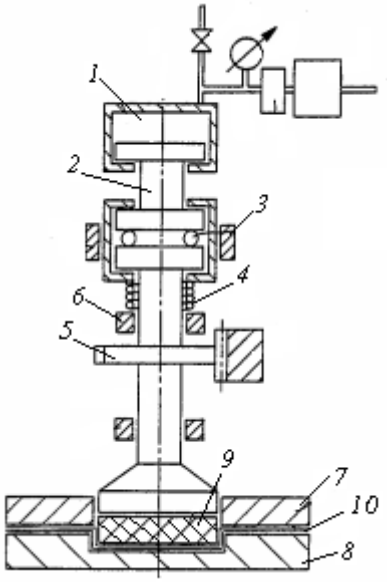

Figure 2 *Section of the working position for tableting coffee*

4. Specifics of the extraction process of coffee

When the coffee powder comes into contact with the water, the phase responsible for the beverage preparation – extraction - occurs. Flavoring substances are extracted immediately and taste ones - later. The taste and flavor of the coffee depend on the amount of taste and flavoring substances that pass into the drink as a result of the interaction of the coffee powder with water [3].

In the most general case, the kinetics of extraction is described by the general equation of mass transfer:

$$M = K \Delta_c F t, \quad (1)$$

where: M is the amount of extracted substance, K - coefficient of passing the mass, Δ_c - the average difference between the concentrations of the extracted material in both phases, F - the size of the interphase surface, t-time [4].

Good strong coffee contains the highest percentage of soluble substances. Sometimes coffee is called strong just because it is well roasted and has a bitter taste. Coffee experts consider that an excellent cup of coffee is just in case that 19% of aromatic and taste substances of the coffee powder were extracted in the coffee. Under this condition, in a cup of coffee there are 98.75% of water and 1.25% of dissolved solids; 19% - this is a critical value. Extraction can be almost 50%, but the coffee is not more delicious as it becomes very bitter. By the extraction of less than 19%, coffee will be weak. French prepare black coffee containing 5% of the extracted material in the beverage. Arabs have this norm five times lower.

The rate of extraction depends on many factors, mainly on the temperature - optimum fluctuates within 93-96 ^{0}C. The ratio of the rate of milling of grains and the extraction time affect the quality of the drink. The extraction also depends on the ratio between the quantity of water and coffee. For E.S.E. standard one tablet contains 7 g of coffee. Some experts say the rate should be 10 to 12 g (one or two teaspoons) of ground coffee and 180 mm of water (one cup). When the extraction continues for a long time unwanted substances can dissolve into the drink. Therefore when you need to prepare weak coffee it is recommended to add water at the right temperature to the readymade coffee and not to increase the extraction time [3].

5. Identification of input factors and hypotheses about their influence on the output quality of the coffee drink

To connect to the target function it is required the input factors to be identified by drawing inferences about their possible impact on the output quality drink. This is a compulsory part of pre-experimental preparation for the study [5].

Factors affecting the tableting process can generally be divided into factors related to the characteristics of the material entering the machine and factors associated with the specific process of tableting – Figure 3.

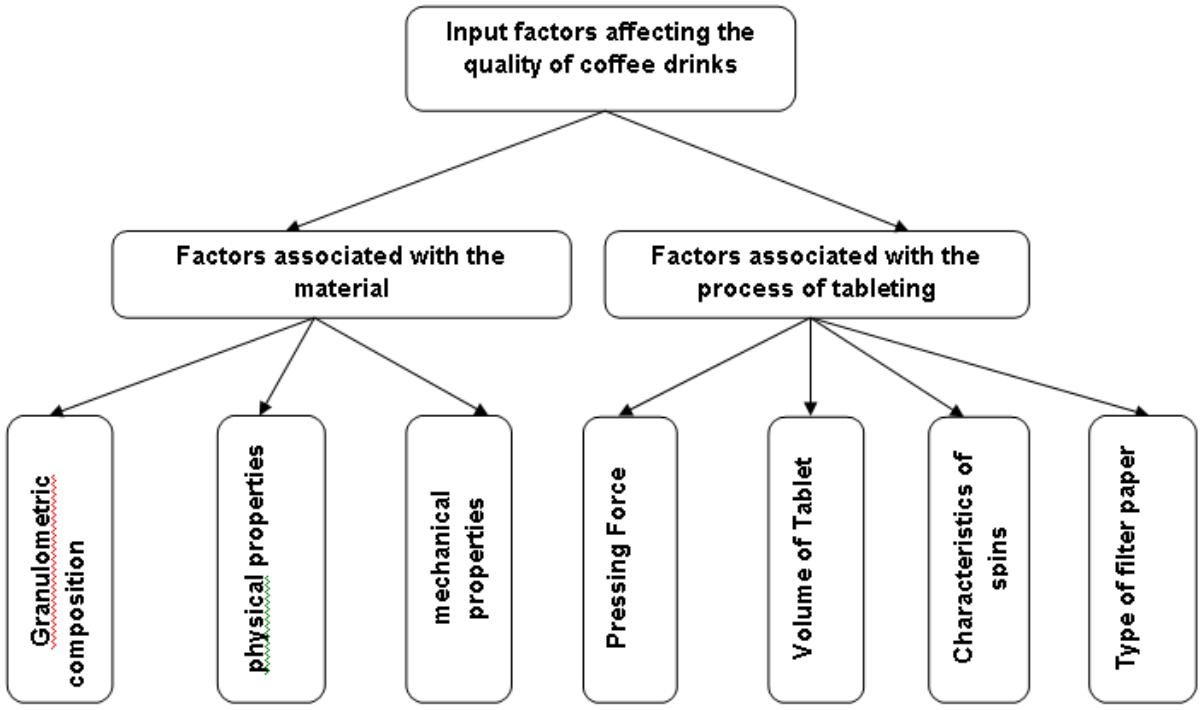

Figure 3. *Classification of the input factors affecting the quality of coffee drinks during the tableting*

FACTORS RELATED TO THE MATERIAL

Granulometric (granulous) composition

Coffee is a part of so-called "bulk materials". A "bulk material" means a disperse system consisting

of solids of arbitrary shape which are in contact. The space between the particles is filled with gas and sometimes partially with fluid. Depending on the diameter d of the particles, a bulk material can be in different states [6].

Bulk materials mostly consist of particles of different shapes and sizes. Irregularly shaped particles are characterized by their **equivalent diameter**:

$$d_e = \frac{6}{S_{sp}} = \frac{6V}{S}, \qquad (2)$$

where: S_{sp} is the specific surface of the particle equal to the ratio of the surface S to the volume V of the particle.

It can be expected that the increase in equivalent diameter in the beginning will lead to increase in the area of the particle in which the extraction of the extract is done and hence the volume of extracted material from the coffee. Since the area increases in the second degree and the volume in the third degree, with an increase in the linear dimensions the volume of the particles will outpace the growth of the area and a bigger relative part of the substance will remain "hidden" inside the particles and unavailable for extraction. This means that at some point the growth of the particles will lead to inefficiency of the extraction process.

Physical Properties

Density ρ of the bulk material is called the mass of the volume of the substance, a part of which are the material particles. ***Bulk density*** ρ_b is called the mass of the volume of the bulk material, which is taken when pouring into a measuring cup [6]. ***Porosity*** of the layer of a bulk material is called:

$$\varepsilon = \frac{V_1}{V_0}, \qquad (3)$$

where: V_1 is the free volume of the space between the particles in a layer of bulk material which has a volume V_0 (6). The magnitude of **ε** depends on the arrangement of particles, their shape, size, the impact of external factors.

The presence of large pores will help to facilitate the passing of water into the tablet, and hence the extraction, but with a larger pore volume a part of the water will not interact with the particles of coffee at all, and this will reduce the effectiveness of the process.

Mechanical properties

Among the components of the bulk material, there are forces of interaction of different nature - both adhesion and cohesion as coffee powder is a mixture of two or three varieties of coffee, i.e. there are both homogeneous and heterogeneous particles. These forces are united by some authors (e.g. Gusev) in the term "autoheziya" (6). Autoheziya term covers all types and forms of relationships between particles whatever the number and properties of the interacting particles are, the nature of the forces determining this interaction, causes and conditions for their occurrence. Ultimately autoheziyata can lead to spontaneous aggregation of particles of a bulk material and the variation of its density and porosity, about whose influence on the extraction process the hypothesis above has been developed .

FACTORS ASSOCIATED WITH THE PROCESS OF TABLETING

The first and main input factor is the ***pressing force of the tablet***, pneumatic pressure, respectively. At a higher pressure the pores between the particles will be smaller, the material will be highly compacted and the amount of solvent in the extraction process, washing the area of an elementary particle of the material will be less. This implies a lower concentration of substances gone from coffee to the solvent - water. On the other hand, the compaction of the material in the tablet results in higher pressure and temperature and at that moment the separation of the extract begins , which encourages increasing the concentration of substances released from the coffee into the final drink.

The second major factor is ***the characteristics of spins*** - especially the inclination of the screw line that describes the piston on the descent down. At a smaller inclination angle, respectively rotation angle, the movement is closer to rectilinear pressing and the pores between particles of ground coffee will be larger. At a higher inclination the rotation angle will be bigger and the pores between the particles smaller.

The ***volume of the tablet*** is the next factor affecting the extraction process. Since the mass (weight) of coffee is standardized, in a larger volume there will be larger pores between the particles in the final tablet, and in a smaller volume the pores will be smaller.

The ***type of filter paper*** is another factor influencing the extraction process. Depending on the characteristics of the paper some substances can be leaked into the final drink and others can be held up (filtered) in it.

Of course, an important factor is the ***pre-mixing of varieties of coffee***, since the concentration of the ingredients of different varieties is different in their home mixtures.

Conclusions

1. The development, advantages and features of the standard E.S.E. for the manufacture of coffee tablets - "coffee pods" – have been discussed.

2. The essence of the process of tabletting in the version of "coffee pods" has been clarified.

3. The input factors in coffee tableting are identified and classified and hypotheses about their influence on the final qualities of the coffee drink have been made.

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The mathematical simulation of heat-mass transfer in bread baking process

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Abstract. *The problem of mathematical model designing of the heat-mass transfer processes in bread baking is considered. The analytical part of mathematical model (analytical model) is submitted. The mathematical model is focused on the modern computer technologies using.*

Keywords: *mathematical model, process of heat-mass transfer, multicomponential system, analytical model*

Introduction

The baking industry enterprises uses a variety of furnaces, which differ among themselves by productivity, design features, heat distribution system, operation stability, bread products quality etc. The modern furnace design development is based on the great practical experience in the design and operation of the equipment with the experimental and theoretical studies of the baking processes using [1,2]. Therefore a theoretical basis for the processes that occurs during "dough workpiece – bread product" is the actual scientific problem. At the same time the latest research analysis shows that the reasonable calculation methods for optimal mode definition of baking equipment are absent. Existing design methods for baking furnace are based on productivity, heat and fuel calculations without taking in account the internal heat processes and bread quality indicators (color, luster, shape, size, taste, smell, etc.) creation [1, 4]. Such calculations could be carried out by the way of complete and accurate mathematical description of each of the processes that occur during bread baking. So, mathematical simulation of the baking process may be the base for the optimal process conditions substantiation and allow to formulate the requirements for thermal regime and furnace construction.

Materials and methods

The proposed methods for construction and technological parameters of baking prosseces are based on information practice of design (IPD) [5]. IPD has the type: "mathematical model - intellectual expert system - design automation system" and considers the baking processes as multicomponential system of interconnected subjects of inquiry: dough workpiece (DW), technological equipment elements, thermo- mechanical loading etc. Schematically IPD represented in Figure 1. The functional basis of IPD is the mathematical model of heat-mass transfer in the DW under specified conditions of heating. At construction of the analytical part of the mathematical model of the "DW – bread product" transformation we are guided by a principle of its conditional division on three groups: 1 - solid particles; 2 - water in various kinds and conditions; 3 - gaseous inclusions. Dough workpiece is considered as the moisture contained dispersed system with concrete geometrical parameters.

Results and discussions

One of the main parameter which characterizes the moisture transfer process is the mass content [1]:

$$\alpha_m(\mathrm{t}) = M_l(t)/M_m, \quad (1)$$

or volume material content:

$$\alpha_v(t) = V_l(t)/V_m, \quad (2)$$

where: $M_l(t)$ – the liquid phase mass of the volume V_l (t) in the disperse material representative element with the volume V_m ; M_m (t)- - mass of the porous skeleton (solid phase). The moisture in the porous skeleton can be located in a liquid or gaseous states (depending on the temperature). Moisture content changes occur as a result of redistribution in the volume of the porous material (diffusion mechanism) with the possibility of going beyond borders through the surface of the DW. The DW temperature determines not only by the physical state of moisture, but also by the thermodynamic forces, which realize the transfer of heat and moisture:

$$F_t = -\frac{1}{T} gradT$$
$$F_u = -Tgrad(\frac{\eta}{T}) \quad (3)$$

where: η -diffuse potential [6], T - temperature.

The density of heat and moisture fluxes are defined by Onsager linear principle [6]:

$$J_t = -\frac{L_{11}}{T} gradT - L_{12} T\ grad(\frac{\eta}{T}), \quad (4)$$

$$J_u = -\frac{L_{21}}{T} gradT - L_{22} T\ grad(\frac{\eta}{T}). \quad (5)$$

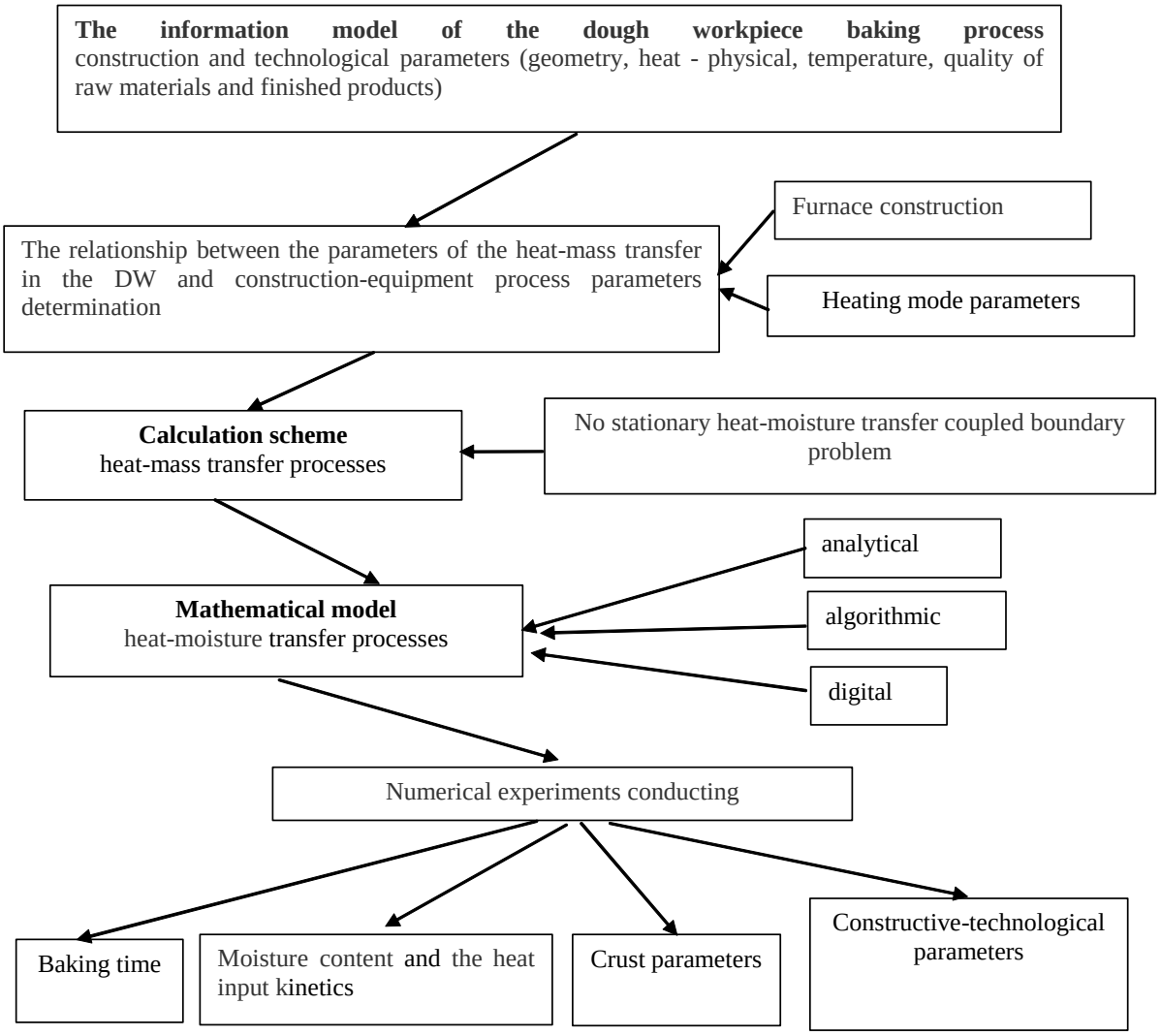

Figure 1. *Scheme for the structural and technological parameters of the bread baking process determination*

From (4) and (5) follows, that the heat flux is determined not only by the temperature gradient but by the potential diffusion gradient also. Similarly the mass of the moisture flow determined not only by the capacity of the diffusion gradient but by temperature gradient (thermal diffusion) also. Assuming the principle of reciprocity $L_{12} = L_{21}$ heat-moisture transfer process in disperse material may be defined by the generalized state vector:

$$\{Y\} = \begin{Bmatrix} T \\ u \end{Bmatrix}, \qquad (6)$$

where: u - moisture mass per unit volume.

Using (6) the process moisture transfer is described by the equations [2]:

$$\frac{\partial Y}{\partial t} = A\,div\,grad\,Y + D\,div\,grad\,Y^{-1} + W, \qquad (7)$$

where: $Y^{-1} = \begin{Bmatrix} u \\ T \end{Bmatrix}$; (8)

$$A = \begin{Bmatrix} a_t \\ a_m \end{Bmatrix}; \qquad (9)$$

a_t - the temperature – conductivity coefficient:

$$a_t = \frac{\lambda}{c_p \rho}, \qquad (10)$$

where: λ - the material thermal conductivity coefficient.

For moisture contained material

$$\lambda = \alpha_г \lambda_г + \alpha_m \lambda_m;\ \alpha_г + \alpha_m = 1, \qquad (11)$$

where: $\alpha_г$, $\alpha_т$ - the volume contents of the gas and solid phases respectively; $\lambda_г$ - the gas thermal conductivity coefficient; $\lambda_т$ - the solid phase material thermal conductivity coefficient:

$$\lambda_т = \lambda_0 + c(T - T_0), \quad (12)$$

where: λ_0, c, T_0- constants.

The heat capacity of the material c_p is determined as:

$$c_p = \alpha_г c_г + \alpha_m c_m; \quad (13)$$

where: $c_г$ - the gas phase heat capacity coefficient; c_m - the solid phase heat capacity coefficient:

$$c_m = c_0 + d(T - T_0), \quad (14)$$

where: c_0, d, T_0 - constants.

The disperse material density:

$$\rho = \alpha_г \rho_г + \alpha_т \rho_т; \quad (15)$$

$\rho_г, \rho_т$ - the gas and solid phases densities respectively; $\rho_г$ - accepted as a constant; $\rho_т = \rho_0 - b(T - T_0)$, ρ_0, b, T_0 - constants; a_m - the moisture diffusion coefficient.

$$D = \begin{Bmatrix} d_t \\ d_m \end{Bmatrix}, \quad (16)$$

d_t - the diffusive thermal conductivity coefficient:

$$d_t = \frac{d_m T}{C_ж \alpha_m} \left(\frac{\partial \eta}{\partial u}\right); \quad (17)$$

d_m - the thermal diffusion coefficient: $d_m = a_m \delta_u$,

where δ_u - the relative molecular moisture flow coefficient:

$$W = \begin{Bmatrix} W_T \\ W_u \end{Bmatrix}; \quad (18)$$

W_T - specific power of the internal heat sources:

$$W_T = W_s + W_q; \quad (19)$$

$$W_s = \varepsilon \frac{C_m}{C_q} \frac{\partial u}{\partial t}, \quad (20)$$

the source due to the "vapor-liquid" transformation; ε - phase transformation coefficient, which is determined from the experimental data:

$\varepsilon = \exp(-0{,}138(100 - T))$ at $T \le 100^0$C;

$\varepsilon = 1$ at $T \ge 100^0$C; (21)

W_q - source due to the different physical mechanisms; W_u - moisture source specific power.

For the phase transformations modeling of the DW nonsteady heating the following criteria used:

1. Moisture according "vapor-liquid" system – temperature condition $T \ge 100^0$C. The moisture physical state is determined by the appropriate set of thermophysical characteristics and phases volume contents according (1), (2), (11), (13).

2. The dispersed material solid phase according "dough-crumb-crust" system. This transformation is simulated by the moisture content changing in each element of the considered area:

a) "crumb" $u_k \le u \le u_т$, where $u_т$ – the dough moisture content, u_k – the "crust" moisture content;

b) "crust" $u \le u_к$;

For the system of equations (1) - (21) closing we must supplement them by initial and boundary conditions:

1. At t = 0 the distribution of the parameter Y(0) = Y_0(X) are given.

2. On the DW boundary part the parameter Y_1(X, t)) are given.

3. On the DW boundary part thermal mass flow are defined:

$$\frac{\partial Y}{\partial n} = \varphi_2(X, t). \quad (22)$$

4. On the DW boundary part vector $Q = \beta(Y - Y_0)$) is given (means heat-mass transfer), β - the heat-mass transfer coefficient.

Conclusions

Equations (1) - (22) are consist the analytical model of DW baking processes. The future investigation will be devoted to the development of the methods for presented equations solving (algorithmic model) and the application of computer technology to effectively caring out calculation experiments (digital model). So, presented mathematical relations are the basis for the creation of an automated high-performance system for dough-bread transformation regularities analysis.

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Definition of cracking force needed for breaking walnut shells in relation of their moisture level and temperature

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Abstract. *Definition of cracking force needed for breaking walnut shells in relation of their moisture level and temperature. The results are presented as graphs describing correlation and significance values of the factors – moisture and temperature, influencing the force needed to crack a walnut shell.*

Keywords: walnut, shells, cracking, force, moisture, temperature.

I. Introduction

According to BDS 461-89 the requirements for a walnut appearance are as follows: to be whole, not cracked, symmetrically shaped. Moisture shall not exceed 10%. Dry skin and wood fibers shall not be present on the shell.

The industrial method for removing the skin and other material from the shell is a mechanical brushing accompanied by washing [2] that leads to shell hydration.

During the hydration process of dry walnuts sunk in water, the increase in moisture is most intense during the first 24 hours, and equiaxial moisture sets in after the 60^{th} hour as it depends on water temperature and hydration time [3].

By increasing the moisture we are decreasing the energy needed to tear up the inner joints of the shell [1].

When using the controlled method of cracking the shells between flat surfaces, the biggest number of resulting whole and half nuts is reached when the force is applied vertically on the shell [4].

The goal of this study is to define the relative connection between hydration level and temperature of the shell with the force needed for controlled process of breaking.

II. Materials and methods

The walnut variety used for this experiment is "Perushtinski", crop of 2011. The preparation and determination of hydration level is described with the methods used in [3].

Measuring the force needed for controlled cracking is accomplished by the experimental device showed in [4] that has flat surfaces and the force is applied vertically on the shell.

The graphic results presented in "Results and discussions" are obtained with "Statgraphics" software for mathematical modeling and statistical analysis.

Before the multi level factorial experiment, with parameter – force needed for controlled cracking of walnuts and factors – moisture and temperature, two other experiments are carried out to defy the intervals in factor variation. The first one determines how moisture influences the cracking force needed, as measurements were taken for three different temperatures: 5 ˚C, 25 ˚C and 40 ˚C.

The second experiment determines the how temperature influences the cracking force needed for three different shell moisture levels: 8%, 20% и 32%.

The cracking force values are defined as an average of three different measurements for each point.

The multi level factorial experiment plan is 2^2 in natural and coded aspect shown in Figure 1

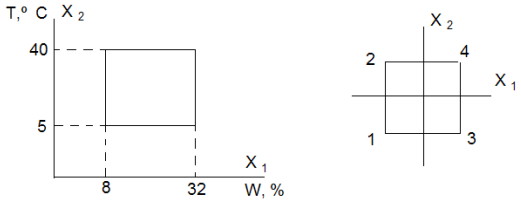

Figure 1. *The 2^2 multi level factorial experiment plan*

The algorithm [5] defines the regression equation, the values of the relevant parameters and an adequacy check is made on the equation using the Fischer criteria.

$$Y = b_0 + b_1 x_1 + b_2 x_2 + b_{12} x_1 x_2 . \quad (1)$$

III. Results and discussion

The graphs in Figure 2 represent the experimental and approximate dependencies between the cracking force and moisture level for three constant temperatures.

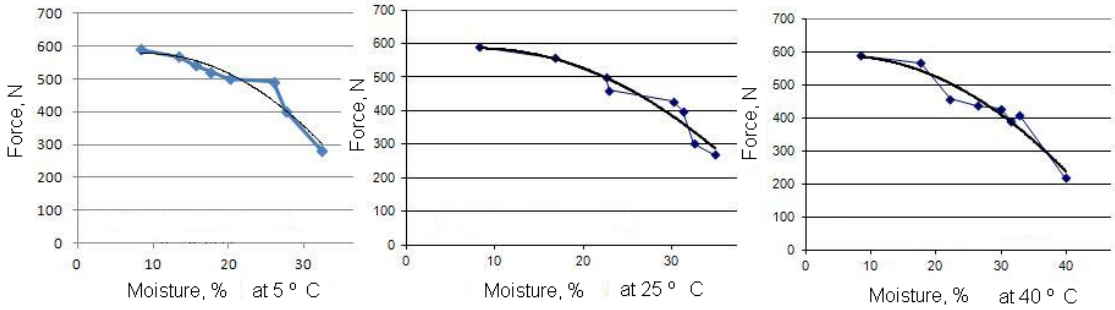

Figure 2. *Dependencies between the cracking force and moisture level at constant temperature*

Figure 3 only compares the approximate results from the measurements at three temperatures and their equations are shown. All experiments were carried out for 96 hours. We can see from Figure 3 that for a moisture level lower than the equiaxial, the cracking force is lower at the lower temperature and higher at the higher temperature.

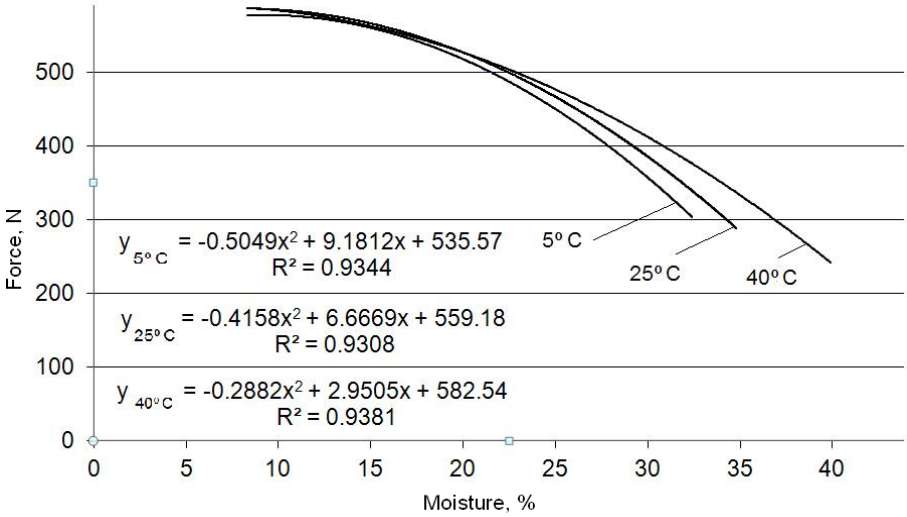

Figure 3. *Approximate dependencies between force and moisture at different temperatures and their equations.*

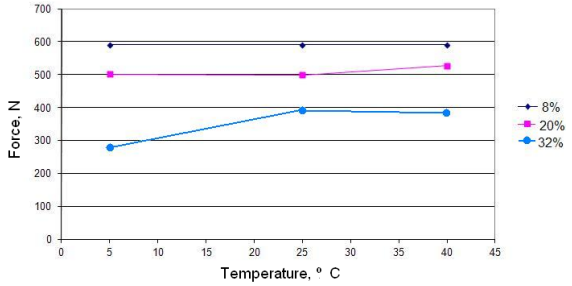

Figure 4. *Cracking force related to temperature at constant moisture*

Figure 4 shows how temperature influences the cracking force at different moisture levels (8%, 20%, 32%). The lowest force levels are observed for moisture levels of 20% and 32% and at lowest temperature.

The natural and coded values for the factors moisture and temperature, and the parameter force are determined by the averaged measurements are shown in Table 1.

Table 1. *Natural values of factors (X_i) and parameter (y_i) of the experiment*

N	X_1	X_2	X_1	X_2	X_1X_2	Y_1	Y_2	Y_3	$Y_{cp.}$
1	8	5	-	-	+	590	590	590	590
2	8	40	-	+	-	590	590	590	590
3	32	5	+	-	-	229	383	231	281
4	32	40	+	+	+	414	460	306	393

The resulting equation of regression is:

$$Y= 463,5 - 126,5\ x_1 + 28\ x_2 + 28\ x_1\ x_2\ .(2)$$

From the surface representing the cracking force (Figure 5) we can clearly see that its value decreases with increasing the moisture level. For initial moisture of 8% the force is 590N and at equaxial moisture of 32%, the force drops down to 310-319N.

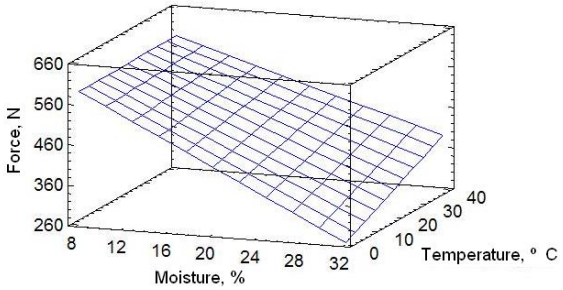

Figure 5. *Reflection surface*

The isolines on Figure 6 show that the force decreases faster at lower temperatures.

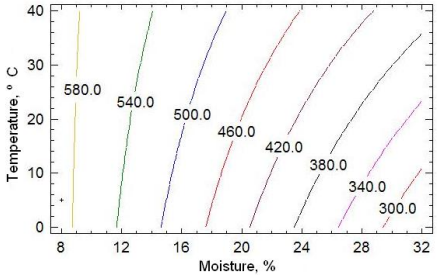

Figure. 6 *Cracking force isolines*

The Pareto diagram on fig. 7 displays how significant the moisture and temperature of walnuts are. The calculation software used displays a vertical line which is the critical value of the Student criteria. If any of the input factors does not exceed that line than it is considered insignificant. In this case, the moisture value is a significant factor for controlling the cracking force, and the water temperature could be considered as insignificant.

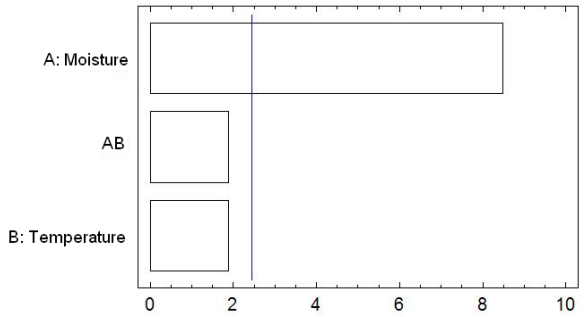

Figure 7. *Pareto diagram differentiating significant from insignificant factors*

IV. Conclusions

1. If moisture level within the walnuts is 10% according to BDS 461-89, than the cracking force decreases by approximately 10% from initial value of 590N, at 8% moisture.

2. Temperature as a factor influencing the cracking force could be considered as insignificant.

3. The cracking force for moist nuts is 30-35% lower than the cracking force for dry nuts.

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Biochemical and technological properties of *Lactobacillus plantarum* X2 from naturally fermented sourdough

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Abstract. *The strain Lactobacillus X2 from naturally fermented sourdough is identified as a Lactobacillus plantarum strain using physiological and biochemical methods (API 50 CHL) and molecular-genetic methods (ARDRA). The enzyme profile of the strain is determined using API ZYM test kit. The strain allows industrial cultivation with accumulation of high concentrations of viable cells. The results of these studies on some probiotic properties of Lactobacillus plantarum X2 make the strain suitable for incorporation in probiotics and probiotic foods.*

Keywords: Lactobacillus plantarum, identification, API 50 CHL, ARDRA, API ZYM, probiotic, batch cultivation

I. Introduction

There are a number of factors that negatively influence the interaction between intestinal microorganisms, such as stress and diet, that lead to detrimental effects in health. Increasing evidence indicates that consumption of 'probiotic' microorganisms can help maintain such a favourable microbial profile and results in several therapeutic benefits [13].

Probiotics are live microorganisms that confer a beneficial effect on the host when administered in proper amounts [2, 8]. Probiotics have proven beneficial effects on gastrointestinal infections, the protection of the immune system, the reduction of serum cholesterol, the improvement in inflammatory bowel disease and suppression of *Helicobacter pylori* infection, Crohn's disease, restoration of the microflora in the stomach and the intestines after antibiotic treatment; they are also characterized by anti-cancer properties, antimutagenic action, anti-diarrheal properties [1, 6, 12, 15].

Lactobacilli and bifidobacteria are a natural part of the intestinal microflora of the healthy human. They are incorporated in the composition of probiotics and probiotic foods due to their proven health effects on the body [5, 7, 10]. They play a major role in maintaining the balance of the gastrointestinal microflora [13].

Not all strains of lactobacilli and bifidobacteria can be used as components of probiotics and probiotic foods, but only those that posses certain properties. Probiotic microorganisms should be of human origin, resistant to gastric acid, bile and to the antibiotics, administered in medical practice, non-pathogenic; they should also have the potential to adhere to the gut epithelial tissue and produce antimicrobial substances; they should allow the conduction of technological processes, in which high concentrations of viable cells are obtained as well as to allow industrial cultivation, encapsulation and freeze-drying and they should remain active during storage [9, 11]. This demands the selection of strains of the genera *Lactobacillus* and *Bifidobacterium* with probiotic properties. Moreover, the concentration of viable cells of microorganisms in the composition of a probiotic preparation should exceed 1 million per gram [4] in order to observe a therapeutic and prophylactic effect.

The purpose of this paper is to identify the strain *Lactobacillus* X2, isolated from naturally fermented sourdough, and to examine some of its technological properties – enzyme profile and ability for industrial cultivation.

II. Materials and methods

2.1. Microorganisms

The studied *Lactobacillus* strain, *Lactobacillus* X2, is isolated from naturally fermented sourdough.

Reference microorganisms: *Lactobacillus acidophilus* DSM 20079, *Lactobacillus delbrueckii ssp.bulgaricus* DSM 20081, *Lactobacillus casei ssp.casei* DSM 20011, *Lactobacillus casei ssp.paracasei* DSM 20312, *Lactobacillus casei ssp.rhamnosus* LMG 6400, *Lactobacillus fermentum* DSM 20052, *Lactobacillus helveticus* DSM 20075, *Lactobacillus plantarum* DSM 20174.

2.2. Media

Saline solution. Composition (g/dm^3): NaCl - 5. The medium is sterilized for 20 minutes at 121ºC.

LAPTg10-broth medium. Composition (g/dm^3): peptone - 15, yeast extract - 10; tryptone - 10, glucose - 10. pH is adjusted to 6.6 - 6.8 and Tween 80 - 1cm^3/dm^3 is added. The medium is sterilized for 20 minutes at 121ºC.

LAPTg10-agar. Composition (g/dm^3): LAPTg10-broth medium and 2% agar. The medium is sterilized for 20 minutes at 121ºC.

MRS – broth medium (Scharlau)

2.3. Cultivation and storage of the studied microorganisms

The studied strain *Lactobacillus* X2 is cultivated in LAPTg10-broth medium and on LAPTg10-agar medium at 37°C for different periods of time.

*2.4. Determination of the biochemical profile*The determination of the biochemical profile is performed, using the system API 50 CHL (BioMerieux SA, France) for rapid identification of species belonging to the genus *Lactobacillus* on the basis of their ability to utilize 49 carbon sources. Fresh 24-hour culture of the studied strain is centrifuged for 15 minutes at 5,000 x g. The resulting biomass sludge is washed twice with PBS-buffer and resuspended in L resuspension medium, which is an integral part of the used kit. The API strips are placed in incubation boxes and the microtubules are inoculated with the prepared cell suspension and sealed with sterile liquid paraffin. The results are reported on the 24th and on the 48th hour of incubation at optimum temperature for the development of the studied strain (37°C). Reporting is done according to colour change in comparison to the control (microtubule 0). Positive results are reported in the case of a colour change from green to bright yellow. The results are processed with apiweb^R identification software.

2.5. Identification

Isolation of total DNA

The isolation of DNA is performed by the method of Delley et al. [3].

PCR reactions and visualization

All PCR reactions are performed using the PCR kit - Ready To GoTM PCR beads (Amersham Biosciences), in a volume of 25 µl in a Progene cycler (Techne, UK). The resulting products are visualized on a 2% agarose gel stained with ethidium bromide solution (0.5 µg/ml), using an UVP Documentation System (UK).

16S rDNA amplification and 16S rDNA ARDRA (Amplified Ribosomal DNA Restriction Analysis)

The method ARDRA involves enzymatic multiplication of the gene encoding the 16S rRNA, using primers complementary to the conservative regions at both ends of the 16S rRNA gene and the product of the multiplication is then restricted with restriction enzymes. The resulting profile is highly specific for the particular studied species.

DNA of the studied strain is amplified using universal primers for the 16S rDNA gene - fD1 and rD1 [16]. The amplification program includes: denaturation - 95°C for 3 minutes, 40 cycles - 93°C for 30 s, 48°C for 60 s, 72°C for 60 s, final elongation - 72°C for 5 min. The resulting PCR product from the 16S rDNA amplification of the tested strain is treated with the endonucleases *Eco* RI, *Hae* III and *Hap* II (Boehringer Mannhem GmbH, Germany). Reactions are carried out according to the following quantities: PCR products - 10µl, enzyme solution - 10 µl (1 µl of the respective enzyme, 2 µl buffer, 7 µl dH2O). Incubation for 1 night at 37°C is performed. The resulting restriction products are visualized on a 2% agarose gel.

2.6. Determination of the profile of enzyme activity

The determination of the profile of enzyme activity is performed, using the test kit API ZYM (BioMeriaux, France) for semi-quantitative determination of the enzyme profile of the studied strain. Fresh 24-hour culture of the tested strain is centrifuged for 15 minutes at 5000 x g, the obtained biomass sludge is washed twice and resuspended in API suspension medium. The API ZYM strips are placed in the incubation boxes and the microtubules are inoculated with the prepared cell suspension. The sample is incubated for 4,5 hours at 37°C. After the incubation one drop of reagent A and one drop of reagent B are pipetted into each microtubule. After 5 min staining is reported according to the colour

scheme described in the manufacturer's instructions. The enzyme activity is determined according to the color scale from 0 (no enzyme activity) to 5 (maximum enzyme activity).

2.7. Batch cultivation in a bioreactor with continuous stirring and in a thermostat at static conditions

The laboratory cultural vessel (Figure 1) is a cylinder with geometric volume of 2 dm^3 and displacement – 1,5 dm^3.

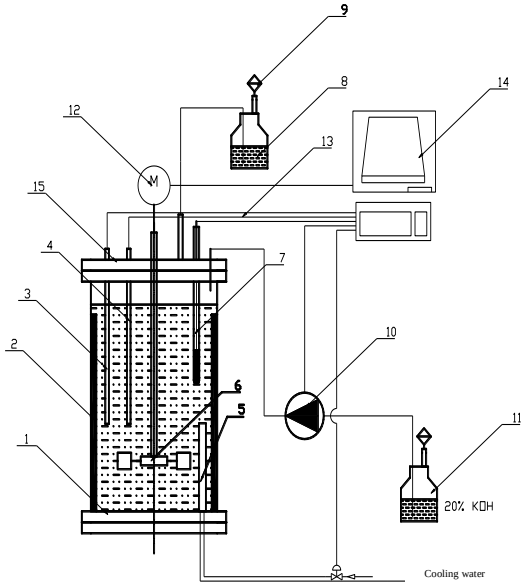

Figure 1. *Scheme of the laboratory bioreactor 1 - vessel with geometric volume of 2 dm^3; 2-four repulse devises; 3–thermo-strength Pt100; 4–heater; 5-heat exchanger for cold water ; 6–turbine stirrer; 7–pH electrode; 8–exit for CO_2; 9–filter; 10–peristaltic pump for pH correction; 11– reagent for pH correction – 20% KOH; 12–motor; 13-control links; 14–control device "Applikon"*

The periodic cultivation processes are conducted in MRS-broth without pH adjustment. The medium is sterilized at 118ºC for 15 min. After cooling to 39-40ºC the prepared medium in the bioreactor (MRS-broth) is inoculated with 5% (v/v) inoculum. The process of cultuvation is conducted at 37ºC, stirring speed of 100 rpm, without air supply. During the cultivation pH, Eh, number of colony-forming units and tirable acidity are examined.

Along with the carried out periodical cultivation with constant stirring (in a bioreactor), static cultivation (in an incubator) under the same conditions is carried out as well.

The number of viable cells of *Lactobacillus plantarum* X2 is determined through appropriate tenfold dillusions of the samples and plating on coloured LAPTg10 – agar medium. The Petri dishes are cultivated for 72 hours at 37°C until single colonies can be counted. The titratable acidity is determined using 0,1N NaOH. 5 cm^3 of each sample are mixed with 10 cm^3 dH_2O and titrated with 0,1N NaOH, using phenolphtalein as an indicator, until the appearance of pale pink colour, which retains for 1 minute. The value for the titratable acidity is obtained by multiplying the millilitres 0,1N NaOH by the factor of the 0,1N NaOH and the number 20.

III. Results and Discussion

The strain *Lactobacillus* X2 is isolated from naturally fermented sourdough.

Identification of Lactobacillus plantarum X2

The identification of the strain is performed using physiological and biochemical method (API 50 CHL) and molecular-genetic methods (ARDRA analysis).

Physiological and biochemical identification

Based on its ability to utilize the 49 carbon sources, included in the test kit (Table 1) *Lactobacillus* X2 is identified as a strain of the species *Lactobacillus plantarum* with a rate of reliability 97.8%.

ARDRA analysis. The ARDRA analysis is performed in order to confirm the identification results from the physiological and biochemical identification with API 50 CHL.

Table 1. *API 50 CHL of the strain Lactobacillus X2*

#	Carbohydrates	X2
1	Glycerol	-
2	Erythriol	-
3	D-arabinose	-
4	L-arabinose	+ (90-100%)
5	Ribose	+ (90-100%)
6	D-xylose	-
7	L-xylose	-
8	Adonitol	-
9	β-metil-D-xyloside	-
10	Galactose	+ (90-100%)
11	D-glucose	+ (90-100%)
12	D-fructose	+ (90-100%)
13	D-mannose	+ (90-100%)
14	L-sorbose	-
15	Rhamnose	-
16	Dulcitol	-
17	Inositol	-
18	Manitol	+ (90-100%)

19	Sorbitol	+ (90-100%)
20	α-methyl-D-mannoside	-
21	α-methyl-D-glucoside	-
22	N-acetyl-glucosamine	+ (90-100%)
23	Amigdalin	+ (90-100%)
24	Arbutin	+ (90-100%)
25	Esculin	+ (90-100%)
26	Salicin	+ (90-100%)
27	Cellobiose	+ (90-100%)
28	Maltose	+ (90-100%)
29	Lactose	+ (90-100%)
30	Melibiose	+ (90-100%)
31	Saccharose	+ (90-100%)
32	Trehalose	+ (90-100%)
33	Inulin	-
34	Melezitose	+ (90-100%)
35	D-raffinose	+ (90-100%)
36	Amidon	+ (50%)
37	Glycogen	+ (50%)
38	Xylitol	-
39	β-gentiobiose	+ (90-100%)
40	D-turanose	+ (90-100%)
41	D-lyxose	-
42	D-tagarose	-
43	D-fuccose	-
44	L-fuccose	-
45	D-arabitol	-
46	L-arabitol	-
47	Gluconate	+ (50%)
48	2-keto-gluconate	-
49	5-keto-gluconate	-

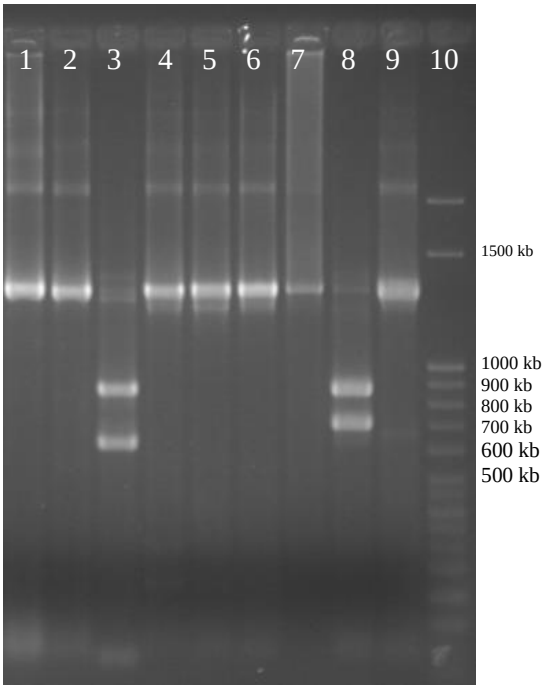

Figure 1. *Restriction profile of the 16S rDNA with EcoRI*

1. *Lactobacillus* X2
2. *Lactobacillus acidophilus* DSM 20079
3. *Lactobacillus delbrueckii ssp.bulgaricus* DSM 20081
4. *Lactobacillus casei ssp.casei* DSM 20011
5. *Lactobacillus casei ssp.paracasei* DSM 20312
6. *Lactobacillus casei ssp.rhamnosus* LMG 6400
7. *Lactobacillus fermentum* DSM 20052
8. *Lactobacillus helveticus* DSM 20075
9. *Lactobacillus plantarum* DSM 20174
10. M 100 bp

As a result of the ARDRA analysis with the enzymes *Eco* RI (Figure 1), *Hae* III (Figure 2) and *Alu* I (Figure 3) the studied strain is confirmed to be a representative of the species *Lactobacillus plantarum*.

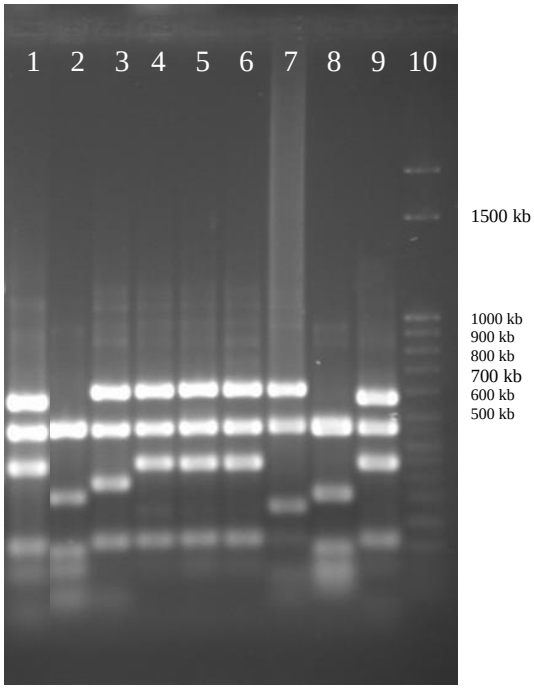

Figure 2. *Restriction profile of the 16S rDNA with Hae III*

1. *Lactobacillus* X2
2. *Lactobacillus acidophilus* DSM 20079
3. *Lactobacillus delbrueckii ssp.bulgaricus* DSM 20081
4. *Lactobacillus casei ssp.casei* DSM 20011
5. *Lactobacillus casei ssp.paracasei* DSM 20312
6. *Lactobacillus casei ssp.rhamnosus* LMG 6400
7. *Lactobacillus fermentum* DSM 20052
8. *Lactobacillus helveticus* DSM 20075
9. *Lactobacillus plantarum* DSM 20174
10. M 100 bp

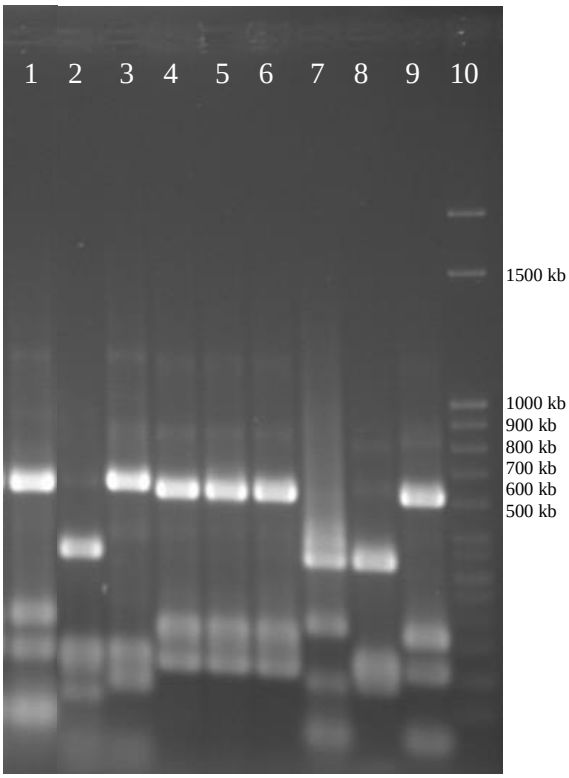

Figure 3. *Restriction profile of the 16S rDNA with Alu I*
1. *Lactobacillus* X2
2. *Lactobacillus acidophilus* DSM 20079
3. *Lactobacillus delbrueckii ssp.bulgaricus* DSM 20081
4. *Lactobacillus casei ssp.casei* DSM 20011
5. *Lactobacillus casei ssp.paracasei* DSM 20312
6. *Lactobacillus casei ssp.rhamnosus* LMG 6400
7. *Lactobacillus fermentum* DSM 20052
8. *Lactobacillus helveticus* DSM 20075
9. *Lactobacillus plantarum* DSM 20174
10. M 100 bp

It is important to determine the enzyme profile of a strain because it is a major factor for determining the technological characteristics of a strain and its applicability as a component of starters or additives for the production of different food products.

The enzyme profile of *Lactobacillus plantarum* X2 is studied by determining the presence of a set of 19 enzymes involved in the system for semi-quantitative determination of key enzyme activities API ZYM (Table 2).

Lactobacillus plantarum X2 exhibits the following enzyme activities: esterase-lipase, leucine-aminopeptidase, valine-aminopeptidase, cysteine-aminopeptidase, acid phosphatase, phosphohydrolase, beta-galactosidase, alpha-glucosidase, beta-glucosidase and alpha-glucoseaminidase (Table 2).

Table 2. *Enzyme profile of L. plantarum X2*

	Enzyme	Activity* X2
1	Control	-
2	Alkaline phosphatase	-
3	Esterase	-
4	Esterase-lipase	1,5
5	Lipase	-
6	Leucine-aminopeptidase	4,5
7	Valine-aminopeptidase	4,5
8	Cysteine-aminopeptidase	0,5
9	Trypsin	-
10	Chymotrypsin	-
11	Acid phosphatase	2
12	Phosphohydrolase	1
13	α-galactosidase	-
14	β-galactosidase	4,5
15	β-glucuronidase	-
16	α-glucosidase	4
17	β-glucosidase	5
18	α-glucoseaminidase	3
19	α-manosidase	-
20	α-fucosidase	-

*the enzyme activity is determined according to the colour scale from 0 (lack of enzyme activity) to 5 (maximum enzyme activity)

Batch cultivation in a bioreactor with continuous stirring and at static conditions of Lactobacillus plantarum X2

In the cultivation of *Lactobacillus plantarum* X2 in MRS-broth in a laboratory bioreactor with continuous stirring at 37ºC the time to reach high concentration of viable cells is reduced compared with cultivation at static conditions (Figure 4, 5). At the 18th hour the number of cells reaches 3x10^{12}cfu/cm^3 (Figure 4), while under static conditions, the same concentration of cells is reached at the 24th hour from the beginning of the process (Figure 5).

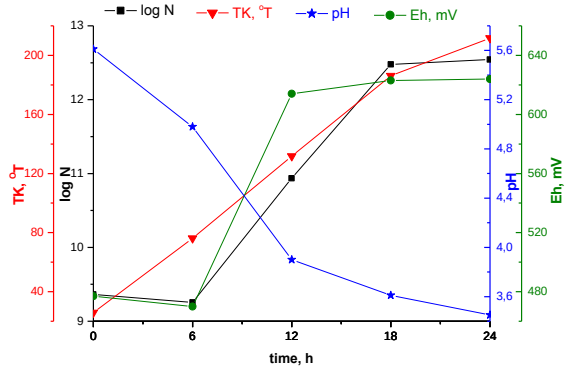

Figure 4. *Batch cultivation of Lactobacillus plantarum X2 in MRS-broth in a bioreactor with constant stirring*

During cultivation in a bioreactor with continuous stirring higher concentration of viable cells is obtained and the titrable acidity of the medium increases from 25,8 to 211,7°T, while at static conditions it reaches 231°T. These studies confirm the results obtained by Schiraldi et al., 2003 [14] that products with higher concentration of viable cells at lower acidity are produced in a bioreactor in the presence of oxygen.

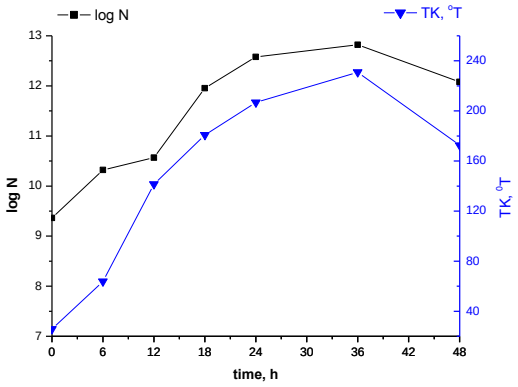

Figure 5. *Static cultivation of Lactobacillus plantarum X2 in MRS-broth*

The redox potential of the system decreases during the first 6 hours from the start of the batch process and reaches +470 mV, then increases during the logarithmic phase to +623 mV and this value is retained as the culture passes from the exponential to the stationary growth phase (Fig. 4).

The strain *Lactobacillus plantarum* X2 allows industrial cultivation with accumulation of high concentrations of viable cells.

IV. Conclusion

The strain *Lactobacillus* X2 is identified as belonging to the species *Lactobacillus plantarum*. The strain allows industrial cultivation with accumulation of high concentrations of viable cells, which makes it potentially probiotic and after further research it can be included in the composition of probiotic preparations for prevention and treatment.

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Research of the interrelationship of structural, mechanical and organoleptic properties of the finished product, obtained from protein-vegetable based semi-finished product

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Abstract. *The results of the study of organoleptic and rheological parameters of sambuca and butter cream obtained through traditional technology and simplified technological procedure based on vegetable protein semi-finished products from whey with different percentages.*

Keywords: sambuca, butter cream, whey based protein-vegetable semi-finished priduct, organoleptic evaluation, rheological properties, flow curves.

Introduction

To effectively address the problem of providing the population with vitamins and minerals there needs to be an introduction to the diet of foods rich in valuable biologicaly-active compounds, as well as the development of new technologies to produce products based on recycled raw milk using plant materials - herbs, fruits, berries and the spice - aromatic plants that have a positive health effect. A promising direction of technological developments is to create products of herbal raw materials using low-waste technologies and secondary products of milk processing. One type of protein-carbohydrate raw milk produced during processing is whey, which has an optimal ratio of protein efficiency. At present, the restaurant industry has increased the demand for dessert products. Reserve production efficiency of these products is the integrated use of by-products of milk processing (whey) with the use of local herbal raw materials. [1].

The most objective data of the properties and structures that characterize the quality of the products is derived during the organoleptic evaluation and rheological studies [2, 3].

The purpose of this paper is to conduct organoleptic evaluation, conduct a series of structure - mechanical studies, obtain a behavioral characteristics of sambuca cream and oil under the pressures and speeds of their applications and identify the nature of changes in these characteristics.

Materials and methods

Our analysis of the types of formula and process of finished products showed that most of the recipes include, for example, sugar syrup, which is requires long-term heat treatment preparation followed by cooling, which leads to the long process of making the finished product. It should also be noted that some formulations require prior prescription thickening mixture (eg, fruit puree) by boiling, which increases the duration of the process, as well as lead to a partial destruction of nutrients (vitamins) caused by high temperatures.

To avoid the above defects, we have developed a powdered protein-vegetable semi-finished goods containing whey, sugar and raw materials from which finished products are produced using simplified technological procedure [4].

The technological process of producing sambuca and oil cream based on semi-finished vegetable protein is as follows: the dissolution of semi-finished product in a predetermined amount of liquid, stirring of the mixture until the smooth consistency; curement to dissolve the components in the mixture; pasteurization, cooling, adding prescription ingredients, whisking the mixture, cooling, and distribution of the product.

The derived results lay at the basis of the production process of the sambuca and oil cream from vegetable protein semi-finished products based on whey.

The objects of research were: control samples of sambuca and oil cream produced using traditional technology without adding a semi-finished product and test samples, prepared using vegetable protein and semi-finished products. Experimental studies of the rheological characteristics of the samples were carried out with four sambuca samples: a control sample and three samples containing

protein - vegetable semi-finished product in amounts of 60%, 65% and 70%., and four samples of oil cream: a control sample and test samples containing semi-finished product in quantities : 10%, 15% and 20% respectively.

Organoleptic assessment of the developed models has been conducted to determine the

dependence of the quality of the investigated product from vegetable protein and semi-finished in finished products.

To determine the organoleptic characteristics of finished products based on vegetable protein and semifinished product a grade assessment method was used where a quality parameters were determined using conventional grading with consideration of weighting factor.

Of particular importance are the rheological studies for the creation of new technologies for food, as it is important to determine the effect to be added to the product obtained by the traditional technology components on the structure of the new product. The rheological characteristics of the samples and the oil sambuca cream determined in experimental studies using a rotational viscometer Rheotest RN4.1 [3].

Sambuca and cream have a complex chemical composition, are elastic - viscous - plastic material. They are a dispersed system in which air bubbles are related membranes that create a solid structure. The viscosity of these compounds is due to the number of air bubbles, the phase space, the properties of the dispersion medium, etc. One of the most important indicators of the quality of these products is the ability to maintain long-term fixed shape, which is characterized by the critical shear stress, which determines the ability of foam to keep the original shape of the masses.

The rheological characteristics of the investigated products depend on temperature, moisture content, duration of whipping. Therefore, temperature test was chosen from the condition that the mass is in visco - plastic state with enough for molding. This condition corresponds to temperatures -5 ° C to 14 ° C for sambuca and butter cream. Throughout the experiment, temperature control was used, which allowed the temperature is kept constant, as even minor variations in temperature of the samples lead to instability of the rheological characteristics.

The studies were conducted in a range of speeds up to 100 s^{-1} for sambuca and to 40 s^{-1} for butter cream, as preliminary studies have shown that in these ranges we get the flow curves as far as complete destruction of the structure of the samples.

Results and discussion

Organoleptic characteristics of sambuca and butter cream with vegetable protein and semi-finished products based on whey is shown in Table 1.

Analyzing the sensory characteristics listed in the Table 2, it should be noted that the values of organoleptic characteristics of finished products higher than the control samples for over 2.3 ... 2.7 % for sambuca, and 0.2 ... 0.4% over for cream for the following parameters: uniformity consistency, conciseness, clarity is the balance of flavors - for the sambuca, is the uniformity of color, intensity and tenderness consistency for cream.

Thus, the analysis of organoleptic characteristics reflects the high quality characteristics of the finished product, made from the vegetable protein semi-finished products.

In experimental studies, we obtained flow curves showing the properties of the samples in shear, the quantitative values of the characteristics, the kinetics of changes in viscosity and shear stress, a relation of the flow of the product to the degree of the structure destruction.

Table 1. *Characteristics of organoleptic data*

The name of the product	Characteristics of organoleptic data
Sambuca	Appearance: molded product with a glossy surface. Color: corresponding to that of Sambuca. Slight inclusions particles of fruits, without other additives. Odor: clear, distinct, appropriate raw materials, which is part of the product. Taste: sweet and sour, fresh, gentle, appropriate raw materials, which is part of the product. Consistency: foamy structure, finely porous, soft, uniform throughout the mass, consistent.
Butter Cream	Appearance: fluffy mass with a glossy finish. Color: cream to straw yellow. Smell: butter and raw materials, which is part of the cream. Flavor: butter, gentle, appropriate raw materials, which is part of the cream. Consistency: a homogeneous, well-saved form.

Table 2. *Organoleptic evaluation of finished products made with protein-vegetable semifinished product*

Data	Weightiness coefficient	Weightiness coefficient of property value	Property value	samples			
				sambuca control	sambuca	butter cream control	butter cream
1	2	3	4	5	6	7	8
appearance	0,2	1,0		5,00	5,00	5,00	4,90
Overall assessment of value property				5,00	5,00	5,00	4,90
Overall assessment of value				1,00	1,00	1,00	0,98
color	0,2	0,4	uniformity	4,95	5,00	5,00	4,85
		0,2	intensity	3,55	4,00	4,80	4,30
		0,4	naturalness	4,00	3,90	3,85	4,00
Overall assessment of value property				4,29	4,36	4,50	4,40
Overall assessment of value				0,86	0,87	0,9	0,88
consistency	0,3	0,3	uniformity	4,80	5,00	5,00	4,90
		0,5	overrun	4,90	5,00	4,98	4,90
		0,2	tenderness	5,00	4,95	5,00	4,90
Overall assessment of value property				4,89	4,99	4,99	4,90
Overall assessment of value				1,47	1,50	1,50	1,47
smell	0,1	0,4	expression	3,50	3,65	4,20	3,90
		0,2	intensity	4,00	4,00	4,00	3,85
		0,4	purity	3,95	3,85	4,00	3,95
Overall assessment of value property				3,78	3,80	4,08	3,91
Overall assessment of value				0,38	0,38	0,41	0,39
taste	0,2	0,2	expression	3,50	3,90	4,35	4,50
		0,2	balance	3,80	4,00	4,00	4,30
		0,3	purity	4,00	4,00	4,25	4,00
		0,3	naturalness	3,47	3,95	4,00	4,45
Overall assessment of value property				3,70	3,97	4,15	4,30
Overall assessment of value				0,74	0,79	0,83	0,86
Overall assessment of prepared meals				4,53	4,54	4,64	4,58
Overall assessment of prepared meals, % to maximum				90,6	90,8	92,8	91,6

The curves of viscosity and shear stress obtained from the experimental data shown in Figures 1 - for sambuca, 2 - for the butter cream, have the same look and similar quantitative values for sambuca and for the butter cream, respectively, that is, introduction into the formula of these semi-finished products did not significantly affect the structure of products.

With increasing shear rate viscosity of the sample decreases, the structure is partially destroyed, and after the complete destruction of the structure viscosity stabilized. The sharp drop in viscosity is in the range of relatively low shear rates up to 5 s^{-1} at sambuca and up to 4,5 s^{-1} for butter cream. At these data areas, the viscosity is reduced by 80-90% for all samples. The rate of deviations in pressure shifts in these data areas is the greatest.

With further increase in shear rate up to 75 $^{s-1}$ for sambuca and 20 $^{s-1}$ for butter cream viscosity changes by 30-35%, increase the values of shear stress at the same time are slowing down. At shear rates in excess of the above, there is a complete breakdown of the structure and stabilization of the viscosity. At 100 $^{s-1}$ for sambuca and 40 $^{s-1}$ for butter cream yields the values of the limit shear stress patterns.

For pressures less than the limit of shear stress, which characterizes the strength of the structure, there is a smooth flow, in which the structure is destroyed, but than the structure is restoring itself which signifies that there a small equilibrium degree of destruction.

Flow curves show that the critical shear stress for all samples of sambuca reached at a shear rate of 95 s^{-1}, and for the butter cream - at 38 s^{-1}. The variation of the critical shear stress for sambuca and cream for oil is 8-9% at these high shear rates. This indicates that the addition of protein - vegetable semi-finished products of whey formulas tested product does not affect their ability to hold a

steady form. For all the sambuca samples curves of shear stress versus shear rate with a high coefficient of correlation function is approximated by the general law of casson, the largest deviation between the calculated and experimental data does not exceed 5%.

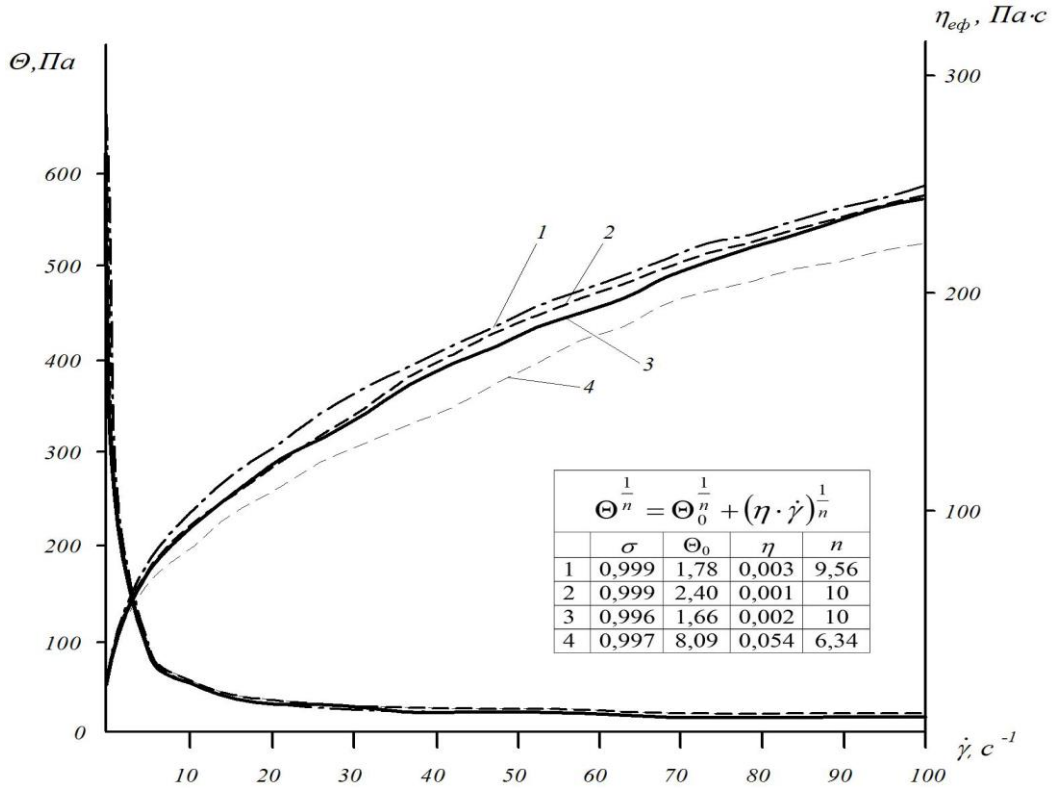

Figure 1. *Flow curves of sambuca samples*

1 - control sample, 2 - sample containing 60% of the intermediate product, 3 - sample containing 65% of the semi-finished product, 4 - sample containing 70% of the semi-finished product.

Figure 1 shows the flow curves of four samples of sambuca and describes their equations.

Casson law equation takes into account the relationship between the yield stress (Pa), viscosity (Pa·s), and the exponent of the curvature of the flow curve.

Flow curves of the control sample without intermediate product of protein-vegetable semi-finished product and experimental samples with intermediate product 10%, 15%, 20% butter cream, depending on the shear rate are shown in figure 2.

For all samples butter cream described by Bingham law.

The analysis of experimental data by Bingham law yield curve is approximated by a straight line. Analytical equation takes into account the actual characteristics of the material: plastic viscosity (Pa·s), and yield strength.

The equations describing the flow curves of samples obtained during the processing of the experimental data are shown in Table 3.

Table 3. *The equations describe the flow curves of samples*

general flow law	specimen type	Flow law	correlation coefficient
$\theta = \theta_0 + \eta \cdot \dot{\gamma}$	Control sample	$\theta = 217,88 + 1,28\dot{\gamma}$	σ =0,878
	Semi-finished product content 10%	$\theta = 150,58 + 3,60\dot{\gamma}$	σ =0,866
	Semi-finished product content 15%	$\theta = 113,93 + 3,38\dot{\gamma}$	σ =0,912
	Semi-finished product content 20%	$\theta = 111,37 + 2,97\dot{\gamma}$	σ =0,947

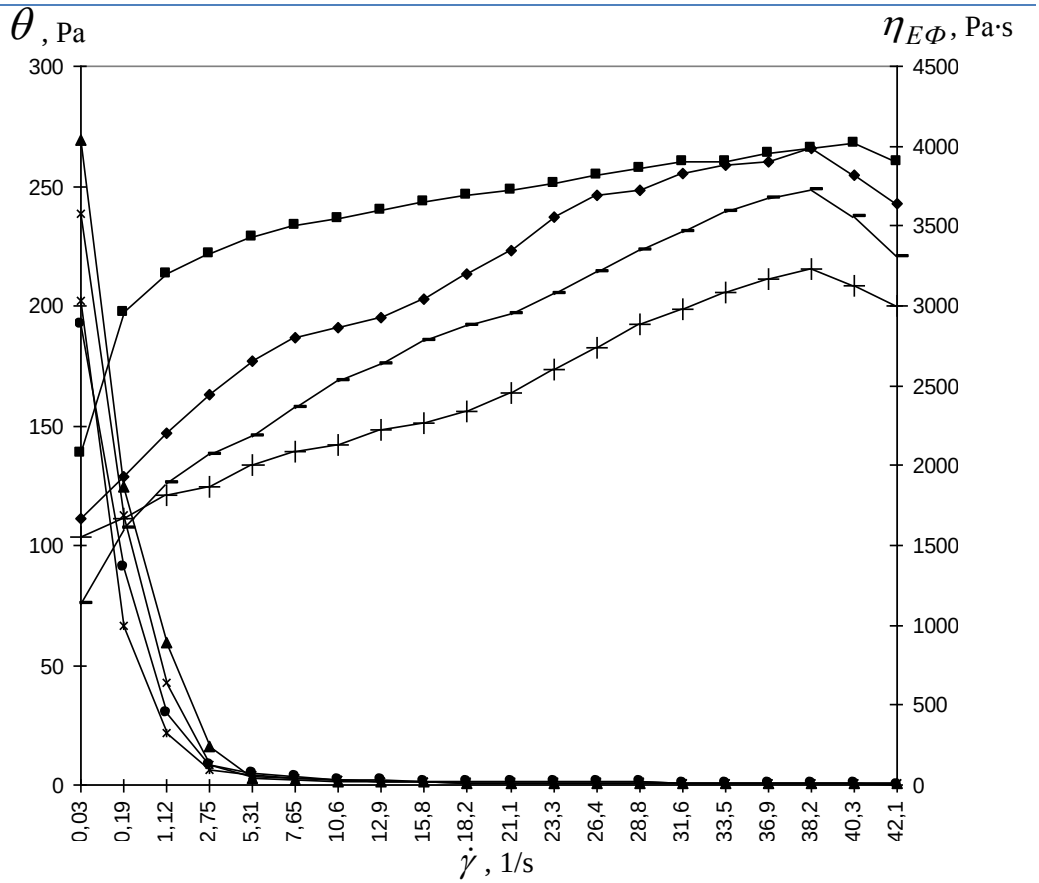

Figure 2. *The flow curves of butter cream samples*

Conclusion

The results of organoleptic evaluation and rheological studies have shown that the establishment of sambuca and butter cream with the addition of the classic formulation of protein - vegetable semifinished products allows faster workflow. The same behavior of the flow curve and close the numerical values of the viscosity and shear stress at the corresponding shear rates indicates that the addition of protein - vegetable semi-finished product derived from whey does not affect the final product structure.

That is, the studies make it possible to claim that the product obtained by developed technology has better quality than the existing elder sumbuca and butter cream.

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The system of food market control mechanisms and of food safety development in Ukraine

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Abstract. *The food safety regulation and development issues are observed, the consumer's market factors of danger are analyzed, the main components of the guaranteed food products consumption level in Ukraine is determined in the article.*

Key words: Food safety, consumer's market, regulation, mechanisms, dangers, guaranteeing

Transition to the civilized food market demands on the contrary a serious state involvement and support. If being guided by the profound essence of the reformed economic relations in general and in Agro-industrial Complex particularly, the food market formation as a constituent part of the present agricultural policy and thereupon creation of civilized grounds for purchase and sale of food products means that the food problem is being actually and significantly solved in the state and the conditions for high-powered export resources of food and raw material are created.

Over the past years a number of important documents in formation, functioning and improvement of consumer market are developed: "Strategy of economical and social development for 2000-2004", "Strategic program "Ukraine – 2010", "Ukraine: entry in the 21st century", "Strategy of overcoming the poverty", "The state program of industry development for 2003-2011" and others.

The most complex and fundamental document in this sphere is "The strategy of economic and social development in Ukraine for 2004-2015 by means of European integration". This document determines the basic strategic priorities for Ukraine for 2004-2015, where the main are creation of prerequisites for Ukraine's membership in the EU, providing of sustained economical development, social reorientation of economical policy, approval of innovative development model and others [1].

The Ukrainian consumer market is regulated by the Law of Ukraine "On consumers' rights protection" that establishes relations between a producer and a consumer, consumers' rights, determines consumers' rights protection mechanism [2]. Consumers' rights protection is also provided by executive bodies: the State Committee for Consumers' rights protection, the Prosecutor's General Office "Ukrainian research and training center for solving of standardization, certification and quality problems" (the leading organization of Ministry of economic development and trade in Ukraine), the State Committee of Ukraine for technical regulation and consumer policy, state bodies of sanitary-epidemiological supervision.

Management and supervision over vital activity safety, of production and food consumption in particular, are governed by special authorized bodies.

Different state and public organizations control legislation as to the vital activity safety in Ukraine.

There are state bodies of common, special and branch-wise competence among them. The Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, executive committees of local soviets of people's deputies, local authorities. The state bodies of special competence are authorized to control the activity of enterprises, institutions, organizations and citizens over labour, health, environment protection. In Ukraine labour protection is governed by: the Cabinet of Ministers of Ukraine; ministries and other central bodies of the state executive power; local state authorities, local soviets of people's deputies. The Cabinet of Ministers of Ukraine and the National Council under the Cabinet of Ministers of Ukraine realize the state policy creating necessary conditions for vital activity protection of the population according with their authorities.

The State Sanitary and Epidemiological Service of the country is very important in production and consumption of food products and is subordinated to the Ministry of Health, the Ministry of Defence of Ukraine, the Ministry of Internal Affairs, the State Committee on issues of protection of the state border of Ukraine, the Security Service of Ukraine. The main role in supervision and control of sanitary legislation, state standards, criteria and requirements aimed at sanitary and epidemiological wealth of population is assigned to the Ministry of Health of Ukraine [3;4;5;6].

The national social ecological strategy formation considers the priority of social and economical problems of the country by the criteria of the risk influence upon all spheres of life of society, population's health and interests of future generations. The national social economical strategy is realized in the national strategy of transition to the innovative model of economy development in accordance with decisions of the World's summit in Johannesburg and political guidelines of the pan-European process determined at the summit as "Environment for Europe Kiev-2003". The rich resource and nature potential, highly educated population, developed industry and infrastructure create all necessary prerequisites in order to introduce requirements of these summits in Ukraine. According to their decisions, "The main directions of the state ecological policy" (1998), national programs mentioned above "Health of the nation", "Quality of life", "Food safety – to Ukraine" and the European program "Health for everybody in the 21st century" as well are developed in our country. The government develops programs considering environment protection and ecological and food safety in Ukraine based on this document. Ecological problems influence the most upon the development and functioning of the food market. Pollution of water, air and soils prevents growth and stocking of food raw materials used for high quality food production, after that it is distributed and stored in the threatening number in the food chain soil-plant-animal-person. It is the state of the raw material base, processing of food raw material, namely development of agriculture, and the state of natural resources that determine the effective operation of food industry enterprises and, as a result, of the consumer market.

According to the source data [7], the inspection of Ukrainian enterprises showed that 16,3% of meat products in 2009 didn't comply with the standards (48,7 tones of production in the sum of 637 thousand 300 hrv. didn't comply with the requirements of the normative documentation). While inspection of fresh and frozen meat, frozen semi-finished meat products by the State Inspectorate Supervision Derzhspozhyvstandard of Ukraine, it was found that 293,34 tones of production in the sum of 5 million 108 thousand 92 hrv. didn't comply with the normative requirements in production and the total amount of fines was 192 thousand 400 hrv. The producers were fined in the total sum of 274 thousand 381 hrv. for violations during inspection of sausage goods in 2009. In whole, 301 inspections were carried out, violations were found in 259 cases (86% of cases). From the inspected 257,25 thousands of wine products that valued 19 million 89 thousand 79,3 thousands (30%) that valued about 9 million 124 thousand hrv. were rejected due to non-compliance with requirements of the normative documentation. Almost the half of inspected enterprises – 56 out of 99 – produced wine products with obvious violations, they were fined in the sum of 165 thousand 767 hrv. in accordance with 67 regulations.

In picture 1 there are data reflecting all kinds of defects and requirement violations of the normative documentation on products inspected by the Donetsk centre GP "RCSMS" that confirms the decision on separation of variables with high rates of connection (three-dimensional displaying of dependencies for kinds of defects and violations is developed in the program gnuplot).

Among the main drawbacks identified during the inspection there were common drawbacks for all food products: the lack of technological documentation (receipts, technological instructions); non-compliance of production with organoleptic and physical-chemical indicators; the periodicity of the finished food control on safety indicators wasn't carried out in full; the lack of the finished food control (or not being full) on organoleptic, physical-chemical and microbiological indicators; unsatisfactory or without transport and consumer labelling; violation of metrological rules and regulations.

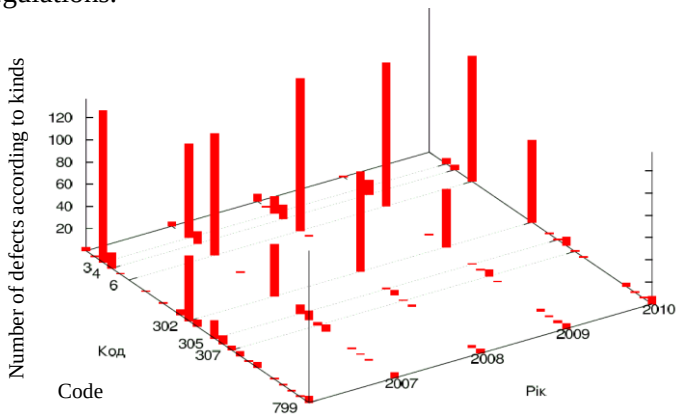

Figure 1 *Results of safety product inspection*

The given violations became possible due to drawbacks of production preparation; failure to receipts and insufficient control while raw material putting; unsatisfactory organisation of receiving and periodic control of finished products; non-compliance with requirements of the normative documentation while product labelling; unsatisfactory or insufficient metrological production provision.

According to the article 50 of the Constitution of Ukraine "Everyone is guaranteed the right of free

access to information about the environmental situation, the quality of food and consumer goods, and also the right to disseminate such information. No one shall make such information secret", it is worth remarking that over several years the final monitoring of the social development is carried out in Ukraine, when the quality of life including health protection, housing, food supply and the state, quality and safety of food is studied.

To sum up, it should be noted: the guaranteed level of food products supply on the sate level is connected, first of all, with providing of the proper quality of goods (that directly depends upon the ecological state of environment) and trading service.

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Comparison of indicators and inspection methods of wheat grains dockage in ukraine and the USA

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Abstract. *Framework conditions of the WTO demand from its members a radical change of approaches as to the complex of scientific-technical and economical measures of the grain market export component.*

Key words: Grain, quality, impurities, methods, export, import, Ukraine, the USA

This concerns Ukraine as well, and participation in the WTO demands from our country harmonization and adaptation of the existed normative-technical, industrial and infrastructure basis to international requirements [1].

According to international market rules, the objective grain quality assessment can be given only under the terms of meeting the requirements of the contract that includes the requirements of the corresponding inspection system. Unfortunately, grain traders in Ukraine are not informed about activities and structure of the world inspection systems. It's obvious that the differences in inspection methods and registration of results cause great technical problems and financial expenditure.

There are hundreds of international standards as to the methods determining the indicators of grain quality and its products processing for determining the grain quality nowadays.

By evaluating the wheat drains dockage and its determination methods the Federal Grain Inspection System (FGIS) is the most significant and favourable for analysis.

The aim of the article is the comparison of requirements to indicators and determination methods of wheat grains dockage by inspection systems in Ukraine and the USA.

Every production lot is under control of grain quality during export-import operations. The source [2] of the grain production lot is the certain amount of the crop, its homogeneous quality meant for storage or realization.

The first step of inspection procedures is the organoleptic assessment and establishment of production lot homogeneity followed by sampling. The sampling method must be checked thoroughly and appropriately and estimated if it is representative by receiving a sample. The sampling is carried out in accordance with DSTU 3355, DSTU ISO 3690, GOST 13586.3 in Ukraine.

According to the functional GOST 2422-94 "Grain for supply and delivery. Terms and definitions", there isn't any definition of grain or of the list of botanical species on which the standard is extended [3]. Although, it is known that nowadays two botanical species of grain are grown in Ukraine – Triticum durum Desf. – durum wheat and Triticum aestivum L. – common wheat or soft wheat. According to the data of the State register of kinds for cultivation in Ukraine, 193 kinds of winter soft wheat (Triticum aestivum L.) are districted and 24 sorts are perspective [4].

The following is referred to the basic wheat grain in the Ukrainian standard DSTU 3768-2010 [7]: whole and damaged wheat grains, not referring to weed and grain admixture by the nature of their damage; grain with the germ coloured (soft wheat of group A up to 8% inclusive, soft wheat of group B and class 6 – up to 30% inclusive), soft wheat of class 6 – grains and seeds of grain and leguminous crops not referring in accordance with the standards to these crops by the nature of their damage of weed and grain admixture.

In the American standard "Official grain standards of the United States, section 6 – "Wheat standards" there is a definition of wheat including the names of botanical species on which the standard is spread. According to the standard of the USA, wheat is grain that, before the dockage is removed, contains not less than 50% of common wheat (Triticum aestivum L.), dwarf wheat (Triticum compactum Host.) and durum wheat (Triticum durum Desf.) and not more than 10% of other grain crops being standardized in accordance with the law of the USA grain standards and that, after the dockage is removed, contains not less than 50% of whole grains of one or several kinds of these wheats.

The American standard defines the dockage as the whole material different from wheat, being easily and quickly removed from it without any complex equipment, used in winnowing mill sections. Underdeveloped, shriveled grains and small pieces of wheat grains removed with wheaten impurities and not being left after rescreening or cleaning are

referred to the dockage. The dockage content is established for all types and subtypes of wheat in accordance with methodical instructions of the Federal grain inspection with the help of the Carter Dockage tester that consists of grain speed controller, an aspirator and a set of sieves. This device provides removing of impurities that are lighter and bigger or smaller than wheat grains. In most of cases the dockage consists of weeds, stones, mud and large grains (of corn or soy beans), straw and empty glume. The dockage content in wheat is given with the rounding up to one tenth of one procent, e.g. 0, 86% is rounded to 0,9%; 1, 34% is rounded to 1, 3%.

Thereby, the comparison concludes that the significant difference of the American standard is in dividing of wheat into quality types and classes only after removing and estimating of the dockage content.

After this first step, the dockage of grain in a wheat sample is analyzed by setting the percentage of impurities in it.

In most cases, in grain exported from Ukraine can be found impurities including pieces of straw, empty glume, sand, ground, stones, weed seeds, other crops seeds, broken grains of the main crop as well as grains damaged by insects and affected by fungal diseases . The grain dockage is determined by GOST 30483 in Ukraine.

The large number of impurities is determined at first. The average samples weigh up to decimal fractions of a gram, the large number of impurities is taken out after sifting.

The average sample is sifted in circular motions through a sieve with top diameter of 6 mm. The large number of impurities is taken out manually from the

top of the sieve. The impurities are large if they are bigger than grains of the main crop (wheat). Ears of wheat are referred to weed impurities after grains are taken out from them.

The isolated impurities are divided into fractions that are considered in accordance with the grain standard.

The content of the marked grain and weed impurities is determined after the average sample is cleaned of large weed impurities.

According to DSTU 3768:2010 [5], there are impurities of organic and non-organic origin, divided into grain and weed impurities. Broken, empty, sprouted, damaged by heat, infested grain, grain with coloured germ and grain of cereals (triticale, rye, barley) are referred to grain impurities in Ukraine.

Visual inspection of damaged or empty grains (the grain inspection is carried out in Ukraine as well) causes subjective opinions. The American inspection system on damaged and defected grain is maximum subjective due to the present inspection system: as reference material an American inspector uses the set of slides that contains pictures of all possible grain damages and defects that maximum excludes any possible opinions.

Sieves of 1,626 mm size are used to define the fraction of small grains in accordance with the USA standards. Sieves of 1,7 x 20 mm size are used in Ukraine.

The whole passage of grains through the sieve of 1, 626 mm size refers to broken grains in the American standards, and all broken grains that are more than 1, 626 mm are considered to be healthy. The weed wheat impurities in Ukraine are: the passage through the sieve with the 1,0x20,0 top size that refers to mineral impurities and harmful impurities in the residue on the sieve of 1,0x20,0 top size; mineral, organic and harmful impurities, damaged grains of wheat, rye, triticale, barley with fully eaten out endosperm.

The part of weed impurities can also be the reason of confusion. According to the American inspection system, the weed impurities are the whole non-wheat material that is left in the sample after removing of dockage and broken grains. Other crops are also considered to be a weed impurity. It is known that several weed seeds are poisonous and hard to be removed from the main crop grain because of their similar size parameters and specific weight.

According to Ukrainian approaches, such seeds refer to harmful weed impurities and other not damaged crops to grain impurities.

Conclusions

The analysis has shown that Ukrainian indicators and methods of wheat grain dockage differ from requirements of the inspection system of this indicator in accordance with the Federal Grain Inspection System (FGIS). These differences are of fundamental importance and can lead to significant disagreements in the wheat grain dockage level while export-import operations.

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Innovation management in food industry

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Abstract. *This presentation covers the innovations as a business strategy, as well as an object of management. For this purpose the innovations have been defined and classified and the stages of the innovation process are shown, in accordance with the life cycle of the product. There are some examples for innovation in the food industry.*

In relation with the innovation management we have presented the methodical basis and systems for innovation process management in a given organization.

Keywords: Cycle of Deming, innovation, innovation process, management, management system, evaluation and efficiency of the innovations.

INTRODUCTION

Companies, in accordance with their mission and dynamically changing external environment, aiming to sustainable development and competitiveness, should formulate their innovative development.

Wherever there is lack of innovations, there is stagnation and where we have innovations, there is development and competitiveness.

The innovations are not only desirable, but they are vital and effective anti-crisis tool.

Strategy for innovation development in the organization requires that the presumed innovations include the creation and implementation of:

- New products (services);
- Technologies;
- Capability of the organization to implement a specific production;
- Markets;
- Structures;
- Management systems.

Innovation and the innovation process have significant economic importance for organizations and business influence. We can give India as an example, where 10% of the fruits and 13% of vegetables from the total global production are produced. Recently India has the innovations and investments in the food industry as a national priority. In this relation India establishes direct cooperation for innovations and investments with Germany, France, the Netherlands, Canada and USA and has planned the implementation of 30 mega food parks for year 2012. The aim is to develop the food industry to a sector, which can be a propeller of the economical growth in India.

One of the directions of innovation in the food industry for some organizations is research, implementation and production of functional foods that work at the cellular level of the body and are a much better alternative to consumer health, than the various medications and synthetic based vitamins.

The innovations in a specific country and its economical development are directly correlated. In this contest we can classify the thirty countries, which are innovation leaders: 1. Singapore; 2. South Korea; 3. Switzerland; 4. Iceland; 5. Ireland; 6. Hong Kong; 7. Finland; 8. USA; 9. Japan; 10. Sweden; 11. Denmark; 12. the Netherlands; 13. Luxemburg; 14. Canada; 15. England; 16. Israel; 17. Austria; 18. Norway; 19. Germany; 20. France; 21. Malaysia; 22. Austria; 23. Estonia; 24. Spain; 25. Belgium; 26. New Zealand; 27. China; 28. Cyprus; 29. Portugal; 30. Qatar. Switzerland is the world leader in pharmacy and food researches, and Singapore, Denmark and England are leaders in the biotechnologies.

Innovation must be the subject of innovation management. The Deming cycle should be embedded in the philosophy of this management.

INNOVATION AND INNOVATIVE PROCESS

Innovation and novation can be used as synonyms, but they have the following definitions:

Innovation is the final result from implementation of innovations, which aims to achieving economical, social, ecological, technical or other effect, i.e. the innovation is a process of using innovations.

Innovation is a formed result of fundamental, applied or experimental research, in any scope of activity for increasing its efficiency.

The essence of innovation lies in the definition of **the innovation process** - activities for introduction of new products (services) and technology for socio-economic development of society.

The innovation process is illustrated on Figure 1.

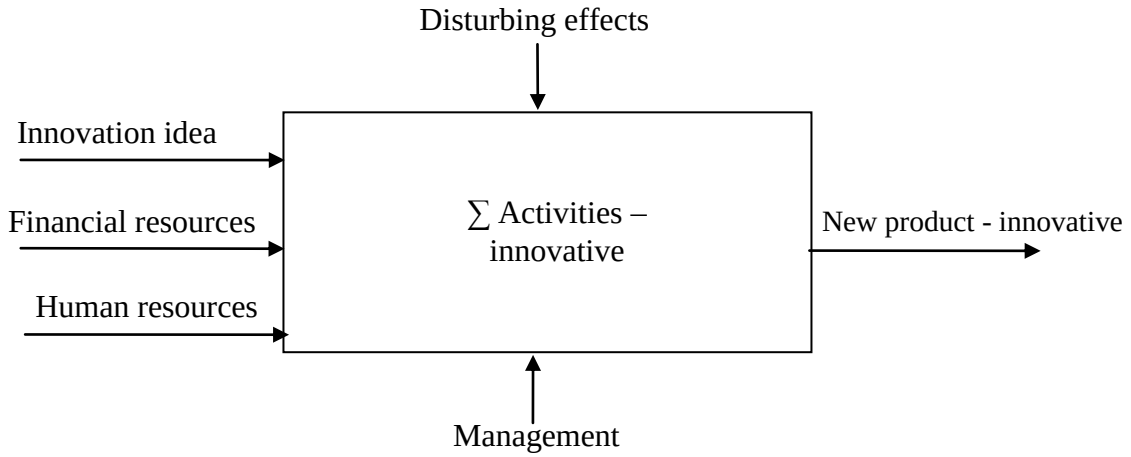


Figure 1. *Presentation of innovation process*

The main activities in the innovation process are:

- Alteration of the existing situation;
- Formulation of the final objectives (innovation for the company and the market);
- Determination of the process duration;
- Providing the necessary resources (financial and human);
- Legal and organizational provision of the innovation project.

In order to understand the essence of the innovation and its nature we have to point out the two tendencies for the organizations existing: **functioning** and **development.**

Tendency for functioning means keeping the viability of the organization, which is expressed in **keeping its entirety and quality distinctness.**

Tendency for development means **Тенденцията за развитие** означава **transforming the organization** through a new quality that enhances its viability in a competitive environment. Both tendencies for functioning and development have dialectical character – unity and struggle of opposites. The functioning includes development, and the development destroys many processes from the functioning, creating conditions for more stable future functioning of the organization.

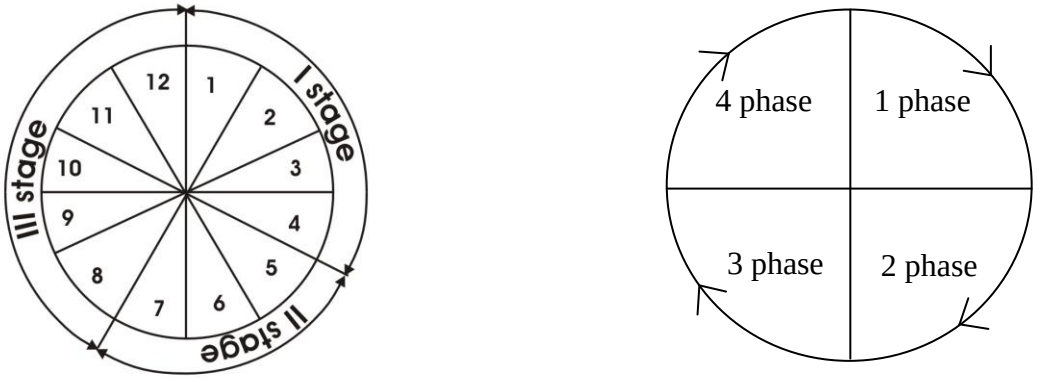
LIFE CYCLE OF THE INNOVATION PROCESS AND THE PRODUCT

Any growing organization in a competitive external environment and globalization needs:

- Intensive innovation activity;
- Increased attention to the effectiveness of the organization on key researches, which are:
  - **Innovation** (searching);

- **Condemning** (critical);
- **Specifying**;
- **Confirmatory** (re-creative).

- Innovations in all stages and phases of the product life cycle (see Figure 2a);
- Shortening of the cycle;
- Innovation risk reduction;
- Strategy management of the innovations and the organization.



a) *b)*

Figure 2. *Life cycle of the product (LCP) (a) and Life cycle of the innovation process (LCIP) (b)*

LCP

I Pre-production stage:
1 ph. Marketing and market research
2 ph. Product development
3 ph. Technology process development
4 ph. Purchasing (adding raw materials and consumables)

II Production stage:
5 ph. Production
6 ph. Control, testing and study
7 ph. Packaging and storage

III After-production stage:
8 ph. Realization and sale
9 ph. Installation and exploitation
10 ph. Technical maintenance and support
11 ph. Observing the product on the market
12 ph.Scrapping product when goes out of use

LCIP

1 phase – carrying out of scientific researches

2 phase – carrying out of applied scientific activity.

3 phase – performing experimental-design and engineering works

4 phase – utilization of the production and implementation of the process of commercialization of innovation. The commercialization must follow the stages of LCP, after production and market release

It is important to know that for every stage and phase of the LCP two types of processes must be paired: **stable (SP)** and **innovation process (IP)**.

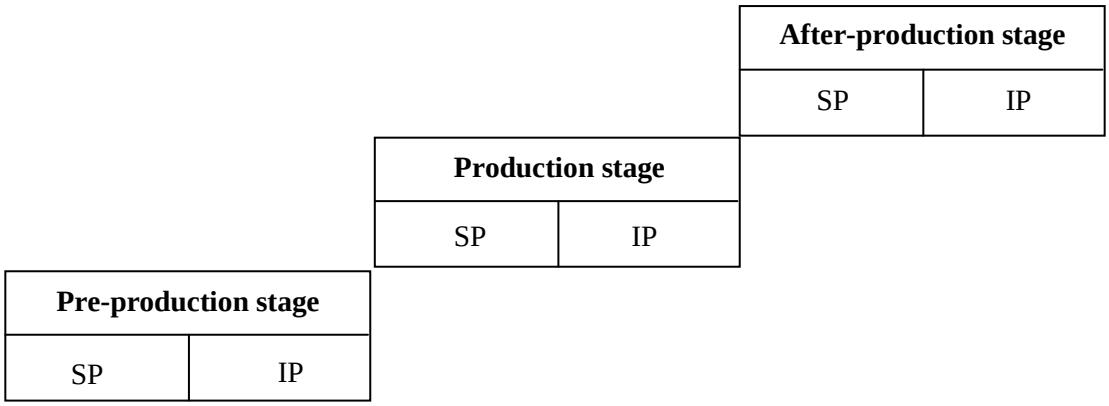


Figure 3. *Stable and innovation processes in stages and phases of LCP*

We have to consider that stable and innovative processes are complementary to each other, ie the state of the stable process is determined by the innovative activities and the result is stable process. At the same time, between the two processes (stable and innovative) there are significant differences and contradictions, which are as follows: final target, ways to reach the targets; risk at reaching the targets; the type of processes (continuous / discrete); type of plans (short term / long term); degree of equal interests (high / low); type of responsibilities distributiondestination paths for achieving the objectives; risk in achieving the objectives, the type of process (continuous / discrete) types of plans (short / long), degree of coincidence of interests (high / low), type of distribution of responsibilities (stable / reallocated) form of organization (rigid / flexible) and others.

We can see the relation between the stages of the innovation process and the stages of the product life cycle on Fig. 3.

There are four phases of the innovation process (see Fig. 2b):

- **Phase 1** – carrying out scientific research. This phase is characterized with giving, motivation and experimental test of the innovative ideas (ideas for new methods);
- **Phase 2** – carrying out of applied scientific activity. This phase is characterized by defining the qualitative characteristics of the new methods, while developing the corresponding technological assignment and technical project of the innovation;
- **Phase 3** – performing experimental-design and engineering works;
- **Phase 4** – utilization of the production and implementation of the process of commercialization of innovation. The commercialization must follow the stages of LCP, after production and market release.

INNOVATION MANAGEMENT METHODOLOGY AND SYSTEMS FOR MANAGEMENT OF THE INNOVATION PROCESS

As we already noted, the innovations must be subject of innovation management.

The innovation management philosophy is based on the Deming cycle (Figure 4).

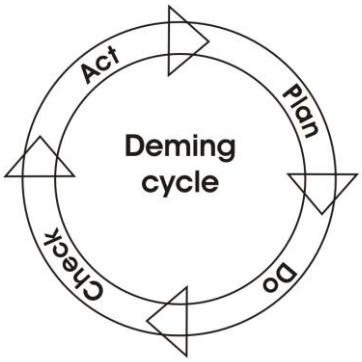


Figure 4. *Deming cycle*

The innovation management must be embedded in the functional/ strategy management of the organization (Figure 5).

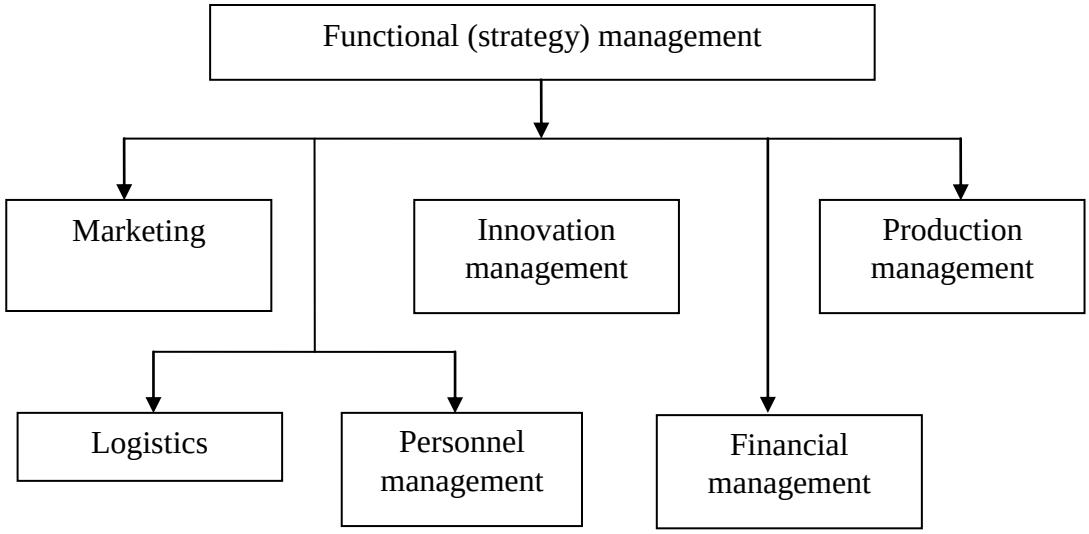


Figure 5. *Elements of the functional/ strategy management of the organization*

The innovation management by itself is one of the many types of functional management of the organization.

The innovation management is a set of principles, methods and forms of innovation process management in any organization, including the personnel.

The innovation management can be executed at two levels.

The First level is called strategy level, where the management is facing the implementation of the strategy for growth and development of the organization.

The second level is called functional level, where the management is facing the effective management of the process of research, implementation, production and commercialization of the innovation.

The innovation managers are important subject and they must perform the following:

- Forming and management of designer teams;
- Searching and promulgation of innovations.
- Formation of port-foils for requests for scientific research and works;

- Evaluation of the innovation efficiency.

The Systems for innovation management (SIM) should be integrated, ie they should be a part of an

integrated system for organization management (IMS).

Depending on the area of activity of the organization IMS can be built with different international standards namely:

IMS → QMS (ISO 9001) + SIM
IMS → FSMS (ISO 22000) + SIM
IMS → EMS (ISO 14001) + SIM
IMS → EMS (ISO 50001) + SIM
IMS → ISMS (ISO 27001) + SIM
etc.

CONCLUSION

The changes in the world business related to globalization, increasing competition, limited resources (raw materials and energy) and the new vision for jobs, need very serious attitude towards the innovation management systems.

The managing system of the companies must provide **the balance of needs and interests of the company at one side and the needs and expectation of the consumers, at the other.**

Any country that requires thriving economy, its state policy must stand for innovation development and must provide the necessary national innovation capacity and potential.

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A study regarding the migration of Cu and Zn from the food cans during their storage

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Abstract: *For to study the interactions between the packaging and the can content in practical conditions during one and respectively two years of storage there were tested four types of canned products fabricated with different lacquers. For to compare the protection features of several lacquering systems it was used the same type of tin the tinplate. Thus, it was observed the migration of several metals from the packaging into the product during the packaging as well as the modifications that take place during the storage for to extend the shelf life of the studied protection systems.*

For to verify the protection lacquer can surface applied stability the meat and vegetables products were analyzed before and after the oven thermostating at a temperature of 50 ^{0}C, for one month and respectively two months.

Thus the lab procedure for determining the stability of the lacquer layer was verified in practical conditions for most of the analyzed systems and it was established an accelerated ageing method of the epoxy phenolic resins based lacquers.

Keywords: metals, cans, interaction, migration

Introduction

The globalization of the food industry enforces international standards and compliance with multiple regulations. New technologies should also be examined for their effect on product quality and public health, and the results of these tests should be disclosed to the public. (Paul Finglas 2011).

The current approach for the authorization and control of substances used in food contact materials is cautious in estimating the potential exposure of the consumer to these substances. Approaches, which take better account of the actual exposure of the consumer to food contact materials in risk assessment, are under discussion. To estimate dietary exposure to a substance migrating from a food packaging material, information is needed on the types of food packaged, the nature of the packaging material, migration data, packaging usage factors and food consumption (ILSI Europe, 2001).

Moreover, there has been considerable scientific progress in understanding and modeling the migration of adventitious substances with hazardous potential from packages into foodstuffs that are in direct or indirect contact with the packages (3, 4, 5, 6, 7).

The heavy metals are very stable chemical elements that do not degrade thermically or chemically but according to their binding in the vegetal tissue they can migrate.

The tomato paste subscribe to the group of very aggressive environments regarding the risk of corrosion for the metal cans as a consequence of their high titrable acidity (7,58 - 7,60 g citric acid/100g s.u, in the case of the studied product). Due to these in the case of canning tomato paste in metal cans their surface must be protected by applying acido resistant lacquers.

Material and methods

The determination of the heavy metals content was done according to the standard mineralization methods followed by the atomic absorption (F-AAS; GF-AAS).

The materials used in the experiments vegetable species taken from polluted and non polluted areas were subjected to the specific technological operations for to obtain products preserved in metallic cans.

There were also analyzed the metals from different food cans (peas, tomatoes, meat cans and fois gras) at different moments of their storage. The results are exposed in the following figures.

The analytical methodology comprises::

a) testing the heavy metals migration from the food simulants

- preparing the sample**:** - in water extract ;- in acetic extract;

- determination: **-atomic absorption** spectrophotometry (GAAS, FAAS);

b) determination of the metal content in the canned foods

- preparing the sample: - mineralizing the sample with moisture:

- according to STAS 5954/1-1986, in the case of the vegetables and fruits cans; - according to STAS 10542/1-1986, in the case of meat cans and vegetables and meat mixed cans.

The mineralization of the samples (dehydrated peas and tomato paste) was done according to STAS 5954/1-86: the organic substance is destroyed by burning and incineration in the electric oven at 450...500 °C, the resulted ash being transferred into solution by dissolvation in diluted hydrochloric acid (dry mineralization).

The analysis of the metal content was done by AAS spectrometry the results being given by the soft of the device and expressed in ppm (mg metal/ kg product).

It was used an atomic absorption spectrophotometer "AAnalyst 400", with air-acetylene flame and background absorption correction (D_2 lamp), for analyzing all the materials.

Results and discussions

From Figure 1 we see that during the 360-1080 days of storage the migration of the Zn content is much higher for the white lacquer cooverd cans than for the yellow lacquer covered cans.

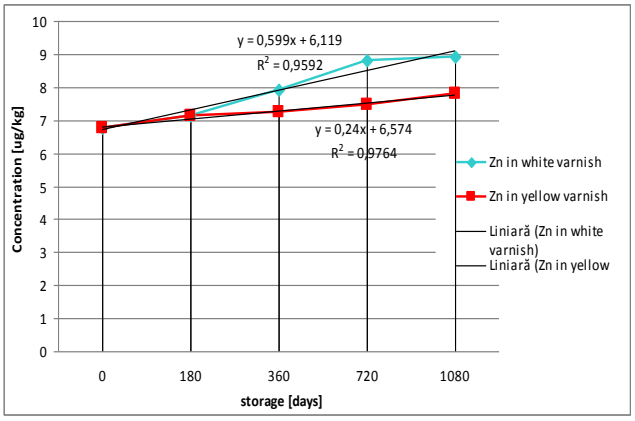

Figure 1. *The modification of the Zn in time*

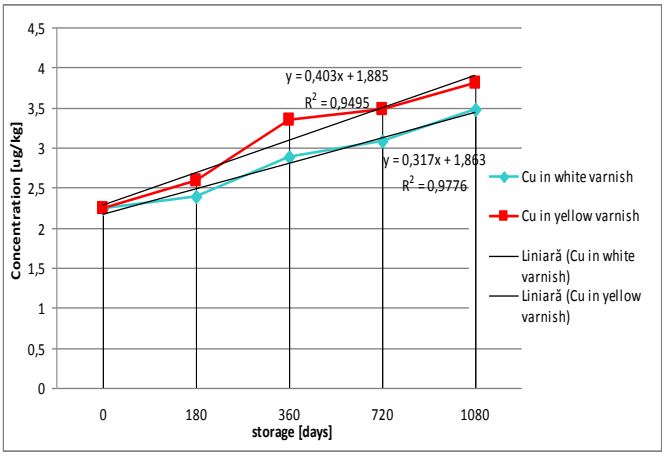

Figure 2. *The modification of the Cu content in time (peas)*

In the Figure 2 we can observe a linear increasement of the Cu content during the storage for both the white and yellow lacquer covered cans.

From the above figures we can see that the modification of the Cu content in time is linear for all the analyzed products.

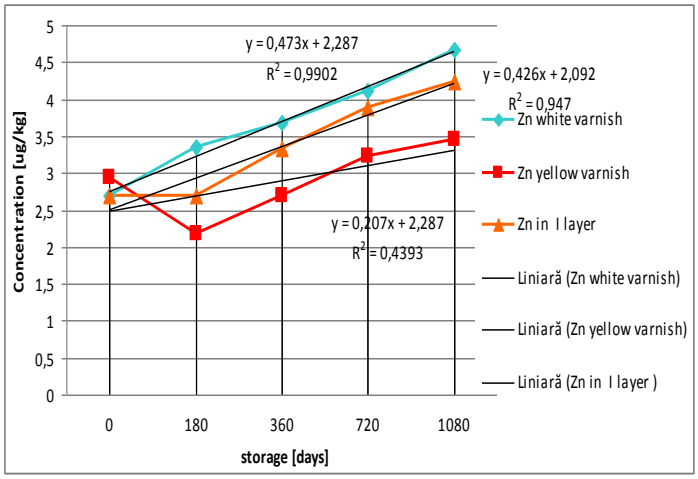

Fig. 3. Evolution of Zn migration in tomato cans

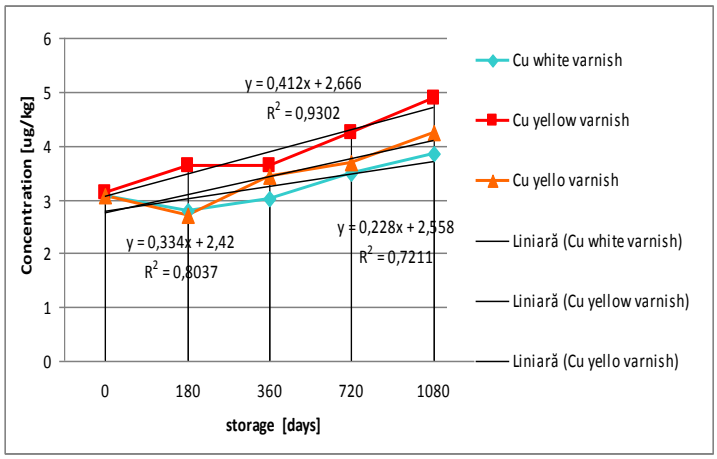

Fig.4. Evolution of Cu migration in tomato cans

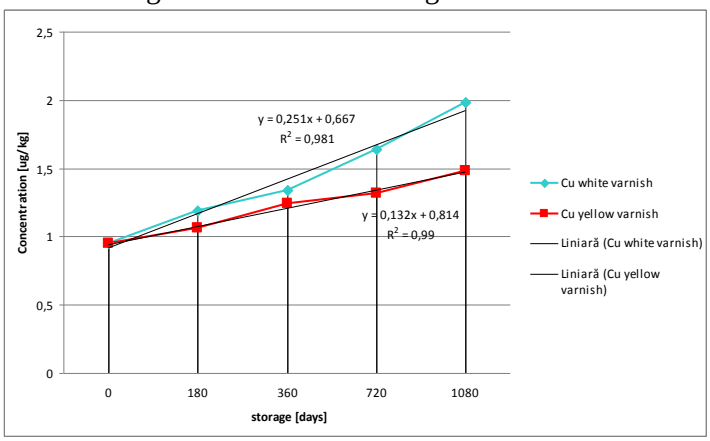

Figure 3. *The modification of the Cu in the meat cans at storage*

In the above figure we can observe a constant increasement of the Cu content in the first part of the storage and a significant increasement in the second part in the case of both cans used in the experiment.

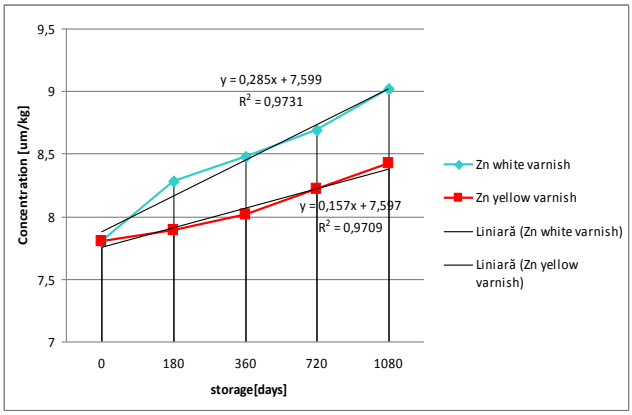

Figure 4. *The modification of the Zn in the meat cans at storage*

In the above figure we can observe a progressive increasement of the Zn content during the storage time for both types of cans used in the experiment.

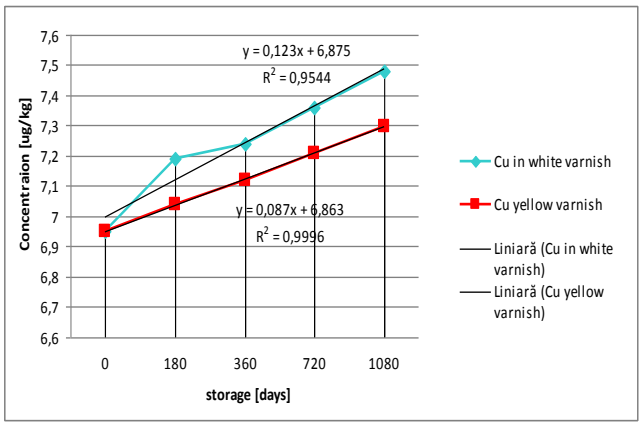

Figure 5. *The modification of the Cu content at storage*

In the above figure we can observe a higher increasement of the Cu content for the cans covered with white lacquer than for those covered with yellow lacquer.

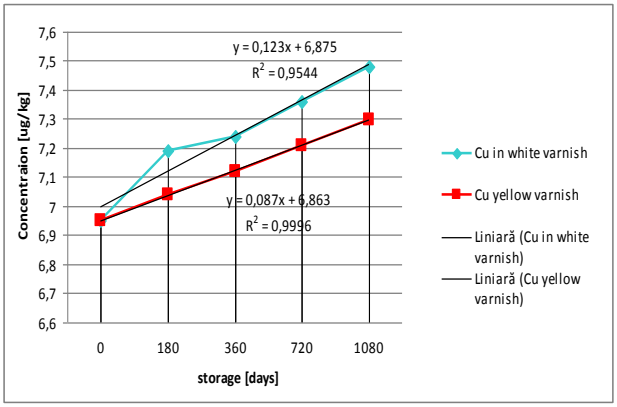

Figure 6.. *Evolution of migration of Cu in pate cans*

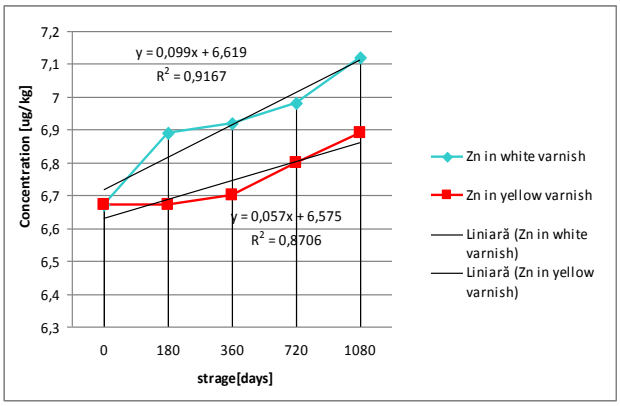

Figure 6. *The modification of the Zn content at storage*

In Figure 6 we can observe a much higher increasement of the Zn in the white lacquer covered cans than the yellow lacuer covered can in the time of storage.

Conclusions

For to establish the shelf life of the packaging taking on account the risks presented by the protection lacquers in the matter of package preservation there are necessary extensive tests according to the type of foods packed. from the above mentioned methods of analysis only those of high performance allow the perception of the detection and quantification limits imposed by UE regarding the testing methodology for canned foods lacquers.

The harmonization of the hygienic sanitary testing methodology (food cans) will have at the base similar analyzing techniques for to ensure the conformity with the international recommendations regarding the metals that come in contact with the food stuff. The heavy metals presence in vegetables and fruits with all their economic but mostly sanitary implications is nowadays a matter of concern for the specialists in the field and the control authorities. The using in the industrialization process of primary materials such as heavy metals contaminated vegetables and fruits lead to the obtain of finished products with a clear content of polluting elements.

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Extractors with vibratory mixing devices and prospects of their use in the food industry

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Abstract. *The low efficiency of the existing technologies for the extraction of desired components from vegetable raw materials with a high degree of milling is due to the imperfection of extraction equipment. Though the designs of modern periodic and continuous extractors are fairly diversified, there exist common disadvantages caused by the insignificant porosity of fine-fraction vegetable raw materials or the mass prepared from them for counterflow continuous extraction, their poor transportability, densification, and, as a result, the low permeability for the extractant. It has been established that vibratory extractors are most promising in this respect. In the present work, we present results of investigations of the intensifying action of low-frequency mechanical vibrations on the extraction process of desired components from vegetable raw materials under conditions of continuous vibration extraction.*

For industry, we propose a new design of a periodical and a continuous apparatus with vibratory mixing devices.

Key Words: vibratory extraction, mathematical modeling, intensification, mass transfer, vegetable raw material, hydrodynamic flow

I. Introduction

At present, the most important line of investigations on extraction in the solid body–liquid system is the search of methods of the intensification of extraction process and the development of the engineering methods for the computation of apparatuses. The existing extraction equipment, which is extensively used in the food industry with screw, belt, rack, and bucket transporters for continuous processes or with mixing devices of different kind of rotational character for periodic technologies, is inefficient or low-capacity in extraction of desired components from vegetable raw materials with a high degree of milling [1]. For instance, vegetable raw materials or mass prepared from them do not have a sufficient porosity for efficient counterflow extraction and are not densified under the action of transporters in the apparatus, which leads to the screening of the largest part of their active surface and disruption of the counterflow of phases.

In this connection, the use of low-frequency mechanical vibrations in periodic and continuous apparatuses can be a promising method of the intensification of the extraction process [2].

The practice of investigations in this direction brought to the forefront the necessity of studying the action of vibrations on the internal and external mass exchange, structure, velocities of flows in the working medium, time of processes, degree of extraction of desired components, and scaling of apparatuses with regard for technological requirements.

II. Materials and methods

In the present work, kapron crumbs, beet chips and hop were used as raw materials.

Methods of investigations include analytic modeling, multifactor experiments, and typical procedures for the determination of qualitative indices of extracts of vegetable raw materials.

The output of a continuous vibratory extractor was determined by the weight method using an AJ-220CE balance. The frequency of vibrations of vibratory mixing devices was set with an Eurotron CT 50 electronic tachometer, which uses stroboscopy. The amount of soluble extractive substances of vegetable raw materials was determined by the refractometric method with the use of an RPL refractometer. The intensity of vibrations of the vibratory transporting system was established in accord from the distance of propagation of pulsing turbulent jets, which do not cause the critical level of longitudinal mixing in the working zone of the apparatus, in the closed medium of pulsing turbulent jets. The distance of propagation of turbulent pulsing jets generated by the elements of vibrating mixing devices was determined with the help of Prandtl–Pitot tubes from the indications of differential manometers.

Processing of experimental data and computations were performed by using the modern integrated systems such as MathCAD 15, KOMPAS – 3D V13, AutoCAD 2012, CorelDRAW X5, etc.

III. Results and discussion

The indicated problems were solved as a result of the development of new extraction continuous and periodic equipment at the Department of Processes and Apparatuses for Food Production of the Kiev National University of Food Technologies (Ukraine) [3, 4, 5].

In apparatuses intended for performing continuous processes, a new principle of counterflow transportation (separation) of phases with the help of vibrating partitions of special design [3,4] was used. These vibrating partitions rule out the possibility of pressing of raw materials and provide their porosity independently of the particle size (Figure 1).

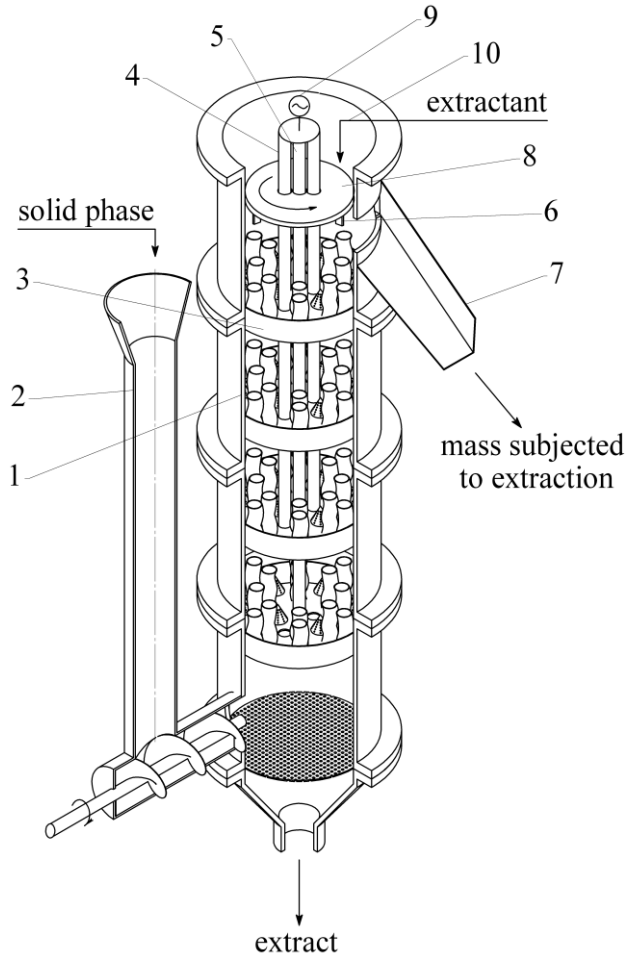

Figure 1. *Scheme of a continuous extractor: (1) apparatus body; (2) charging device; (3) vibratory transporting plate; (4,5) rods; (6) scraper; (7) tray; (8) discharging mechanism; (9) vibratory drive; (10) sprinkler*

The apparatus consists of a cylindrical column (1) with an U-shaped charging device (2), vibratory transporter with transverse partitions (plates) (3) that are fixed in turn on vertical rods (4) and (5) and execute harmonic vibrations shifted by a one-half period. A vibratory drive (9) with a crank mechanism provides constant amplitude and a constant frequency of motion of rods. A scraper (6) and a tray (7) serve for discharging extracted raw materials from the apparatus. A sprinkler (10) located above the upper plate serves for feeding the extractant into the apparatus.

In continuous vibratory extraction of desired components from vegetable raw materials, the activation of the interface is accompanied by the counterflow separation of phases. The mechanism of this separation (filtering or sedimentation mechanism) consists in the displacement and accumulation of the solid phase on one side of a vibratory transporting partition in the direction of its transportation. The transporting capacity of the vibratory extractor was studied at different intensities of vibrations of plates. The amplitude of vibrations was varied within the range $(5–20)\cdot10^{-3}$ m, and the frequency was changed in the range 1–4 Hz. The results of investigations were generalized by graphic dependences in Figure 2 for different types of vegetable raw materials.

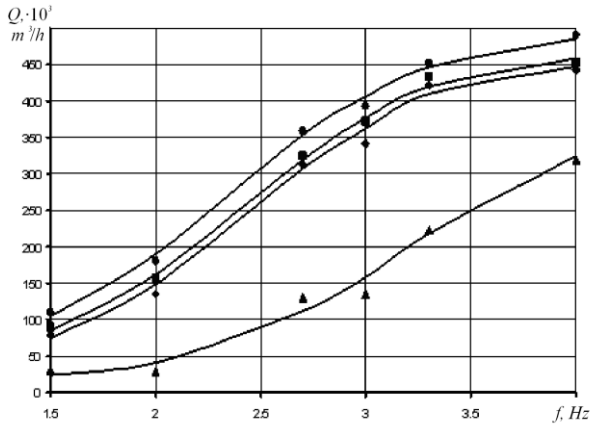

Figure 2. *Dependence of the output of the vibratory extractor on the frequency of vibrations of the vibratory transporting system: (●) hop; (◆) kapron crumbs; (■) beet chips;(▲) hop*

As a result of the mathematical modeling of the transporting capacity of the apparatus, the following formula for computing the solid-phase output was obtained:

$$V = \frac{m_{tr} F_{tr} \left(\rho_{s_2} \omega_{tr_2} - \rho_{s_1} \omega_{s.tr_1} \right)}{\rho_{c_1}} + \frac{\rho_f \omega_f F_f \left(\omega_{f_2} - \omega_{f_1} \right)}{\rho_{s_1}} \Bigg] T , \qquad (1)$$

where: m_{tr} and m_f are, respectively, the number of transporting elements and the number of filtering elements; F_{tr} and F_f are, respectively, the cross-sectional areas of the transporting and filtering elements, m^2; ρ_{s_1} and ρ_{s_2} are, respectively, the density of the suspension that passes through a transporting element in motion of the plate upward and downward and the density of the suspension that passes through the transporting element and the filtering element, kg/m^3; $\omega_{f_1}, \omega_{f_2}, \omega_{tr_2}$, and $\omega_{s.tr_1}$ are, respectively, the velocities of media through individual transporting and filtering elements, m/sec, and T is the period of vibrations of the plate, s.

The results of investigation of the mass-exchange characteristics of the vibratory extractor are generalized in the coordinates $Sh/Sc^{0.5} = f(Re)$ in Fig. 3 for sugar beet, where $Sh = \beta d_e/D$ is the Sherwood number, $Sc = \nu_f/D$ is the Schmidt number, $Re = \omega_L d_e/\nu_f$ is the Reynolds number, d_e is the equivalent particle diameter, m, ν_f is the kinematic viscosity of the boundary film on the particle surface, m^2/s; D is the diffusion coefficient of the matter solution, m^2/s, and β is the mass-transfer coefficient, m/s.

It can be seen from the graph that the substantial activation of the interface occurs at $Re \approx 2300$, and the mass-exchange characteristics of the apparatus can be represented by the following criterion dependences:

$$Sh = 0.85\ 10^{-3} Re^{1.0} Sc^{0.5} \text{ for } Re < 2300, \quad (2)$$

$$Sh = 1.71\ 10^{-3} Re^{1.0} Sc^{0.5} \text{ for } Re > 2300. \quad (3)$$

The operation of a periodically acting apparatus (Figure 4) is based on the formation of pulsing turbulent flows of a medium due to low-frequency mechanical vibrations of a perforated disk (5) and periodic squeezing of vegetable raw materials in a screening container (6), connected to this disk.

The vibratory extractor consists of a cylindrical body (1) with a heating casing (9), vibratory system, which consists of a mixing device of special design, namely, a flexible container (6), fixed on a lower screening support (7) and connected to a vibratory drive (3) by a rod (4) through the upper perforated disk (5) (the design of the vibratory mixing system is determined by the type of the raw material).

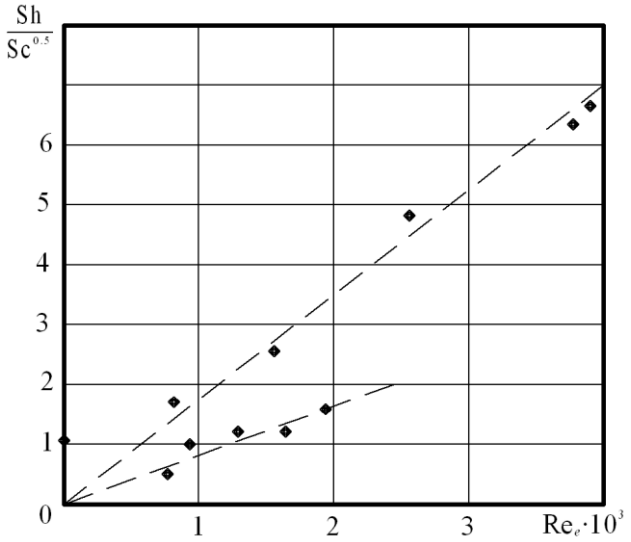

Figure 3. *Generalization of experimental data of the investigation of mass exchange in continuous vibratory extraction*

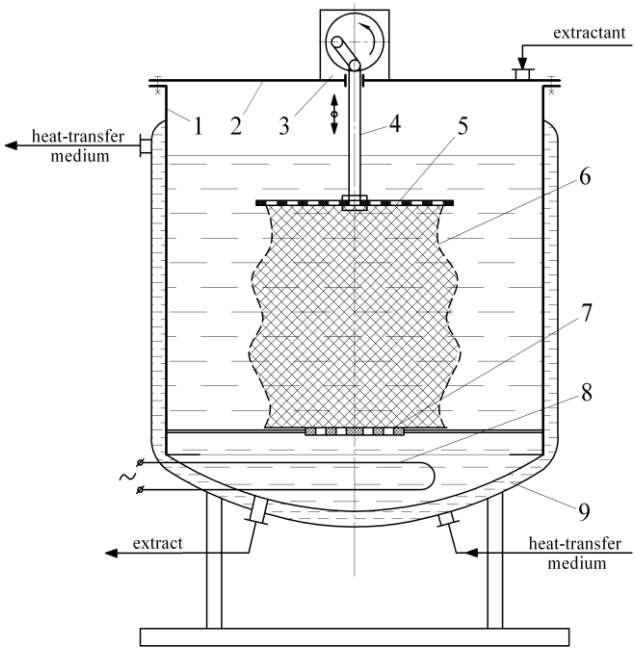

Figure 4. *Scheme of a periodic vibratory extractor:*
(1) apparatus body; (2) cover; (3) vibratory drive; (4) rod; (5) perforated disk;(6) screening container; (7) lower screening static support; (8) vibratory drive;(9) heating casing

Investigations of mass exchange were performed in wide ranges of the regime and technological parameters of operation of the apparatus (water consumption per unit time and area, frequency and amplitude of vibrations, temperature, and rarefaction of the system). In Figure 5, we show the variation in the Biot number with time as a variant of the generalization of experimental results.

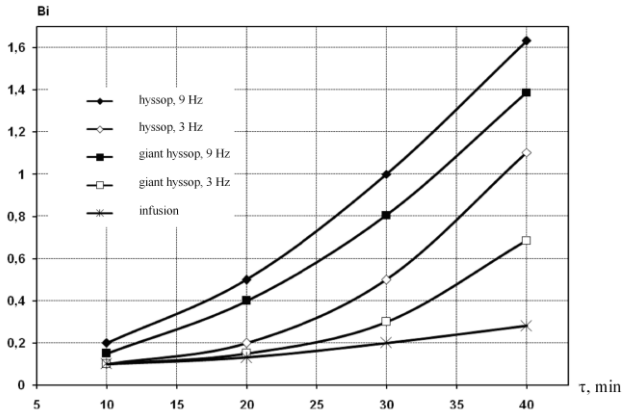

Figure 5. *Variation in the Biot criterion (Bi) with time in vibratory extraction of flavonoid matters from giant hyssop and hyssop*

In the case where the driving force of the process is represented as the difference between the concentration in the extractant on the interface and the concentration in the volume of the extractant ($\hat{c} - c$), on condition that resistance is absent on the interface, we can write

$$\begin{cases} \dfrac{dc}{d\tau} = K_V(\hat{c} - c); \\ c(\tau_0) = c_{0_i}, \end{cases} \qquad (4)$$

where: K_V is the volume mass-transfer coefficient, s^{-1}, and τ is the process time.

Taking into account that, at the initial moment of time, $\tau_0 = 0$ and $c_0 = 0$, system (4) can be transformed to the form

$$c(\tau) = \hat{c}\left(1^{-K_V \cdot \tau}\right). \qquad (5)$$

The obtained equation enables us to predict the change in the current concentration of the desired component in the volume of the apparatus in extraction from vegetable raw materials and determine the maximum time of the process.

IV. Conclusions

The application of a field of low-frequency mechanical vibrations on interacting phases in extraction is an efficient method of the formation of hydrodynamic conditions and a strong source of intensification of the process due to an increase in the velocity of relative motion of the phases.

If in the counterflow extraction process, only 20–25% of the whole external surface of particles takes part, then the application of the field of vibrations promotes a decrease in the external diffusion resistance and brings the fraction of the active surface closer to 100%. Thus, the developed periodic and continuous vibratory extractors can be successfully used in different processing industries for processing of vegetable raw materials of herbal, root, cereal, and fruit–berry origin.

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Studiing of the viscous food producnts dosing accuracy by the piston batcher

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Abstract. *Were provided the research of plug-forming devices gaps size, technological mistakes, and mounting type of kinematic couples and parts of the actuator, influence on dosing systematic error.*

Key Words: batcher, dosing accuracy, systematic error, primary errors, viscous products.

Dosing accuracy – one of the main characteristics for any batcher, it's his ability to assure the error size lower then allowable, when the moving lows are specified and the input sections moves with errors.

There are several requirements for dosing accuracy, depending on product type and dose size. Also there are a lot of factors that can effect on the accuracy, such as hopper filling degree, uneven supply of the product to the dosing mechanism, the character of interaction of product and dosing mechanism, the changes of product characteristics in dosing process under the environment influence. Also it can be mounting incorrectness of the kinematic pars, deformation of the parts of the machine and speed difference of input section, speed and acceleration of output sections is different against ideal, it's also have influence on the dosing accuracy. The difference in kinematic parameters and the positioning of driven section are caused by technological inaccuracies of dimensions, forms of the relative positioning of kinematic pars elements and sections, that is, the primary errors, operation errors, dynamic errors and also structural errors.

Dosing error it's the difference between the real and the estimated (ideal) value of the product dose. Estimation of the accuracy is providing in percent ratio of nominal dose.

Calculation of absolute dosing error:

$$\Delta = \Delta_{ser} + \Delta_{aer}, \qquad (1)$$

where: Δ_{ser} - systematic error;

Δ_{aer} - accidental error.

Systematic measurement error - error, that mostly lives unchanged or that changes in order of remeasure and depends from the technical parameters of dosing system. Accidental error – error that is permanently different (by the value and sign) in measurement process and depends on

subjective and objective factors of product interaction with technological dosing system and operator functioning.

Now days error calculation methods, their influence on the kinematics and dynamics of dosing mechanism, methods of their compensation and reduction and also the main tasks of accuracy analysis and synthesis of mechanisms, are based on mechanism accuracy theory, probability theory and mathematic statistics [2].

In some constructions of dosing equipment when performing the comparing calculations, it's needed to find out the mechanism section movement error, which is understand as the difference of driven section movement of real and ideal mechanism under the same movement of driving sections.

If the movement error is repeated in one of the position of driving section, but in different movement direction than the expression

$$\Delta\psi_{np} = \Delta\psi_{к} - \Delta\psi_{n}, \qquad (2)$$

where: $\Delta\psi_{np}$ - movement error of driven section,

$\Delta\psi_{n}$ - start movement error of driven section,

$\Delta\psi_{к}$ - end movement error of driven section, determines the free (dead) stroke of the mechanism, which appears by reason of gaps presence in kinematic pars or spring strain of the sections.

For the determination of systematic error the analytical method of mechanism accuracy analysis

can be used. The coordinate of driven section of ideal mechanism will be ψ_0, driving section – ψ and the matrix parameter of sections – q_j, where $j = 1,2...$ - the index number of section. Coordinates ψ_0 and ψ can be linear and angular.

In ideal mechanism with the main ties, ψ_0 coordinate have the functional dependence of several variables (but not speeds):

$$\psi_0 = \psi_0(\varphi, q_1, q_2, ...q_n), \qquad (3)$$

where: $q_1, q_2, ...q_n$ determine the size, form and interposition mechanism sections. Because of the presence of primary errors Δq_j the parameters of real mechanism is not the same with ideal mechanism parameters, and so the position of the real mechanism are determined by coordinate

$$\psi = \psi_0 + \Delta\psi_{вм} = \psi(\varphi + \Delta\varphi, q_1 + \Delta q_1, +...+, q_n + \Delta q) \qquad (4)$$

where: $\Delta\psi_{вм}$ - the real mechanism driven section position error;

$\Delta\varphi$ - driving section position error.

Mostly the Δq_j error is not bigger then section sizes allowance, it means that it's much smaller then q_j parameter. Considering relatively small values of $\Delta\varphi$ and Δq_j, let's expand the function in to Teylor's line, limiting only it's zero and linear parts, receiving:

$$\psi = \psi_0 + \Delta\psi_{вм} = \psi_0(\varphi, q_1, ..., q_n) + \left(\frac{\partial\psi}{\partial\varphi}\right)_0 \Delta\varphi + \sum_{j=1}^{n}\left(\frac{\partial\psi}{\partial q_j}\right)_0 \Delta q_j, \qquad (5)$$

where: from we will find approximate expression to define the real mechanism position error:

$$\Delta\psi_{вм} = \left(\frac{\partial\psi}{\partial\varphi}\right)_0 \Delta\varphi + \sum_{j=1}^{n}\left(\frac{\partial\psi}{\partial q_j}\right)_0 \Delta q_j. \qquad (6)$$

Real mechanism position error with ideal scheme:

$$\Delta\psi = \sum_{j=1}^{n}\left(\frac{\partial\psi}{\partial q_j}\right)_0 \Delta q_j, \qquad (7)$$

position error, are caused only by primary error $\Delta q_к$ of $q_к$ parameter:

$$\Delta\psi_к = \sum_{j=1}^{n}\left(\frac{\partial\psi}{\partial q_к}\right)_0 \Delta q_к. \qquad (8)$$

Proceeding from upper reflections the conclusion can be made that, partial derivative:

$$\left(\frac{\partial\psi}{\partial q_к}\right)_0 = \frac{\Delta\psi_к}{\Delta q_к}, \qquad (9)$$

are gear ratio of the error $\Delta\psi_к$ from driven section to $q_к$ section, that contains error $\Delta q_к$.

Practical application of such error definition methodic we will consider on constructive scheme of piston batcher example. For viscous and plastic products (Figure 1) and will define dosing systematic error value, having no primary errors.

For such scheme $q_i = f(a, b, \alpha, \beta)$

$$\Delta X_c = (\Delta X_c)_a + (\Delta X_c)_b + (\Delta X_c)_\alpha + (\Delta X_c)_\beta \qquad (10)$$

For defining of mechanism driven section movement error we will wright an expression for defining X_C coordinate:

$$X_C = b \cdot cos\beta \pm a \cdot \sin\alpha, \qquad (11)$$

where: "+" – for first quarter of coordenats system;

"-" – for second quarter of coordenats system (Figure 1).

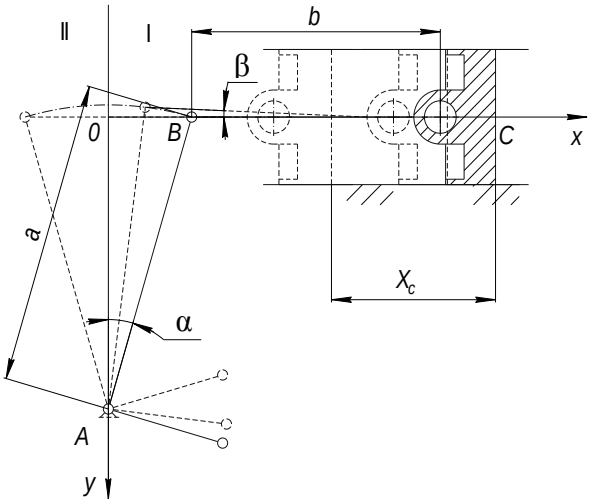

Figure 1. *Construction scheme of piston batcher for viscous food products: d – piston diameter:* a, *b – section length; α, β – angels at sections;* X_C *– driven section movement.*

For the further calculations we will use the following relation:

$$\beta = \arcsin\left(\frac{a \times \cos\alpha - h}{b}\right). \qquad (12)$$

Movement error caused by rocker length a difference:

$$(\Delta X_C)_a = \frac{\partial X_C}{\partial a} \cdot \Delta a, \qquad (13)$$

where: Δa - rocker length difference error (including size lines allowance and boundary deviation plantings of kinematic pars)

$$(\Delta X_C)_a = \pm \sin\alpha \cdot \Delta a . \quad (14)$$

Bell crank length difference b:

$$(\Delta X_C)_b = \frac{\partial X_C}{\partial b} \cdot \Delta b , \quad (15)$$

where: Δb - crossbeam length difference error (including size lines allowance and boundary deviation plantings of kinematic pars).

$$(\Delta X_C)_b = \cos\beta \cdot \Delta b . \quad (16)$$

Error from rocker position angel α:

$$(\Delta X_C)_\alpha = \frac{\partial X_C}{\partial \alpha} \cdot \Delta\alpha , \quad (17)$$

$$(\Delta X_C)_\alpha = \pm a \cdot \cos\alpha \cdot \Delta\alpha . \quad (18)$$

Error from crossbeam position angel β:

$$(\Delta X_C)_\beta = \frac{\partial X_C}{\partial \beta} \cdot \Delta\beta , \quad (19)$$

$$(\Delta X_C)\beta = -b \cdot \sin\beta \cdot \Delta\beta . \quad (20)$$

Then the total driven mechanism element position error will be defined by the expression:

$$\begin{aligned} \Delta X_c &= (\Delta X_c)_a + (\Delta X_c)_b + (\Delta X_c)_\alpha + (\Delta X_c)_\beta = \\ &= \pm \sin\alpha \cdot \Delta a + \cos\beta \cdot \Delta b \pm \\ &\pm a \cdot \cos\alpha \cdot \Delta\alpha - b \cdot \sin\beta \cdot \Delta\beta . \end{aligned} \quad (21)$$

Error value defines by next terms: parts of the batcher (rocker, crossbeam) are made by workmanship 7-10; loose fit kinematic pars, 7-10 workmanship (fit H7/f7, H78/f8, H9/f9, H9/f9 for slide bearings) [1]; the error value for modern packing equipment is approximately ±1% (that means the systematic error is approximately ≈0,1%) from dose value [5]; Calculation results are displayed in graph (Figure 2). When the crankgear mechanism batcher is used the accuracy of his sections and kinematic pars must be at lest 7 – 8 workmanship with respective fits.

Transportation of the product to the container are provided through output channel of piston batcher (Figure 3). Some parts of the products can Whereas the transverse gap size is small and the viscosity of the product is high, the leakage from the gap can be called crawling flat [4]. To make the calculations easier, we will take that product movement through the pap is permanent, so we can ignore the laggo through the gaps between the body parts of batcher and stop elements.

Velocity distribution in product layer is calculated by the next expression:

$$V_x = \frac{1}{2 \cdot \mu} \cdot \frac{dp}{dx} y^2 + C_1 \cdot y + C_2 , \quad (22)$$

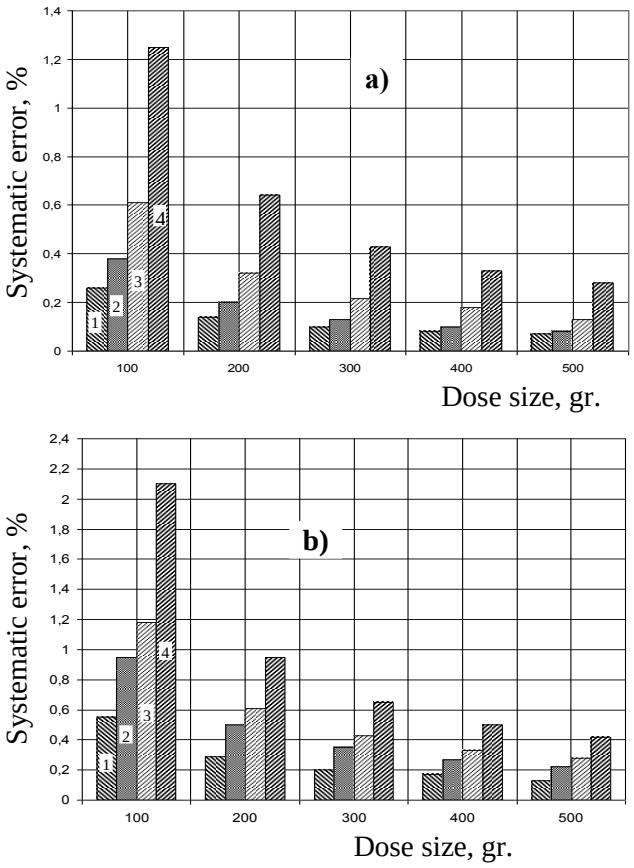

Figure 2. *The dependence of dosing systematic error from batcher elements manufacturing accuracy with different dose value: a – minimum boundary deviation; b – maximum boundary deviation; 1 – 7 workmanship; 2 – 8 workmanship; 3 – 9 workmanship; 4 – 10 workmanship.*

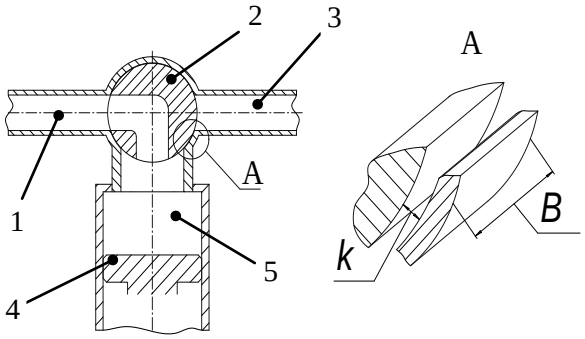

Figure 3. *Principle scheme of a batcher with stop ball valve: 1 – output channel; 2 – ball valve; 3 – input channel; 4 – piston; 5 – measure cylinder; k – gap height; B – gap width.*

where x i y – coordinates by height and width, μ - dynamic velocity value.

Boundary terms:

- $V_x = 0$, $V_y = 0$ when y = 0,
- $V_x = 0$, $V_y = 0$ when y = k,

where: k – gap height, calculate the constants C_1, C_2 substituting the boundary terms in to expression(22): $C_1 = -\frac{k}{2\times\mu}\cdot\frac{dp}{dx}$, $C_2 = 0$.

Velocity distribution in product layer low will be expressed as: [3]:

$$V_x = \frac{1}{2\times\mu}\cdot\frac{dp}{dx}\cdot y^2 - \frac{k}{2\times\mu}\cdot\frac{dp}{dx}\cdot y = \frac{1}{2\times\mu}\cdot\frac{dp}{dx}\cdot y\cdot(y-k) \quad (23)$$

By using expression (23) we can calculate the required consumption of the product, considering the term that main movement direction is coaxial with environment movement, along the top of the gap:

$$q = -\int_0^k V_x dy = -\int_0^k \frac{1}{2\times\mu}\cdot\frac{dp}{dx}\cdot y\cdot(y-k)dy = -\frac{1}{2\times\mu}\cdot\frac{dp}{dx}\cdot\left(\int_0^k y^2 dy - \int_0^k y\cdot h dy\right) = \frac{k^3}{12\cdot\mu}\cdot\frac{dp}{dx}. \quad (24)$$

From this expression we can define product consumption from the gap, accepting, that consumption is defined as multiplication of required consumption and gap width:

$$dp = \frac{12\cdot Q_{in}\cdot\mu}{k^3\cdot d}dx, \quad (25)$$

That means

$$Q_{in} = \frac{k^3{}_{in}\cdot d_{вхз}}{12\cdot\mu\cdot B_{in}}\cdot(P_{in} - P_{out}), \quad (26)$$

where: Q_{in} – product consumption through the gap;

B_{in} – gap length;

K_{in}– gap height;

P_{in} – pressure on the inlet to the gap;

P_{out}– pressure on the outlet to the gap.

Product quantity, which will move from cylinder through gap, will be defended as:

$$Q_в = Q_{in}\cdot t_d, \quad (27)$$

where: t_d – time to push out the product from measure cylinder

By the time of calculation we will accept that product width in the gap is equal to ball valve working part width. Pressure on the inlet of the gap will be:

$$P_{in} = \Delta P_p - \Delta P_{1out} - \Delta P_{mout}, \quad (28)$$

where: ΔP_p – pressure, made by the piston;

ΔP_{1out} – pressure drop on exhaust valve;

ΔP_{mout} – pressure drop caused by constriction of exhaust channel.

Knowing the pressure value of the gap on the inlet and outlet, we can define product loss through the gap between the body and valve ball. Knowing the dosing time and product loss through the gap, we can define the product loss. By using the expression (27), will define batcher error for deferent kinds of viscous products (Figure 4).

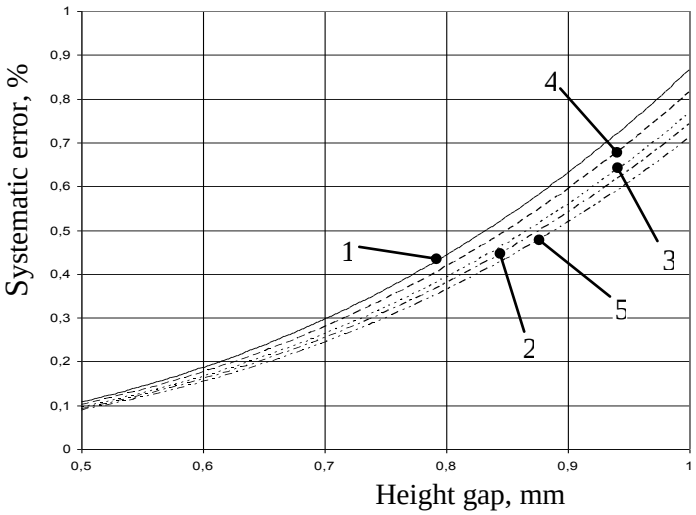

Figure 4. *Dependence character between the dosing systematic error and gap size (dose mass 250 gr.): 1 – evaporated milk; 2 – cream; 3 – melted cheese "Drujba"; 4 – melted cheese "Krestatik"; 5 – mayonnaise "Olivkovi".*

Conclusions.

On the ground of studies been made, the character of dosing systematic error and manufacturing accuracy of working mechanism dependence, have been defined. When using the crankgear mechanism as the working mechanism of the batcher, manufacturing accuracy of the sections and kinematic pars must be 7 – 8 workmanship with respective fits. Dosing error value is equal to the product volume which went through exhaust valve. Considering this, the fewer will be the error or product volume which went through exhaust valve, which is the same, the greater will be the accuracy of the batcher. Knowing the properties of the product, which is packed and also a constructive parameters of batcher, we can define the value of product losses or dosing error at the product dosing time; also if we know the rheological properties of the product and dosing accuracy which is needed, on the ground of

calculation been made, we can define the allowable value of the gap between valve ball surface and cylinder body, which will give the opportunity to avoid product loss to inlet valve.

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