Ministry of Agrarian Policy and Food of Ukraine
Ministry of Education and Science of Ukraine
National University of Food Technologies
Institute of Food Resources of the National Academy
of Agricultural Sciences of Ukraine
AKKO International

Proceedings of the
8th International Specialized
Scientific and Practical Conference

Resource and Energy Saving Technologies of Production and Packing of Food Products as the Main Fundamentals of Their Competitiveness

Kyiv, Ukraine, 12th, September , 2019

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Proceedings of the 8h International Specialized Scientific and Practical Conference
September 12, 2019

Kyiv, Ukraine

Resource and Energy Saving Technologies of Production and Packing of Food Products as the Main Fundamentals of Their Competitiveness: Proceedings of the 7th International Specialized Scientific and Practical Conference, September 12, 2019. Kyiv, NUFT, 2019.

ISBN 978-966-612-238-7

Published by	National University of Food Technologies str. Volodymyrska 68 Kyiv 01601 **Ukraine**
Chief editor	Oleksandr Gavva
Technical editor	Oleksii Gubenia, Lesia Martsynkevych
Organizing committee	Oleksii Gubenia, Yurii Kishchak, Kateryna Kopylova, Anatolii Sokolenko, Valerii Myronchuk, Galyna Simakhina, Igor Mikulionok

ISBN 978-966-612-238-7

Contents

Effect of extrusion conditions on the expansion of extruded apple pomace – wheat semolina mixtures

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Abstract
Apple pomace – wheat semolina mixtures were extruded in a laboratory single screw extruder (Brabender 20 DN, Germany) with screw diameter 19 mm and die diameter 5 mm. Effects of apple pomace content in the mixtures, moisture content, screw speed, and barrel temperature on the expansion of the extruded products were studied. Response surface methodology with combinations of apple pomace content in the mixtures (10, 30, 50, 70, 90%), moisture content (17, 20, 23, 26, 29%), screw speed (120, 150, 180, 210, 240 rpm), and barrel temperature (130, 140, 150, 160, 170°C) was applied. Feed screw speed was fixed at 70 rpm. The compression ratio of the screw was 3:1. The temperatures of the feed and kneading zone were 150 and 160ºC, respectively. Sectional expansion index (*SEI*), the ratio of diameter of extrudate and the diameter of die, was used to express the expansion of extrudate. The average *SEI* values ranged from 0.827 to 1.637. Statistical analysis showed that apple pomace content in the mixtures, moisture content, and barrel temperature had effect on *SEI* while screw speed had not affect expansion index of the extrudates.
Key words: *apple, pomace, wheat, semolina, extrusion.*

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DOI: 10.24263/RES-2019-3

Introduction

Apple pomace (AP) is the main by-product of cider processing and pose a serious environmental problem due to the large amounts produced every year. AP is composed mainly of carbohydrates and dietary fibre, small amounts of protein, fat and ash [1]. AP is a good source of phytochemicals primarily phenolic acids and flavonoids [2].

The common applications of this by-product are the direct disposal to soil in a landfill and for pectin recovery usage. In recent years, investigations into the incorporation of apple pomace in foods especially in baked foods [1].

Extruded snack products made predominantly from cereal flour tend to be low in protein with low biological value. The incorporation of enriched fibre flours with significant values of antioxidants is a way to improve the nutritional value of these

snacks. Apple pomace rich in fibre with significant amounts of antioxidants can be incorporated in human food-chain thus generating new potential functional foods.

Extrudate expansion is a complex phenomenon which occurs usually during high-temperature, low-moisture extrusion cooking. Most extruded foods are actually made out of complex formulations which have different effects on the expansion [3]. Processing conditions and equipment-related variables also have the ability to influence the degree of expansion significantly.

The quality of the end product depends upon how the thermal performance of the extruder is controlled and what the thermomechanical history of the product is inside the extruder [4].

The object of this work was to study the effect of extrusion conditions on the expansion of extruded apple pomace – wheat semolina mixtures.

Materials and methods

Apple pomace is a by-product obtained during juice processing. Commercial apples (Granny Smith variety) were refrigerated and stored until the juice processing. The apple pomaces were dried a laboratory heat dryer at 60°C. The dried pomaces were ground using a hammer mill then mixed with commercial wheat semolina and distilled water to be obtained the desired ratios (Table 1). The prepared wet samples were extruded in a laboratory single screw extruder (Brabender 20 DN, Germany). The feed screw speed was fixed at 70 rpm. The screw speed was according to the experimental design (Table 1). The compression ratio of the screw was 3:1. The temperatures of the feed and kneading zone were 150 and 160ºC, respectively. The temperature of the final cooking zone was 130, 140, 150, 160, 170°C. The die diameter was 5 mm.

Sectional expansion index (*SEI*), the ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate [5, 6]. The diameter of the extrudate was determined as the mean of 10 random measurements. The extrudate expansion index was calculated as

$$SEI = \frac{D_e}{D_d} \quad (1)$$

where *De* and *Dd* were diameter of the cooled extrudate and diameter of the die, respectively.

The effects of four independent extrusion parameters (variables) apple pomace content (X_1), moisture content (X_2), screw speed (X_3), and barrel temperature (X_4) on the dependent variable (*SEI*) were investigated using central composite rotatable design [5] and response surface methodology (RSM). All variables were controlled at five different levels.

A second-order polynomial equation was used to fit the measured, dependent variable (Y) as a function of the coded, independent extrusion variables (X_i):

$$y = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n} b_{ii} x_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} x_i x_j \quad (2)$$

where b_0 is the value for the fixed response at the central point of the experiment; and b_i, b_j and b_{ij} were the linear, quadratic and cross-product coefficients, respectively. The significance of the effect was given as a p-value. The effect was considered significant if the p-value for each factor or interaction is less than 0.05. SYSTAT statistical software (SPSS Inc., Chicago, USA, version 7.1) and Excel were used to analyze the data results.

Results and discussion

In extrusion cooking, expansion is the primary quality parameter associated with product crispiness, water absorption, and water solubility. During extrusion cooking of biopolymers, the viscoelastic material is forced through the die so that the sudden pressure drop causes part of the water vaporize, giving an expanded porous structure. Extruded products of different physical forms were obtained. The maximum and minimum values of *SEI* of the extrudates were 1.637 and 0.827, respectively (Table 1).

The results of the statistical analysis of variance (ANOVA) for *SEI* show that 4 effects have p-values less than 0.05, indicating that they are significantly different from zero at the 95.0% confidence level. The R-squared statistic is 0.93; the standard error of the estimate – 8.44, the mean absolute error – 4.57. The R-squared is defined as the ratio of the explained variation to the total variation and is a measure of the degree of fit [7]. As the R-squared value for the model is more than 80% it can be considered for further analysis.

The regression equation describing the effect of extrusion variables on *SEI* of extruded apple pomace – wheat semolina mixtures is given in Table 2. The coefficients in the regression equation can be used to examine the significance of each term relative to each other when used with coded values. Statistical analysis showed that apple pomace content in the mixture, moisture content, and barrel temperature had an effect on *SEI* ($p<0.05$), whereas screw speed had no effect on *SEI*.

Each of the estimated effects and interactions are shown in the standardized diagram (Figure 1). The linear effect due to apple pomace content in the mixture had mostly influence on *SEI* followed by linear effects due to the moisture content and barrel temperature. The apple pomace content in the mixture, moisture content and barrel temperature had negative effect on *SEI*. When the apple pomaces content increased from 10 to 90%, the degree of expansion decreased almost twice (Table 1). Yagci & Gogus [8]), Yanniotis et al. [9] reported that pectin-rich fruits have a negative effect on the radial expansion of extrudates which is consistent with this work.

The effect of changes in the moisture content and the barrel temperature on *SEI* of the samples is given in Figure 2. Simultaneously raising the barrel temperature and the moisture content leads to decreasing the degree of expansion. Increased feed moisture content during extrusion may reduce the elasticity of the dough through plasticization of the melt, resulting in reduced the specific mechanical energy and therefore reduced gelatinization, decreasing the expansion [10]. According to Kokini et al. [11], at 160°C

and 26% moisture, expansion index decreased, probably because at high temperatures starch dextrinization occurred. Gujska and Khan [12] found a similar behaviour in navy bean extrudates. They also reported that screw speed did not affect expansion index which is consistent with this work.

Table 1

Central composite rotatable design in coded form and natural units of independent variables and experimental data for sectional expansion index

Run №	Independent variables in coded form				Independent variables in natural units				*SEI* (Y)	
	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	Experimental	Predicted
1	-1	-1	-1	-1	30	20	150	140	1.637	1.630
2	+1	-1	-1	-1	70	20	150	140	1.159	1.078
3	-1	+1	-1	-1	30	26	150	140	1.362	1.373
4	+1	+1	-1	-1	70	26	150	140	0.894	0.921
5	-1	-1	+1	-1	30	20	210	140	1.552	1.566
6	+1	-1	+1	-1	70	20	210	140	1.071	1.012
7	-1	+1	+1	-1	30	26	210	140	1.583	1.471
8	+1	+1	+1	-1	70	26	210	140	0.949	1.017
9	-1	-1	-1	+1	30	20	150	160	1.456	1.431
10	+1	-1	-1	+1	70	20	150	160	1.148	1.156
11	-1	+1	-1	+1	30	26	150	160	1.078	1.033
12	+1	+1	-1	+1	70	26	150	160	0.827	0.857
13	-1	-1	+1	+1	30	20	210	160	1.457	1.326
14	+1	-1	+1	+1	70	20	210	160	1.016	1.049
15	-1	+1	+1	+1	30	26	210	160	0.966	1.090
16	+1	+1	+1	+1	70	26	210	160	1.009	0.912
17	-2.0	0	0	0	10	23	180	150	1.549	1.605
18	+2.0	0	0	0	90	23	180	150	0.871	0.876
19	0	-2.0	0	0	50	17	180	150	1.292	1.386
20	0	+2.0	0	0	50	29	180	150	1.025	0.992
21	0	0	-2.0	0	50	23	120	150	1.053	1.064
22	0	0	+2.0	0	50	23	240	150	1.007	1.056
23	0	0	0	-2.0	50	23	180	130	1.354	1.393
24	0	0	0	+2.0	50	23	180	170	1.069	1.090
25	0	0	0	0	50	23	180	150	1.158	1.109
26	0	0	0	0	50	23	180	150	1.041	1.109
27	0	0	0	0	50	23	180	150	1.104	1.109
28	0	0	0	0	50	23	180	150	1.111	1.109
29	0	0	0	0	50	23	180	150	1.132	1.109

X_1 – apple pomace content in the mixture (C_{pom},%), X_2 – moisture content (W,%), X_3 – screw speed (n, rpm), X_4 – barrel temperature (T_m, °C)

Table 2

Regression equation coefficients and analysis of variance for SEI of extruded

apple pomace – wheat semolina mixtures

Variables	Coefficients	*DF*	*MS*	*p* values
Constant	1178.66			
X_1	-7.84333	1	7971.62	0.0000*
X_2	-5.94505	1	2324.6	0.0001*
X_3	-0.03814	1	1.04167	0.9055
X_4	-9.09125	1	1380.17	0.0006*
X_1X_1	0.00818	1	278.145	0.0683
X_2X_2	0.22074	1	102.405	0.2506
X_3X_3	-0.00136	1	38.9881	0.4718
X_4X_4	0.03312	1	284.553	0.0655
X_1X_2	0.04146	1	99.0025	0.2583
X_1X_3	-0.00008	1	0.04	0.9814
X_1X_4	0.0345	1	761.76	0.0056*
X_2X_3	0.04514	1	264.063	0.0748
X_2X_4	-0.11792	1	200.222	0.1159
X_3X_4	-0.00342	1	16.81	0.6348

*Significant at 95% confidence level, *DF* – degrees of freedom, *MS* – mean square

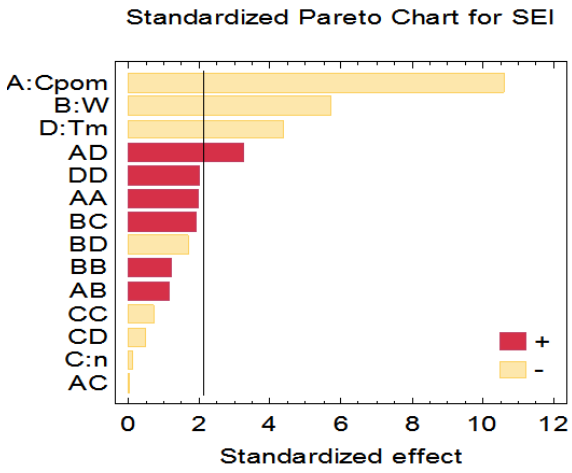

Figure 1. Estimated effects of regression model coefficients on SEI

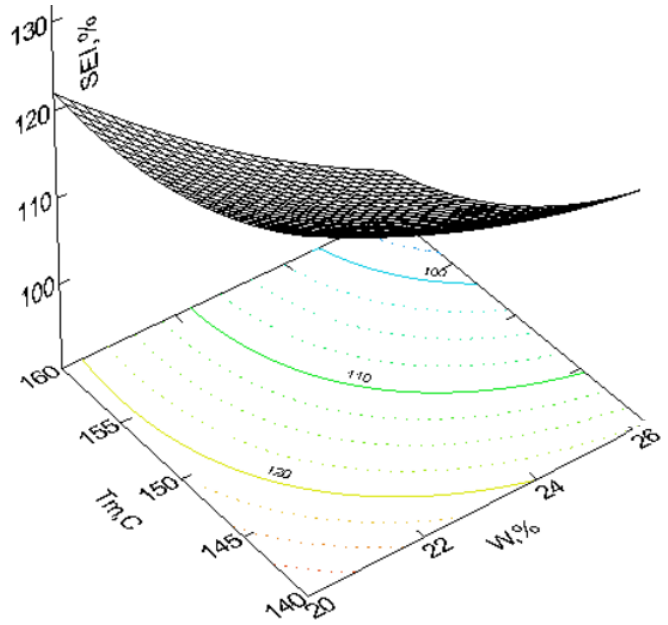

Figure 2. SEI (%) depending on T_m (°C) and W (%) at C_{pom} = 50% and n = 180 rpm

Conclusion

The average *SEI* values ranged from 0.827 to 1.637. Statistical analysis showed that the apple pomace content in the mixture had the highest effect on the expansion. The moisture content and barrel temperature also affected *SEI* while screw speed had not affect expansion index of the extrudates.

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Robust interconnected automated control system for improving reliability of the turbine-generator unit shaft in food industry enterprises

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Abstract

The shafts of the turbine generator units are adversely affected by disturbances of the connected power system, which can be reduced by the use of an automated control system.

On the basis of the system analysis of turbine-generator unit (TGU) control process, the requirements for the automated control system of TGU were formulated and its functional model was created. The main purpose of this control system is to increase the reliability of TGU in terms of assessment and reduce the adverse impact of the power system on TGU's shaft material under uncertainty.

The subsystems of robust interconnected automated control system of TGU (RI ACS TGU) and their interaction within the system are described. RI ACS TGU consists of shaft monitoring systems, robust interconnected regulator of TGU, identification of control plant model, automatic control of shaft rotational oscillations.

Conclusions. The structure and composition of RI ACS TGU has proposed. RI ACS TGU allows improving the damping properties of TGU in perturbations of the electrical system operating modes under conditions of uncertainty by using the methods of robust control and taking into account the mutual influence of generator excitation control system and steam turbine governing system.

Key words: turbine-generator, automation, robust, control.

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DOI: 10.24263/RES-2019-4

Introduction

As a result of electric power system (EPS) disturbances and interaction of the turbine-generator unit (TGU) with EPS, mechanical torsional vibrations occur in the TGU shaft, which cause the accumulation of fatigue damage of the TGU shaft material, significantly reduce the TGU life cycle and its reliability, and what is more, lead to its early decommissioning [**Ошибка! Источник ссылки не найден.**, **Ошибка! Источник ссылки не найден.**, 12].

For damping low-frequency electromechanical oscillations and ensuring EPS stable operation, TGUs are equipped with generator excitation control system (ECS) and

steam turbine governing system (TGS). These control systems are generally designed as separate independent subsystems and do not always provide effective damping of TGU shaft torsional vibrations. There are cases when certain ECS and TGS adjustment parameters caused the excitation of torsional vibrations in the TGU shaft [**Ошибка! Источник ссылки не найден.**].

One of the reasons for decreasing rotational speed control quality and poor damping of the shaft torsional oscillations is that the control systems of the turbine and the synchronous generator, having common input control signals, are not only designed, but also adjusted separately. The problem of coordinating the work of TGS and ECS was solved, for example, in [4, 10] by creating methodologies for matched adjustment of these regulators. However, these approaches, without using methods of robust control, do not guarantee obtaining control system with taking the uncertainties of controlled object into consideration. In [**Ошибка! Источник ссылки не найден.**] the authors proposed a new solution to the problem of coordinating the operation of ECS and TGS by using an additional interconnected robust controller. The synthesis of this controller was performed using robust control methods, taking into account the fact that the TGU operation in the power system occurs under conditions of uncertainty due to changes in the TGU parameters in different modes of its operation.

The implementation of this regulator requires the development of a set of related technical solutions that can be implemented by creating an appropriate automated control system (ACS) of TGU, which it will be part of. Thus, the purpose of this work is to determine the functions, place in the thermal power plant (TPP) ACS, the designing of the ASC TGU structure on the principles of interconnectivity and robustness. The main purpose of ASC TGU is supposed to provide high-quality damping of torsional and low-frequency electromechanical oscillations of the shaft line in uncertainty conditions for reducing the accumulation of fatigue damage of the TGU shaft material and ensuring its durability.

Materials and methods

Methods of system analysis were used by authors to solve the set of formulated tasks within the problem of ASC TGU development. As a result of the system analysis, the factors that influence the torsional oscillations and the shaft durability, their mutual connection, were identified.

System analysis of TGU control processes allowed developing approaches to ASC TGU design, which will provide structuring and integrity of the control process and operation coordination of its individual subsystems and functions.

Results and discussion

The control functions of the individual components of TGU in the existing systems are performed by the automated control system of technological process of the power unit (ACS TP PU), which includes TGU [**Ошибка! Источник ссылки не найден.**]. In this case, the components of TGU, such as turbine and turbine generator act as separate unconnected control plants with autonomous automatic control systems, the control signals to which are generated directly from ACS TP PU. The logic of control of the turbine (T) and the turbine generator (TG) is combined at the level of ACS TP PU to accomplish such complex control tasks that require the participation of all components of the power unit, including boiler unit (BU), such as starting and stopping processes, etc. However, there are control tasks that relate only to TGU subsystems that can be combined at a separate level in the control hierarchy. One of these tasks is to control the reliability of the shaft of a turbine unit, one part of which relates to T and another to TG.

To solve this problem, it is proposed to create a robust interconnected automated control system of TGU (RI ACS TGU) with the monitoring function of fatigue damage of the TGU shaft material, which includes TGU control subsystem (CSS TGU) with an automatic interconnected regulator (AIR). The place of this system in ACS TPP is shown in Figure 1.

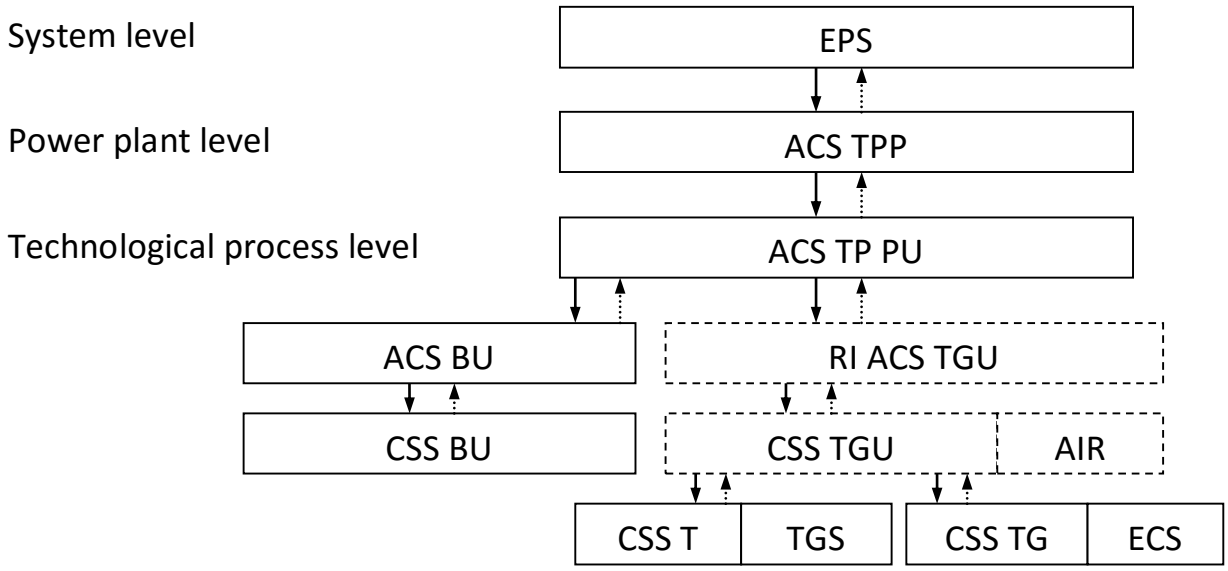

Figure 1. Place of RI ACS TGU in ACS TPP structure

Let's distinguish the functions performed by RI ACS TGU: robust interconnected control of the rotation speed of the TGU shaft; monitoring of fatigue damage of the shaft material; control of the operation of special equipment related to the damping of TGU shaft torsional oscillations: devices for compensating the torsional vibrations, which are capable of creating additional torque. The following functions are proposed to be implemented by means of the respective functional subsystems:

– subsystem of robust interconnected control of TGU;

– control plant identification model subsystem;
– subsystem of automatic control of TGU shaft torsional oscillations;
– monitoring the TGU shaft state subsystem;
– subsystem of identification of TGU shaft mechanical parameters.

Functional structure of RI ACS TGU is shown in the scheme in Figure 2. As it can be seen from Figure 2, subsystems receive data from a sensor data processing system that statistically processes data in real time, preparing them for calculations. The robust, interconnected shaft speed control subsystem sends control signals to AIR, which through separate TGS and ECS control channels act on their actuators and regulators. The AIR can be reconFigure d from the automated workstation (AW) of the power unit dispatcher, which sends the appropriate command to the robust interconnected control subsystem that triggers the reconfiguration using the control plant identification subsystem data. The control plant identification subsystem uses in its work the identification algorithm of the control plant matrix transfer function proposed by the authors in [**Ошибка! Источник ссылки не найден.**].

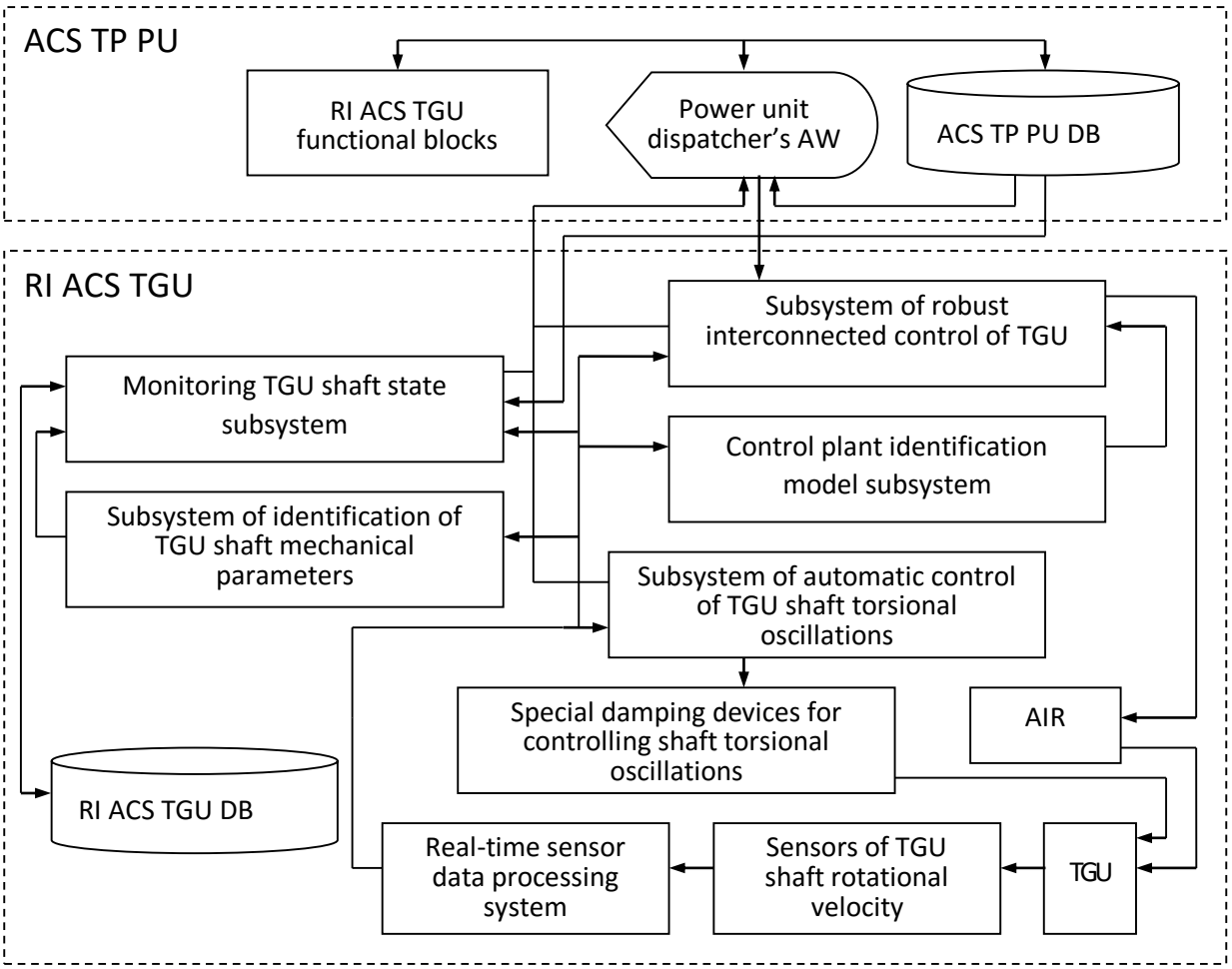

Figure 2. Functional structure of RI ACS TGU

One of the main tasks of the TGU shaft monitoring subsystem is to estimate the initial value of parameter D [9], which is a measure of fatigue damage of the shaft

material according to Palmgren–Miner rule, to calculate it in real time, and to send information about its current status and exceeding the critical level to the power unit dispatcher. In its work the monitoring subsystem uses the data of the subsystem of identification of mechanical parameters of the TGU shaft [**Ошибка! Источник ссылки не найден.**]. On the basis of the monitoring data of the shaft and the identification of parameters, the dispatcher, by established procedures, solves the issue of removal of TGU in repair, controls the state of transients in TGU.

The automatic TGU shaft torsion control subsystem also controls special damping devices for controlling shaft torsional oscillations [**Ошибка! Источник ссылки не найден.**], which, due to their design, can create additional torque in a particular section of the shaft.

Conclusions

The solution of the problem of ensuring the durability and reliability of TGU operation in various transients in the power system is proposed by creating an automated system of robust interconnected control of TGU with the function of monitoring the state of the TGU shaft. Development of the TGU automated system of interconnected control consists in the organization of the multilevel control system taking into account the mutual influence of the generator's ECS and turbine's TGS subsystems, the use of local and centralized control systems. The designed system provides improvement of the TGU damping characteristics in conditions of uncertainty in the perturbations of power grid mode with the use of robust control methods, procedures for identifying parameters, monitoring the state of the shaft through the proposed methods of assessing the damage of its material.

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Quality evaluation of dietetic sucrose-free sponge cakes with einkorn wholemeal flour (*Triticum Monococcum* l.)

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Abstract

The possibility of the use of einkorn wholemeal flour, which application is almost unknown in sucrose-free sponge cake, is presented in this article. Four types of sucrose-free sponge cakes production by a substitution of wheat flour with einkorn wholemeal flour (with 25%, 50%, 75% and 100% einkorn wholemeal flour). The sponge cake batters recipe composition is specified as the physical characteristics of the goods are determined. The methods of descriptive sensory analysis are used for a comparative analysis of the new and the control sponge cakes sugar free. The newly obtained baker's goods are characterized with very good quality properties in comparison with those of the cake without einkorn wholemeal flour (the control cake-sample). On the grounds of the received results it can be expected a potential consumer interest in pastry food products enriched with functional components.
Key words: *sucrose-free, sponge, cake, einkorn.*

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DOI: 10.24263/RES-2019-5

Introduction

Cakes are sweet baked goods that are consumed by people from all over the globe. Cake is a complex system. For the success of a cake, the batter should have appropriate and properly balanced formula as well as suitable ingredients. Different types of cakes need different kind of ingredients and formula balance. Each ingredient has its own special functionality.

The number of people suffering from obesity, cardiovascular disease and type-2-diabetes, increased enormously. The published statistic is shocking: 1.9 billion adults over the age of 18 and 41 million children under the age of 5 are overweight or obese [1]. The reduction of sugar in sweet bakery products is challenging, however, since sugar fulfils more functions than only sweetness and flavour. Sugar also influences the colour of the cake. Sugar is one of the essential ingredients in biscuits and cakes, not just to ensure taste and flavour, but also to give products their unique texture. It is

essential to investigate the interactions of sugar with the main ingredients in baked goods and to understand the role of sugar in different products. By now two main strategies to reduce sugar with a promising result have been introduced: firstly, the replacement of sugar by a sweet bulking agent, such as polyols, and secondly, sugar substitution by a combination of non-sweet bulking agents and high-intensive sweeteners. A total sugar replacement in sponge cake (sugar content of 23.19% based on the whole recipe) by the combination of fructose, polydextrose and acesulfame-K or aspartame showed high consumer acceptance and reduced calories by 40% [2].

Mannitol, sorbitol, maltitol, erythritol, isomalt, xylitol and lactitol are considered as food additives and listed as a 'E' number in the list of ingredients. They are only allowed to be added as sweeteners in products which are either 'energy-reduced' or have 'no additional sugar' [3]. Foods containing more than 10% added polyols has to be claimed as 'excessive consumption may produce laxative effects' [2].

Einkorn (*Triticum monococcum* L.) is a diploid hulled wheat appreciated for its excellent nutritional properties, including high protein, carotenoids, β-glucans and antioxidants contents, and as such it is a promising candidate for the development of functional bakery products. Einkorn-enriched cookies had higher ash, polyphenols, carotenoids, antioxidants and beta-glucans content than pure wheat flour cookies, and might possibly be classified as functional foods. The addition of different flours to bakery products creates an opportunity to combine beneficial technological properties with beneficial biological health promoting properties. Addition of different flours to bakery products creates an opportunity to combine beneficial technological properties with beneficial biological health promoting properties. Since the wholemeal products consumption became a part of well-being trends, addition of natural components, incorporating the biological activity, would enhance food's quality and pro-health value. Designed sponge cakes with functional ingredients would be the answer to the increasing interest in health promoting aspects and nutritional value of food [4].

The objective of this article is the investigation of the influence of einkorn wholemeal flour on physical and sensory characteristics of sucrose-free sponge cakes.

Materials and methods

The products used in the preparation of the sucrose-free sponge cakes without and with einkorn wholemeal flour: wheat flour, wheat starch, eggs, distilled water, sodium bicarbonate, citric acid, sorbitol, encapsulated aspartame, einkorn wholemeal flour. The amounts of sorbitol and that of the high-potency sweetener (encapsulated aspartame). The cake batter (control batter) was made according to the technological scheme described in a patent form № 463 of 02.07.2001 – Bulgaria [5], and a double-bowl mixing procedure was used. The recipe for making batter included preliminary separation of egg whites and yolks. The egg whites were whipped by a mixer at easy speed increasing from 1 (19 rpm) to 3 (31 rpm) grade. The egg yolks were mixed with a half of water amount and whipped at speed of 1 grade. Then the rest water amount

warmed up to 18-20°C, sodium bicarbonate, citric acid and sorbitol was added. The mixture was whipped again at speed of 1 grade and the screened wheat starch was added under continuous mixing. The egg white foam was incorporated to the egg yolk mixture. Finally the screened wheat flour and encapsulated aspartame were added to the mixture. The sponge cakes were baked in a metallic pan containing 95 g of batter and placed in an electric oven for 30 min at 180°C.

The specific gravity of the sponge cake batter was calculated by dividing the weight of a standard batter cup to the weight of an equal volume of distilled water at batter temperature (20.0± 0.5°C) [6]. The physical characteristics of the sponge cakes were determined 2h after baking. Volume was measured by the small uniform seed displacement method [7], and and porosity was assessed according to the Bulgarian State Standard method [8]. The specific volume was expressed as the ratio of the sponge cake volume to its mass. The water-absorbing capacity of the sponge cake was measured by the extent of biscuit swelling according to the Bulgarian State Standard method [9]. Total sample moisture was determined after drying the sample at 105°C up to a constant weight according to the standard method [10].

Sensory characteristics: The descriptive test for a quantitative sensory profiling was used to establish the sensory characteristics (shape, colour, cell size and uniformity, odour, crumb tenderness) of the sponge cakes, 6 h after baking, following the ISO 8586:2014 and ISO 13299:2016 methods [11-12]. The sponge cakes samples were ready 1 h before the evaluation. Samples of different cakes were kept in coded plates covered with aluminium foil. Twelve trained panelists were selected to guarantee the evaluation accuracy. The intensity of each sensory characteristic was recorded on a ten-point linear scale after 1 h orientation sessions of the panelists, where they specified terminology and anchor points on the scale. The coded samples were shown simultaneously and evaluated in random order among the panelists.

Results and discussion

The developed recipe composition of sucrose-free sponge cakes with einkorn wholemeal flour was prepared by the replacement of wheat flour with einkorn wholemeal flour in quantity 25%, 50%, 75% and 100%. The stages of technology were kept because of their easy fulfillment and the considerably small duration of the technological cycle. The sponge cakes containing einkorn wholemeal flour were processed at constant regime of baking concurrent with that of the control sample, which according to the technological instruction was baked for 30 min at 180°C.

Changes in the physical characteristics of batters and sponge cakes containing einkorn wholemeal flour in different amounts are summerized in Table 1. The specific gravity of cake batter affects volume, porosity, water-absorbing capacity of the sponge cake and is important for the formation of crumb texture of the cake. The sponge batter, obtained by replacing wheat flour with einkorn wholemeal flour (50%, 75% and 100%), had a lower specific gravity than that of the control batter. Lower specific

gravity is an indicator of more aeration, which is a desired property of cake batter. No significant differences were found in the specific gravity of the batter values between the control batter (0.65±0.01) and 25% einkorn wholemeal flour sponge cake batter (0.66±0.01), which could encourage the formation of larger bubbles during baking and therefore result in greater product height and volume. In this studying the volume of cake-sample (185.00±10.00 cm^3) was smaller than this of cakes containing 25%, 50% and 75% einkorn wholemeal flour, as the volume of the cake with 75% einkorn wholemeal flour (230.00±8.16 cm^3) is the largest, while the cake with a higher quantity of einkorn wholemeal flour (100%) had the smallest volume (160.00 ± 15.00 cm^3). Ronda, Gómez, Blanco & Caballero (2005) studied the effect on sponge cake volume, colour and texture properties of total replacement of sucrose by seven bulking agents, including PD. The results showed that xylitol-PDwas a good option to replace sugar.Specific volume of cakes varied between 2.67±0.35 cm^3/g and 3.76±0.27 cm^3/g. For the cake with 100% einkorn wholemeal flour, was characterized with a smaller specific volume (2.67±0.35) and porosity (64.81±4.14) were measured. The greatest porosity was observed in the cake with 75% einkorn wholemeal flour. In comparison with the control (47.33±2.52 PU and 80.33±8.02 PU), a decrease in springiness and shrinkage was found when wheat flour was replaced by einkorn wholemeal flour. It was observed that the total moisture content of the sponge cakes with einkorn wholemeal flour decrease. The water-absorbing capacity of the cake control (317.22 ± 13.14%) is the lowest than that of the cakes with different levels of einkorn wholemeal flour.

Table 1

Physical characteristics of sucrose-free sponge cakes

Physical characteristics[1]	Sponge cake type				
	Control	with 25% EWF	with 50% EWF	with 75% EWF	with 100% EWF
Specific gravity (for batter)[2]	0.65±0.01	0.66±0.01	0.62±0.02	0.63±0.03	0.63±0.01
Volume, cm^3	185.00±10.00	208.75±6.29	210.00±8.16	230.00±8.16	160.00±15.00
Specific volume, cm^3/g	3.48±0.18	3.45±0.16	3.69±0.26	3.76±0.27	2.67±0.35
Porosity,%	66.67±3.02	68.06±3.51	68.52±2.14	73.15±1.85	64.81±4.14
Springiness, PU[3]	47.33±2.52	27.75±2.50	40.00±12.49	28.75±2.50	31.33±10.21
Shrinkage, PU	80.33±8.02	71.25±3.10	70.00±5.00	74.75±1.71	59.67±6.11
Water-absorbing capacity,%	317.2 ±13.14	372.55±7.86	379.18±10.93	342.07±4.87	325.54±11.68
Total moisture,%	46.81±0.17	40.00±2.10	42.55±0.50	36.17±1.14	41.39±1.60

[1] The values are mean ± SD ($p \leq 0.05$).

[2] The temperature of the batter is on the average 20.0 ± 0.5ºC.

[3] PU – Penetrometer Units.

Sensory analysis evaluations were performed in order to determine the optimum sensory characteristics of sponge cakes with regard to the panelists' preferences. The results of the sensory evaluation are given in Figure 1. Ratings test revealed that sensory characteristics including shape, colour, cell size and uniformity, odour and crumb tenderness were perceived without significant differences between the control cake and those supplemented with different concentrations of einkorn wholemeal flour. In terms of their shape, the cakes with the addition of einkorn wholemeal flour were perceived very well. Lin & Lee (2005) studied the effect of replacement of sucrose by a mixture of sucralose and a type of indigestible dextrin in chiffon cakes obtaining good results in physical and sensory properties in samples with less than 50% replacement.

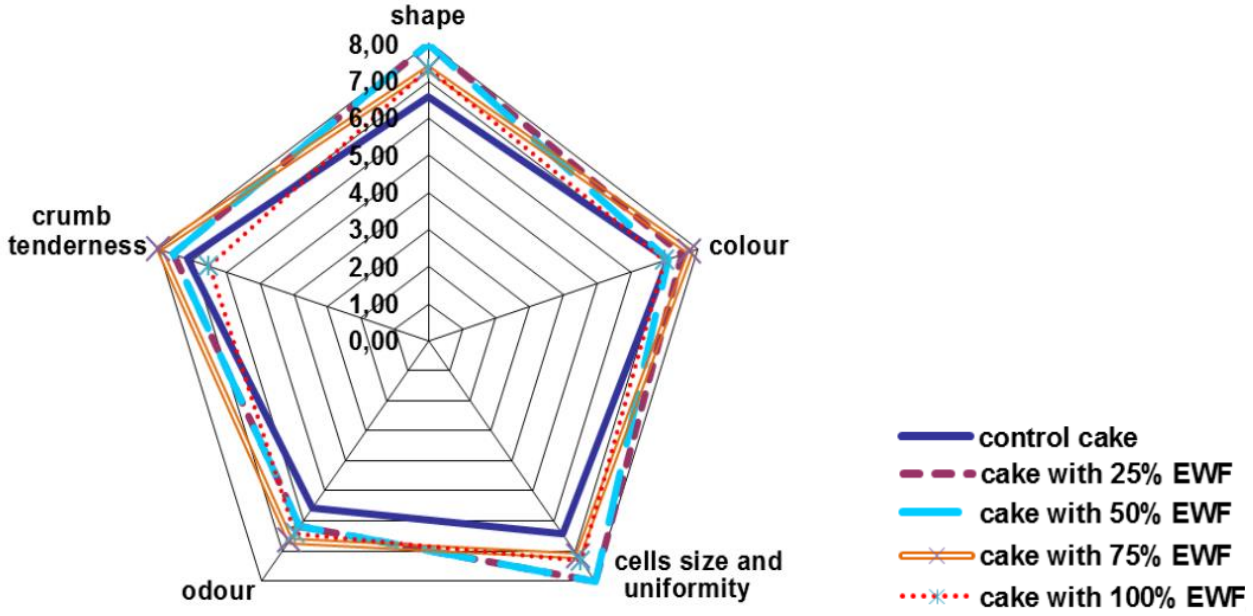

Figure 1. Sensory characteristics of sucrose-free sponge cakes[1]

The all cakes have a crust and crumb with more pronounced light-yellow colour due to the presence of the dying components in the yolks of egg and einkorn (especially carotenoids and lutein). The data showed that size and uniformity of cells and crumb tenderness of cakes with einkorn wholemeal flour is bigger than that of the cake-control. The cells of the new sponge cakes with einkorn wholemeal flour were small and equal, uniformly distributed in the crumb, and were thin-walled. Amin *et al.* (2016) study sugar-free cookies fortified with Pea (*Pisum sativum* L.) flour, soya bean (*Glycine max* L.) flour and oat (*Avena sativa* L.) flakes, sensory evaluation of cookies showed that with regard to color, taste, flavor and texture, cookies with 5% to 10% pea flour and soya bean flour scored highest. The mean score of sponge cakes with einkorn wholemeal flour evaluated in terms of crumb tenderness was higher than that of the cake control.

Conclusion

The physical and sensory characteristics of the sucrose-free sponge cakes with einkorn wholemeal flour are juxtaposed with those of the control cake. On the grounds of this we consider that newly prepared sponge cakes containing einkorn wholemeal flour are suitable as intermediate products in confectioneries designed for functional nutrition.

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Prospects for the use of fermentation technology in meat products

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Abstract

The topicality of the work is to justify the choice of low-grade meat raw material as a matrix for tying together calcium ions. The rumen of cattle, leaf mussels, semi-finished and ready-minced sausages are studied.

It was determined rational pH parameters, temperature, duration, duty of water curve of environment and amount of enzyme preparation for efficient proteolysis on model systems.

By means of complete factorial test, mathematical model of dependence of length and temperature of proteolysis is developed. The indicator of amino nitrogen content in the received hydrolyzate of paunch of cattle was selected as the parameter of optimization. The study is conducted and the confirmation of the data in model environments during proteolysis of by-products of the second category (cow tripe) is received.

The required amount of enzyme economically feasible for efficient proteolysis in technological processes – 0,01% by weight of raw materials. Settings rational pH parameters – 5,0–7,5, temperature – 25–40 °C, amount of enzyme preparation for efficient proteolysis on model systems – 3 h., duty of water curve of environment – 1:2.

The results are suggested to use in meat products industry of special food – gerodietetic. The development enables to reduce price of finished product, enrich it with micronutrients and improve it digestion by the human body.

The results of the recommended meat products in special food – Gerontologic. Development reduces the cost of finished products, enriches its micronutrients and improves its absorption by the human body.

Key words: meat, gerodietetic, tripe, proteolysis enzyme, collagenase.

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DOI: 10.24263/RES-2019-6

Introduction

Disruption of the normal flow of processes of natural reproduction of population led to a decrease in the proportion of people whose age is under working age, to growth in working age and older than working age, which generally resulted in an increase in population pressure on the working age population. Overall mortality exceeds twice the corresponding rates of EU countries, the mortality rate of working age people exceeds in 2–3 times.

So, ensuring and strengthening of population health, extending the period of active longevity, prolonging life expectancy, focusing on health as a social value can provide citizen with competitiveness in the labor market, professional longevity, welfare and as a result – improvement of life quality, strengthening of human potential, preservation of the gene pool of the people, improvement of the demographic situation in the country. The economic business costs for employment potential recovery from disability will reduce. However, it is important to form an understanding of individual responsibility for health.

Meat is the most important food product that provides human with essential, high-quality and full value animal protein. One of the most important tasks of providing humanity with food is to increase production of meat and meat products to satisfy the needs of population. It is important not only to increase the total production of meat products, but also provide their maximum production of each ton of raw materials, improve the quality, nutritional value and commodity indices extend the range. Solving this problem requires work to create precocious meat breeds of cattle, rational use of meat and products of animal slaughter, the intensification of technological processes, creating meat analogy and the use of plant and microbial proteins.

It is known that to achieve high economic efficiency of processing by-products it is necessary to strive to maximize their use in cost-effective high-quality manufactured meat products, such as sausages and smoked sausages that are most in demand and more stable to storage. One of the most promising ways to achieve maximum production efficiency, improve and stabilize the quality of sausages is the production with a minimum cost. This is achieved through the most rational use of raw materials, first of all, through the usage of muscle protein, the wide use of secondary raw materials (scrap, offal, protein components of plant and animal origin).

By-products of the second category have a full set of essential amino acids. As it is shown in Table 1, cattle rumen is the most significant source of collagen, which has more than half of connective tissue proteins (contains 61,3% of collagen of the total protein). Collagens form insoluble filaments (fibrils), which are the part of extracellular matrix and connective tissues.

Table 1

Chemical composition of beef by-products of the second category

By-products	Protein content,%			
	total protein	collagen	salt-soluble	collagen of the protein
Lips	20,3±2,9	13,4±1,4	0,6±0,1	66,0
Abomasum	14,4±1,5	5,9±0,2	0,7±0,2	41,2
Cattle rumen	17,1±1,8	10,5±0,8	0,8±0,1	61,2
Gullet meat	16,3±1,4	5,7±0,7	1,9±0,1	34,7
Spleen	16,4±0,6	1,9±0,4	7,9±0,2	11,3
Lungs	16,1±1,0	4,3±0,5	4,4±0,1	26,3
Trachea	15,6±0,8	6,2±0,9	-	39,5
Head’ meat	18,8±0,4	6,5±0,2	-	36,3
Ears	25,2±0,1	17,9±0,1	-	71,0

Materials and methods

The rumen of cattle, leaf mussels, semi-finished and ready-minced sausages are studied.

Rumen of cattle receiving from healthy adult cattle from private farms. Leaf mussels were collected from private mussel farms in the Black Sea in the waters of Kerch. All parties were selected toxicological and radiological control center for evaluating the quality and safety of food materials. Semi-finished and ready-minced sausages produced in the scientific laboratory of the university.

It was determined rational pH parameters, temperature, duration, duty of water curve of environment and amount of enzyme preparation for efficient proteolysis on model systems.

Processing of the experimental data was carried out statistical modeling using Excel spreadsheet and problem-oriented mathematical calculations package Math Cad. A mathematical model of comprehensive quality index calculated by the method of numerical characteristics of the object, based on the law of additivity, which can be used to construct a model of food quality designation. The results of any measurements always contain some error.

The experimental results were treated by mathematical statistics, given the repetition of experiments, average values of the studied parameters, the rate of approximation.

Results and discussion

Cleaned rumens were cooled in the tub with running water and kept for 20–30 min on frames with hooks. At the end of the process rumens were chopped in the meat mincer with a grating diameter of 2–3 mm. Salt was added at a rate of 3 kg per 100 kg of raw material (3%) and dimethyl sulfoxide – 200 ml per 100 kg of rumen (0,25%).

The ready substance is mixed thoroughly for 3–4 minutes and placed in a refrigerator (2–4 °C). Filling was prepared after 24 hours of storage. Before cooking the filling, we poured liquid that was released from the rumen softened in salt mixture.

Before salting, beef was chopped in the meat mincer with a grilles diameter of 16–22 mm, and for pork – 8–12 mm. Meat was` salted and kept at a temperature of 2–4 °C overnight. During this process the raw was stored in a container with a layer of 15 cm.

Enzymatic treatment leads to destructive changes of raw materials, increase of number of hydrophilic centers, increase of functional groups as a result of rupture of polypeptide chains, which further will be more accessible for reactions including calcium. However, our goal was not a complete hydrolyzate of protein molecules to amino acids, we tried to achieve only partial hydrolysis to increase the number of free functional groups, including those that are capable of binding calcium (Figure 1).

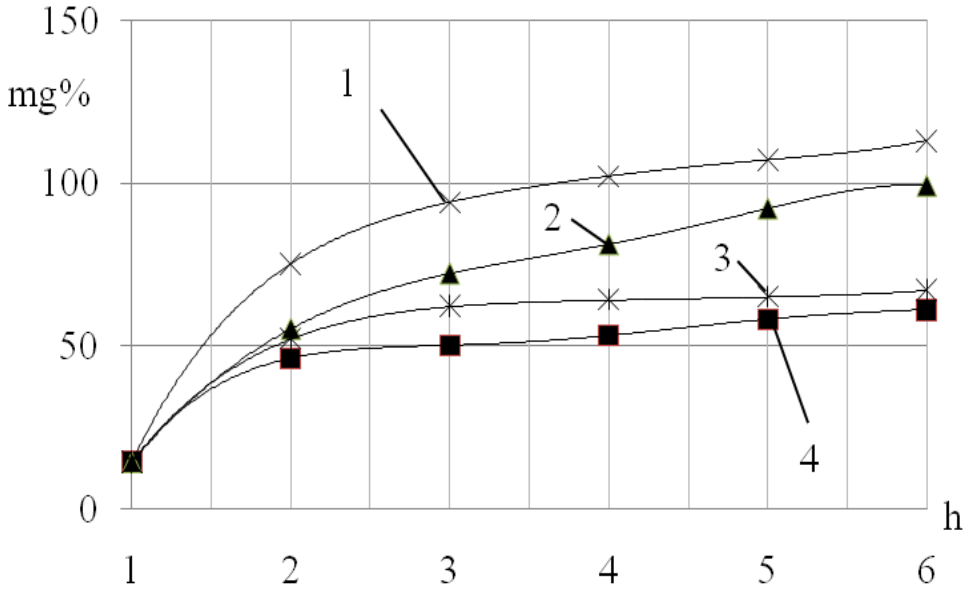

Figure 1. Diagram of accumulation of amino nitrogen in the processing of the rumen of cattle, depending on the ambient temperature: 1 – treatment at 2 °C; 2 – treatment at 12 °C; 3 – treatment at 37 °C; 4 – treatment at 50 °C (pH – 7,0).

Processing of cattle rumen was held by 0,05% solution of the enzyme by weight of raw materials at temperature regimes: 2 °C (cold chamber), 12 °C (in meat processing plants in the shops), 37 °C (norm of body temperature) and 50 °C (thermostat) for 5 hours.

Proteolysis of protein of collagen containing tissue is observed in all modes, as evidenced by the accumulation of amino nitrogen. The highest rate of proteolysis of proteins is observed during the first time, as shown by angle curves from the second processing time it is reduced. The largest number of amino nitrogen was observed at 37 °C in each period, minimum – at 2 °C. So, after 2 hours of fermentation amount of amino nitrogen in samples that were treated at 37 °C increased by 5.8 times at 12 °C – 4.5 times, at 2 °C – 3 times, further the rate of decay of proteins to peptides and amino acids gradually decreased. Thus, the most effective fermentation temperature is 37 °C.

In conditions of production the support of 37 °C entails additional costs for equipment and energy, which is undesirable in the development of new technologies. Also such temperature creates optimal conditions for microbial growth. Therefore, temperature 12 °C is more suitable, which is chosen for further studies because it is constantly maintained at a meat processing enterprises in manufacturing plants, but also increased the concentration of enzyme to 0,1%.

Salted beef was minced in meat mincer with hole diameter of 2–3 mm before cooking. Preparation and processing of minced were performed in mixer. Minced meat and rumen were mixed with spices and auxiliary materials for 2 3 min. Six batches of minced meat were prepared under the first variant, one batch under the second variant to assess the influence of the composition of minced meat with rumen on the quality of sausages (Table 2).

Pork bellies were filled with minced meat of each batch, twisted like a long loaf of 20 – 25cm long. After ling loaf sinking at temperatures above 8 °C for 2–4 hours it

was boiled at 80±5°C for 60 min. to achieve the temperature inside the long loaf 75±2 °C. After, the sausage was cooled at a temperature of 12±2°C.

Spices and support materials are the following components (g/100kg, raw): sodium nitrite (solution) – 5; sugar sand – 100; ground black pepper – 100; allspice powder – 100; coriander – 150; fresh garlic – 200.

Table 2

Composition of cooked sausages

Ingredients,%	Variant						
	1						2
	A	B	C	D	E	F	-
First class beef	60	60	60	60	60	60	60
Half-fat, veiny pork	35	33	30	28	22	20	30
Cattle rumen	3	5	7	8	9	11	7
Starch of flour	2	2	3	4	4	4	3

Samples of each batch were selected and analyzed under the established rules to (5-7) at the Department of Technology of meat and meat products of National University of Food Technologies determine the organoleptic and physico-chemical parameters and yield. Table 3 and 4 show that batches A, B, C and D meet the requires of cooked sausages. In terms of profitability of used raw and the possibility of using the optimal quantity of rumen batch formulation C and D can be used.

Studies showed that the shelf life of such a sausage is no more than 8 days at a temperature not higher than 12 °C and a relative humidity of 75 – 78%. The moisture content in the finished product 57 – 60%, salt – 3%. The output of finished products (sausages) to substance of unsalted raw is 115 – 128%.

Conclusion

1. The use of the rumen in the production of cooked sausages is the best way to use rumen collagen and dimethyl sulfoxide + NaCl may serve as an inhibitory agent.
2. It is shown that the effective concentration of nutritive collagenase during proteolysis of the cattle rumen is – 0.1% by weight of raw material.
3. It is founded that the maximum proteolytic activity of enzyme preparation – nutritive collagenase at pH – 7,0; duty water curve – 1:1; temperature – 12 °C, proteolysis duration – 3 hours.

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Cyclic rectification technology in column mass exchange apparatuses with perforated plates

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Abstract

Proposed below is the technology of cyclic rectification at continuous supply of heating steam to the mass exchange column apparatus equipped with perforated plates. The method allows to prolong the time of contact of steam and liquid on plates up to 40-60 s and reduce the time of overflow up to 1-2 s. Hydrodynamic modes of operation of perforated plates are determined to ensure their cyclic action: the lower critical velocity of steam in barbotage openings of meshes plates is 5,4 m/s, of scalesplates is 6,5 m/s; the upper critical velocity at which fluid is carried away is 8 and 16 m/s, respectively. A prerequisite for spilling the liquid through barbotage openings is an instantaneous reduction of the steam velocity in the openings to 1,5-1 m /s due to the instantaneous change of the free cross-section of the plate from 2,6 to 51,7% and more. Efficiency research of the offered technology was carried out in industrial conditions in processes of distillation of alcohol-containing fractions and epuration of alcoholic fermentations distillates in the experimental column. It has been established that the technical solution allows to increase the degree of separation of higher alcohols of fusel oil and methanol by 38%, to increase the multiplicity of the concentration of head impurities by 25%, the upper intermediate impurities – by 40% and the end impurities – by 37%. In such conditions, the specific consumption of heating steam in the separating column decreases from 25 to 16 kg/dl of anhydrous alcohol introduced on the acceptance plate, and in the epurational column – from 15 to 8,2 kg/dl of anhydrous alcohol.
Keywords: rectification, column, alcohol, impurity.

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DOI: 10.24263/RES-2019-7

Introduction

In columns with mass transfer on perforated plates, vapours and liquids pass through the same holes or slots. These plates are called perforated plates. These include scales, meshes, tubular, wavy and other plates. Advantages of perforated plates – simplicity of a design, low cost of manufacturing and installation, rather small hydraulic resistance. The main drawback is the short speed change interval of steam and liquid within which steady and efficient operation is maintained, insufficient time of contact of phases, also agitation of liquid on adjacent plates.

The authors proposed the technology of cyclic rectification, which provides for continuous supply of heating steam in the mass-exchanging column apparatus with barbotage-perforated plates. The innovative technology provides the implementation of controlled cycles of liquid retention on perforated plates and its periodic overflow through all the openings from the upper plates to the lower ones due to the instantaneous change of steam speed. While the liquid is retained on the plates, there is a mass transfer between the liquid and the steam, which goes through the contact device holes. During this cycle period, the floating valve closes the overflow port and the fluid is held on the plate. When the overflow opening is opened, the steam velocity in the barbotage openings becomes lower than the critical speed at which it is held on the plate and the liquid is transferred to the lower plates. The versatility of the operation of the barbored-perforated plates is in the alternation of the steam velocity in the contact device holes by changing the free cross-section of the plates in a given range of values according to a given algorithm (Patent of Ukraine # 89874, Patent of Ukraine # 136560). With aforementioned conditions, the driving force of the mass transfer process increases due to the increase in the concentration gradient of volatile components, improves the diffuse characteristics of contact devices, the efficiency of operation increased and the specific flow rate of heating steam is reduced [2, 4, 6, 9].

The aim of the research is conditioned by the definition of the hydrodynamic mode of operation of barbotage perforated plates, of the efficiency of the technology of cyclic rectification in the mass-exchange columns equipped with barbotage perforated plates with variable free cross-sectionin and determining the consumption of heating steam in the separating and epurational columns.

Materials and methods

Research methods – analytical, chemical, physico-chemical with the use of instruments and research methods used in the production of rectified ethyl alcohol. Fluid consumption was controlled with the help of flowmeter RM, air velocity in the free section of the column – anemometer MS-13, in the holes of the plates – by calculation method. The concentration of volatile impurities of alcohol was determined on a gas chromatograph with a column HP FFAP 50 m × 0.32 m.

Analysis of research samples was performed according to gas chromatographic method for determination of microcomponents content [10, 11].

Results and discussions

Operation efficiency of barbotage perforated plates in conditions of cyclic rectification depends on the adopted hydrodynamic regimes that determine the boundaries of stable operation of mass transfer tower apparatuses. The necessary condition for their determination is the establishment of the maximum allowable steam velocity (upper and lower critical velocity) in the free section of the column and

barbotage holes. The lower limit corresponds to the steam velocity at which the "sink" of the liquid from the upper plates to the lower ones stops, the upper limit corresponds to the steam velocity at which the liquid from the lower plates begins to drift to the upper ones, which leads to a reduction of the phase contact surface.

The research was carried out on an experimental rectification column equipped with replaceable contact devices – meshes and scales in the water-air system. Characteristics of the column: diameter – 300 mm; number of plates – 5 pcs.; distance between plates – 300 mm; diameter of barbotage holes – 2,4 mm; area of section of holes of arched type scales – 19,42 mm^2; thickness of a cloth of a plate – 2 mm; free section of a plate – 2,6%; height of a layer of a liquid on plates – 35 mm. For the meshes plates the air flow rate was changed in the range of 1-15 dm^3/s, which corresponds to the change of speed in the barbotage openings of 1,5-10 m/s, the irrigation density fluctuated in the range of 4 to 11 $m^2/(м^2h)$. For scales plates the irrigation density varied from 5 to 15 $m^3/(м^2h)$.

It is known that in order to increase the efficiency of plate of various designs it is advisable to delay the liquid on their canvas by organizing the flow of separate vapor-liquid jets with mutual collision of jets or additional installation of partitions and reflectors. Liquid brake devices are made in the form of holes, nozzles, etc. The area of free cross-section of holes with a counter flow of steam is 2-3% of the total area of the plate. To increase the duration of the contact between steam and liquid and to intensify the mass transfer, vertical dividers are installed in some areas of the plate [1–9].

In spite of positive results, proved by methods of mathematical modeling, the known methods and models have not found wide practical application because of complexity of the chosen constructive decisions, absence of mass exchange in the steam period, fluctuations of pressure of steam in a collector and low throughput of column mass exchange apparatuses on steam and a liquid.

In order to solve the set tasks the authors proposed the technology of cyclic rectification, which allows to exclude the above mentioned disadvantages, and the construction of a column mass exchange apparatus equipped with perforated plates of cyclic action. The method provides for periodic overflow of liquid from the plate to the plate due to the forced operation of overflow devices containing moving elements associated with the drive mechanisms (Patent of Ukraine # 116565). To implement the technology, the column apparatus will be equipped with mesh or scale-shaped plates with coaxial arrangement of scales. Such technical solution allows to exclude unidirectionality of steam and liquid flows over the whole area of the plate, and in case of separation of mixtures containing suspended particles (for example, in the braga column of the distillation unit), to exclude the possibility of formation of stagnant zones, sticking of suspended particles on the surface of the plates and thus to increase their service life without stopping for preventive work.

For realization of the offered method and carrying out of researches of a plate of an experimental column have been equipped by the rotary segments equipped with microprocessor pneumatics of firm FESTO (connected to standard pneumocylinders

of bilateral action of type DNT 63-50-PPV-A) which moved in turns according to the program of controller M340 of firm "Schneider Electric" [5, 6, 9]. Movable segments opened and closed the overflow openings of the plates in such a way that the liquid overflow occurred periodically from top to bottom in the height of the column (Figure 1).

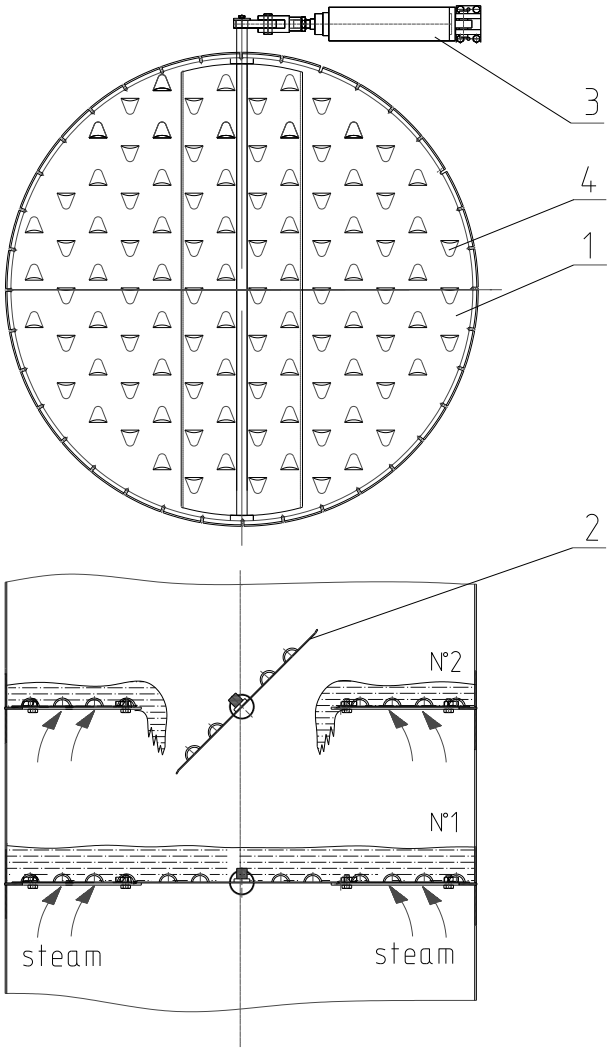

Figure 1. Cyclic plate with scales and variable free cross section:
1 – plate; 2 – turning segment; 3 – drive mechanism; 4 – scales

The column includes plates 1 and movable segments of plates 2 associated with the drive mechanisms 3. On the plates 1 and segments 2 are placed scales 4 so that the direction of the scales arranged in one row is opposite to the direction of the scales located in adjacents rows. The mass transfer contact plate works as follows. Liquid enters the sheet 1 of plate No. 1 from above the located plate No. 2 through the overflow hole, which is formed after the opening of the movable segment 2. During this period, the movable segment of the web 1 of the plate No. 1 is closed for a specified period of time. From the bottom upwards, heating steam flows continuously through the scales'

slots and comes into contact with the liquid on the plate web. Mass exchange between liquid and steam takes place in barbotage mode. After the set time of liquid delay, the moving segment 2 of plate No. 1 is opened, and the liquid is poured to the bottom of the plate through the hole, which was formed, and spilled through all the slots of the scales (Patent of Ukraine # 136561).

At the first stage of researches hydrodynamic modes of stable work of mesh and scaly plates in a mode of controllable cycles of a delay and overflow of a liquid have been established, maximum admissible values of speed of air in barbotage apertures and in a free section of a column at which the liquid is kept on plates and at which its carrying away (ejection) on the top plates begins are defined. It is established that the lower critical air velocity in the barbotage openings of meshes plates (V_{hole}) was 5,4 m/s; the linear air velocity in the free section of the column (V_{lin}) – 0,25 m/s. For scales plates: (V_{hole}) is equal to 6,5 m/s; in barbotage mode of plate (V_{lin}) was 0,5-0,9 m/s, in transition – 0,9-1,3 m/s and in jet – 1,3-2,0 m/s.

At the second stage of the studies, the air velocity in the bubbling holes (V_{drift}) was determined, at which the entrainment of liquid onto the upper plates began. In the columned apparatus with meshes plates (V_{drift}) was 8 m/s; while (V_{lin}) was equal to 0,7 m/s; the relative value of fluid entrainment (e) did not exceed 0,01 kg per 1 kg of air. In a column with scales plates (V_{lin}) was equal to 1,3-1,5 m/s; in mode of barbotage not more than 0,1 kg/kg, in jet mode – 0,2 kg/kg. Intense fluid overflow was observed at steam speeds below critical. For perforated plates the steam speed should not exceed 1,5-1 m/s. The obtained experimental data can be used in the development of mass transfer apparatus with perforated plates operating in a cyclic mode of rectification.

Research of efficiency of the offered technology was carried out in production conditions of Stonibabsky place of business of the State Enterprise Ukrspirt in processes of distillation of alcohol-containing fractions and epuration of distillate in a hydroselection mode. For research, an experimental cyclic column with perforated plateswas mounted (Figure 2).

The column had a diameter of 950 mm and was equipped with scales in the amount of 30 pieces. The distance between the plates was 300 mm. Rotating segments of the plates were connected to mechatronic subsystems, which were controlled by modern computer-integrated means.

Figure 2. Experimental cyclic column with perforated plates

During the periodic movement of the rotating segments alternately opened and closed the overflow holes of the plates according to the given algorithm in such a way that the overflow of liquid occurred cyclically along the height of the column from top to bottom with the continuous movement of steam from bottom to top. When the overflow opening was opened by the movable segment, the free area of the plate instantly changed from 2,6 to 51,7%. As a result, the steam velocity in the barbotage openings became less than 1,5-1,0 m/s, and the liquid simultaneously overflowed through the overflow opening and fell through all the openings. The technical solution made it possible to intensify the overflow process, reduce the overflow time to 1-2 s and increase the throughput capacity of the column apparatus.

The head fraction of ethyl alcohol and the alcohol-containing fractions from the condensers of the fermentation column, carbon dioxide separator, fusel alcohol, washing fusel water and streams from alcohol traps were fed into the column. The total supply volume was 688,3 dm^3/h or 250 dm^3/h in terms of anhydrous alcohol (a.a).The upper plate of the column continuously received hot softened water in the amount of 4050-4500 dm^3/h for hydroselection of impurities. The specified water consumption

provided concentration of ethyl alcohol in a cube liquid within the limits of 3,5-3,8% vol. Under such conditions, the distillation coefficient of all impurities of alcohol (including higher alcohols of fusel oil) exceeded one, and impurities were effectively released. The cube liquid released in the process of distillation from volatile impurities was supplied to the upper zone of the concentration part of the epuration column for double hydroselection of head impurities and effective extraction together with the head fraction of isopropyl alcohol. Such a solution allowed to reduce the consumption of hot softened water for hydroselection of impurities to 2000 dm^3/h. The retention time of the liquid on the plates was 40-60 s, the time of its overflow was 1-2 s.The pressure in the cub part of the column was maintained within 1,15-1,20 meters of the water column, the temperature was 100,5-101 °C, the temperature above the upper plate was 93,5-94 °C.Aldehyde-methanol concentrate was taken from the upper stage condenser in the amount of 7-9 dm^3/h. Esters and higher alcohols of sea liquor oil were taken out of the unit from the upper decanting zone in the form of ester-sivushnogo concentrate in the amount of 2-3 dm^3/h after the separation of the water-alcohol mixture. Aldehyde-methanol and estero-sivushy concentrates were mixed in the admixture concentrate collector.

In the course of the research, samples of feed *(F),* cube fluid *(CL),* impurity concentrate *(IC),* euphrates *(E),* head fraction *(HF)* and rectified ethyl alcohol *(RA)* were taken. The results of chromatographic analysis of the research samples and calculated values of the extraction degree (α) and multiplicity of concentration (β) volatile alcohol impurities at the operation of the perforated plates in the selected hydrodynamic mode, and the separating column at the above technological parameters are given in tabl.1.

Table 1

Results of the chromatographic analysis of the test samples and the calculated values of the degree of extraction (α) and the multiplicity of concentration (β) of volatile impurities of alcohol

A group of impurities	Concentration, mg/dm^3 in terms of a.a.						α	β
	F	CL	IC	E	HF	RA		
Ethanol,% об.	30,5	3,7	67	30,1	92,5	96,5	8,2	2,2
Aldehydes	318,6	2,75	2302	0,29	1135	0,18	115,9	7,2
Esters	40,5	–	448615	–	2395	–	∞	11077
Methanol,%	0,18	0,0003	2,69	0,0023	0,49	0,0003	600	14,9
Fusel oil	105882	726,9	726463	1179,8	3113	0,88	145,7	6,9

The analysis of the received results has shown that at prolongation of time of stay of a liquid on sagging plates up to 40 s ester and isopropyl alcohol are completely removed. It is known that by the content of isopropanol the quality and power of distillation units are estimated. The degree of extraction of higher alcohols of fusel oil and methanol increased by 38%, the multiplicity of concentration of head impurities

increased by 25%, of upper intermediate impurities – by 40%, of end impurities – by 37% in comparison with a typical installation operating in stationary mode. It is established that in the cyclic mode of rectification the specific consumption of heating steam in the process of distillation of alcohol-containing fractions decreased from 25 to 16 kg/dl a.a., introduced on the feeding plate, and in the process of epuration of draga distillate – from 15 to 8,2 kg/dl a.a. in comparison with column apparatuses operating in stationary mode. After inclusion of an experimental acceleration column in the scheme of distillation unit the output of distilled ethyl alcohol increased by 3,8%. According to all indicators, the ethyl distilled alcohol obtained met the requirements for the variety «Lux».

The expected payback period of the upper stage does not exceed 5 months.

Conclusion

The authors proposed the technology of cyclic rectification in column apparatuses equipped with barbotage perforated plates with variable free cross-section. Experimental data of the maximum permissible steam velocity in the free section of the column and barbotage openings of meshts and scales plates during the period of mass transfer and liquid overflow are obtained.

It is established that the increase of the time of liquid stay on the plates up to 40–60 s in the chosen hydrodynamic mode allows to increase the degree of extraction and the multiplicity of concentration of head, intermediate and end impurities by 25–40%, and the instantaneous change of the steam speed in the barbotage holes below the critical one allows to reduce the liquid overflow time to 1–2 s and thus to increase the throughput of the column apparatus. Due to the increased phase contact time, the specific heating steam consumption in the processes of distillation of alcoholic fractions and epuration of fermented distillate is reduced by at least 36% in comparison with column units operating in stationary mode.

The expected payback period of the proposed energy-saving mass transfer column apparatuses of cyclic action does not exceed 5 months.

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Application of pumpkin seed powder in sponge cakes

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Abstract

In this study, the physical, color and sensory properties of sponge cake supplemented with two different levels of pumpkin seed powder (0, 5 and 10%) were evaluated. Sensory evaluation of sponge cakes with pumpkin seed powder revealed very high consumer acceptance. In this studying the volume of the cakes with pumpkin seed powder was smaller than this of cake control (255.00 ± 5.07 cm^3) as the volume of the cake with 5% pumpkin seed powder had the smallest volume (229.00 ± 5.17 cm^3). The greatest porosity was observed in the cake control (65.62 ± 1.41%) and cake with 5% pumpkin seed powder (64.20 ± 1.00%). The water-absorbing capacity of the cake control (312.60 ± 3.15%) is the lowest than that of the cakes with 5 and 10% pumpkin seed powder. The lowest values for chroma were detected at the crust for the cake containing 10% pumpkin seed powder as fiber source. The color of crust and crumb on the control was similar to that of the cake with 5% pumpkin seed powder.

Key words: *sponge, cake, pumpkin, seed.*

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DOI: 10.24263/RES-2019-8

Introduction

Now-a-days, consumers are much more concerned about their health and demand the food products conferring health benefits with reduced calories, low sugar content, high protein and dietary fiber. Consumers also look for the products that are more natural-like.

Pumpkin belongs to the family *Cucurbitaceae* and is widely grown vegetable all over the world. Pumpkin processing into puree, juice, candied fruit and pumpkin seed oil results in large amount of by-products. Pumpkins are rich in carotenoids, vitamins, minerals, pectin and dietary fibre. Pumpkin seed has received considerable attention in recent years because of the nutritional and health protective values of the seeds. The seed is an excellent source of protein and also has pharmacological activities such as anti-diabetic, antifungal, antibacterial, anti-inflammation activities and antioxidant effects. Besides, the pumpkin is economical and a nutrient dense source, the pumpkin seed. flour fortified complementary food mix is economical, with highly acceptable

sensory qualities and a rich nutritive value, quoted that, pumpkin seeds offer a nutritious, sweet, somewhat soft and chewy snack or food additive [1]. They also have omega 3 & omega 6 fatty acids needed for hormone balance, brain function and skin health. Tryptophan present in these seeds aids in milk production in lactating mothers and used to reduce postpartum swelling of the hands and feet. Hence Pumpkin seeds serve as a good nutritious snack and helps in promoting good health. Pumpkin seeds have one of the highest levels of antioxidants of any nut, seed or food [2]. Fresh seeds of Cucurbita moschata contain moisture, 28.5%; protein, 37.7%; and ash, 4.4%; where as, dried pumpkin seeds contain moisture content of 5.6%, protein content of 37.4% and ash content of 4.4% [1]. Pumpkin seeds are reported to be a excellent source of B-complex vitamins, proteins and also has pharamacological activities such as anti-diabetic, antifungal, antibacterial and anti-inflammation and antioxidant. Pumpkin seeds are rich in exogenous amino acids (e.g. lysine, thyrosine, tryptophan, methionine) and in iron (96 ± 33 ppm), thus being recommendable to children and adolescents often prone to iron deficiencycaused anaemia [3]. The addition of pumpkin seed flour to this product, conducted to an increased of the total essential amino acids, protein, fat and mineral content, showing that the pumpkin seed flour is a good source of protein and nutrients for bread fortification [4]. All those specificities of pumpkin seed flour make it a potentially valuable additive to sponge cakes.

This study had investigated the effects of the addition of pumpkin seed powder on the physical, color and sensory characteristics of sponge cakes.

Materials and methods

Cake preparation. Materials for production of sponge cakes were wheat flour, sugar, eggs, defatted pumpkin seed powder from local market. The control cake was prepared, following a traditional technology and formulation [5]. The batter formulation of the control cake was as follows (based on flour weight): egg yolk 43.23%, egg white 96.77%, granulated sugar 83.87%, and wheat flour 100%. In particular, a double mixing procedure was applied by partitioning whipping of whites and egg yolks. Defatted pumpkin seed powder was added into sponge cake flour at different levels 0, 5 and 10%, by replacing wheat flour, respectively. Each sponge cakes batter of 95 g was poured out into metallic forms and baked in an electric oven at 180°C for 30 min. The sponge cakes were stored at standard conditions (at temperature of 18°C and 75% relative humidity). The humidity and the temperature were kept constant by means of a desiccator supplied with psychrometer, and put in a thermostat with accuracy of ± 0.5°C.

Physical characteristics. The specific gravity of the sponge cake was calculated by dividing the weight of a standard batter cup with the weight of an equal volume of distilled water, at batter temperature (20.8± 0.5ºC) [6]. The physical characteristics of the sponge cakes were determined 2h after baking. Volume was measured by the small

uniform seed displacement method [7], and and porosity was assessed according to the Bulgarian State Standard method [8]. The porosity of sponge cake was defined as the ratio between the volume of the air-pockets in the cake crumb and the volume of the crumb. The porosity determination was performed using a cylinder driller. The specific volume was expressed as the ratio of the sponge cake volume to its mass. The water-absorbing capacity of the sponge cake was measured by the extent of biscuit swelling according to the Bulgarian State Standard method [9].

Color characteristics of sponge cakes. The instrumental measurement of the cakes color was carried out with a colorimeter Color-guide 45/0 Colorimeter, BYK-Gardner Inc, USA, and the results were expressed in accordance with the CIELAB system. Color was measured at four predetermined places of the sponge cakes crust and crumb. The parameters determined were L* (L* = 0 [black] and L* = 100 [white]), a* (–a* = greenness and +a* = redness), b* (–b* = blueness and +b* = yellowness). Colorimeters give measurements that can be correlated with human eye-brain perception, and give tristimulus (L*, a* and b*) values directly.

Chroma, C*, is the aspect of color in by which a sample appears to difference from a gray of the same lightness or brightness, as defined by the following equations:

$C^*=\sqrt{a^{*2}+ b^{*2}}$.

The total color difference (ΔE*) between the control cake and the sponge cakes with functional ingredients was calculated as follows:

$\Delta E^*=\sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 +(\Delta b^*)^2}$,

as: $\Delta L^*= L_1 – L_0$; $\Delta a^*= a_1 – a_0$; $\Delta b^*= b_1 – b_0$.

The values used to determine if the total color difference was visually obvious were the following.

$\Delta E^* < 1$ color differences are not obvious for the human eye;

$1 < \Delta E^* < 3$ color differences are not appreciative by the human eye;

$\Delta E^* > 3$ color differences are obvious for the human eye [10-11].

Sensory characteristics. The descriptive test for a quantitative sensory profiling was used to establish the sensory characteristics (shape, color, cell size and uniformity, odour, sweetness, aftertaste, crumb tenderness) of the sponge cakes, 6 h after baking, following the ISO 8586:2014 and ISO 13299:2016 methods [12-13]. The sponge cakes samples were ready 1 h before the evaluation. Samples of different cakes were kept in coded plates covered with aluminium foil. Twelve trained panelists were selected to guarantee the evaluation accuracy. The intensity of each sensory characteristic was recorded on a ten-point linear scale after 1 h orientation sessions of the panelists, where they specified terminology and anchor points on the scale. The coded samples were shown simultaneously and evaluated in random order among the panelists.

Results and discussion

The developed recipe composition of sponge cakes with an additive of pumpkin seeds was prepared by the replacement of wheat flour with defatted pumpkin seed powder in quantity 5% and 10%. The recipe compositions of the control sample and the investigated cakes containing an additive of defatted pumpkin seed powder are presented in Table 1.

Tab le 1

Sponge cake batters formulations

Ingredients	Amount based on:		
	Flour weight [%]	Flour mix (wheat flour and defatted pumpkin seed powder) weight [%]	
	Control sample	With 5% defatted pumpkin seed powder	With 10% defatted pumpkin seed powder
Yolk of egg	43.23	43.23	43.23
White of egg	96.77	96.77	96.77
Refined granulated sugar	83.87	83.87	83.87
Wheat flour type 500	100.00	95.00	90.00
Defatted pumpkin seed powder	-	5.00	10.00

The stages of technology were kept because of their easy fulfillment and the considerably small duration of the technological cycle. The sponge cakes containing defatted pumpkin seed powder were processed at constant regime of baking concurrent with that of the control sample, which according to the technological instruction was baked for 30 min at 180 °C.

The addition of pumpkin seeds powder in sponge cakes improves their physical characteristics (Table 2). Specific gravity in cake batter provides an indication of the total air holding capacity of the batter. Low specific gravity values indicate good incorporation of air, yielding a higher final volume after baking; however, many other factors also affect this quality parameter. The difference in respect the specific volume between the control cake-sample and the sponge cakes with pumpkin seed powder is minimal. In this studying the volume of the cakes with pumpkin seed powder was smaller than this of cake control (255.00 ± 5.07 cm^3) as the volume of the cake with 5% pumpkin seed powder had the smallest volume (229.00 ± 5.17 cm^3). The greatest porosity was observed in the cake control (65.62 ± 1.41%) and cake with 5% pumpkin seed powder (64.20 ± 1.00%). The water-absorbing capacity of the cake control (312.60 ± 3.15%) is the lowest than that of the cakes with 5 and 10% pumpkin seed powder.

Table 2

Physical characteristics of the sponge batters and cakes

Physical characteristics[a]	Sponge cake types		
	Control sample	with 5% pumpkin seed powder	with 10% pumpkin seed powder
Specific gravity (for batter)[b]	0.75 ± 0.04^{c}	0.79 ± 0.02^{d}	0.80 ± 0.01^{d}
Volume, cm^3	255.00 ± 5.07^{c}	229.00 ± 5.17^{d}	235.00 ± 7.95^{d}
Specific volume, cm^3/g	3.56 ± 0.11^{c}	3.40 ± 0.21^{c}	3.17 ± 0.09^{d}
Porosity,%	65.62 ± 1.41^{c}	64.20 ± 1.00^{c}	63.88 ± 1.03^{cd}
Water-absorbing capacity,%	312.60 ± 3.15^{c}	317.20 ± 3.07^{d}	321.37 ± 4.00^{d}

[a] The values are mean ± SD ($p < 0.05$).

[b] The temperature of the batter is on the average 20.7 ± 0.5^{0}C.

[c-d] The values in a line with identical letters do not different statistical significantly ($p < 0.05$).

Color characteristics of sponge cakes

Measurements of color properties for the tested compositions of sponge cakes with functional components were conducted on crust and crumb of fresh cakes (Figure 1 and Figure 2).

Crust color of cakes. The lightest samples (highest L* values) were control cake (56.21±2.23) present in Figure 1. The control and cake with with 5% pumpkin seed powder have the highest values of b* (yellow component) indicating a significantly brighter and more saturated yellow color. The lightness, a* and b* values for control were not significantly different from those of the cake with pumpkin seed powder. The control cakes had the highest value of chroma of crust. The lowest values for chroma were detected at the crust for the cake containing 10% pumpkin seed powder as fibre source. According to these results, cakes with functional component – pumpkin seed powder where the ΔE* was appreciable by the human eye (ΔE*> 3).

Crumb color of cakes. The variations in the crumb color of the cakes with functional components as flour replacer were similar to the variations in crust color (Figure 2). The cake with with 5% pumpkin seed powder was the lightest and the b* values showed that this sample had a brighter color. The crumb color on the control sample was similar to that of the cake with einkorn wholemeal flour. The lowest values for chroma were detected at the crumb for the cake containing 5% pumpkin seed powder. According to these results, cakes with 10% pumpkin seed powder where the ΔE* was appreciable by the human eye.

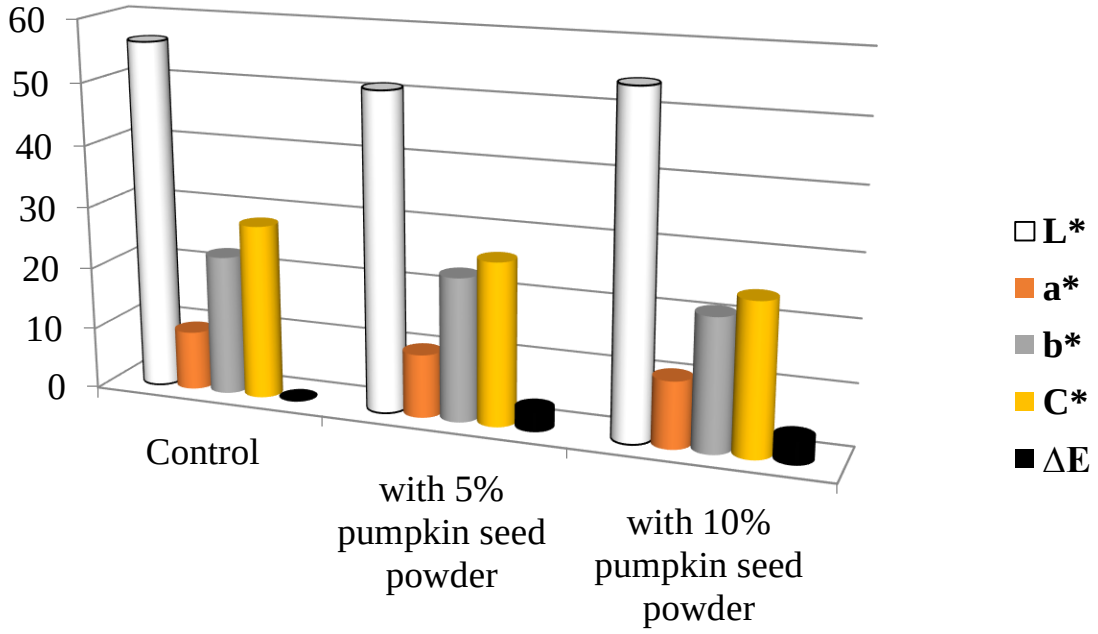

Figure 1. Crust color values of sponge cakes

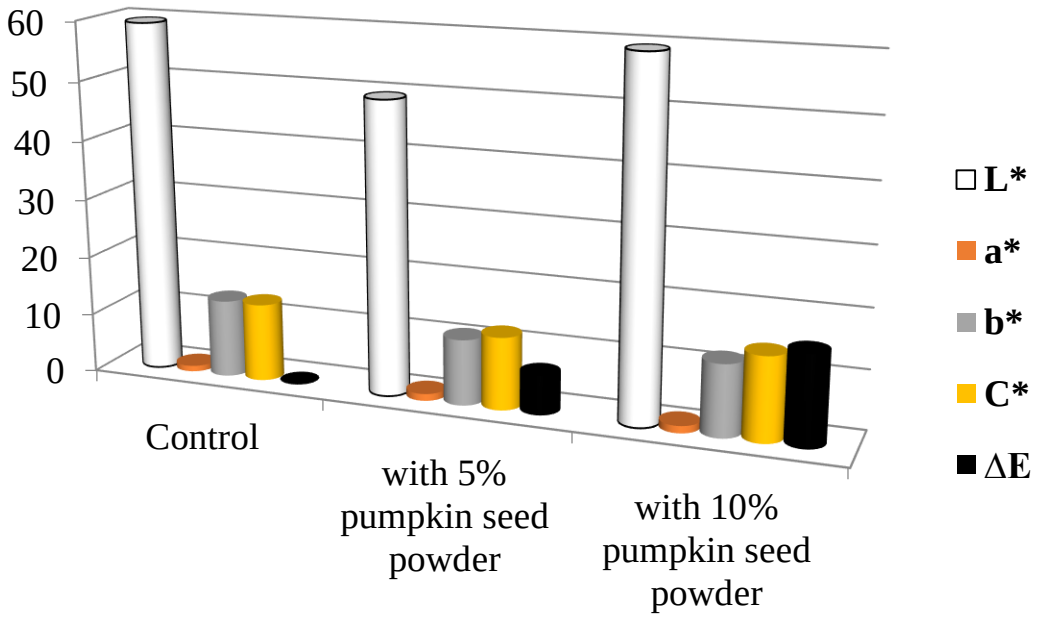

Figure 2. Crumb color values of sponge cakes

Sensory evaluation

Taste is the primary factor in determining the acceptability of any product and has the highest impact in determining the market success of product.

The sponge cakes containing an additive of pumpkin seed powder have good sensory characteristics present in Table 3. The sensory analysis demonstrates that the structure is fine-porous in all kinds of investigated sponge cakes. The control cake and the cakes with pumpkin seeds have approximately similar form. The crumb pores of cakes with pumpkin seeds in the investigated three kinds of cakes are with thicker walls, small and equal in size. The odour of the cakes with pumpkin seeds is perceived as more pleasant than the control cake-sample one. The color of the cakes with pumpkin seeds is perceived well from the testers. The intensity of the sweetness for all investigated sponge cakes is close, but when the concentration of the pumpkin seed is greater a bitter aftertaste is read.

Table 3

Sensory characteristics of the sponge cakes

Sensory characteristics[a]	Sponge sucrose-sweetened cake type		
	Control sample	5% pumpkin seed powder	10% pumpkin seed powder
Shape	8.58± 0.26[c]	8.31± 0.97[d]	8.04 ± 0.71[d]
Color	8.00 ± 0.74[c]	6.42 ± 1.05[d]	6.49 ± 1.02[d]
Cells size and uniformity[b]	8.42 ± 1.02 [c]	7.46 ± 1.16 [d]	7.77 ± 1.12 [d]
Odour	7.52 ± 1.19[c]	7.78 ± 2.40[d]	7.66 ± 2.07[d]
Sweetness	6.07 ± 1.08[c]	5.54 ± 1.26[d]	5.77 ± 1.35[d]
Aftertaste	2.46 ± 2.48[c]	1.62 ± 1.99[d]	1.83 ± 1.92[d]
Crumb tenderness	8.51 ± 0.75[c]	8.32 ± 1.65[d]	8.15 ± 1.56[d]

[a] The values are mean ± SD ($p < 0.05$).

[b]A scale from 0 to 9 was used to evaluate sensory characteristics. Nine is ideal for the third sensory characteristic when the cells are small and equal in size.

[c-d] The values in a line with identical letters do not differ statistical significantly ($p < 0.05$).

It was observed that the higher crumb tenderness scores for control resulted an increase in the overall liking values. The all cakes have similar shape (Table 5). The crumb pore cells of the cake with 5% pumpkin seed powder had thicker walls, and they were larger and equal in size. The cells of the sponge cake-control were smaller and almost uniformly distributed in the crumb, with thinner walls. The cake-control had a crust and crumb with more pronounced light-yellow colour due to the presence of the color components in the yolks of the egg (carotenoids). The colour of the crust and crumb of the cakes with 5% and 10% pumpkin seed powder are light-brown with light-green nuance. The odour of the all cakes is perceived by the sensory panelists as pleasant. The intensity of the sweetness for all investigated sponge cakes is close.

Conclusions

This study investigated the potentials of pumpkin by-products in sponge cake production. The physical and sensory characteristics of the sponge cakes with 5% and 10% pumpkin seed powder are juxtaposed with those of the control sample. The color on the control was similar to that of the cake with 5% pumpkin seed powder. The lightness, a* and b* values for crust control were not significantly different from those of the cake with 5% pumpkin seed powder. The crumb color on the control sample was similar to that of the cake with pumpkin seed powder. According to these results, cakes with 10% pumpkin seed powder where the ΔE* was appreciable by the human eye. On the grounds of this we consider that newly prepared products have good qualitative characteristics, and they are suitable as intermediate products in confectioneries designed for rational and functional nutrition.

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Improvemen of technology of low-calorie diet beer

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Abstract

The technology of low-calorie diet beer using inulin-containing raw materials of plant origin, namely chicory root, is researched. For the preparation of low-calorie diet beer, it is proposed to introduce into the malt mash at the beginning of the rubbing of an aqueous extract of chicory obtained by extraction of water-soluble substances of crushed dried at a temperature of 80 °C to a moisture content of 12–14% of root vegetables, in the amount of 3–10% by weight of malt, in the ratio of water 1:(4–7), temperature 70–80 °C for 40–60 min and enzyme preparation inulinase. The resulting mash is then kept at 55–56 °C for 20–30 min until complete hydrolysis of inulin. The introduction of bitter chicory in the wort allows to reduce the expense of bitter hops by 25–30% compared with traditional methods and to increase the stability of beer to 90 days without pasteurization. Substitution of chicory malt makes it possible to obtain new varieties of high biological value beer by enriching the product with inulin, trace elements and other biologically active compounds of vegetable raw materials, reducing the content of dextrins, reducing carbohydrates and energy in the finished product. fermentation of beer wort, as well as increase the value of the bread.

Keywords*: chicory, mash, wort, beer, inulin, aqueous extract, hops.*

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DOI: 10.24263/RES-2019-9

Introduction

Consumers who are forced to consume low-calorie foods have increased their interest in dietary and diabetic beers [1, 8, 9]. In such varieties of beer the content of carbohydrates (glucose, sucrose, maltose, low molecular weight dextrins, starch and products of its hydrolysis), alcohol, as well as the caloric content of the product are limited. The production of low-calorie beer is possible provided that the beer wort is cooked with the maximum content of fermented substances [11]. The degree of digestion of low-calorie beer reaches 80–90%. For its preparation as unsweetened raw materials use vegetable raw materials therapeutic and prophylactic action, enriched with carbohydrates, which are easily absorbed by the human body. Diet beer is low in dextrins, reducing carbohydrates, low energy (calorie) and nutritional value (in carbohydrates) [3–5].

The aim os reseach is impovement the low-calorie diet beer by increasing the degree of fermentation of wort carbohydrates, biological value and stability of beer during storage through the enrichment of the components of fresh inulin-containing raw materials that are easily absorbed by diabetics, and bitter nutrients.

Materials and methods

Research methods – analytical, chemical, physico-chemical, using instruments and research methods used in beer production.

Analysis of aqueous extracts of dried and roasted chicory, beer wort and beer was performed according to traditional methods [4].

Results and discussions

The main raw material for the preparation of wort is soluble malt with high amylolytic activity and protein content of up to 10%. Known methods for the production of diet beer include increasing the consumption of hops by 40–50% to cover the empty taste of beer, which is a consequence of deep digestion of carbohydrates, which leads to an increase in the cost of beer [4, 5, 7].

One way of expanding the range and preparation of low-calorie diet beer is the use of inulin-containing raw materials of plant origin, which helps to reduce blood sugar, normalize metabolism, improve the immunological status of the organism, remove from it slag, toxins and other substances. Inulin-containing raw materials include chicory, Jerusalem artichoke, dahlia, burdock, medicinal dandelion, etc. The most promising raw material for beer production is chicory and Jerusalem artichoke. The most valuable component of chicory and Jerusalem artichoke is inulin, a polysaccharide that has therapeutic and prophylactic properties and, unlike starch, is readily absorbed by diabetics. Its content in fresh root crops is 60.8–65.0%, in dried root crops – 51.7–59.7%, in fried – 25.9–28.0% on dry matter (DM). Inulin has low calories. In its presence, the shelf life of the food is increased. The final product of inulin hydrolysis is fructose, which is not harmful to diabetic patients. Along with pure inulin, chicory contains a significant amount of inulides (fructose polymers with less polymerization), pectin, cellulose, organic acids, amino nitrogen, amino acids, vitamins, macro- and microelements, as well as valuable bitter substances (glycosidic, ataraxatol, etc.). The concentration of bitter substances in fresh roots is 0.18–0.32% on DM, bitterness index is 1:600 [2–4, 6, 7].

Known methods of preparation of light and dark beer include the introduction into the beer wort of aqueous extracts of potatoes or aerial parts of Jerusalem artichoke, dry powders with a moisture content of not more than 14% relative to malt from 1:100 to

1:16 based on DM, concentrated aqueous extract. chicory in the amount of 2...7% or crushed dried root vegetables in the amount of 4...10% by weight of grain products, adding to the porridge enzyme preparation «Diazim X4» and others [1, 5, 6]. Their use makes it possible to obtain new varieties of high biological value beer by enriching the product with inulin, trace elements and other biologically active compounds of vegetable raw materials, reducing dextrins, reducing carbohydrates in the finished product, reducing nutritional content and energy.

The main disadvantages of these methods are the increase in the cost of beer due to the increase in the cost of expensive hops due to the absence of bitter substances in the composition of Jerusalem artichoke roots and their low content in concentrated aqueous chicory extracts. In addition, the use of an aqueous extract of roasted chicory for the preparation of dark beer leads to a decrease in the content of amine nitrogen, vitamins, pectic substances, fibers and water-soluble carbohydrates due to their loss during roasting of roots at high temperatures. The absence of a temperature break, which is optimal for the action of the inulinase enzyme, reduces the degree of fermentation of the wort.

To solve this problem, it is proposed (patent of Ukraine according to the invention № 115398) to apply malt puree at the beginning of puree from an aqueous extract of chicory obtained by extraction of water-soluble substances, crushed dried at 80 °C to a moisture content of 12–14% of root crops, in the amount of 3–10% by weight of malt, in a ratio of water 1: (4–7), temperature 70–80 ºC for 40–60 min, and the enzyme preparation inulinase, maintain the paste at a temperature of 55– 56 ºC for 20–30 min until complete hydrolysis of inulin. This method eliminates the negative effects of high temperatures to preserve bitter chicory.

A temperature of 55–56 °C is optimal for the enulinase enzyme. Within 20– 30 min, inulinase completely hydrolyzes inulin to fermented carbohydrates, thereby increasing the degree of digestion of diet beer and reducing its caloric content [4].

As can be seen from the table, the use of dried chicory root can additionally enrich the beer wort with valuable biologically active substances and increase the feed value of the pellets due to the increased chicory pectin content.

In the extract obtained from dried root crops, the content of inulin is 48% higher than its concentration in the extract obtained from fried chicory, the content of alcohol-soluble carbohydrates – by 35%, the protein – by 320 times, the protein – by 30%, the concentration of amino acids – in 30 times. But the active acidity of the aqueous extract coincides with the acidity of the cluster of malt and is optimal for the hydrolysis of starch. Amine nitrogen and amino acids introduced into the chicory wort are the nutrition source of the yeast. The introduction of bitter chicory bridges helps to reduce the consumption of bitter hops by 25–30% compared to traditional methods and increase the stability of beer.

To prepare the extract, dried chicory in the amount of 3–10% Bx. The grains are poured into the extractor, mixed with water in a ratio of 1:(4–7) and maintained at 70–80 °C for 40–60 min. The hydraulic module is calculated depending on the desired DM concentration in the starting wort.

Table 1

Comparative characteristics of the physical and chemical parameters of aqueous extracts of dried and roasted chicory

Name of the indicator	Aqueous extract of chicory	
	dried	fried
Content: DM,%	15,2	17,1
inulin,% in terms of DM	54,5	28,0
alcohol-soluble carbohydrates,% in terms of DM	24,7	19,0
pectic substances,% in terms of DM	1,0	0,42
total nitrogen, g /100 g of extract	1,012	0,845
of amine nitrogen, mg /100 g of extract	409,3	13,4
protein, g /100 g of extract	6,47	5,28
aminoacids, g /100 g of extract	2,35	0,084
Active acidity (pH)	5,3	4,3
Titrated acidity, deg	0,5	0,9

At temperatures below 70 °C, the solubility of inulin decreases, its intensity is extracted, and favorable conditions for the development of microorganisms are created. At temperatures in excess of 80 °C, the chicory bitters are destroyed, the consumption of sugars and amino acids for the formation of melanoidins increases. It is established that the maximum extraction of water-soluble chicory substances is reached in 40–60 min.

The method of preparation of low-calorie diet beer is as follows. For protein hydrolysis, light brewed malt is ground and mixed with water at a temperature of 45–47 °C in a ratio of 1:(4–5) in a mash machine and kept for 20–30 min with constant stirring. When mixing aqueous chicory extract with malt congestion, the temperature of the mixture is raised to 55...56 °C. At this temperature, the enzyme preparation of inulinase (for example, «Xyloglucanophoidin P10X» in the amount of 0.6–0.9% by weight of chicory, «Fructozume l», «Aspergillius awamori 2250», «Diazim X4» or other hydrolytic enzymes, is introduced into the mash. hydrolyzing polyfructans – inulin). At this temperature, the inulinase enzyme has maximum activity. After holding for 20–30 min, the congestion temperature is raised to 63 °C to continue enzymatic hydrolysis of inulin, maltose and malt starch. The mash was maintained for 30 min,

after which the temperature was adjusted to 70 ° C. The paste is maintained until the starch and inulin are completely saccharified. Then the saccharified mash is heated to a temperature of 76 °C and filtered. The resulting wort is boiled with hops, clarified and pumped into the fermentation shop. With boiling wort, the expense of bitter hops is reduced from 20 to 14–16 g/dal.

The beer samples obtained were characterized by a rich malt taste with hop bitterness and a pure hop aroma with pleasant tones of rye bread. Due to the high content of alcohol and bitter substances of chicory, the shelf life of beer was increased to 90 days.

Conclusion

For the preparation of low-calorie diet beer as unsweetened raw material, it is advisable to use fresh or dried to humidity 14% chicory root. The proposed method allows to reduce the cost of hops by 20–30% compared to the known ones. The introduction of the enulinase enzyme preparation and holding the congestion at a temperature of 55–56 °C for 20–30 min before complete hydrolysis of the inulin polysaccharide allows to increase the degree of beer fermentation to 90%. Obtained low-calorie diet beer in terms of organoleptic and physicochemical parameters fully comply with the current standarts requirements.

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Features of simulation of the technical parameters of the packaging line for single food products

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Abstract

The modern development of scientific and technological process is based on new directions in the creation and design of technical equipment and technical systems. In this article considers research results of packaging line work, as technical system, for single food products which includes different technical equipment. Creating a new product packaging line is involved the need for analysis, systematization of many parameters of constituent mechanisms, devices, modules, packaging equipment, transport systems and choose of optimal ones. The main parameters for the selection of equipment are technological; technical; conditions of compatibility of mechanisms, devices, modules; overall dimensions and weight, electric energy consumption indicators; economic indicators; efficiency of capital costs for its purchase, place and put into operation; payback period of the packaging machine or line. To organize a multi-stage packaging process is necessary to solve the following problems: to distribute the flow of products between the same modules to increase line productivity, to determine the required amount of modules, to determine the operating modes and required productivity of all packing line modules, to create a single orderly lined product stream from many ones in the final stages of packaging, to ensure uniformity of output product based on a uniform calculated clock cycles. Research of the products moving at the stages and levels of packaging, analysis of the intensity of products moving in transport systems and modules give the opportunity to visual observe of the products moving; to find an optimal load and number of the same type of modules; to distribute the products flow between them; to find rational kinematic parameters for work of transport systems and modules; to provide product moving incessant during changing product moving direction and distributing streams during forming a one stream from several; to ensure a uniform release of products based on the same calculated clock cycles of line packaging.

Key words: *packaging, transporting, food.*

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DOI: 10.24263/RES-2019-10

Introduction

Creating a new packaging line is related to the need for analysis, systematization of many parameters for mechanisms, devices, modules, packaging equipment,

transport systems and a choice of rational ones [1–5]. The analysis of technical system components which is based on the principle of functional and modular equipment construction was performed with using a multi-stage packaging process and providing a streaming production method. To organize a multi-stage packaging process is necessary to solve the following problems: to distribute the flow of products between the same modules to increase line productivity, to determine the required amount of modules, to determine the operating modes and required productivity of all packing line modules, to create a single orderly lined product stream from many ones in the final stages of packaging, to ensure uniformity of output product based on a uniform calculated clock cycles. A multi-stage packaging process that provides a streamlined production method takes place for packing machines, machine to machine transport systems and handling devices of the packaging line.

The choice and justification of rational parameters in compliance with a type of product, organization of the packaging process, choice of package type, a type of material are ensuring subject to minimal or limited using of production area. The main parameters for the selection of equipment are: technological (productivity, mode of operation, stage of universalization, level of automation, number of performed operations); technical (operating pressure and temperature, frequency of operating entities); conditions of compatibility of mechanisms, devices, modules; overall dimensions and weight, electric energy consumption indicators (in particular consumed electrical power, voltage, etc.); economic indicators (an indicator of the economic viability of using the same equipment in the production process); efficiency of capital costs for its purchase, place and put into operation; payback period of the packaging machine or line.

The purpose of the research is determining the rational parameters of the components of the packaging line by simulating a multi-stage packaging process and providing a streamlined production method.

Result and discussion

Consider the structure of a flow-technological line with different layout complexity and operating requirements.

The search for functional, parametric and criterion limitations and formulation of a multicriteria structural-parametric method of the packaging machine synthesis was conducted on the basis of functional modules (FM). Mathematically, the input parameters of a future FM modul that is a part of a streamed technological line (STL) are a set of values $x_1, x_2, \ldots, x_N$. These values describe the state of the system at some point in time $t = t_0$. Values x_i can take on any value, and two different sets of values x_1 and x_2 in accordance with two different states. These parameters were denoted as x_i, i=1,…n, given that the number of these parameters n can be large [6-12].

Connection between a design and a technological preparation of production is two-way process, because it is often necessary to modify the product specifications in

accordance with the existing equipment and vice versa. The correlation between input and output states (process mode P) is seen as mathematical transformation of vector X into vector Y:

$$\begin{cases} Y = F(X); \\ \varphi : X \xrightarrow{F} Y; \\ P : Res \to Prod, \end{cases} \quad (1)$$

where X, Y are in accordance with the set of resources spent and production volume.

An assessment of performance characteristics of the FM in accordance with conditions of operation of FPL is carried out during the modeling process. Information on failures and other defects, changes in operating conditions is used at design and development stage. The relationship between processes enables to measure and analyze of data, use corrective and preventive actions, use loss prevention methods, that will contribute to the continuous improvement of current and future projects and their efficiency. Process control involves control of interactions that helps to eliminate congestion or unnecessary energy costs.

Based on the analysis of the stages of operation of the functional module in the composition of the packaging machine or line, the following product levels were considered: 1- the product as an object that is exploited; 2 – the product as an object of manufacture; 3 – product as an object of improvement. The levels have direct and reverse relationships, that provide a continuous flow of information on the conditions of product using (technological system), and ensuring the product properties at the refinement and manufacture level. This approach makes possible to take into account all the functional features of the product operation in the process of its manufacture and improvement. Usually three heterogeneous components – the technical equipment complex (TEC), the software (S) and the operational staff (OS) can be identified as part of streamed technological system (STS) of the packaging line. These three components have influence on the effectiveness of the system results not in isolation but in close relationship, resulting in it is possible to adjust an efficiency of function performance of a component with help other two components. Such systems are multifunctional and the functions they perform can be significantly different, so the functional approach is used in many issues.

For our research in accordance with some *j*-th function of the technical, software and ergatic (man-operator or group of operators, personnel) groups of components involved in performing this function (Figure 1) are identified among other components. This group of components forms the *j*-th functional subsystem (*j*-a FSS or FSS*j*) in ethe provided system.

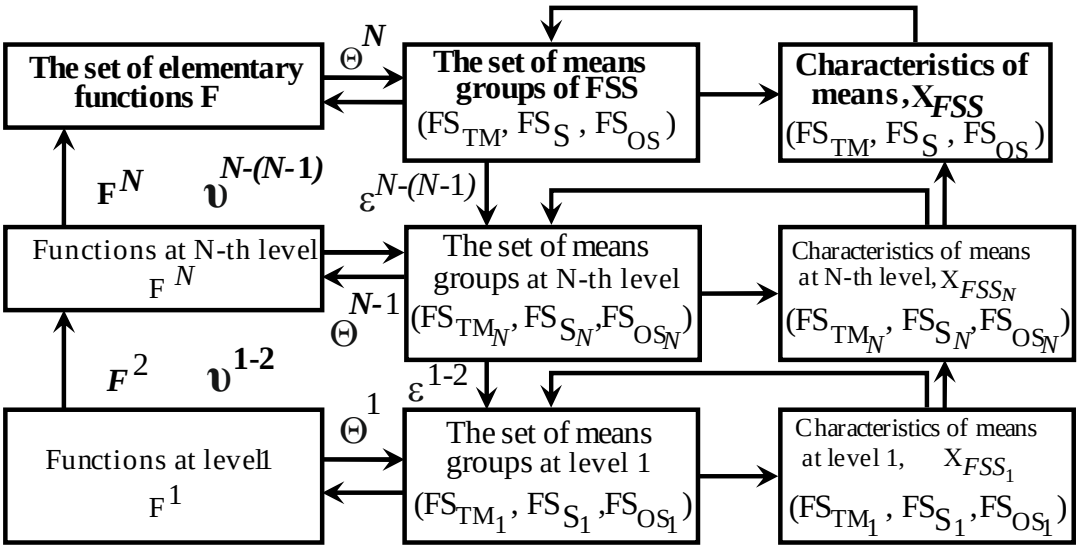

Figure 1. Hierarchical structure of a functional modular subsystem

Usually three components are parts of FSSj . There are a group of technical means that takes part in performance of the j-th function (j-th functional subsystem TM – FSTMj); a group of software that takes part in the performance of the j-th function (j-a functional software subsystem S – FSSj); a group of ergatics that takes part in the performance of the j-th function (j-th functional subsystem St – FSOS j). One of the most important components of the quality of a modern system, which largely determines the effectiveness of its operation in real operating conditions, is reliability. Trouble-free exploitation and maintenance are the main components of reliability for most systems under consideration.

All groups of means can be divided into two sets of components of the functional subsystem: ready at time *t* for using and not ready. As a result, set of components of system means can be described as:

$$FS = FS^{R} \cup FS^{R*} \cup FS^{R*,S}, \tag{2}$$

where FS^{R} – set of component is ready at time *t* for operating using*;* FS^{R*} – set of component not ready for operating using (incentive component); $FS^{R*,S}$ – sets of critical components of means system.

Complex indicators of FSS readiness are: the coefficient of readiness (C_R) and the coefficient of operational readiness (C_{OR}). The assessment of the reliability of staff functioning contains the probability of the uptime of the individual performer, taking into account the reliability of the related technical equipment and means of transferring information (software):

$$P_{FS_{OR}} = \left(P_0 P_1 \left[P_2 (1-P_0) + P_0\right] P_3 (1-P_4)\right)\left[1 - P_{FS_{TM}} (1-P_0)\right]^2, \tag{3}$$

where P_i – probability; P_0 – probability of perform necessary actions by the staff; P_1 – probability of a timely reception and information processing by software; P_2 – probability of the right decision made by the staff; P_3 – probability of correct a performance operations; P_4 – probability of control for performance operations and self-control; $P_{FS_{TM}}$ – probability of technical means failure. A description of the multifunctional reliability system is described for each function (for each FSS) separately. Finding a solution to a design assessment of a reliability system having *N* functions is to *N* -time repetition of the problem solution for one FSS. Three components (private subsystems – FS_{TM}, FS_S and FS_{OS}), failures (errors) are in FSS. There's a compliance between functions hierarchy and functional subsystem hierarchy. The relationship between the set of elementary functions (F) and the set of means groups (FS_{TM}, FS_S and FS_{OS}) is determined at all levels of the hierarchy. The function $F_{lj}^{\mu} \in F^0$ complies with a set of means types $\{FS_{lj}^{\mu}\}_Y$ (*j* – the hierarchy level function index, l – the hierarchy level function number) at each μ decomposition level. The means type provides a fundamental possibility of function performing. So multiple showing system F in the FSS subsystem is given.

The system of means is designed on the principle of relationships with levels and formed as a set of elementary means $FS = \{FS^0, FS^1, \ldots, FS^{\mu-1}\}$, each of them ensures the performance of each elementary function of the set $F = \{FS^0, FS^1, \ldots, F^{\mu-1}\}$.

The analysis of functional subsystems shows the multidimensionality of their indicators, so cluster analysis can be used in practical calculations. For proximate classification of functional subsystems It is necessary to carry out rationing of their indicators. One of approaches involves indicators transformation and showing their possible values in the interval [0; 1]. This is realized through system of the following equations:

$$\begin{cases} X_{FSS_{ij}}^{H} = \dfrac{X_{FSS_{ij}} - X_{FSS\min_j}}{X_{FSS\max_j} - X_{FSS\min_j}}; \\ X_{FSS\max_j} = \max\limits_i \left\{ X_{FSS_{ij}} \right\}, \\ X_{FSS\min_j} = \min\limits_i \left\{ X_{FSS_{ij}} \right\}, \end{cases} \quad (5)$$

where $X_{FSS_{ij}}^{H}$ – the rational *i*-th indicator of the *j*-th functional subsystem; $X_{FSS_{ij}}$ – the value of the i-th characteristic of the *j*-th functional subsystem.

The classification of functional subsystems by Shortest-path tree involves the design of the tree and calculating the average distance between *k* peaks which is taken as a boundary value:

$$\bar{\rho} = \frac{1}{n-1} \sum_{k-1}^{n} \rho_k. \quad (5)$$

Next, we define the maximum of the distances for which the inequality is true:

$$\rho_{k*-1} < \rho_{k*} < \rho_{k*+1}. \tag{6}$$

All found maximum values are compared with the limit value $\bar{\rho}$. Therefore, the functional subsystem can be shown as a set of hierarchically organized set: elementary functions of F^N, groups of means (FS_{TM}, FS_S and FS_{OS}) which participate in the implementation of the function at each level and their relevant characteristics X_{FSS}. The set of elementary functions of F^N defines the set of groups FSS_{iN}^N and elementary means (FS_{TM}, FS_S and FS_{OS}) with a way to use relationships Θ^N between them.

A set of characteristics $X_{FSS}{}^N \left(X_{FSSi}{}^N \in X_{FSS}{}^N\right)$ that ensure the effectiveness of perfomance functions is under limited parameters and formed inside the set X_{FSS}^N by relationships Θ^N.

Each component of the means system $FS_i \in FSS^0$ can be described without material Θ and energy ε relationships and using readiness R and forced F characteristics:

$$FS^0 = \bigcup_{\mu=1}^{N} FS^{\mu}\left(\Theta^{\mu}, \varepsilon^{\mu}, R^{\mu}, F^{\mu}\right). \tag{7}$$

The implementation of this approach shows the controlled formation of the specified STL properties. The process of creating a STL involves a consistent transformation of the needs for the implementation of the purpose into clearly formulated specific requirements.

The characteristics of the quality of products for industrial and technical purposes are determined by the type, composition, and range of parameters of functional subsystems and their components, which perform different functions in the design and manufacturing process.

Beneath is presented an example of a line for packing muffins in Figure 2 as a line for packaging single products with a multi-stage packing process.

The line includes an inlet conveyor belt 1. The muffins are arranged in a row of 6 pieces and move on this conveyor. Also the line includes handling devices 2 which stops the muffins on conveyor 1 and transports them on conveyor belts 3, modules 4 for flow pack packaging, modules 5 for packing muffins into a cardboard box, a module 6 for closing a carton box, a module 7 for making a group package, a manipulator 8, a pallet store dispenser 8, a module 10 for making a transport package, an outlet roller conveyor 11. The muffins are arranged in 3 by 3 in a carton box.

The conducted analysis of moving products and packaging materials was allowed to create a layout of material flows moving in the packaging line and to make a conclusion about the need for modeling the areas with the greatest complexity and a lot of technical equipment, specifically at the stage of making consumer cartons.

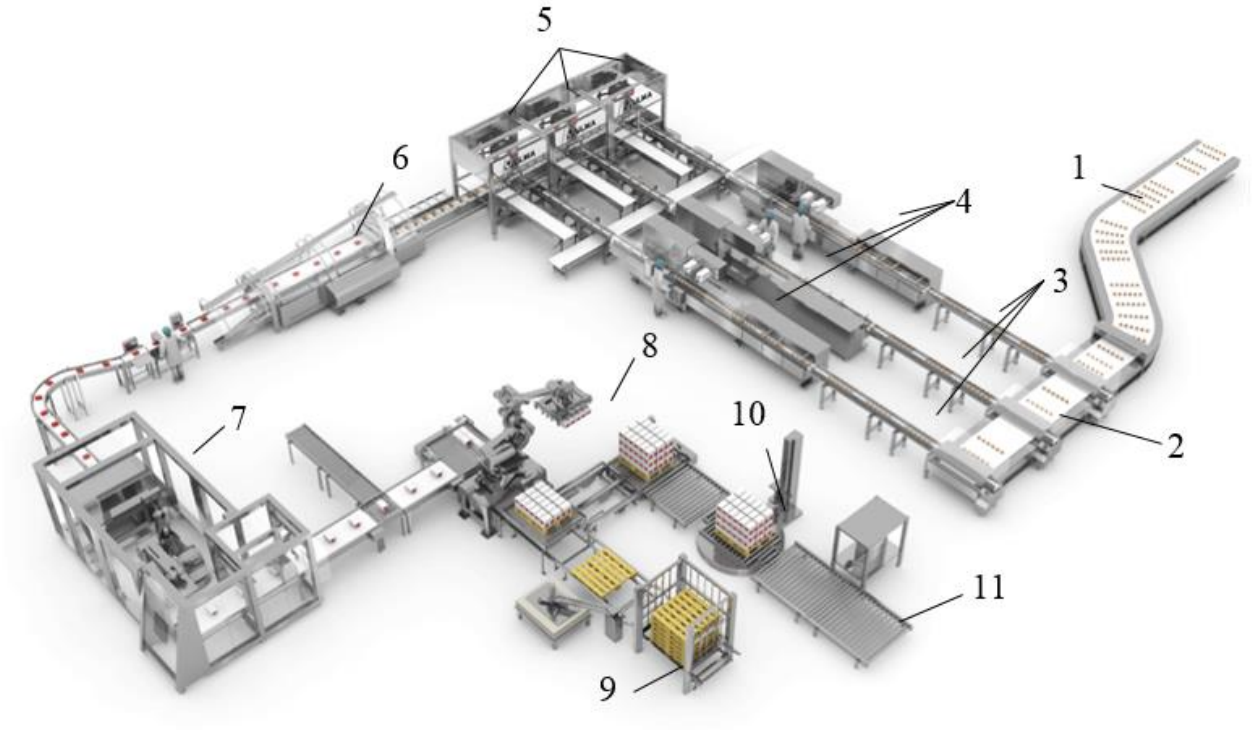

Figure 2. Muffin packaging line layout

The layout of muffin packaging line was designed according to the layout of material flow in the AnyLogic program. This layout includes simulation of muffins moving process and packaging muffins into a cardboard box (Figure 3).

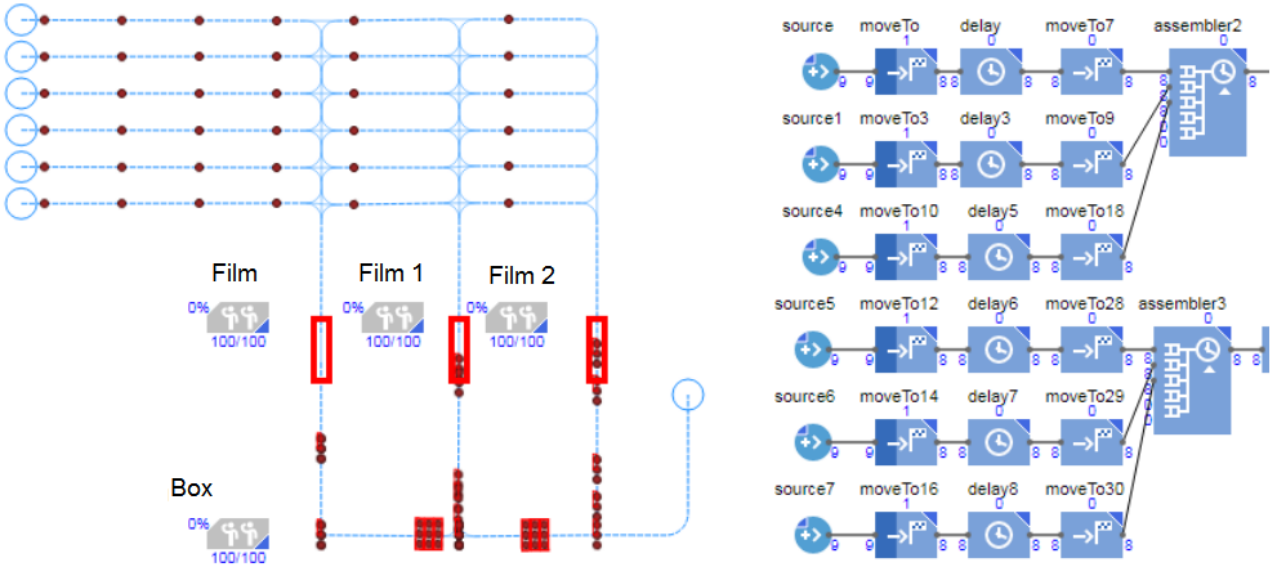

Figure 3. Simulation window for muffins moving which are packed into a cardboard box in the AnyLogic program

Conclusions

The result of the simulation is to determine the rational characteristics of work of the functional subsystem for product production. Improvement of existing and development of new methods of multicriteria synthesis for streaming technical system by the set characteristics which are based on systematic approach to the assessment of their quality and competitiveness, is relevant and extremely important task for the domestic engineering . Using the model of effective modes choice for realization of joint interaction of functional modular subsystems made possible to evaluate each machine-building product design in terms of costs for design, production and operation.

Visual observation of the products moving at the stages and levels of packaging, analysis of the intensity of products moving in transport systems and modules give the opportunity: to choose the need load of the same type of modules, to justify its optimal number, to distribute the products flow between them, to find rational kinematic parameters for work of transport systems and modules, to provide product moving incessant during changing product moving direction and distributing streams during forming a one stream from several, to ensure a uniform release of products based on the same calculated clock cycles of line packaging.

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Achieving competitive advantages in the production of baby food

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Abstract
It is considered the possibilities of increasing the competitiveness of baby food products. Competitive advantages of baby food can be achieved by providing traceability, digital product labeling and "traffic light" labeling, and customer-oriented product design. Consumers perceive traceability not as an additional parameter of food product quality, but as a mandatory right to obtain reliable information about the sources of raw materials, the production technologies used and ensuring the safety of the final product, its prescription composition, storage methods and conditions, and shelf life. Voluntary "traffic light" labeling helps consumers understand how the product meets the principles of healthy nutrition. Digital product labeling can reduce and even prevent the turnover of illegal products. The food product design process was studied on the basis of factor analysis, taking into account consumer, technological and economic factors. Developing a product that is attractive to a child is very difficult. This is due to the fact that it must take into account the possible responses of the receptors of almost all human senses.
Key words: *traceability, labeling, baby food.*

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DOI: 10.24263/RES-2019-11

Introduction

In the conditions of saturation of the food market with goods, it is still difficult for the consumer, especially in the field of baby food, to manage the advantages and disadvantages of the range of food products present in retail outlets. Today, the range of food products is evaluated by the consumer according to two sources of information available to them: labeling and organoleptic indicators. Therefore, to date, competitive advantages can be achieved by:

- Traceability;
- Labeling – "traffic light»;
- Digital product labeling;
- Customer-oriented product design.

Traceability requires establishing the integrity, reliability, and identification of the product at all production stages, including a quality and safety verification and certification system. Traceability helps the consumer to navigate when buying healthy food products, which should include, among other things, baby food. Requirements for the quality of life and health of a person at any age – from infancy to old age-are inextricably linked to a healthy diet [1].

Voluntary marking "traffic light" helps consumers understand how the product meets the principles of healthy nutrition. In accordance with the " traffic light» [7]:

– The red color indicates the content of more than 17.5 g of fat in the product (including 5 g of saturated fatty acids), 22.5 g of total sugar, 1.5 g of salt per 100 g of the product;
– The green color indicates that the product contains less than 3 g of fat (1.5 g of saturated fatty acids), 5 g of total sugar, and 0.3 g of salt per 100 g of product;
– Between the red and green zones, the content of critical food substances is indicated in yellow.

It should be noted that the term "total sugar" on this label consists of the sum of the sugars originally contained in the raw material and the added sugar added to the product formulation during its production.

The introduction of a digital labeling system is beneficial to the state (it can increase tax collection and make the market transparent), legal manufacturers will increase their revenue due to the growth of market share, and the consumer will be able to trust the quality and safety of the purchased product. At the same time, for each product group, digital labeling should include additional important information, such as expiration dates, the possible presence of allergens in the product (which is important for baby food, since children are more susceptible to allergies). If you compare the "traffic light" and "honest sign" labels, the latter is convenient because data on the nutritional value and safety of the product can be placed in a digital code [2].

As a priority, there is a need to mark many groups of food products in the assortment with a digital code – meat, dairy, fish, flavoring, baby food, etc. the Introduction of digital labeling will increase the cost of the final product, and it is still necessary to find a place on the packaging for its placement.

Another competitive advantage of baby food products is the use of customer-oriented design methodology. One of the most important tasks facing the food industry during the economic crisis is the introduction of new food products to the market that contribute to improving the financial position of the enterprise. The analysis showed that the reasons that determine the need for product development include: a decrease in the level of sales of the main products and market share, while the sales volumes of competitors remain the same; expansion of the product range by competing companies; reduction of the target audience for the main products of the company, despite the increase in advertising and marketing costs; the flow of target consumers from more expensive categories to cheaper ones; the appearance of new types of innovative products on the market. Research in the field of food design (food product design

(FPD)) allowed us to form five clusters of this process: defining goals and objectives and risk analysis; identifying the target segment of consumers and creating trial concepts; forming the final concept and creating a prototype; production of a pilot batch and trial marketing; launch of serial production and creation of a system for ensuring product safety and quality. The FPD process was studied on the basis of factor analysis, taking into account consumer, technological and economic factors. When designing new products, special emphasis is placed on risk assessment and management procedures. In the group of risks related to the loss of project management, the risks associated with the leakage of information about the design to competitors, the formation of a negative attitude to the product when entering the market are noted; with the possibility of significant changes in the composition of the FPD group. Economic risks primarily depend on underfunding the FPD process, increasing purchasing prices for raw materials, low product competitiveness, and not achieving the planned level of product quality. The FPD process is one of the most complex and time-consuming, but it can lead to a significant improvement in the financial and economic situation of the company if the new product is successful in the market [7].

Results and discussions

From the position of the world health organization, healthy nutrition is associated with the state's policy in the field of food production, food security, and providing children and adults with vital nutrients. Healthy nutrition is a combination of food ingredients in products that ensure growth, full development and normal functioning of the individual with constant use, and contributes to the prevention of diseases, health promotion and active longevity. Healthy food products are obtained from raw materials where pesticides and other plant protection products, mineral fertilizers, growth stimulants were not used, and animals were not fattened using antibiotics or hormonal veterinary drugs. In healthy food products, the presence of GMOs should be completely excluded. It is most promising to produce healthy food products using nanotechnology, which allows you to preserve biologically active substances in the processing of food raw materials.

Consumers perceive traceability not as an additional parameter of food product quality, but as a mandatory right to obtain reliable information about the sources of raw materials, the production technologies used and ensuring the safety of the final product, its prescription composition, storage methods and conditions, and shelf life [1].

The concept of introducing "traceability" in the agro-industrial sector and moving it beyond the borders of a single production is not new. Both the government and business have realized its need. However, if manufacturers thought about this in the first place to gain competitive advantages and optimize their business processes, then over time, traceability issues have become of strategic importance as the main tool for countering bio-terrorism. The main principles of traceability were laid down in the ISO

and HACCP standards, developed for the control of biological, chemical and physical risks of production. [1] Further, the need for traceability has been developed in a number of standards: HFS International Food Standar, BRC Global Standard, SQF 1000 Code, Global Food Safety Standards, etc. At the same time, the implementation of these standards within individual industries and network enterprises does not allow to solve the problems of countries and cross-country trade processes in a comprehensive way, since there are no coordinated mechanisms for communication and exchange between all market participants along the entire product chain and information data. Research results demonstrate the importance of traceability for the end user. So for 8 out of 10 consumers, "ingredient traceability" is the most important factor affecting the purchase of food products [6]. More and more consumers perceive traceability not as an additional parameter of product quality, but as an integral and mandatory right to obtain reliable information about the sources of raw materials, the production and safety technologies used, the composition of the final product and logistics features during distribution. Consumers are increasingly aware of the importance of completeness of information when choosing food, and this explains the effect of increasing aggregate consumer demand for "greater transparency" and "better ingredients"[1].

Consumers want to buy and consume healthy, safe foods and pay more for them if they get reliable information about their quality and safety. Marking should help the consumer with this. Marking refers to the means of commodity information and it has the highest proportion of fundamental and consumer information, and the lowest – on commercial. The most important functions of marking are distinguished: informational, identifying, motivational, and functional. Among them, the information function is the main one. It is implemented to a greater extent with the help of fundamental and consumer information, to a lesser extent with the help of commercial information.

The consumer wants to get information on the label that the product is healthy and does not contain undesirable components (for example, GMOs), as well as excessive content of free sugars, sodium, saturated fatty acids, transisomers of fatty acids (after hydrogenation of vegetable fats) [5]. A clear understanding of the component composition and traceability of prescription ingredients can give the consumer such guarantees. And here it is effective to apply additional color markings on the packaging of food products. This marking called "traffic light" has already been widely used in European countries, the United States, Latin America, and China [8].

There was an obstacle to the widespread introduction of the "traffic light" label. Consumers perceive red as a danger. But the "traffic light" label is intended to provide the consumer with visual information about the content of certain critical substances in the product (added sugar, salt, saturated and trans-isomers of fatty acids) for an informed choice in favor of a healthy diet. And this is especially important if the consumer has health problems, when excessive content of such substances in the purchased product can negatively affect health. Thus, the "traffic light" label contributes to the consumer's careful attitude to their health, and the manufacturer is

simply forced to introduce new technologies to improve the quality and safety of its products [4].

In some countries, such as the United States, all food producers with sales of $ 100 million in 2020 will be able to do so. and more are required to switch to color-coded mandatory labeling introduced by the U.S. Food and drug administration. In addition, requirements have been introduced to indicate the percentage of daily value of such critical substances for human health as added sugar, saturated and trans-fats. In Russia, guidelines were also developed – MR 2.3.0122-18.2.3 "Food Hygiene. Color indication on food product labels for the purpose of informing consumers." Currently, on the territory of the Eurasian economic Union (EEU), the color indication on the packaging of food products at the first stage is voluntary and is carried out in accordance with the above guidelines (MP). The first product for color display was dairy products. The following indicators can be displayed on the packaging of dairy products: red, green or yellow [9]. Unilever and Danon began using the "traffic light" label for food products.

Labeling can reduce and even prevent the turnover of illegal products. To do this, many countries have established national systems for digital labeling and product traceability. In this case, labeling means attaching a special code to each item sold at retail, which will help you track who its manufacturer is and how this product moved on the way from the manufacturer to the store where it is sold [3]. Leading positions in the field of digital labeling are occupied by North America, Europe and China. Digital labeling is in demand in the production and sale of food products.

There are a lot of traceability technologies available, and among them, the marking associated with the 2D matrix has become very popular [1].

The economic impact of the introduction of digital labeling is significant: in countries where digital labeling has been introduced, the number of falsifications has decreased by 30-40%. There are no uniform standards for implementing digital labeling – different models are being implemented in different countries. In the EU, digital labeling has been implemented for 7 years, and a centralized model is used: the IT system belongs to the state, and services related to code generation are provided by the operator, which is also controlled by the state [3]. In the USA, there is a decentralized market where six companies provide traceability services on commercial terms, and the government does not control the database.

The most popular and developed model operating in other countries is based on the principles of public-private partnership (PPP), when the state and business cooperate using a single centralized database. In particular, China is actively using digital labeling based on PPP principles. Manufacturers on a voluntary basis are willing to use digital labeling of their products to confirm their quality and safety. In Russia, the system of digital marking and traceability of goods called "Honest mark" is also formed on the principles of PPP. An honest mark will be assigned to each unit of the product. This is a unique digital code protected by cryptography that cannot be forged. The product code will consist of two parts-the identification code and the verification code [3]. The introduction of digital labeling will be based on two principles: the first

is based on the exclusive right of the state to access aggregated data and software; the second provides non-discriminatory access to data stored in the system, free of charge.

Before introducing anything into baby food, it makes sense to check it on "adult" food products. The marking of product samples produced by Belarusian enterprises was analyzed:

– Products of JSC "dyatlovsky cheese factory" – "Dutch new" young cheese (#1), "Capresi elite" cheese (#2);
– Products of JSC "Savushkin product" – drinking yogurt enriched with bifidobacteria fat-free with fruit filling (#1), drinking yogurt enriched with bifidobacteria with a mass fraction of fat 2.0% with fruit filling "strawberry-raspberry" (#2), yogurt product with a mass fraction of fat 1.5% with fruit filling "cherry" (#3), yogurt product with a mass fraction of fat 1.5% with fruit filling "pineapple" (#4);
– Products of JSC "Minsk dairy plant #1" – cheese glazed with vanilla flavor and fat mass fraction of 23.0% (#1), cheese glazed with cocoa and vanilla flavor with fat mass fraction of 23.0% (#2), cheese glazed with fat mass fraction of 23.0% with vanilla flavor (#3), cheese glazed with fat mass fraction of 23.0% with cocoa (#4).

During the analysis, the information provided on the product label was determined to meet the requirements of CU TR 022/2011 and the standards of the "technical conditions" type for the analyzed products.

The products of JSC "dyatlovsky cheese-making plant". Analysis of the product labeling of this company showed that it meets the requirements of regulatory documents. However, the packaging of these types of cheese does not contain recommendations for the use of the food product, and the sample number 1 "Dutch new cheese" does not specify the type of cheese. The analyzed samples have a small size of the marking font: the height and width are less than 1 mm. this significantly reduces the readability of the text and makes such marking of the product for the consumer low-competitive. The degree of contrast at this minimum font size still ensures the readability of the text, since the colors selected by the manufacturer for marking are polar and provide the desired contrast. In addition, it should be noted that there is a positive induction of colors, in which the selected white color has a favorable effect on the contrast color when compared with black, and the text becomes clearer, but still because of the small font, the text remains less readable.

Products of JSC "Savushkin product". In accordance with CU TR 022/2011, information about: name, product composition, food additives, flavorings, biologically active additives, ingredients of non-traditional composition, as well as the trademark, number of products, date of manufacture, shelf life, storage conditions, name and location of the manufacturer, recommendations for use, indicators of nutritional value, information about the presence of GMOs, mark of product circulation on the market, information about the regulatory document according to which food products are produced and can be identified.

However, for yogurt samples # 1 and # 2, the font height and width are less than 1 mm, while for samples #3 and #4, the contrast Ratio does not exceed 2 mm with such a minimum font size (especially less than 1 mm). The colors selected by the manufacturer for marking are not polar and do not provide the maximum contrast.

Products of JSC "Minsk dairy plant # 1". The requirements of CU TR 022/2011 for labeling glazed cheeses are met in the same volumes as for drinking yoghurts, which is indicated above. The background color of the packaging for all cheese samples is white, the text is dark blue, and this contributes to the perception of product labeling information. However, the small font size of samples # 1 and # 2 (height and width 1 mm) and even smaller for samples # 3 and # 4 (height and width 0.5 mm) does not contribute to the readability of the marking. In addition, the production date of samples #3 and #4 was partially erased during transportation of the product, and this is the result of its placement on the seam of the package.

Digital labeling of food products is just beginning to develop in the EurAsEU market. no one in the Republic of Belarus does this, but it is a guarantee of the authenticity of the product and confirmation of its quality and safety for consumers.

It is well known that correctly executed product labeling contributes to the success of sales. Today, the consumer often encounters a situation where it is impossible to read the marking information on the product due to the font size, contrast of the main background and font color, and all this reduces the competitiveness of the product and does not satisfy the consumer's request for sufficient, reliable and accessible information. It is no accident that changes were made to CU TR 022/2011 "Food products in terms of their labeling" related to the font size, contrast of the main background and font color.

Developing a product that is attractive to a child is very difficult. This is due to the fact that it must take into account the possible responses of receptors in almost all human senses. In the first place, obviously, should be located the taste buds of the language. At the same time, according to modern scientific ideas, a bright and memorable taste of a food product can not be provided by using the simplest combinations of shades of sour, sweet, salty and bitter. This is because the taste of food is really formed due to the presence in their composition of tens and sometimes even hundreds of different compounds, the identification of which is difficult to carry out even with the most modern analytical methods. It should be recognized that at present, in the field of creation and practical application of new flavoring food ingredients, impressive progress has been made. experts in the field of flavor chemistry have learned to give food products with a very different initial food matrix such original tastes and flavors that they become attractive to a wide range of consumers. Similar judgments can also be made about the design of the flavor and color that the product should have. The visual organs in the process of hedonistic evaluation are responsible for the perception of the appearance of a food product. In modern conditions, this means making high aesthetic requirements for industrial food packaging, since the vast majority of products are sold to consumers today in this form. Hearing and touch also contribute to the hedonistic quality of the food product. The exact placement of the

identified hedonic preferences in relation to the sensory indicators registered by the consumer's sensory organs will largely determine the commercial success of the food product being developed in the future. In addition, the consumption of food that is hedonistically attractive, as shown by the research of physiologists, objectively improves the process of its digestion and assimilation by the body. The relationship between the hedonistic appeal of a food product and its scientifically based health benefits is not simple and straightforward. From the point of view of the mathematical foundations of optimization theory, the taste of a food product and its health benefits are two different target functions. In this regard, it is almost impossible to achieve their simultaneous maximum for a single object. This is well illustrated by real-life examples. The greatest satisfaction is often delivered by products with a high content of sugar and fat, for example, confectionery, frequent consumption of which in large quantities can cause significant harm to human health. It can only be noted in this connection that a win-win strategy for including sweet and fatty components in food products in many cases has an objective evolutionary basis. In this regard, it should be remembered that a person previously managed to eat to his full not every day, and therefore when a food source appeared, he tried to get enough as quickly as possible and create certain energy reserves in his body. The easiest way to do this was to consume fats with their high calorie content, which is more than twice the energy value of proteins and carbohydrates. The possibility of consuming foods with a sweet taste was extremely rare, only when getting access to wild honey or ripe fruit. The widespread use of sugar and sugar substitutes in food products currently based on the dopamine pleasure theory has a simple rationale. The human body in the process of eating to create a sense of food saturation requires not only providing energy and plastic needs of the body, but also the allocation of a certain amount of free dopamine to form a sense of food pleasure. In this case, to achieve this effect, the specific source of its origin, unlike the previous case, does not play a special role – the main thing is the correct loading of the receptors responsible for producing the corresponding signal sent to the brain. Because of the objective features of the diet of our ancestors, we are programmed from childhood to give preference to sweet and fatty components. Their combination for a person has a synergistic, i.e. mutually reinforcing effect, accompanied by a particularly strong release of dopamine. The apparent preference of many people for salty food remains a mystery to experts at the moment. Regarding low-calorie dietary fibers with the absence of pleasant taste substances in their composition, it can be noted that their number in the diet of our ancestors with their collection of food in the form of edible plants was so great that they were really considered as ballast substances. This trend has continued to this day.

Conclusion

From this analysis, the following recommendations for improving the quality of food labeling for Belarusian manufacturers immediately arise:

1. Take note of the changes to CU TR 022/2011, especially for font sizes that should not be less than 8 pins.
2. Pay attention to the color of the main background of the label for the perception of the information text applied to it.
3. The shelf life, date of manufacture of the product, and net weight should be placed on the label in places that are easy for the consumer to read. For the analyzed products, the information on the net weight is marked in prominent places, in large font, and this is easily detected by the consumer when purchasing. However, there are examples of labeling products from other manufacturers, when it is not easy to find the net weight on the product label at once: it can be applied in a very small font (up to 0.5 mm) somewhere in the corner of the label, and this creates great inconvenience for consumers.
4. The time has come to use modern ways to improve the labeling of food products, and the manufacturer should start with the "traffic light" label. This marking will be especially useful for baby food, which is always legally subject to increased requirements for quality and safety.

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System of balanced indicators as the basis of the organizational effectiveness model

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Abstract

Based on the results of the study, the necessity of using modern methods for assessing the performance indicators of an organization is substantiated. From a variety of methods, a balanced KPI scorecard for poultry enterprises was selected. The process of strategic analysis in all case studies in various fields. It is a research procedure, very useful for experts in the field of data analysis from different points of view.

This system more fully reflects the strategic goals and objectives that any organization seeks.

Criteria for choosing a system of balanced indicators are determined taking into account the specifics of the industry sector of organizations.

A mechanism has been developed to form a system of balanced indicators for the development of organizations. This mechanism includes the stages of the formation of a system of balanced indicators and the characteristic features of the implementation of each stage.

Based on the analysis of the organizational structure and specialization of the organization, middle managers were selected who are responsible for the performance of KPI indicators. The basic functional tasks for each of the managers are proposed depending on the specific KPI indicator.

Key words: *balance, scorecard, poultry-farming, effectiveness.*

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DOI: 10.24263/RES-2019-12

Introduction

One of the most important conditions for the competitive development of an organization is to take into account multifaceted influence factors, which can be implemented using the strategic analysis method, which allows a comprehensive assessment of industry factors and factors of marko-and microenvironment, as well as taking into account the degree of influence.

Within the framework of the presented criteria, qualitative assessment methods, such as a SWOT analysis, a McKinsey matrix, a SWN analysis, a PEST analysis, etc. can be used. At the present stage, quantitative estimates of the organization's development goals are no less significant.

Among the quantitative indicators of the formation of strategic goals and program activities, poultry organizations most often stand out indicators of financial stability and the results of production and economic activity (profitability of the enterprise, profitability of assets, profit from sales of products, etc.).

One of the conditions for the successful development of an enterprise is a correctly substantiated and formulated policy and strategy, on the basis of which the organization's management line is built to improve its performance.

The general growth of the introduction of information technologies in business processes and the subsequent development of information systems that take into account the specifics of organizations' activities necessitates the coordination of the organization's general strategy and the informatization strategy.

The effective strategic management is possible when using and accounting for indicators that determine the target setting in various areas of business. According to E.Y. Voronova stated problems will be solved by a balanced scorecard – an enterprise management system based on measuring and evaluating its effectiveness by a set of indicators that reflect all aspects of the activity, that are significant from the point of view of strategy (financial, manufacturing, marketing, innovative, etc.) [1, p. 108].

In the context of the growing need for timely management decisions in the framework of the ever-changing external environment of the organization, there is a need to use modern models of organizational effectiveness.

One of the options for this model can be a comprehensive model of organizational effectiveness, taking into account:

– system-resource model, which involves the rational use of unique and rare resources;
– the target model, the main task of which is to achieve the organization's goals;
– models of participants' satisfaction based on an assessment of the quality characteristics or evaluations of the organization's activities by its employees.

The integrated use of all of the above models is possible in the preparation of specific goals and objectives. The implementation of the strategic goals and development goals of the organization today should be carried out using reference points of growth and control, selected from a wide range of indicators – the balanced performance system (KPI – Key Performance Indicator) [7]. This system of indicators determines the effectiveness of the organization's business in the following groups of factors:

– financial factors;
– factors of development of the organization's staff;
– factors of the effectiveness of internal business processes;
– factors of efficiency of work with consumers [2, p. 96].

The presented system is flexible for modification depending on the chosen development strategy of the organization and allows achieving target goals due to the synergy of interaction between components of the organization's business.

Results and discussion

The presented mechanism for developing a system of balanced indicators for the development of organizations includes one of the most significant stages – drawing up a strategic goal map, which indicates goals depending on a group of factors and their impact on the ultimate general goal [9].

In this case, the selection of specific indicators and their recognition as key is accompanied by an assessment of them according to the following parameters:

– Reflects and measures the strategic points of development of the organization;
– Based on common standard measurements;
– Based on real data;
– Easy to interpret;
– Relevant;
– Represented by a positive effect [10, 11]

On the example of OJSC "1st Minsk Poultry Factory" based on the organizational structure of the enterprise, streamlined information flows, functional tasks, responsibilities of middle and senior managers, table 1 presents a list of balanced indicators of strategic management accounting [7].

Table 1

Mechanism for developing a system of balanced indicators of development of organizations [8]

Stage	Characteristic
Goal Definition	Determination of the main goals and objectives of the organization's development (ranking by degree of importance) for four groups of factors and their compliance with the general goal.
Strategic Mapping	Identification of the causal relationship of the proposed goals, their adjustment and selection. Planning strategic communications, information support for managers.
Create metrics	Interpretation of presented interlinked goals in quantitative indicators.
Setting target values	Drawing up target values of selected indicators taking into account the starting point of organization detail.
Development of strategic activities	Concretization of activities contributing to the achievement of BSC indicators, the choice of terms of implementation and responsible persons.
Implementation BSC	Project implementation and monitoring of its implementation.

The main activities of OJSC "1st Minsk Poultry Factory" are the production of poultry products (eggs and poultry meat) and their processing, the production of dairy products and crop production is partially represented, commercial activity with the right to wholesale and retail trade is actively developing.

A local network has been established in the organization for information transfer, and management information is recorded in a software product on the 1C: Enterprise

7.7 platform from 1C: BITRIX. Within the framework of this information system, automation of certain areas of management accounting is presented: fixed assets, material assets, animals for growing and fattening, labor and wages, finished products, including shipping and sales, financial transactions, other means and sources [9].

The presented indicators should be taken into account in the process of forecasting and monitoring the organization's activities by responsible persons, who must respond in a timely manner and adjust their actions if necessary. This balanced scorecard within the framework of a comprehensive model of organizational effectiveness is advisory in nature, in the process a more detailed selection of significant components is possible [4].

Table 2

Balanced scorecard for strategic management accounting of a poultry organization [10]

Groups	Indicators	Responsible
Financial performance	1. Return on assets, production, sales. 2. Financial stability and solvency. 3. The value of the business.	Deputy gene. director of finance and economics, chief accountant and chief economist
Staff development	1. Level of qualification. 2. The degree of satisfaction and motivation, commitment to the organization. 3. The level of automation of information support.	Deputy gene. director for ideology, head of human resources, head of ACS
Consumer Performance Indicators	1. The level of customer loyalty. 2. Market share, the development trend of new markets. 3. Consideration of potential customer needs.	Deputy gene. director of commercial affairs, head of FEA, head of marketing and head of sales
Performance indicators of internal business processes [11]	1. Innovative susceptibility of the organization. 2. Logistics. 3. Management costs, production costs.	Head of the planning and economic department, head of the department of logistics, chief economist

Conclusion

The priority of indicators and their values should be formed according to the strategic vision and mission of the organization, taking into account trends in factors and the external environment (target model). The above indicators in the form of separate elements do not represent the possibility of a full-fledged analysis of the organization's details, for this reason a comprehensive, systematic approach to assessing organizational effectiveness is required taking into account the distribution of the weight coefficients of each indicator based on available resources and their significance (system-resource model).

Moreover, in this case, the most optimal will be the use of group methods for making managerial decisions among top and middle managers as an interpretation of a qualitative assessment of the organization's activity (participants' satisfaction model) [8,11].

Summarizing, it is necessary to note the need to use a balanced scorecard system in the process of creating a comprehensive model of organizational effectiveness in combination with an information system for providing analytics and the possibility of making managerial decisions of the ERP II class, which includes accounting for all production business processes and their relationship with external contractors.

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Optimal packaging for food products is an effective solution to save resources and minimize the environmental impact

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Abstract
An analytical and calculation approach to the optimal packaging choice based on the rating of importance of various factors has been developed to ensure the balance of packaging functions, such as: proper preservation of the packaged product during shelf life, product safety for consumption, efficient use of resources. Based on the analysis of the most important factors, such as: the properties of the packaged product, its shelf life, the possible interaction between the product and packaging material, the optimal mass of the filled goods, as well as economic and environmental factors, the approach to choice optimal packaging for certain food product has been proposed. The optimal packaging is selected based on the comparison of total scores calculated for different packages. Total score is the sum of all evaluated requirements. Each requirement value is a result of multiplication of the degree of conformity of the package to a specific requirement in comparison with other types of packaging analyzed and rating of importance of a certain requirement.
As an example the analysis and comparison of different packaging for milk. The optimal packaging was considered the pillow bag with the "total score" equal to 2 when other packaging types had lower total scores.
Such an approach can ensure the economic competitiveness of a packaged product on the market and minimize environmental impact by preventing product losses and minimizing of the recourses for packaging production and recycling.
Keywords: *packaging, food, milk, recycling.*

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DOI: 10.24263/RES-2019-13

Introduction

One of the most important problems in a rapidly growing planet population is the availability of adequate quality and safety food [11]. Another acute problem is the depletion of the resources needed to meet the needs of humanity [10,11]. Human activity leads not only to a reduction of resources, but also to a negative impact on the environment. According to the FAO World Food and Nutrition Status Report 2017, a hunger affected 815 million people (11% of the world population) in 2017 [11].

At the same time, annually around the world, around 30 to 50% of food is wasted, which is about 1.3 billion tons. In 2014, food losses in Europe reached more that 100

million tones. In 2020, it will be around 120 million tones (+ 20%) unless the situation changes.[12]

The role of packaging in food preservation is difficult to overestimate. To solve these problems, it is important to use the optimal packaging that will save the packaged products, but at the lowest cost of its production and recycling. Food products have a higher value than the packaging for them protection [10,12].

Thus, the loss of food products because of inefficient packaging may have a more negative result in for rational use of resources and impact on the environment. Also over costs of manufacturing and recycling the packaging could not be considered justified.

Materials and methods

Materials. Different types of milk packaging:

– Pillow bag produced from polyethylene film;
– Tetra Pack produced from combined material such as: cardboard / Alu foil / PE;
– Bottle produced from rigid polyethylene plastic [3,8]

Methods. The analytical and calculation approach to the choice of optimal packaging, taking into account the rating of importance of various factors [2].

Results and discussion

The basic properties of the products and the factors which are important for choosing a optimal packaging solution have been analyzed. An analytical and calculation approach to the optimal packaging choice has been proposed, taking into account the rating of importance of various factors.

The concept of "optimal packaging" or "optimal packaging design" corresponds to the balance between providing all the packaging functions for a certain foodstuff and the cost of manufacturing and recycling it after use [1,3]. Optimal packaging is packaging that is good enough for a certain product, taking into account the shelf life and conditions of storage. Figure 1 shows the scheme for determining the optimal packaging design [9].

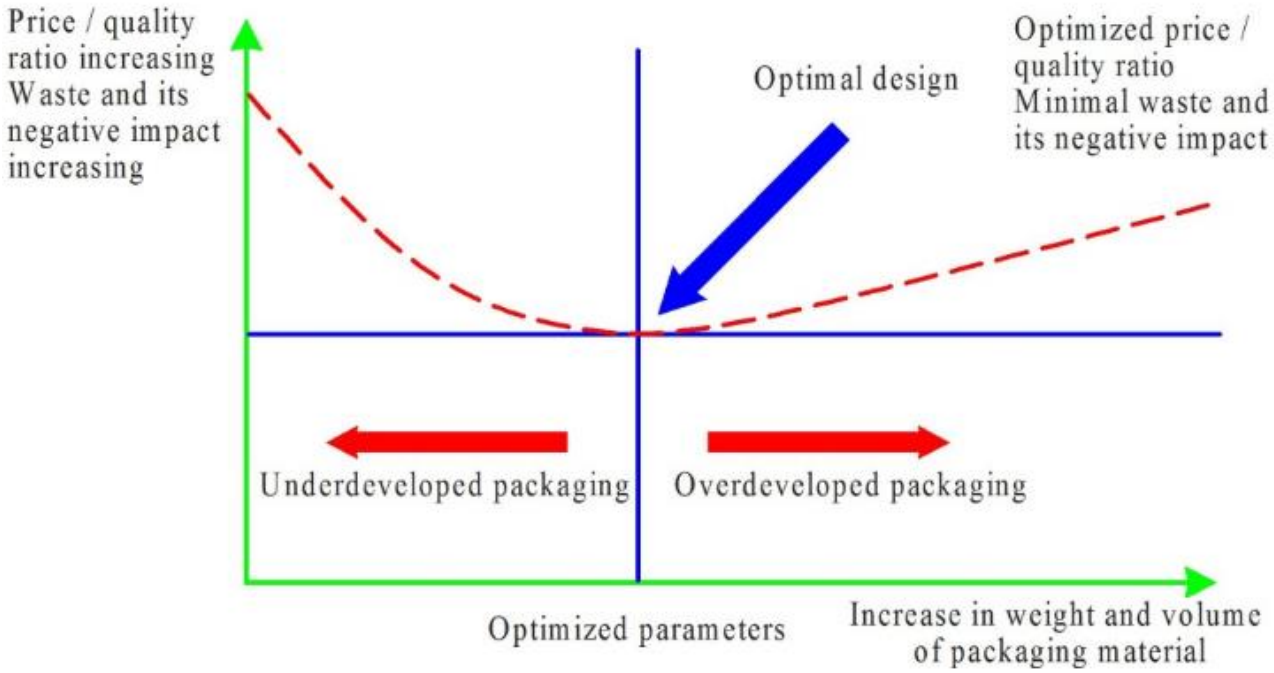

Figure 1. Optimal packaging design

Packaging optimization begins with the choice of the proper material and the size of the packaging. The product's properties and safety is a priority factor that cannot be neglected or compromised. The following basic product features and logistical factors must be considered to determine and select the optimal packaging for a particular product [4,5]:

- *Packed product properties* (aggregate condition, composition, packaging conditions and subsequent processing of the packed product (temperature, pressure, humidity, time, etc.));
- *Shelf life of the packaged product to be provided*, storage and transportation conditions; analysis of potential risks and factors of impact on the product during transportation and storage;
- *Possible interaction between the product and the internal environment as well as packaging material*, minimizing such interaction is ensured by the correct selection of the packaging structure, the technology of its production and packaging;
- *The optimum weight of the packaged product* on the basis of determination of the potential consumer group of a certain product, rational norms and terms of its consumption;
- *Economic analysis*: the choice of the optimal packaging solution for a certain product in order to provide all the technical requirements with the minimum consumption of resources;
- *Environmentally friendly packaging solution*: recyclability, loss of product prevention due to proper protection during the shelf life, packaging safety for the product and ensuring 100% product consumption.

The packaging must correspond to the composition and properties of the packaged products to preserve them. In evaluating the packaging complex, the following components should be taken into account: the packaged product, the internal environment in the packaging above the product, the packaging material, the external environment into the packaging. (Figure 2) [6].

To ensure the protection of food products from changes in their composition and properties it is necessary to choose the optimal packaging based on the analysis of the product properties and processes that occur during storage and transportation of packed food goods, as follows: (Figure 2).

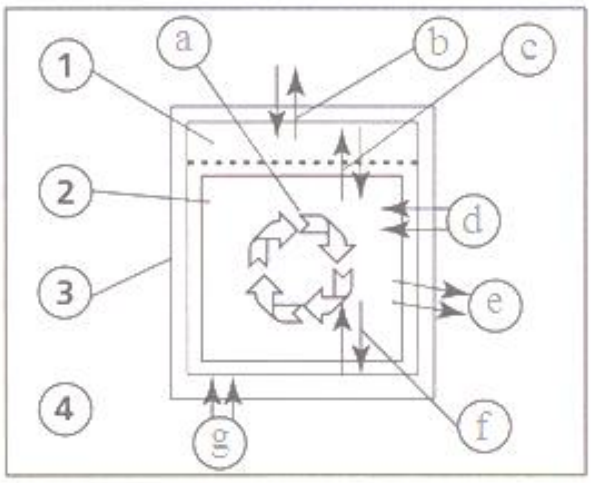

Figure 2. Processes in packaging complex

a – biochemical processes in the product;
b – interaction between the internal and external environment;
c – interaction between the product and the internal microenvironment;
d – penetration of liquids, vapors, gases, sunlight and other outside influences
e – product loss;
e – interaction between the product and the packaging material;
g – the influence of the environment on the packaging material.
1– internal environment in the packaging above the product;
2 – packaged product;
3 – packaging material;
4 – external environment.

The analytical and calculation approach to the choice of optimal packaging, taking into account the rating of importance of various factors, can be demonstrated by the example of choosing the optimal packaging for milk [7]. The approach includes two steps: the first is the analysis of the different types of packaging (Table 1), the second one is the calculation of the rating taking into account the importance of different requirements (Table 2).

Table 1

Analysis of different types of milk packaging

Characteristics	**Packaging 1**	**Packaging 2**	**Packaging 3**
Quality deterioration processes	Oxidation, clotting, growth of microorganisms		
The main factors of influence	Oxygen, temperature, impurities, raw materials		
Type of packaging (package, bottle, jar, box, etc.)	Pillow bag	Tetra Pack	Bottle
Packaging material (paper, polymer film, combined flexible material, cardboard, tin, glass, etc.)	PE* film	Combined material cardboard / Alu foil / PE	PE, rigid plastic
Advantages	Low packaging weight, recyclable packaging, lowest cost	The medium weight of the package, the packaging provides a long shelf life	The packaging can be recycled, easy to use, reclosed
Disadvantages	The packaging is sensitive to mechanical damage, not very convenient to use	Recycling packaging with the combined material is not cost-effective, the highest cost	The largest weight of the packaging

*PE-polyethylene

Food manufacturers can add and / or modify the list of packaging requirements, as well as the importance of rating the importance of those requirements, taking into account the characteristics of their product, technical and economic objectives. This approach facilitates the selection of the optimal packaging for a certain product and makes it possible to provide clear arguments for such a choice to be discussed by a group of interested professionals and to make a packaging decision that will guarantee the safe storage of the product for the required time, product safety for consumption and efficient and economical use of resources.

This will ensure the economic competitiveness of the packaged product on the market and minimize environmental impact through the prevention of product losses and the minimum use of resources for packaging production with a view to its recycling.

Table 2

Rating calculation based on the importance of different requirements

№	Requirements	Rating, R	Packaging 1	Packaging 2	Packaging 3
1	Packaging response requires the preservation and safety of the products	0,4	1×0,4=0,4	3×0,4=1,2	2×0,4=0,8
2	Economic efficiency	0,3	3×0,3=0,9	1×0,3=0,3	2×0,3=0,4
3	Environmental impact	0,2	3×0,2=0,6	1×0,2=0,2	2×0,2=0,4
4	Convenience for use	0,1	1×0,1=0,1	2×0,1=0,2	3×0,1=0,3
	Total score*, Σ, points		2,0	1,9	1,9

* The total score is the sum of points when evaluating all the requirements by the formula:
$\Sigma = L \times R$
where, L is the degree of conformity of the package to a specific requirement in comparison with other types of packaging analyzed (1 – the lowest level, 3 – the highest level)
R – rating of importance of a certain requirement (the sum should be equal to 1) or weight factor.
The packaging that has the highest score can be considered optimal.

Conclusions

1. The global problem of today is the loss of food products, which account for more than 30%. Food waste does more harm to the environment than packaging waste.
2. Packaging is an important component and an integral part of the food industry. The packaging saves more resources than is spent on its production, preventing the formation of food waste. Choosing the best packaging based on an analytical and computational approach is an effective solution for the rational use of resources and the minimization of environmental impact.

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Accuracy of precision dosage of liquid food products with valve dispenser

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Abstract
The purpose of research is to develop mechatronic dispensers for liquid food products based on continuous control of the movement of valves with functional units for improving the accuracy and speed of dosing systems. It is established that to ensure the accuracy of dispensing, it is necessary to specify the law of movement of the valve. During the research, a parabolic law of valve motion is proposed, which consists of three stages. The mathematical model of pressure change in the channel of the metering device for the case of closing of the metering valve and the speed of the valve is determined. Based on the results of the analysis of the designs of the dispensers, the scheme of mechatronic module for dispensing of liquid food products with conical valve was proposed. Experimental studies have determined the square of mass flow response of a liquid food product Q as a function of changing the metering channel area created between the valve and the saddle (f) and the air pressure (P) in the pneumatic cylinder with flexible frame.
Keywords: mechatronic, module, dispensing, valve, liquid.

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DOI: 10.24263/RES-2019-14

Introduction

Traditionally, liquid metering units consist of three basic elements: saddle, valves and cases [1]. The most responsible link of the dispenser is the working body – the shut-off valve, which is in direct contact with the metering fluid and the saddle (Figure 1).

Modeling the process of the interaction of the conic valve and the saddle is a complicate task, the solution of which depends on the assumptions which was made made, related to the structural features of the valve shape, its material (polymer, metal) and the physical and mechanical characteristics of the liquid food product, etc [2]. However, in practice, the accuracy of precision dispensing of liquid food products over the lifetime of the dispenser is significantly reduced. This is primarily due to the change in the size of the gap between the valve and the saddle, which is characterized by wear of the materials at their contact points. Therefore, such metering systems need constant regulation [3].

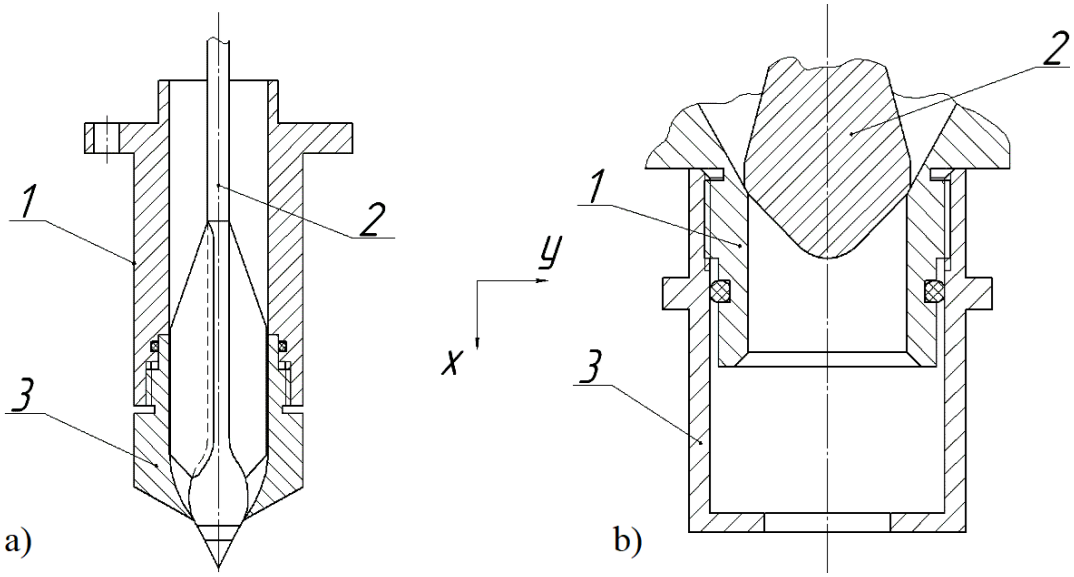

Figure 1. The design of the working body in weighing dispensers:
a – conical; b – cylindrical;
1 – saddle; 2- valve; 3 – the case.

Materials and methods

For the study, an experimental and theoretical method was used to investigate the accuracy of precision dosing of liquid foods by valve dispensers.

To develop a mathematical model of valve movement, the following assumptions were made: liquid food product is considered as an incompressible viscous fluid [4]; the density of the liquid food remains unchanged as the pressure changes, $\rho = \text{const}$.

A fundamentally new scheme of mechatronic module for dispensing liquid food was developed and used for confirming the adequacy of the mathematical model (Figure 2).

The dosage accuracy in the proposed structural system is monitored by the controller by analysis of the moving of the metering valve and the weight of the liquid food product in the consumer packaging [5].

The pilot plant of functional mechatronic module for dosing liquid food with tapered valve was made for checking the adequacy of the obtained analytical results (Figure 3). The operation of the mechatronic module control system was based on the developed mathematical model for the implementation of the specified law of motion of the precision metering valve [6].

The actuator of the dispenser in the mechatronic dosing module is a pneumatic cylinder with a flexible frame, and the control signal is a pressure value [7]. The speed of change of pressure and it's value was ensured by means of the proportional control. Accuracy of dosing was monitored by feedback – the tensile control of liquid food in consumer packaging. All kinematic and dynamic parameters of the mechatronic dosing unit were recorded by a computer in real time.

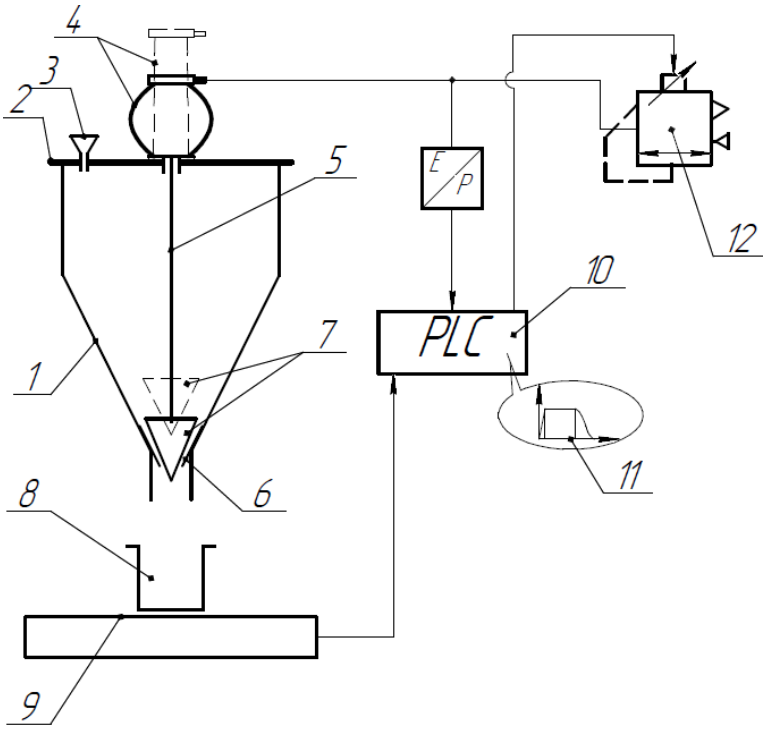

Figure 2. Diagram of functional mechatronic module for dispensing liquid food products with conical valve:
1 – hopper; 2 – cover; 3 – the funnel; 4 – pneumatic cylinder with flexible frame; 5 – stock; 6 – a saddle under a conical valve; 7 – conicial valve; 8 – consumer packaging; 9 – strain gauges; 10 – analog-to-digital converter (ADC) that defines the law of motion 11; 12 – electronic pressure sensor; 13 – control pressure regulator

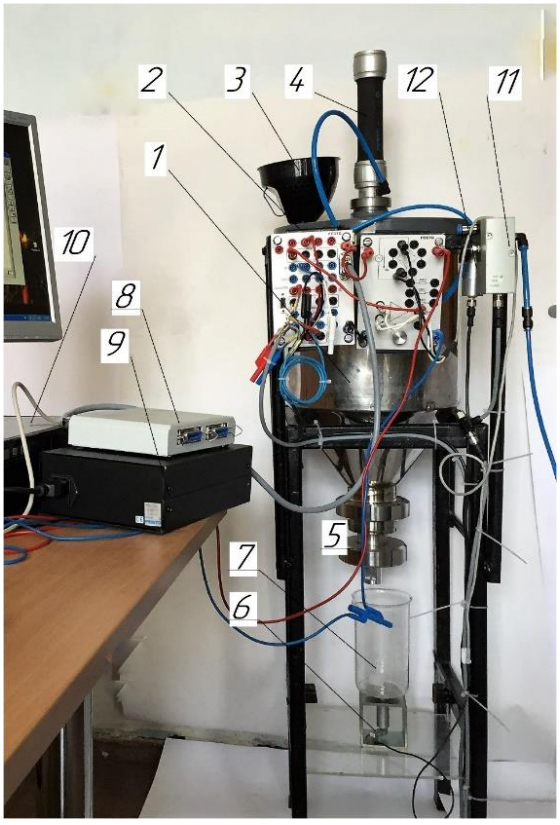

Figure 3. Experimental installation of functional mechatronic module of dispensing of liquid food products:
1 – hopper;
2 – cover;
3 – funnel;
4 – pneumatic cylinder with flexible frame;
5 – saddle under a conical valve;
6 – strain gauges;
7 – measuring capacity;
8 – analog-to-digital converter (ADC);
9 – power supply;
10 – computer;
11 – proportional control pressure regulator;
12 – electronic pressure sensor.

Results and discussion

On the basis of the analysis of the designs of the dispensers and technological processes of dispensing, it can be argued that the given law of the valve movement traditionally consists of three stages (Figure 4): I stage – rapid opening of the dispensing channel; Stage II – open position; Stage III – closing of the dispensing channel.

It is suggested to smooth the movement of the valve at the final stage of dispensing to implement the parabolic law of motion of the valve of the dispenser.

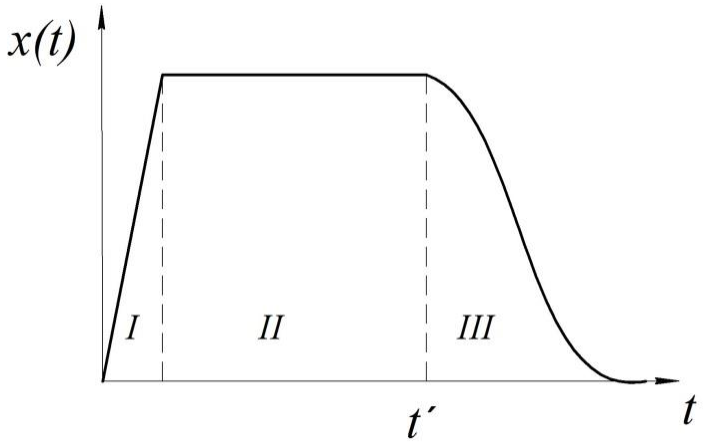

Figure 4. The specified law of motion of the valve of the dispenser with a precise method of control:
I – opening of the dosing channel;
II – valve outlet in open position;
III – closing the dosing channel

It is assumed that the positive expansion of the valve, which creates its working stroke δ of such structures. The dispensers are pneumatic or electromagnetic.

It has been updated that, with precision, the force of the valve significantly applies the kinematic and dynamic characteristics of the fluid flow. The flow diagram of the fluid in the dose at the moment of closing the valves for the parabolic regularities is shown in Figure 5.

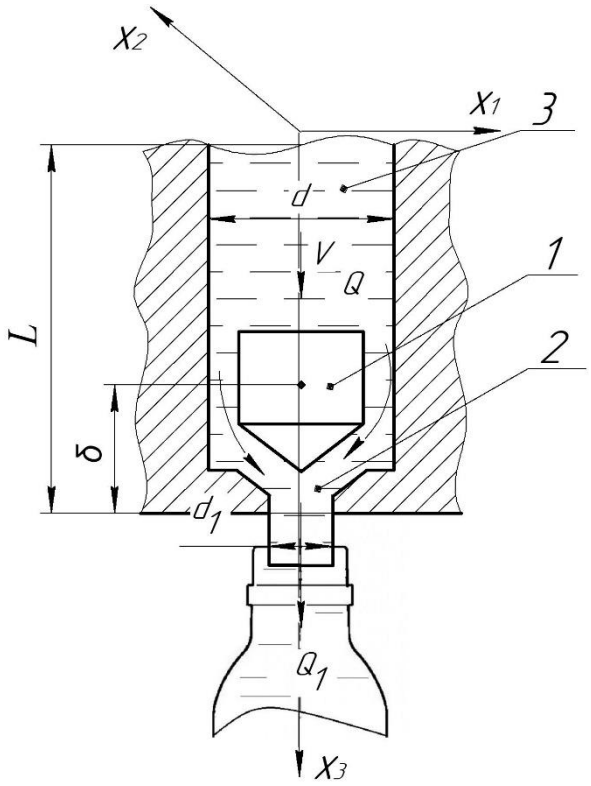

Figure 5. Flow chart of liquid food product in the dispenser at the moment of closing the valve: 1 – dispenser valve; 2 is a simplified channel model of a liquid food system; 3 – liquid food product: Q – volume of the dispenser; Q1- is the volume of liquid food product to be dispensed into the package; V- is the speed of the fluid; d- is the inside diameter of the dispenser; d1- is the diameter of the outlet; L- is the height of the dispenser with nozzles; δ – displacement of the metering valve.

The differential equation of motion of the fluid between the channel and the cone of the dispenser, according to the selected coordinate system, is described by the equation:

$$\frac{dV}{dt} = -\frac{dp}{dx_3}\frac{1}{\rho} + 2nV, \quad (1)$$

where: ρ – is the density of the liquid food product; $2nV$ – the viscous resistance force, where, $n = \frac{2\nu}{\Delta^2}$ where Δ – is the height of the boundary layer of the liquid food product; ν – kinematic coefficient of viscosity.

The movement of the valve during the closing stage is according to a parabolic law:

$$x = at^2/2 + bt + c\,. \quad (2)$$

Accordingly, the valve speed at this stage:

$$V = \frac{dx}{dt} = at + b, \tag{3}$$

Accordingly, the change in pressure in the cylindrical channel between the valve and the dispenser's frame is described by the equation:

$$\frac{dp}{dx} = 2nV\rho - \frac{dV}{dt}\rho = 2n\rho at + 2n\rho b - \frac{dV}{dt}\rho. \tag{4}$$

The initial conditions for the second stage of motion are time t = 0, coordinate and valve speed $x=0$; $V= V_0$; $p=p_0$. The final conditions of the closure step are $t= t_1$, $x = L$, $V=0$.

Substitute the initial conditions $b = V_0$, $a = -b/t_1 = -V_0/t_1$ in equation (3) and obtain the change in speed:

$$V = -\frac{V_0 t}{t_1} + V_0 = V_0\left(1 - \frac{t}{t_1}\right). \tag{5}$$

Substitute expression (5) into equation (4) and obtain a change in pressure:

$$\frac{dp}{dx} = 2n\rho V_0\left(1 - \frac{t}{t_1}\right) + \rho\frac{V_0}{t_1}. \tag{6}$$

Let's integrate equation (5) and determine the pressure: (7)

$$p = \int\left[\rho\frac{V_0}{t_1} + 2n\rho V_0\left(1 - \frac{t}{t_1}\right)\right]dx,$$

With given the channel shape: (8)

$$p = \rho\frac{V_0}{t_1}x + 2n\rho V_0\left(1 - \frac{t}{t_1}\right)x + C.$$

In equation (8) we define a constant integration C, substitute the initial conditions and obtain:

$$C = p_0. \tag{9}$$

Substitute equation (9) into equation (8) and obtain a change in pressure: (10)

$$p = \rho\frac{V_0}{t_1}x + 2n\rho V_0\left(1 - \frac{t}{t_1}\right)x + p_0.$$

Determine the amount of pressure at the time of closing the valve, which meets the final conditions: $x = L$ та $t= t_1$:

$$\Delta p = p - p_0 = \rho\frac{V_0}{t_1}L. \tag{11}$$

Conclusion

Based on the experimental studies of the functional mechatronic module of the dispensing of liquid food products, the dependence of change in the mass of the liquid food products on time and the movement of the precision dispenser valve in real time were determined.

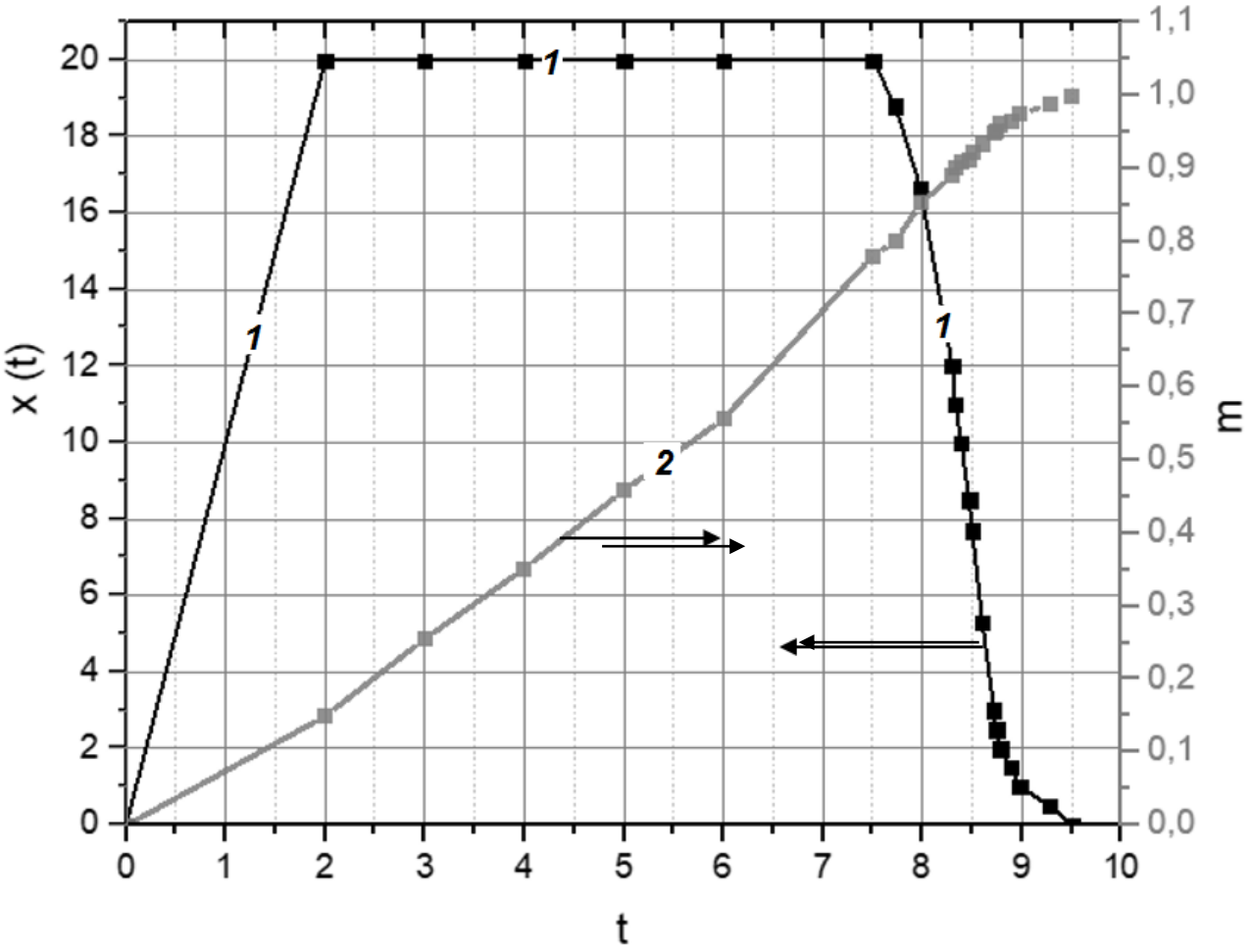

Figure 6. Graph of the dependence of the moving of the valve x(t) and the change in mass of liquid food product m from time t:
1 – x(t); 2 – m.

The obtained characteristics of the mechatronic module of the dosing of liquid products have made possible to make further adjustments to the operation of the control system and to establish the dependence of the mass flow rates of the liquid food product as a function of changing the area of the dosing channel created between the valve and the saddle (f) and the air pressure (P) in the pneumatic cylinder of the flexible frame (Figure 4).

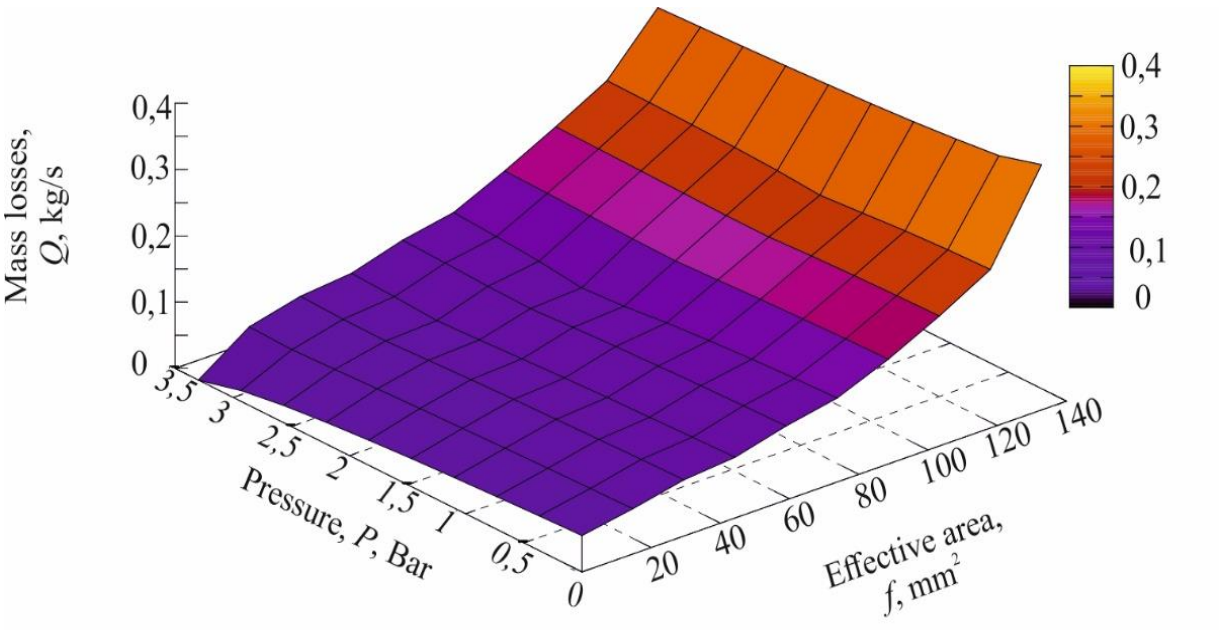

Figure 7. Mass flow response of liquid food product Q as a function of changing the metering channel area created between the valve and the saddle (f) and the air pressure (P) in the pneumatic cylinder with flexible frame.

Based on the studies of the functional mechatronic module of the dispensing of liquid food products, it is established that the mass flow rate of the liquid food product through the channel of the feed system in the container increases linearly until the area of the dosing channel begins to exceed 80 mm2, after which there is a sharp increase in mass consumption up to 40 %. The change in air pressure (P) in the pneumatic cylinder with flexible frame compensates for the dosage error resulting from the effect of fluid pressure on the valve and during dispensing. The results of the study will allow us to further determine the correction coefficients for the implementation of the specified law of valve movement, to provide high accuracy of dosing and to increase the speed of the dispenser.

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Наукове видання

Resource and Energy Saving Technologies of Production and Packing of Food Products as the Main Fundamentals of Their Competitiveness: Proceedings of the 7th International Specialized Scientific and Practical Conference, September 12, 2019.

Підп. до друку 27.12.19 р. Обл.-вид. арк. 9.26
Наклад 100 пр. Вид. № 18н/19
НУХТ. 01601 Київ-33, вул. Володимирська, 68
Свідоцтво про реєстрацію серія ДК № 1786 від 18.05.04 р.