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Editorial office address:
National University of Food Technologies
Volodymyrska str., 68
Kyiv 01601
Ukraine

E-mail:
Ukrfoodscience@meta.ua

Editorial board

Contents

Regularity of structuralization of jelly mammelade on agar polyeshaharides and pectins with low content of sugars

Dariia Matias[1], Julya Kambulova[1], Olena Goncharuk[2]

1 – National University of Food Technologies, Kyiv, Ukraine
2 – O.O. Chuiko Institute of Surface Chemistry of National Academy of Sciences of Ukraine, Kyiv

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Corresponding author:

Dariia Matias
E-mail: matyasd@ukr.net

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Abstract

Introduction. The actual scientific task is to establish the regularities of the structure formation of marmalade on agar polysaccharides and pectins with low sugar content (saccharose, glucose, fructose).

Materials and methods. Rheological characteristics were studied by rotational viscometry. Structural and mechanical characteristics were investigated by penetration method. Marmalade with a low content of saccharose, glucose, fructose with the correction of the content of sugars by the addition of polydextrose and the introduction of natural flavoring additives in the form of fruit and berry puree were used in the research.

Results and discussion. It has been established that the sweet taste of marmalade with the use of any formulation is ensured by the dosage of saccharose and glucose at 35 g / 100 g of product, and fructose – by 25 g/100 g. However, the decrease in the amount of sugars in the system is reflected in the increased index of total deformation and proves that structural and mechanical properties essentially depend on their content. The rheological studies of each marmalade mass have identified a range of values of the gradient of displacement, which recommended its transportation in the technological process. So, for marmalade mass on agar with glucose and saccharose $\gamma = 10–20$ sec^{-1} (t = 55±3 °C), with fructose – $\gamma = 5.4–10$ sec^{-1}, or it is possible to use lower temperatures (t = 50±3 °C); for k-carrageenan – for all types of sugars $\gamma = 5.4–10$ sec^{-1} (t = 77±3 °C), for the masses with fructose and saccharose, lower temperatures are allowed (t = 72±3 °C); on H-pectin – $\gamma = 5.4–8$ sec^{-1} (t = 85±3°C), for mass with glucose and with fructose (t = 88±3 °C); on l-pectin – with glucose $\gamma = 2–8$ sec^{-1} (t = 80±3 °C), for masses with saccharose and with fructose $\gamma = 5–10$ sec^{-1} (t = 85±3 °C).

Time of structuring of marmalade, which is lengthened in comparison with traditional products has been established, on agar from 60 minutes to 120 minutes, on k-carrageenan from 15 minutes to 60 minutes, on H-pectin from 12 minutes to 20 minutes. To a greater extent, such changes are related to the introduction of a significant amount of polydextrose for replacing sugar, which has a higher hydration ability. The most springy properties has marmalades on agar and k-carrageenan, and on pectins, they are characterized by greater plasticity.

Conclusions. The following parameters are set and recommended: maximum speed of the rotary movement during pumping; temperature of transportation and tempering of masses; the duration of cooling and withstanding on the finished marmalade.

Introduction

The range of marmalade on the market today is represented mostly by a group of jelly marmalade, which has an attractive appearance, a diverse form, a pleasant smell and taste, it is quite easy to make. But the high content of sugar (up to 70% along with the bloat), the content of artificial dyes, flavors does not bring benefits to the human body. The use of sweets congested with sugar threatens food metabolism, problems with the endocrine system, diabetes, obesity, cardiovascular problems, etc. This is especially alerts, since children and teenagers are the main consumers of these products, the body of which is more suitable for allergic reactions, is sensitive to disorders of the gastrointestinal tract. According to the recommendations of the WHO [1], all groups of the population, and especially children and people with disturbed metabolism, should use confectionery products with low sugar content or without it at all.

Scientists and manufacturers have proposed [2–4] prescription composition of the marmalade "without sugar" due to the introduction of sugar substitutes and sweeteners; xylitol, sorbitol, lactitol, isomaltitol, stevioside and sucralose. The use of fructose for the production of low-calorie diabetic marmalade becomes very popular too [5–8]. Recently, so-called inert structural fillers, which include polydextrose, inulin, fructooligosaccharides, resistant starches, are increasingly used for complete or partial replacement of saccharose. In addition to providing structural characteristics, these components, representing dietary fiber, have valuable physiological properties. They can provide a prebiotic effect and lower the glycemic index [9, 10].

We believe that the traditional formulations of jelly marmalade for the mass consumer should be revised in order to reduce sugar, and expand the range with the use of other types of sugars – glucose and fructose. This will give consumers the opportunity to choose, ranging products for children and dietary nutrition [11, 12].

For such marmalade it is provided: introduction of an inert textured filler for replacement of the withdrawn amount of sugar, prevention of the process of crystallization of glucose, formation of organoleptic parameters by the introduction of fruit and berry puree [13].

Changes in the formulations of marmalade will change the parameters of the operations of the technological process of production, – the transportation of marmalade masses to the forming, tempering of the masses, cooling and withstanding of products.

The purpose of experimental research was to study the rheological properties and to establish the parameters of transportation and tempering of mass, time and velocity of gel-formation, springy-plastic characteristics of jelly marmalade.

Materials and methods

Materials

For the production of jelly marmalade with a reduced sugar content, such raw materials were used: white crystalline sugar (Agroprodinvest, Ukraine), crystalline glucose (Twell Sansino, China), crystalline fructose (Vitamin, Ukraine), food agar 1200 (Rokogel, Spain), k-carrageenan (Budenheim, Germany), H-L-pectin (Hugestone, China), molasses (Intercorn Corn Processing Industry CJSC, Ukraine), polydextrose (East Chemsources Limited, China), dairy acid (Cosco, China), citric acid (Chi Chin, China), aromatic essences (Ungerer, USA), potassium chloride (Agroprodinvest, Ukraine), sodium lactate (Agroprodinvest, Ukraine), aseptic fruit and berry puree (thorn, dogwood, sea buckthorn, red and black currants, strawberry, raspberry, blackberry and pumpkin) (Juice Plant Kodymsky, Ukraine).

Preparation of marmalade

The technological process of obtaining marmalade mass was not fundamentally different from the traditional, except the addition of dry caramel molasses to replace the liquid. Such technological decision is made in order to simplify the process of preparing molasses and transporting it to the stage of preparation of the formulation mixture, accompanied by a corresponding reduction of energy resources. For marmalade with glucose, the introduction of maltose molasses was (IM-55) in the ratio of 1:0.8. Puree was introduced at the stage of tempering, in order to preserve the biologically active substances and the rich color of the products. Polydextrose was introduced in an amount equal to dry substances to the amount of sugars, which were withdrawn from the formulation [14, 15]. The calculated amount of the structure-forming agent, polydextrose, molasses, were mixed, water was added from the calculation of "mixture: water" as 1:80–100 and components were dissolved at a temperature of 95–100 °C during 15–20 minutes. To prepare marmalade masses on agar, it was previously swirled during 30–40 minutes, after which it was heated to full dissolution and a pre-cooked dry mixture was added to the solution. The syrup was boiled to 80% DM, cooled to a temperature of 90 °C, puree and acid were added, mass was mixed and formed. For k-carrageenan and H-pectin with higher temperature of the gel-formation marmalade mass was not cooled, and the flavor components were introduced immediately after boiling. The content of dry matter in the samples was determined by the refractometric method using the refractometer URL (Automation, Armenia) according to the method [16]. All samples were kept for 24 h (t = 18±2 °C, φ≈75%) for complete gelation (Table 1).

Table 1

Samples of marmalade and the content of the main components g / per 100 g

Abbreviation	Gel-former	Sugar	Polydextrose	Puree	Acid
C1	agar	**saccharose 66.79**	–	–	lactic
M1		saccharose 45.00	24.23	thorn	
M2		glucose 42.21	14.08	dogwood	
M3		fructose 51.53	17.61	sea buckthorn	
C2	k-carrageenan	**saccharose 67.03**	–	–	lactic
M4		saccharose 45.62	24.61	dogwood	
M5		glucose 44.40	16.16	thorn	
M6		fructose 44.99	24.76	sea buckthorn	
C3	H-pectin	**saccharose 68.11**	–	–	citric
M7		saccharose 48.46	20.78	red currant	
M8		glucose 40.00	21.97	pumpkin	
M9		fructose 44.75	24.70	black currant	
C4	L-pectin	**saccharose 68.11**	–	–	citric
M10		saccharose 37.14	24.76	strawberry	
M11		glucose 36.02	24.50	raspberry	
M12		fructose 36.66	25.04	blackberry	

Structural and mechanical parameters and rheological properties were determined in samples of marmalade with reduced sugar content.

Determination of acceptable limits for reducing sugars.

The limit of reduction of sugar was determined on the "Structural ST-1" on the basis of the total deformation under the influence of a stable enclosure load [17, 18].

Determination of rheological properties of marmalade masses

The viscosity characteristics of the (marmalade mass) were determined on the rotating viscosimeter "REOTEST 2.1" with the cylinder cylinder measurement system, removing the curvatures of the kinetics of deformation (flow) at such temperature: for agar masses 55±3 °C, for k-carrageenan – 75±3 °C, for pectin – 80±3 °C. The measuring cylinder (rotor) H1 was selected in such a way that the gradient layer was distributed over the entire thickness of the product layer located in the annular gap of the viscometer gauge. The measurement of shear stress was carried out in twelve values of shear rate γ in the range from 0.6 to 121.5 sec^{-1} with successive incremental rates of shear rate [19].

In the course of studies, the tension of displacement was calculated according to the following formula:

$$\tau = Z \times \alpha$$

where: τ – tension of displacement; Z – constant of measured steam; α – the value from the scale of the recording device.

Effective viscosity of practically undamaged, η_0, Pa·sec, and practically damaged, η_m, Pa·sec, system was calculated according to the formula:

$$\eta = \tau / \gamma$$

where: γ – displacement rate, sec^{-1}.

Based on the results of the calculations, rheological curves of viscosity η = f (γ) were constructed. The nature of the destruction and the beginning of the fluidity of the system were determined.

Determination of structural and mechanical parameters of marmalade

The structural and mechanical parameters of the marmalade were investigated using the penetrometer AP-4/1[20]. According to the results of the research, the following indicators were calculated: the marginal tension of displacement; total, springy and plastic deformation. The marginal tension of displacement was determined using a conical nozzle with an angle of 30 °C and calculated by the Rebinder formula:

$$P_m = K \cdot \frac{P}{h_m^2}$$

where P_m – marginal tension of displacement, Pa; K – cone constant, which depends on the angle at its vertex $K_{30^\circ} = 0{,}959$; P – tension, Pa; h_m – depth of immersion of the cone, m.

To determine the durability of withstanding samples of marmalade, the marginal tension of displacement after every 30 minutes of withstanding was determined. Time of withstanding was defined as a time when the marginal tension of displacement acquires constant values, that is, it is characterized by constant springyness. The springy-plastic characteristics of the finished products, for the purity of the experiment, were determined after complete structuring after 24 hours [21].

Results and discussion

Obviously, the development of jelly marmalade with reduced sugar content will undergo significant changes in the structural and mechanical parameters, which will require solving a number of problems.

Changing the structure, first of all, deformation of the gel, and reducing the sweetness of the marmalade due to the decrease in the amount of sugar, are key factors in determining the maximum permissible limit for reducing sugars. The results of the determination of the maximum permissible limits for the reduction of sugars according to the selected factors are presented in Figures 1 and 2.

The presented data confirms that sugars in jelly marmalade play a significant role not only in the formation of taste, but also in structural and mechanical properties. The gradual decrease in the amount of sugars is reflected in reducing sweetness of the products and increasing the index of total deformation.

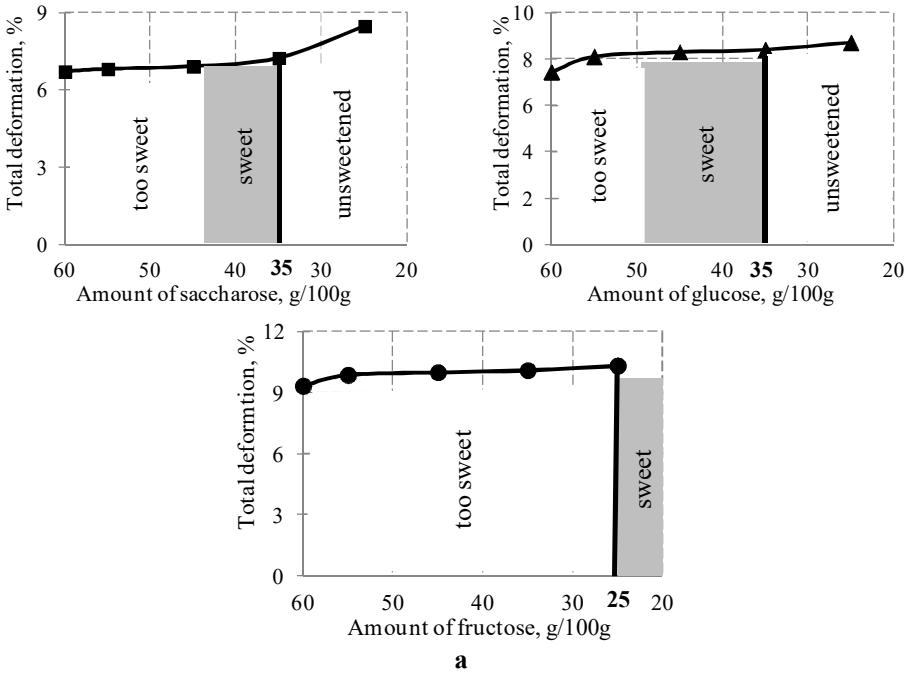
It was established that in agar gels, when the saccharose content is reduced from 60 to 25 g / 100 g, the deformation index increases by 26.4% (from 6.7 to 8.5%); glucose – by 17% (from 7.4 to 8.7%); fructose – by 10.7% (from 9.3 to 10.3%). In k-carrageenan gels patterns are identical, but the effect of sugar is expressed to a much greater extent. Reducing the content of sugars leads to a deterioration of the structure of gel and the rate of total deformation increases: with saccharose – by 67.8% (from 10.5 to 17.6%); with glucose – by 60.3% (from 11.3 to 18.2%); with fructose- by 47.6% (from 12.7 to 18.7%).

Along with this, organoleptically it was found that in formulations on agar polysaccharides, the expressed sweetness is maintained with a reduction of saccharose and glucose by 40% (from 60 to 35 g / 100 g); fructose – by 58% (from 60 to 25 g / 100 g). This amount of sugar forms a gel-like structure with a satisfactory strength, the samples have sweet taste, and therefore it can be used to further improvement of the formula of marmalade with reduced sugar content.

Greater effect sugars have on the total deformation rate of pectin gels, especially on L-pectin. It was found out that the total deformation of samples on L-pectin at extraction of saccharose from 50 to 20 g / 100 g increases by 34% (from 41.9 to 63.4%); glucose – by 16.4% (from 49.8 to 59.6%) and fructose – by 16.8% (from 43 to 51.8%). The maximum permissible limit for reducing the content of sugars is: for saccharose and glucose – up to 35 g / 100 g, for fructose – up to 20/100 g of product.

For samples on H-pectin, saccharose extraction from 60 to 25 g / 100 g leads to an increase in total deformation by 22.3% (from 16.4 to 21.1%); glucose – by 27.7% (from 18.8 to 26%); fructose – by 20% (from 25 to 31%). By the degree of sweetness, it is recommended to reduce the amount of saccharose and glucose – up to 35 g / 100 g, for fructose – up to 25/100 g.

Thus, the decrease in the amount of sugars in the system is reflected in the increased index of total deformation and proves that the structural and mechanical properties are substantially depend on their content. Indeed, in the recommended limits of its use, it provides a sweet taste, but decreases resistance to stress caused by a decrease in the content of dry matter in the system. The reduction of sugar in the formulation of marmalade will also lead to the non-compliance of physico-chemical parameters with the requirements of standard, syneresis of gel, active microorganism development, shortening of storage periods and, probably, deformation of the structure during storage [22]. As a negative factor, the sugaring of glucose was marked after 24 hours, despite a decrease in its amount. Therefore, the improvement of the jelly marmalade technology with the reduced sugar content requires the solution of the following technological problems.



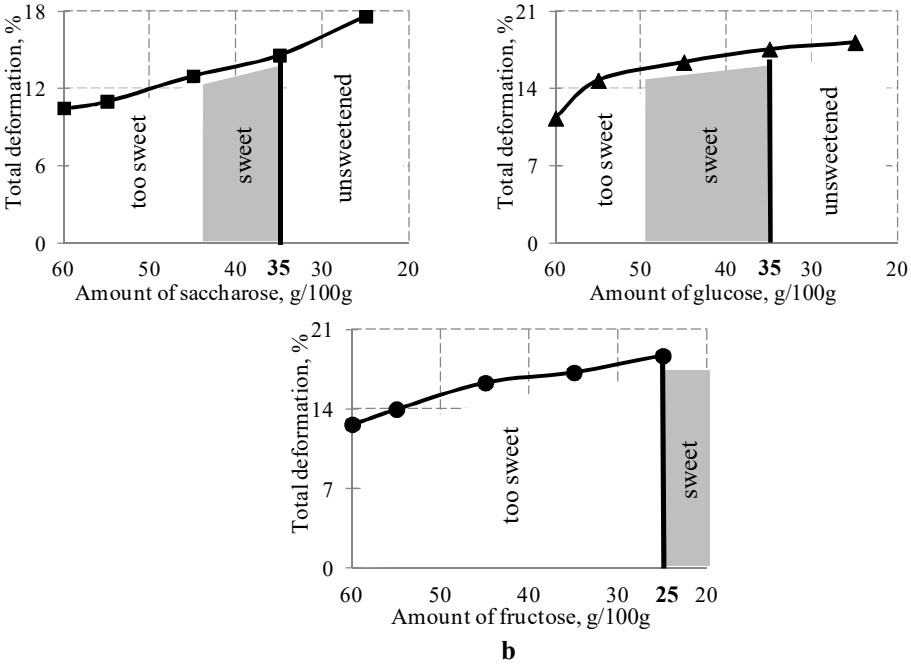


Figure 1. Determination of the acceptable limits of reduction of sugars in jelly marmalade on agar (a) and k-carrageenan (b)

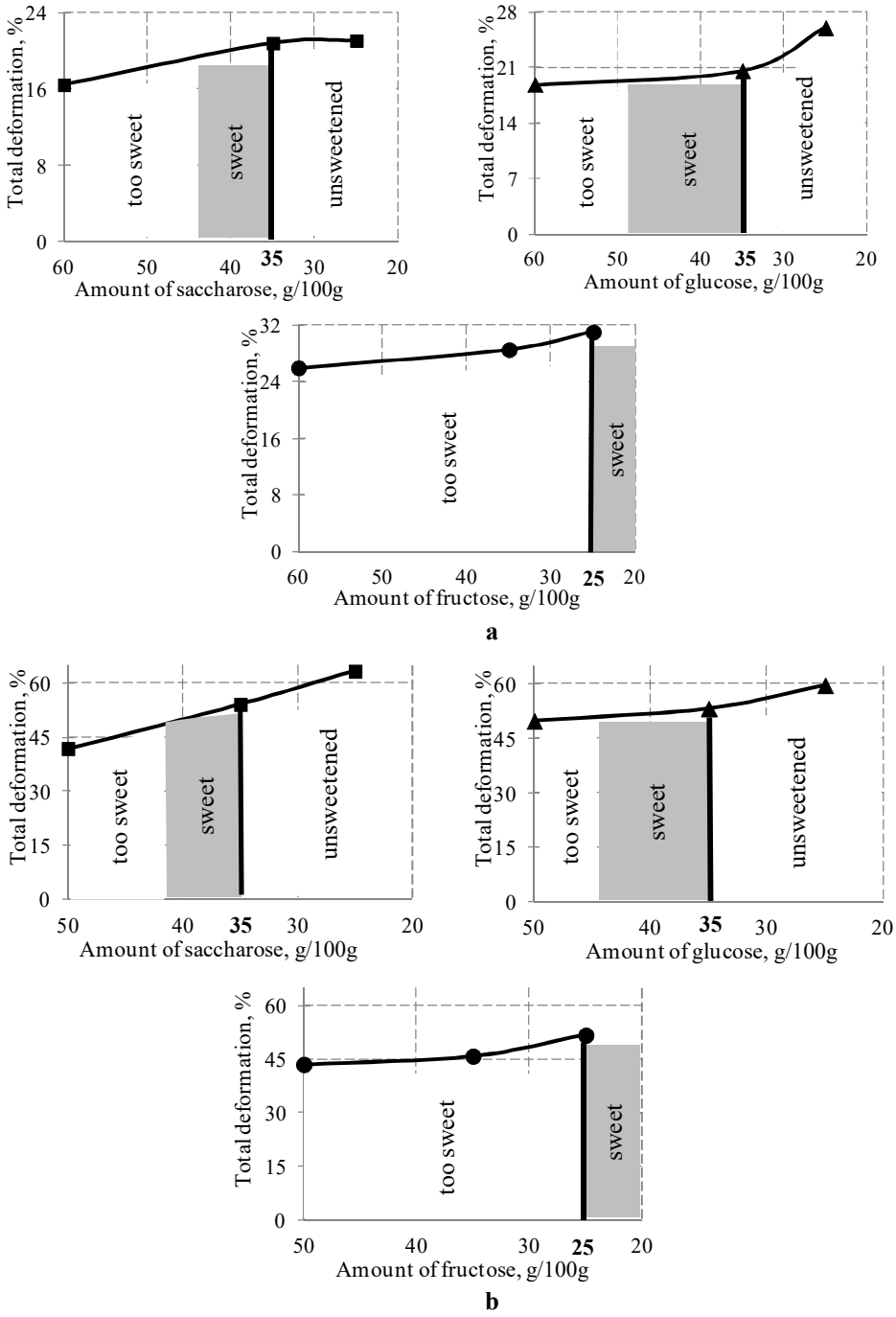


Figure 2. Determination of acceptable limits of reduction of sugars in jelly marmalade on H-pectin (a) and L-pectin (b)

1. To replace the withdrawn prescription sugar amount, an inert texture filler is required to be introduced, which will contribute to the restoration of the DM content, will allow the usual for the consumer consistence of the product; while decreasing the energy value and the index of glycemicity of finished products. In our opinion, polydextrose – a polysaccharide obtained by the hydrolysis of starch, which is used as a filler for the masses without sugar, without fat, corresponds to such requirements [23, 24]. It has the properties of food fiber and prebiotics, does not affect the level of glucose in the blood and is absorbed independently of insulin, has a low glycemic index, high stabilizing ability, barely sweet taste, which will not affect the taste of finished products.

2. In the technological schemes of marmalade with glucose there is a need to prevent the process of crystallization of sugar. A scientific substantiation of the relationship between the quality of the molasses and the obtaining of an amorphous structure of marmalade needs to be scientifically justified.

3. There is a need for the formation of organoleptic indicators (color, smell, taste) by introducing natural fruit and berry puree, which is released by the canning industry in a wide range. Such approach will not only diversify the taste and color of the marmalade without the use of artificial colorants, but will also allow its chemical composition to be enriched with valuable biologically active substances, while acids presented in the puree will reduce the acid consumption, the content of the dietary fiber, including pectin substances, will enhance the structure of the marmalade.

The optimal amounts of formulations of marmalade with reduced sugar content (saccharose, glucose, fructose) were determined by the method of planning a multifactorial experiment (the "steep climb" method of Box-Wilson). The criterion of optimality was the strength of marmalade gel; the amount of sugar, puree, acids were chosen as optimizing factors. On the basis of the optimal ratios of prescription components, unified formulations of jelly marmalade with reduced content of sugars were calculated, Table 1 [25].

The most complete description of the structure of marmalade masses in the process of their transportation from tempering to forming will provide a study of the degree of destruction of the structure under the influence of the rotary motion. Marmelade masses for rheological studies were prepared according to developed and approved recipes (Table 1). The determination was carried out at temperatures close to those of the forming of agar and pectin masses, which prevent structural transformation. The rheological curves of the samples of marmalade masses are presented on the figures 3–6.

The character of the obtained curves shows that all the masses in the indicated range of the gradient of displacement differ in a high degree of structure formation. The exception is the marmalade mass on agar, the values of effective viscosity for which are smaller than other experimental samples. Effective viscosity for the smallest and largest displacement gradients for each marmalade is presented in Table 2.

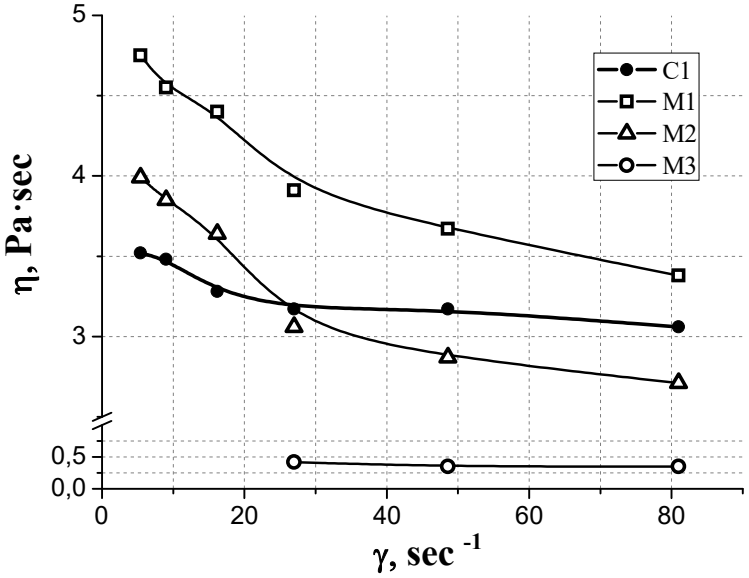


Figure 3. Rheological curves of marmalade masses on agar

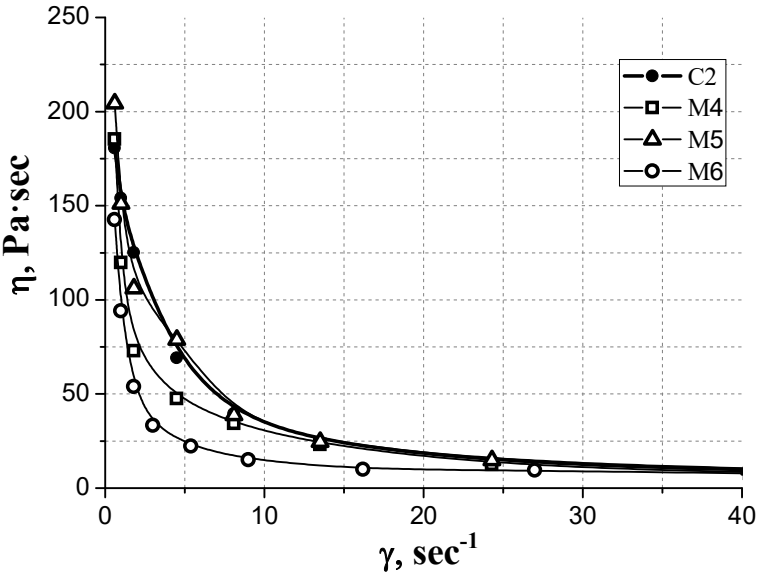


Figure 4. Rheological curves of marmalade masses on k-carrageenan

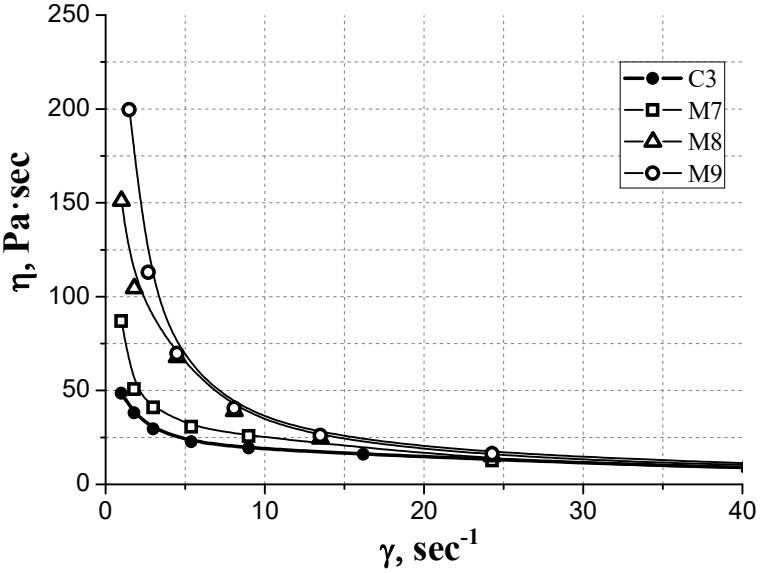


Figure 5. Rheological curves of marmalade masses on H-pectin

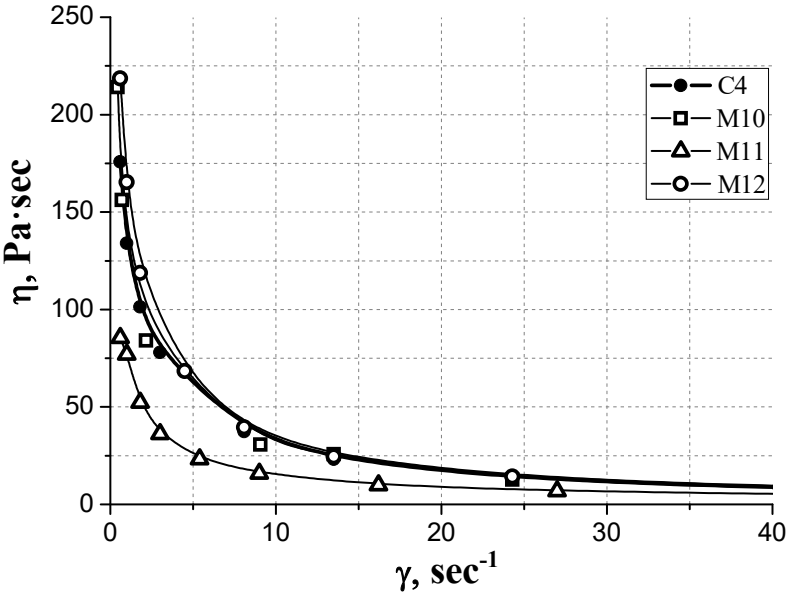


Figure 6. Rheological curves of marmalade masses on L-pectin

Table 2

Effective viscosity for marmalade masses

Abbreviation	Effective viscosity, Pa·sec		Degree of destruction, %
	of practically undamaged ststem, η_0	of practically damaged ststem η_{min}	
	γ=5.4 c^{-1}	**γ=81 c^{-1}**	
C1	3.52	3.06	13.07
M1	4.75	3.38	28.84
M 2	3.99	2.71	13.07
M 3	0.42	0.35	16.67
	γ=0.6 c^{-1}	**γ=121.5 c^{-1}**	
C2	180.5	3.26	98.19
M 4	185.25	2.86	98.46
M 5	204.5	3.66	98.21
M 6	142.5	2.56	98.20
	γ=1.0 c^{-1}	**γ=40.5 c^{-1}**	
C3	48.45	7.81	83.88
M 7	86.93	7.81	91.02
M 8	151.05	9.39	93.78
M 9	199.50	11.19	94.39
	γ=0.6 c^{-1}	**γ=40.5 c^{-1}**	
C4	175.75	8.02	95.44
M 10	213.75	8.23	96.15
M 11	85.50	6.76	92.09
M 12	218.50	8.73	96.00

For each system, a range of values for the gradient of displacement is selected, in which the effective viscosity of the system has a value that ensures its suitability for transportation. This indicator should provide the following values of the effective viscosity that would not exert an excessive load on the mechanical transfer system and reduce the energy consumption of the process. During pumping there also should not be a deep destruction of the structure of marmelade, in order to reduce the time for further gel-formation. Consequently, the interval of values of γ can be extended to the beginning of fluidity.

It was established that the low effective viscosity of agar marmelade masses (η_0 3.75 Pa·sec – with saccharose, η_0 3.99 Pa·sec – with glucose and η_0 0.42 Pa·sec – with fructose) provides a rather slow destruction of the structure. On systems with fructose, the viscosity is so low that destruction is practically not observed. This is evidence of a very slowly structured formation of agar masses with fructose which velocity at the detection temperature does not prevent the development of gel. In samples with glucose and saccharose, for γ = 27 sec^{-1}, the fluidity of their structure begins. Consequently, the range of values γ – 10–20 sec^{-1} can be recommended for the transportation of marmalade masses on agar with glucose and

saccharose. Samples with fructose need to be pumped under less gentle conditions or at temperatures lower than the rest of the test samples on agar.

For carrageenan masses, fluidity begins with smaller gradients of displacement than for agar, despite the fact that the effective viscosity of the practically undamaged ststem on k-carrageenan is much higher than on agar. Figure 4 shows that the fluidity of the samples begins at γ-7–8 sec^{-1}, so transportation must be carried out within the limits closest to the destruction, ≈ 5.4 sec^{-1}. We believe that marmalade masses on carrageenan can be pumped in the traditional modes, without changing the parameter. It is worth noting that the values of effective viscosity of samples with fructose and saccharose inferior to the control sample and sample on glucose, it supposes the possibility of transporting such masses in the selected displacement gradient at lower temperatures.

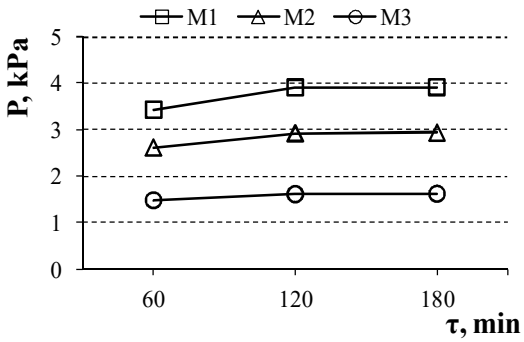
Rheology of marmalade masses on H-pectin with the reduced content of sugars significantly changes in comparison with other polysaccharides. The rheological curves of the experimental samples shown in Figure 5 are higher than the reological curve of the control sample. At the test temperature, the effective viscosity of the practically undamaged systems with glucose and fructose significantly exaggerates this index in masses with sugar. Therefore, the temperature at which the transport of the masses with monosaccharides will be carried out will need to be increased in comparison with the traditional transfer modes. The recommended gradient displacement interval is $\gamma = 5.4–8$ sec^{-1}.

The rheological curves for samples with L-pectin have identical character and close values of the effective viscosity indexes, except for the sample with glucose. This means that the transport of such masses can be carried out according to the experimental studies (t = 80±3); for glucose – reduction is allowed. The recommended interval of values for the gradient of displacement for samples with glucose is $\gamma = 2–8$ sec^{-1}, for saccharose and fructose – $\gamma = 5–10$ sec^{-1}.

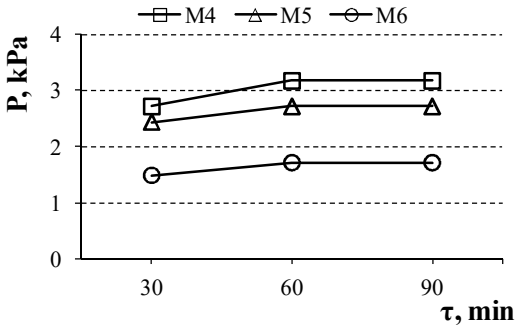
Thus, the peculiarities of the rheology of marmalade masses with a reduced content of sugar should be taken into account when developing the Technological Instructions for production. The interval defined for each group of marmalade masses may be extended in comparison with the traditional recommended standards.

The structure, mechanical strength of marmalade products and, ultimately, the quality of the finished product depends on the process of gel-formation. In the conditions of production, the process of gel-formation occurs in different modes for the gel-forming agents: on agar, the temperature of withstanding of marmalade is t = 10-15 °C, the duration is 30-60 minutes; on k-carrageenans and pectins – t = 10-15 °C, duration is 12-15 min. Determination of the parameters of the gel-formation was carried out based on the dependences of the tension of displacement of marmalade from the time of its was withstanding. The time of gel-formation was defined as the time for which gel with a constant tension of displacement is formed. Dependencies are shown in Figure 7.

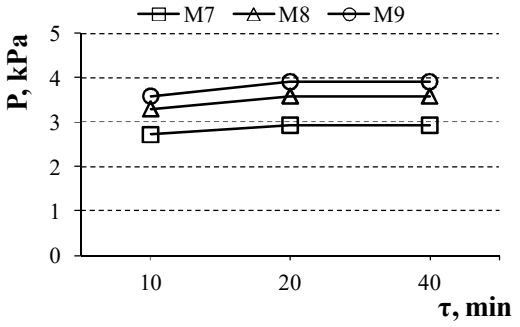
On agar



On k-carrageenan



On H-pectin



On L- pectin

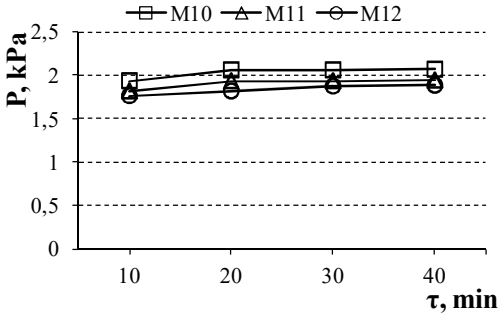


Figure 7. Dependence of the tension of displacement of marmalade with saccharose, glucose and fructose from time of withstanding

It has been determined that the time of gel-formation of marmalade on agar with different types of sugars should be at least 120 minutes. In this case, the samples have different strengths (Table 3): with saccharose, the marginal tension of displacement is 3.91 kPa; with glucose – 2.93 kPa (less by 25%); with fructose – 1.62 kPa (by 58.7% less). However, the resulting strength is sufficient to provide the products with the necessary texture properties typical for marmalade. The resulting marmalade has high consumer properties.

Identical dependences are observed for k-carrageenan, namely: the strength of samples on saccharose is greater than the strength of samples of marmalade on glucose and fructose (the marginal tension of displacement is greater by 14.3 and 46%, respectively). However, the time of gel-formation is reducesd twice compared to marmalade on agar and is 60 minutes.

Samples with pectin have the smallest time of gel-formation: for H-pectin it is enough 20 minutes to obtain constant strength, on L-pectin – 20-30 minutes, depending on the sugar. The dependence of the strength of the structure of the marmalade on the H-pectin differs from the dependencies established for other polysaccharides. Among samples of marmalade on H-pectin, samples with saccharose have, on the contrary, the least strength (marginal tension of displacement is 2.93 kPa), and samples with fructose have the highest (the marginal tension of displacement is 3.91 kPa).

Table 3

Indicators of the structure forming of marmalade

Abbreviation	Marginal tension of displacement, kPa		Time of gel-formation, min	Speed of gel-formation, kPa/min	Total deformation, %	Springy/ plastic defoformation, %
	min	max				
M1	3.44	3.91	120	0.53	9	66.7/33.3
M2	2.62	2.93	120	0.26	27	55.6/44.4
M3	1.49	1.62	120	0.11	31	45.2/54.8
M4	2.72	3.17	60	1.51	31	51.6/48.4
M5	2.44	2.72	60	0.46	35	51.4/48.6
M6	1.49	1.71	60	0.38	40	42.5/57.5
M7	2.72	2.93	20	1.06	61	27.8/72.2
M8	3.30	3.58	20	1.43	75	28.0/72.0
M9	3.58	3.91	20	1.63	80	31.2/68.8
M10	1.82	2.06	20	0.63	81	28.4/71.6
M11	1.93	1.93	20	0.58	85	25.9/74.1
M12	1.76	1.87	30	0.37	86	24.4/75.6

The peculiarity of the structure forming of the masses on L-pectin is the extension of the time of gel-formation for a sample with fructose – by 10 min in comparison with saccharose and glucose. The marginal tension of displacement of the sample with saccharose for the final gel-formation is 2.06 kPa, with glucose is 1.93 kPa (6.2% less), with fructose – 1.87 kPa (9.1% less).

According to the indicators determined on the penetrometer AP-4/1, the springy-plastic deformation of the samples and their correlation were calculated. It has been established that marmalade on agar and k-carraginina differs by springy properties (the proportion of springy

deformationis > 50%); marmalade on pectins is characterized by greater plasticity (the fraction of plastic deformation is > 50%). Along with this, marmalade with fructose on all polysaccharides, except H-pectin, differs by greater plasticity. Sensory evaluation has additionally confirmed that marmalade on pectins has more tender consistency and it is easier to chew; marmalades on agar and k-carragin has more springy consistency.

Conclusions

The multicomponent system, the type of structure former, the type of sugar, and the various ratios influence on the difference in the parameters of the technological process and require separate, specific recommendations. The conducted researches have provided the basis for making changes in the technological schemes of the production of jelly marmaladr. Such parameters have been installed and recommended: maximum speed of the rotary movement during transfer; temperature of transportation and tempering of masses; the cooling time and the production of the finished marmalade.

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Evaluation of quality and antioxidant activity of developed instant black tea and commercial tea (Camellia sinensis) available in Bangladesh

Taslima Ahmed, Nazmul Sarwar

Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh

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Corresponding author:

Nazmul Sarwar
E-mail: nazmulsarwar@cvasu.ac.bd

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Abstract

Introduction. The aim of the current study was to develop a novel technique for the production of antioxidant-rich instant black tea powder.

Materials and methods. Antioxidant-rich instant black tea was produced by spray drying of the concentrated brew of processed tea leaves with the incorporation of bioactive compounds from fruits and vegetables. The quality of instant tea produced was compared with other commercial instant tea and tea granules.

Results and discussion. Developed instant black tea had good liquoring characteristics, and various constituents were also in the acceptable range. Caffeine content was generally high in all the tea samples and ranged from 2.2% to 3.1% in all samples. Total polyphenols content was varied between 17.38% and 22.67% and developed instant black tea has higher polyphenols than others. Tannin content ranged from 7.42 to 10.43% in all samples, while the developed instant black tea had the lowest content such anti-nutrient content than others. Developed instant black tea showed the highest potency of scavenging activity on DPPH radical followed by commercial instant green tea and black tea granules.

Conclusion. Developed instant black tea had higher polyphenol and antioxidant capacity than others Bangladeshi tea which may act as a substitute for natural antioxidants and as a promising agent for beneficial influence in human health.

Introduction

Tea, *Camellia sinensis (L.) O. Kuntze (Theaceae)* is the most extensively consumed beverage among the peoples around the world after water (Muktar and Ahmad, 2000). Although, nowadays tea plants are cultivated all across the world, the best growth of them can be seen in the equatorial and sub-tropical sloping lands of the world as they like torrid, humid climate with sufficient rainfall and well-drained, slightly acidic soil (Graham, 1999). The climate, to which the commercially grown tea plants comply, has a great influence on their ecophysiology (Carr, 1972). The tea plants, cultivated for commercial purposes, come from the hybrids of two specific independent ecotypes i.e., the Assam-type (var. assamica) and the China-type (var. sinensis) (Car *et al.,* 1972). Tea is a very popular beverage especially due to its therapeutic property. In a conventional method, young tea leaves and buds of tea plants (Camellia sinensis) are infused in hot boiling water before consumption. The outlook, restorative property, flavor and aroma of tea vary based on different factors like climatic status, topography, production, processing and different hybrids of tea plants. Based on oxidation tea types are black tea (fully oxidized), green tea (not oxidized) and oolong tea (partially oxidized). The factors like origin, age and processing methods vastly influence the chemical constituents of tea leaves. Hot water helps to extract the flavor, pigment and other soluble compounds from the tea leaves. A large portion of dry matter in tea leaves like polyphenol is soluble in hot water.

Caffeine is a naturally synthesized product occurred by the methylation of hypoxanthine or xanthine mostly found in tea, coffee, seeds etc. The chemical formula of caffeine is $C_8H_{10}N_4O_2$ and the chemical name is 1,3,7-Trimethylpurine-2,6-dione. It is the methylxanthine alkaloid which can differ widely in structure and reactivity. This is often used as psychoactive/therapeutic drugs. The amount of caffeine varies from food to food like tea, coffee, chocolate etc. Among the dry matters of tea leaves, about 2.5-5.5% is caffeine which provides the slightly bitter, astringent taste and flavor in tea. Caffeine has different health effects on our body and high doses of caffeine can cause a bad impact on our health. Light consumption of tea can result in short term headache, nausea and anxiety. An overdose of caffeine can lead a person to different diseases like Parkinson's disease, type-2 diabetes, hepatic diseases, and cardiovascular disease etc. Caffeine interferes with the physiological action of adenosine receptors, a class of G-protein, to make a person vigilant. It is a stimulating agent that plays role in our central nervous system, heart etc. It also increases the production of urine (Komes *et al.,* 2009).

Polyphenol is the vital quality indicators of tea which comprises 25-35% of the dry matters of fresh tea leaves and buds. They are the essential elements providing antioxidant property for which tea leaves are popular. The main classes of polyphenols found in tea are flavonols such as quercetin, myricetin, kaempferol and flavanols or catechins such as (–)-epicatechin, (–) - epigallocatechin, (–)-epicatechin-3-gallate and (–)-epigallocatechin-3-gallate and also some complex catechins such as theaflavins and thearubigins (Wang *et al.,* 2000; Miean and Mohamed, 2001; Yao *et al.,* 2006). Green tea contains more content of tea polyphenols than oolong and black tea (Bharadwaz and Bhattacharjee, 2012).

Tannins are the bioactive compounds found in tea which are also responsible for the dark color and astringent taste. Tea “tannins” are not similar to the other tannins like tannic acid that are found in other plants. The extracts of tea leaves do not contain any tannic acid (Mohammed and Sulaiman, 2009). However, tannins are responsible for antioxidant activities for which they are considered as beneficial. Anti-oxidant activities of tannins are the main reason behind the anti-carcinogenic and anti-mutagenic properties in tea. Apart from this, they also provide anti-microbial properties that act in opposition to the different group

of bacteria, fungi and viruses. The nutrition facts of different foods like vegetables, fruits, tea, cocoa, alcoholic and non-alcoholic beverages may immensely depend on the amount of tannin present in those foods. So the presence of tannins in high amounts may decrease the nutritional values in those foods. This effect leads to some unexpected consequences on the utilization of vitamins and minerals, the inhibition of activities of digestive enzyme and Iron absorption, protein precipitation etc. (Lau *et al.,* 1989, Chung *et al.,* 1998; South and Miller, 1998; Khasnabis *et al.,* 2015). And thus, the application of tannins plays important roles in those effects.

Tea has a long history with the human being. From the very beginning, green tea is providing a high amount of biologically active compounds that have been playing a significant role in the human body. The anti-oxidative agents present in the tea leaves play a consequential role in preventing different diseases like cancer and cardiovascular diseases etc. (Luczaj and Skrzydlewska, 2005; Yang, 2002). Around the world, the consumers of black tea are more significant than that of green tea. However recent researches show that efficient consumption of tea can provide advantageous effects on the human body including reduced risk of cardiovascular disease, certain types of cancer, inflammatory bowel, liver and neurodegenerative diseases, diabetes, and weight loss etc. (Dufresne and Farnworth, 2001). These health benefits of green tea are found due to its immense anti-oxidative property. Recently numerous studies proved the extensive area of anti-carcinogenic effects of green tea on the human body (Muzolf and Tyrakowska, 2007).

But in Bangladesh black tea is more popular than green tea among people due to its brightness, briskness, flavor, and color. That's why the need for antioxidant-rich black tea is demanding nowadays. This investigation was carried out with the objectives to develop new process technology for the preparation of antioxidant-rich instant tea and to evaluate its quality by comparison with commercial black tea available in Bangladesh.

Materials and methods

Collection of samples

A total of 45 samples belonging to three commercial instant teas (B, C, D) and six commercial black tea granule brands (E, F, G, H, I, J) were collected from the local market in Bangladesh for analysis within a period of 6 months from 1st January 2018 to 30th June, 2018. Samples were coded to overcome the sampling biasness.

Development of antioxidant-rich instant tea

For the production of antioxidant-rich instant tea, fresh green leaves were plucked from Kodala Tea Estate, Chittagong, Bangladesh. Young tea (*Camellia sinensis*) shoots with two leaves and an apical bud was naturally withered for 16 h. The withered leaf was macerated in a laboratory hammer mill. The macerated leaf was subjected to fermentation (i.e. oxidation) under the humid environment (30– 32 °C, 80–85% RH) for 80–90 min. The fermented leaf is pressed in a mini hydraulic press at 3234–4312 kPa pressure for 10 min to expel a part of juice containing soluble solids. Whereas, bioactive-rich fruits and vegetables were collected from the local market in Chittagong city, Bangladesh and washed with water and chopped into small pieces with sharp knives. Then transferred into respective beakers added with absolute ethanol, and left to shake on a shaker for 72 h at room temperature. The solvent was separated from the residue by straining. The filtrates were collected and stored

at room temperature while the residues were re-extracted twice, each time with fresh solvent. Finally, all the filtrates were combined and evaporated under reduced pressure at 60 °C using a rotary evaporator to obtain the crude extracts. The crude extracts (5%) were added to tea shoot juice. The juice is then heated for 2 min in a water bath at 90–100 °C till the temperature of the juice rises to 60–70°C which causes the inactivation of enzymes responsible for the oxidation reactions. The mixture is then subjected to spray drying (Mini Spray Dryer B-290, BÜCHI Labortechnik AG, Switzerland) to obtain instant tea powder and stored at room temperature prior to analysis. The process flow chart for the production of instant black tea is presented in Figure 1.

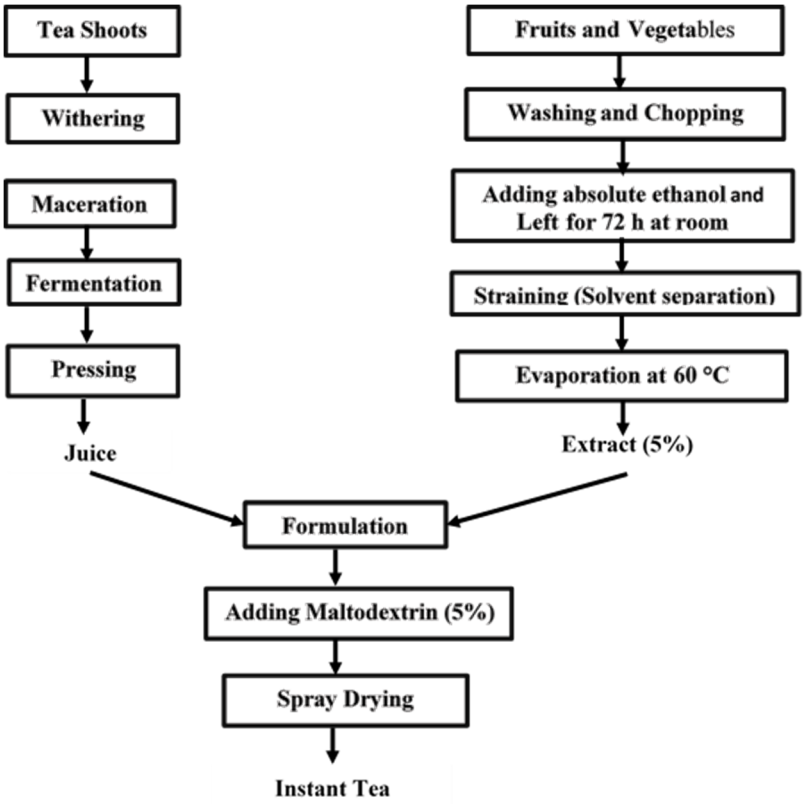

Figure 1. Flowchart of production of antioxidant-rich instant black tea

Sensory evaluation

A group of panelists conducted the sensory evaluation of the tea according to the method described by Potter (1968). Tea samples were evaluated for the various quality attributes using the standard tea testing procedure. The brew was prepared for each sample by the standard method and assessed for color, flavor, pungency, strength, mouthfeel and overall acceptability by a taste panel. The tea samples were evaluated for degree of liking on the basis of quality attributes of dry leaf, liquor, and infused leaf by using 9-point hedonic scales (Overall scale used: 9= like extremely; 8=like very much; 7=like moderately; 6= like slightly;

5= neither like nor dislike; 4= dislike slightly; 3= dislike moderately; 2= dislike very much; 1= dislike extremely) and score 5.0 was considered the borderline of acceptability. Five experienced judges (3 males and 2 females; 25-30 years old) had been involved in the sensory analysis of teas. The sensory evaluation was conducted between 9:30 and 10:30 am and panelist received four samples per session. Sessions were performed in individual partitioned booths and scores among panelists were averaged. The mean sensory score for different quality attributes for various tea samples was determined and statistically analyzed for the variance. The mean sensory score for the quality attributes of various tea samples is given in Table 1.

Extractives determination

Approximately 2g of tea samples were accurately weighed in a tarred flat-bottom dish, dried in the hot air oven for 5 hours at 1000C. After drying, the dish was removed from the oven, cooled and weighted. Dried tea samples were transferred to a round-bottom flask with 100ml distilled water and reflux for one hour in a laboratory reflux unit. Filtration was carried out into a 250 ml graduated flask and residue with the filter paper returned to the reflux flask, further adding 100 ml distilled water and reflux for an additional hour. Filtered into the volumetric flask, rinsed the reflux flask with hot water and passed the rinsing's through the filter. The filter was washed with hot water until the volumetric flask is filled nearly to the mark. Then cooled, diluted to 250 ml, mixed and pipetted 50 ml into a weighed metal evaporating dish. Finally, the solution was evaporated on a rotary evaporator and dried in the oven. Cooled and weighed.

$$\text{Water-soluble extractives} = \text{Weight of residue} \times \frac{250}{50} \times \frac{100}{\text{weight of dried tea}}$$

(Manley, 1965; Iwasa *et al.,* 1966).

Caffeine content determination

The separation process of caffeine from the tea leaves was carried out by following a modified method described by Atomssa and Gholap (2011); Hampp (1996); AOAC (2016). In short, at first 5 g of tea leaves were taken into a 150 mL cleaned beaker followed by the addition of 30 mL of distilled water and 2.0 g of sodium carbonate. Next, the mixture was constantly boiled for 10 minutes on an electric hot plate. A small flat glass was placed on the beaker to avoid undesirable and exceeding evaporation. The hot tea was separated by using a strainer and placed into a 50 mL Erlenmeyer flask. The remaining tea leaves were transferred into the beaker followed by addition of 20 mL of water. Then the previous procedure was repeated again and the 20 mL of hot tea was transferred into the Erlenmeyer flask. The residual tea leaves were discarded. After that, the hot tea was kept to cool at room temperature and transferred into a 125 mL separatory funnel that was supported by a ring stand. About 10 mL of dichloromethane was added followed by the installation of the stopper. Then the separatory funnel was shaken gently in a swirl motion so that no bubble may form. The funnel was frequently vented to relieve the vapor pressure created inside the funnel. After that, the funnel was placed on the ring stand allowing the contents to settle and the stopper was removed. Two individual clear layers were created where the emulsions between the layers were removed by swirling the contents gently with the help of a glass rod. The lower layer containing the dichloromethane was drained out gingerly into a 50 mL Erlenmeyer flask so that no portion of the aqueous layer may issue. When the emulsion between the layers

remained, it was also transferred in to the Erlenmeyer flask. Then, another 10 mL of dichloromethane was added in the separatory funnel and the previous steps were repeated. After that, about half a spoon of anhydrous sodium sulfate was added to the separated dichloromethane extracts and gently shake the Erlenmeyer flask. This sodium sulfate was added to absorb the little water dissolved in the dichloromethane which could not be separated unexpectedly. The sodium sulfate and the water precipitated at the bottom of the flask. Finally, the dichloromethane extract separated into a clean dry beaker and placed on a hot water bath to evaporate the dichloromethane. The remaining caffeine was then weighted and kept in a pre-weighed plastic bag. All the data of the amount of the caffeine were recorded.

Calculation of caffeine percentage:

$$\% \text{ Caffeine} = \frac{W1 \times 100}{W2}$$

W1= weight in g of the evaporation residue, W2= weight in g of tea/coffee used

Total polyphenols content determination

Total phenolic content (TP) was determined according to a modified method of Bharadwaz and Bhattacharjee (2012). Firstly extraction of polyphenols from dried tea leaves were done. 5g of tea leaves were dried and crushed and added to hot water (60oC) in the ratio 1:20 with periodical stirring to deactivate enzymes. Then the filtrate is collected and tea solution is concentrate by using rotavapor (water bath at 60oC). Then, decaffeination of tea extract was done by adding an equal volume (about 245 ml) of CH2Cl2 to the concentrate and shaken in a separating funnel. The lower part being caffeine (chlorophyll, lipid, carbohydrate etc.) dissolved in CH2Cl2 and upper part being the undissolved remaining concentrate. Finally, extraction of polyphenols from decaffeinated crude extract was done by mixing 250ml ethyl acetate and 0.1 g ascorbic acid (to prevent oxidation) in a separating funnel to the undissolved remaining tea concentrate. The mixture is immiscible, the upper yellow part is polyphenol dissolved in ethyl acetate and the lower part is the remaining tea solution (oil, fats, lipids etc.). The solution is then concentrated and the polyphenols were dried and stored in a desiccator to prevent stickiness. The result was expressed in % of extracted polyphenols for tea.

Tannin content determination

Extract preparation. Tea extract was prepared based on the principle of water-soluble property of tannins. At first, 1 g of tea leaves and 25 mL of distilled water were taken in a small beaker and placed on a hot plate magnetic stirrer for 5 minutes at 70˚C. Next, the heated liquor was allowed to cool. Then filtration of the tea leaves was done using Whatman no. 1 filter paper. Then, the filtrate was centrifuged at 1000rpm for 15 mins to separate the tea extracts containing water-soluble compounds. After that, the supernatant was brought into a screw-capped tube which was sterilized previously. Finally, the tube was stored at 4˚C for qualitative and quantitative analysis.

Qualitative analysis of tannin. The presence of tea tannins can be detected by using the ferric chloride test. Tea tannins provide greenish color and precipitation when ferric chloride solution is added to them. According to this principle, 1 g of tea extract was taken in a test tube followed by the addition of 2-3 drops of 5% (w/v) aqueous ferric chloride solution. The

reaction between them resulted in greenish precipitation which indicates the presence of tannins in the tea extract.

Quantitative analysis of tannin. The quantity of tannin in the tea extract was estimated by using the titrimetric method where tea extract was titrated with standard potassium permanganate (KMnO4) solution according to the methods of AOAC (2016). During the determination of the tea tannins by titration, reagents i.e., gelatin solution, acidic NaCl solution and powdered kaolin were used. For the preparation of gelatin solution, 25 g of gelatin was soaked in saturated NaCl solution for 1hr. The mixture was then heated until the gelatin became dissolved and allowed to cool down. Finally saturated NaCl was added and the solution was made up to 1 L. Acidic NaCl solution were prepared by measuring 25 mL of concentrated H2SO4 in a 1L volumetric flask. Then 975 mL of saturated NaCl was added up to the graduation mark of the flask.

Oxidimetric titration of tea extract were done by following procedures. Firstly, 5 mL of tea extract was measured into a 500mL conical flask. Then 12.5 ml of indigo-carmine solution and 375 ml of deionized distilled water were added into the conical flask. Then KMnO4 was used for titration with the mixture which was prepared previously. The KMnO4 was added until the blue color of the mixture changes into final yellow with a faint pink tint at the rim. At the endpoint, the volume of KMnO4 was recorded. This volume ('Y' mL) was required to titrate all the tannins and non-tannin compounds present in that tea extract. The amount of KMnO4 required to titrate the non-tannin compounds was 'X mL'. To determine the volume 'X mL', another 50 mL of tea extract was measured and added to the mixture of 25 mL gelatin solution, 50 ml of the acidic NaCl solution and 5 g powdered kaolin. Next, the mixture was shaken followed by the filtration using Whatman no. 1 filter paper. From the filtrate around 12.5 mL was mixed with 12.5 mL of indigo-carmine solution and 375 mL of distilled deionized water. The whole mixture was titrated against the KMnO4 solution like the previous procedure until the color at the endpoint turned into faint pink. Finally, the real volume of KMnO4 required in the titration of tea tannin was evaluated from the difference between the value of Y and X.

1 ml of standard KMnO4 solution = 0.595 ml of 0.1N Oxalic acid

1 ml of 0.1 N Oxalic acid = 0.0042 g of tannin

Antioxidant activity determination

Antioxidant capacity of the tea extracts was determined using DPPH assay as the method described by Azlim Almey *et al.* (2010) with slight modifications. 6 mg of DPPH was dissolved in 100 mL methanol to prepare Methanolic DPPH solution. An aliquot (0.5 mL) of methanolic solution of extract containing different concentrations of 0.10, 0.20, 0.30, 0.40, 0.60, and 0.80 mg/mL were added to 2.5 mL of methanolic DPPH solution. The mixture was gently shaken and left for 30 min in dark at room temperature. The absorbance was read at wavelength 517 nm using UV-VIS spectrophotometer (UV-2600, Shimadzu Corporation, USA). Control prepared by mixing 1 mL of methanol with 2 mL of DPPH solution while methanol was used as a blank. The scavenging activity was measured as the decrease in absorbance of the samples in comparison with the DPPH standard solution. Antioxidant capacity based on the DPPH free radical scavenging ability of extracts calculated using the following equation:

$$\% \text{ inhibition} = 1 - \text{Absorbance of sample} / \text{Absorbance of control} \times 100\%$$

Statistical analysis

The obtained data were stored in Microsoft Excel 2013 and then all statistical analysis were performed using R Statistical Software (version 3.4.1; R Foundation for Statistical Computing, Vienna, Austria).

Results and discussion

Sensory evaluation

The ranking of the tea samples obtained by evaluating the sensory data is developed instant black tea)> commercial instant tea> commercial black tea. Similar observations were made by Sinija and Mishra (2008); Someswararao and Srivastav (2012) for sensory evaluation of tea. All the quality attributes for instant tea and tea granules were rated from like extremely to moderately.

Table 1

Sensory evaluation of analyzed tea samples

Tea Samples		The degree of liking/hedonic scale score (1-9)				
Kinds of Tea	**Sample**	**Color**	**Flavor**	**Pungency**	**Strength**	**Mouthfeel**
Developed Instant Black Tea	A	8.8	8.7	7.6	8.1	8.6
Commercial Instant Tea	B	8.6	8.2	8.3	7.8	8.4
	C	7.2	7.4	6.8	7.9	7.8
	D	6.9	7.2	6.9	8.0	7.9
Commercial Black Tea	E	8.3	8.1	7.1	7.8	7.8
	F	8.4	8.4	7.5	7.7	7.5
	G	8.5	7.9	8.1	7.9	7.9
	H	7.8	8.1	8.0	8.1	8.0
	I	8.4	8.4	8.2	8.3	8.1
	J	7.9	8.3	7.8	7.6	7.4

Overall scale used: 9= like extremely; 8=like very much; 7=like moderately; 6= like slightly; 5= neither like nor dislike; 4= dislike slightly; 3= dislike moderately; 2= dislike very much; 1= dislike extremely.

% Extractives of Tea

Percentage of Extractives in tea samples determined are reported in Table 2. As Percentage of Extractives is an indicator for black tea granules, in this study only commercial black tea samples were analyzed and values were within 11.29% to 38.62%. Some values were less than the legal limit of Bangladesh Standards and Testing Institution (BSTI) (30%) that could be the indication of spent tea leaves, i.e., those that have been infused, dried and re-used (Hosen *et al.,* 2014).

Caffeine

The amount of caffeine in different tea samples tested was in the range between 2.2% to 3.1% (g/100g materials). The order of caffeine concentration in tea samples types was found as follows: Commercial Black Tea Granules > Commercial Instant Tea > Developed Instant Black Tea. Results obtained were higher than caffeine (%) reported by Rabiul Islam *et al.* (2013) and similar to data reported by Rahman *et al.* (2012) and Hosen *et al.* (2014). The quantitative differences obtained among different kinds of tea is probably due to the method of processing of each kind since caffeine sublimes without decomposition upon exposure to heat, therefore it should be expected that caffeine could be lost during fermentation and processing. Also, the differences of caffeine quantity and consequently the percentage may be due to the different time of harvesting of leaves of the plant.

The caffeine content in standard black tea brew varies between 60 and 115 mg per cup and in a cup of instant tea is 40 mg caffeine content of developed instant black tea was found 2.2%. This showed that the efficiency of conversion of caffeine during processing increases after extracting a part of the juice. Thus, it is seen that the instant tea produced by this method are comparable to that of standard black tea in major chemical constituents. Caffeine the major component of tea and regarded as a stimulant; excess of it can cause impairment of the mechanical properties of growing bone in early life (Oh *et al.,* 2004).

Table 2

% Extractives, Caffeine, Tannin, Total polyphenol content of analyzed tea samples

Tea Samples		Extractives (%)	Caffeine (%)	Total Polyphenol (%)	Tannin **(%)**
Kinds of Tea	**Sample**				
Developed Instant Black Tea	A	-	2.2%	22.67%	7.42%
Commercial Instant Tea	B	-	2.4%	17.45%	8.56%
	C	-	2.5%	17.96%	8.49%
	D	-	2.8%	17.38%	8.03%
Commercial Black Tea	E	27.41%	3.1%	18.01%	9.8%
	F	21.74%	2.6%	19.67%	9.01%
	G	14.58%	2.9%	18.71%	9.72%
	H	38.62%	3.1%	22.56%	10.28%
	I	11.29%	2.6%	18.71%	9.89%
	J	34.61%	3.0%	21.72%	10.43%

Results are means ± standard deviation of triplicates

Total polyphenols content

Total polyphenols of analyzed tea samples were ranged between 17.38% and 22.67%. Kerio *et al.* (2013) found total polyphenols in processed teas from the purple leaf colored cultivars ranged from 17.1% to 21.1% for aerated, is similar to the recent study. The results higher than findings of Rahman *et al.* (2012) who found the polyphenol content of 11.23% to 14.85% in various teas and coincidence with the finding (19.33%) of Bharadwaz and Bhattacharjee (2012). Lin *et al.* (2003) reported that tea leaves contain high phenolic components which account for 25 - 35% on the dry weight basis. Soluble polyphenols

constitute about 15% of black tea but this variation may occur due to the different variety of tea, its geographical origin, environmental conditions and agronomic situations. As the contents of polyphenol found in this study were high in comparison to Lin *et al.* (2003) this may be due to the fact of oxidation of flavanols, flavandiols and theogallin during the conversion of fresh leaf to processed tea. In this study, developed instant black tea was found to have higher polyphenols as compared to others (Table 1). Besides, no significant variation was found between the polyphenol content of commercial instant tea samples because of their homogenous nature in comparison with other varieties ($p > 0.05$). In this analysis, Commercial black tea samples show significant variation in polyphenol content which is higher than all.

Tea polyphenols have been reported to have strong antioxidant property and free radical scavenging activity due to possession of a phenolic hydroxyl group attached to the flavan-3-ol structure. Free radicals are generated constantly due to the metabolism of food ingredients, physical stress, and oxidative stress mediated by various environmental pollutants/chemicals/toxins, radiation etc. These free radicals are implicated in numerous disorders in human such as cancer, angina pectoris, neurodegenerative diseases and atherosclerosis (Lobo *et al.,* 2010). As the developed instant black tea has higher polyphenols than others it will have a beneficial effect against these diseases.

Tannin content

Results of tannin content in different samples of tea have been presented in Table 1. It was found that samples of commercial black tea had higher tannin content than commercial instant tea and developed instant tea. Tannin content in black tea ranged from 9.01 to 10.43%. Highest tannin content in the studied was found in sample J. Developed instant black tea had the lowest tannin content of 7.42%. Results were similar to the study of Ushir *et al.* (2011) 7.99 to 9.82% and lower to the reported value of Khasnabis *et al.* (2015) 11.76 to 15.14%. Differences in tannin contents of different tea samples may be due to the difference in the process of manufacture, aging of tea leaves or the differences in climate and soil texture. Tea tannin, different from tannic acid, is a type of polyphenol present in tea leaves. Kaur *et al.* (2015) estimated the total polyphenolic content of 10 samples of black tea and 6 samples of green tea. They found that the total polyphenol content in green tea (3.066±1.911 mg TAE/g) was significantly higher than in black tea (0.72±0.55 mg TAE/g) ($p<0.05$). The higher levels of polyphenols in green tea than black tea could be due to the conversion of the tea polyphenols into thearubigins and theaflavin during the fermentation process.

Tannins have traditionally been considered anti-nutritional but it is now known that their beneficial or anti-nutritional properties depend upon their chemical structure and dosage. If ingested in excessive quantities, tannins inhibit the absorption of minerals, such as iron which may, if prolonged, lead to anemia (Dommgang *et al.,* 1998). As developed instant black tea has low tannin content (7.42%) as compared to other black tea, consequences of such anti-nutritional factors will be minimized.

Antioxidant activity

Antioxidant activity, measured by the DPPH method, was expressed as inhibition percentage. Inhibition of the free radical DPPH was measured and data are presented in Figure 2. Developed instant black tea (A) showed the highest potency of scavenging activity on DPPH radical followed by commercial instant green tea and black tea granules. No significant difference in potency value was observed for commercial black tea granules (E,

F, G, H, I and J) as evident from Figure 2. When further investigated, significant differences ($p < 0.05$) in DPPH inhibition were observed between commercial instant green and black tea samples.

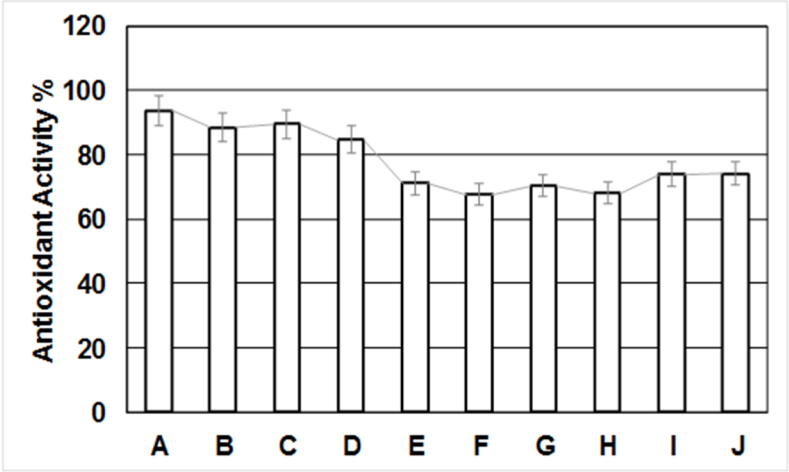

Figure 2. Antioxidant activity (% inhibition) of analyzed tea samples
A – Developed Instant Black Tea;
B, C, D – Commercial instant tea brand;
E, F, G, H, I, J – Commercial black tea granule brands.

Antioxidant activities of commercial instant green tea are higher than green tea from USA (70.1%), Sri Lanka (55.0), China (60%) and Japan (68%) (Rababah *et al.,* 2004; Armoskaite *et al.,* 2011) and the values are closely related to (%) antioxidant activity of Indian green tea (92.84%) (Sandip *et al.,* 2012). Antioxidant activity of green tea brand of South Africa (90.8%) was higher than that reported for in the present study for Bangladesh green tea brand (Gadow *et al.,* 1997). Black tea brand (81.7%) from South Africa, however, is reported to have much higher antioxidant activity than Bangladesh black tea brands tested. However, all instant green tea showed higher antioxidant activity than commercial black tea granules (Figure 2). The antioxidant activity and reducing power of the tested tea samples showed high correlation with the polyphenol content.

Conclusion

A novel technique for the production of antioxidant-rich instant tea has been established in this investigation. The instant tea produced by this method is of good color, pungency and other liquoring characteristics and soluble even in cold water.

Caffeine, tannin and polyphenol contents are also in the acceptable range.

The findings of the present study indicate that developed instant tea will be a good source of plant polyphenols which may possess antioxidant, anti-inflammatory and cancer-preventive action.

The low content of caffeine allows its use by pregnant women, children, and people with cardiovascular diseases and anxiety disorders as a stimulant beverage with proven health properties.

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Influence of thermal processing by steam convector of the pickled game meat

Lyudmyla Peshuk, Oleksandr Gorbach, Oleg Galenko, Nina Budnik

National University of Food Technologies, Kyiv, Ukraine

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Corresponding author:

Oleg Galenko
E-mail: galen@i.ua

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Abstract

Introduction. The aim of researches was a rationale of possibility of the use of different methods of thermal processing in technology of the pickled ready-to-cook foods from wild game meat and determination of its optimal regimes.

Materials and methods. Technology of thermal processing of the pickled ready-to cook product, meat of wild boar, marinades, barbecue is investigated after use of the different methods of thermal processing. For determination of content of iron the sulfosalicylic method of determination of oxide of iron is used, and for determination of the content of zinc is used inverse voltamperometric method. The method of determination of infra-red spectrums with the help of device of "Infrapid" is used.

Results. The food value of meat of wild animals was estimated by physical and chemical indexes. It is set that on physical and chemical indexes meat of wild animals doesn't yields to meat of agricultural animals – pork and beef, but prevail in content of albumen on 2,9–6,8%.

It's proven on that amino acid composition of meat of wild wild boar does not yield to pork, and by such amino acids, as a valine, isoleucine, leucine, threonine and tryptophane considerably prevails it. Also it prevails pork by the total amount of irreplaceable and replaceable amino acids on 2,45 and 0,81 g/100 g of protein accordingly, and its albuminous quality index is higher on 0,35 g/100 g.

The comparative estimation of influence of different methods of thermal treatment on the output of barbecue educed advantages of the use of steam convector and microwave owen compared with traditional frying and steaming. Decline of losses of content of moisture in the finished product on 23% after processing in steam convector serves as reason of increase of output of barbecue.

Preparations of foods in steam convector were carried out due to the convection of hot air which was created by heating of electric tubular heaters or gas. Permanent circulation of hot air provided the even baking of foods in stoves and speed of their preparation. In steam convector sprayer system of moistening is set, that is why humidity of air was in a working chamber was regulated.

Conclusions. The recomended technological mode for preparing of barbecue in steam converter is: t=220-260 °C, φ=15% for 9 minutes. Mineral composition of meat of wild boar surpass meat of pork by maintenance of some micro- and macronutrients. High maintenance of iron – 1500 mcg/100 g in meat of wild boar – is able to satisfy the 20% of daytime ration of man.

Introduction

Thermal processing is a basic reception in the technological process of production of meat products. Mostly it is used on the finishing stage of cooking and is used with the aim of leading the product to the culinary ready condition, and also elimination of potentially toxic microorganisms (due to D.I.Lobanov) [1].

There are many receptions of thermal processing in technology, but in basis there are two methods – moist and dry heating . Therefore roasting and boiling are considered as the basic methods of thermal processing, and other methods are the variety of basic ones. In technology of dietary products most application was found by the moist heating. Boiling of foods is possible in great number of liquids, in a few amount of liquid or in its' own juice and on a steam [2]. In some cases foods are processed at a mionectic temperature (on water bath), at excessive pressure (in autoclaves) and at mionectic pressure (in vacuum pans). Large interest, from the point of view of the use for preparation of dietary foods presents heating in the field microwave radiation because the foods which are coocked by this method, by the organoleptic properties approach to ones that were treated in water environment (A.F.Maliutyn; H.N.Lovacheva, A.I.Mglinets) [3].

With the aim of intensification of process of thermal processing of foods by a steam can be applied such varieties of this heating : treatment the overheated steam, at excessive pressure, with a force convection [1].

Due to researches the advantages of heating of the overheated steam were educed as compared to traditional methods. M.A. Husman marks that duration of thermal processing of ready-to-cook foods in vehicles with the overheated steam are reduced, as compared to heating in SHK-2A, on a 20% and output of the prepared product increases no less than 10% with high organoleptic properties. Data which were got by Beloborodov V. and Khudov V. testify to reduction of process of heating of different products by the overheated steam (at pressure 2,06*105 Pascal) on 50-210% comparing to boiling in water [2].

Acceleration of process of processing of foods by using steam it is possible to attain by heating at exessive pressure. During the increase of temperature on the surface of samples (in comparing to heating at ordinary terms) there is a greater gradient of temperature between layers, that creates more intensive heat-and-mass transfer into a product and stipulates reduction of process of treatment of products. Heating at excessive pressure is widely used in a thermal equipment that is produced abroad by different firms [4].

Realization of principle of a force convection of coolant-moderator also can assist intensification of heating of foods by moist saturated steam (at atmospheric pressure) [5].

However an unambigiuous idea on this issue wasn't set. Researchers contradictory determine the degree of influence of speed of steam on the coefficient of heat emission and its' increase in comparing to the coefficient of heat emission, expected by Nusselt for a clean immobile steam [6].

Thus, at using of steam as a working environment in thermal vehicles it is necessary to aspire to achieve the maximal moving away of air from the swept capacity that will assist for the best heat exchange between a coolant-moderator and processed product. Heating with a force circulation of steam is used in steam converters that are produced in the USA and Germany [5].

It is known that than the lower temperature of thermal processing of meat products is, the greater outcome and the top quality of the product will be (A.A.Sokolov). That's why heating is recommended to conduct in the way, that a temperature across the entire thickness of product was near to minimally necessary (80°C). Observance of this condition during the thermal processing of the meat products can be attained by the use of heating of steam-air

mixture, the temperature of that lies in limits from 80 to 95°C. Experience of application of this method of heating in food industry for heat treatment of sausages testifies about its' efficiency [7].

As a number of authors (A.A. Sokolov; V.V. Karpov and other) reports, the row of advantages has boiling of foods by steam-air mixture as compared to other methods of heating (cooking in water, on a steam). The reduction of losses of mass, power charges, improvement of quality of sausage are one oj the methods [8].

Thus, the analysis of data of literature allows to make conclusion, that the use of heat treatment by steam-air mixture, by a steam at excessive pressure and with a force convection is perspective direction of improvement of technology of production of dietary ready-to-cook foods [5].

To most perspective types of universal thermal equipment belongs steam converter. The wide model row of steam converters is now presented from different producers that have different functional possibilities and price. They are divided by such rules : by the source of heating on electric and gas; by the method of creation and serve of steam on injector and boiler ones; on the method of management with an electromechanics and electronic management. Among the basic foreign producers are next firms: Rational SCC (Germany), Unox (Italy) and Abat PKA 10-1/1-P (Russia). Information about influence of the modes of thermal processing in steam converter on quality of the prepared meat products in particular small-sized and chopped ready-to-cook products are not enough. Zakharov A.A. notes the use of such devices on the catering enterprises, as intensity of heat-exchange processes rises, and also the losses of mass of meat foods (in 1,5 times) are redused in comparing to the traditional methods of thermal processing [4].

Nowadays there is a necessity for more detailed research of influence of thermal processing in steam-converter on quality of culinary products. Data which are got as a result of experiments will allow scientifically to ground the choice of the modes of thermal treatment of culinary products with the use of steam-converters [3].

Materials and methods

By material for research the meat of boar was selected; marinades; ready-to-cook foods after the different methods of thermal processing. In process the chemical and physical and chemical methods of researches were used. For determination of content of iron the sulfosalicylic method of determination of oxide of iron of Fe_2O_3 is used . Preparations of tests to the analysis were conducted by the method of dry mineralization. Two parallel tests are thus used and one control test is also used. A method is based on complete decomposition of organic substances by combustion of test of raw material in electric oven at controlled temperature [5].

Preparation of the sample to mineralization. Porcelain crucibles were washed, heated for hour at a temperature 80–90 °C in 1M solution of aquafortis, washed by the distilled water. Before the use porcelain crucibless burn out in a muffle stove [6].

From the prepared test took batch of 1–3 g ,and carried in porcelain crucible. Added 1–2 $см^3$ of 0,5M solution of hydroxide of natrium and 1–2 $см^3$ of 0,5M solution of nitrite of natrium. Thus a standard sample must not be moistened by solution. The crucible was covered by a lid and abandoned on 10–15 min at a room temperature, carried on a sand-bath that is located on electric oven and dried out carefully. Then crucibless were covered by a lid, carried in a muffle stove and maintained during one hour at a temperature 500 °C. The crucibles were cooled then. Mineralization is considered as completed, when an ash became

white or tinged color, without charry parts. At presence of charry parts treatment of ash solution by nitric acid solutiob of was repeated [5].

Preparation of the sample for determination. The content of crucible was placed in a volumetric flask of 100ml, with adding 5–10ml of a 25% solution of sulfosalicylic acid. In a retort added to the 25% solution of ammonia to appearance of weak smell. On the measure of neutralization of solution the pink-violet colouring passed to yellow. Surplus of ammonia does not influence on determination.

Led to solution in a retort the distilled water to the mark.

Construction of gauge chart. In volumetric flasks of 100 ml took away: 0,2; 0,5; 1,0; 1,5; 2,0; 2,5; 3,0; 4,0; 5,0 mg of the iron solution which was got earlier and took to the mark with distilled water.

Definition (photocolorimetric definition). The painted solution was poured in a cuvette and placed it in a right light stream. In the left cuvette of the same size was poured a "zero" solution that was prepared as follows.

In a volumetric flask of 250 ml capacity brought in 25 ml of a 25% solution of sulfosalicylic acid, conducted with the distilled water to 100ml and by drops added 25% solution of NH OH of the same concentration. Led the solution with distilled water to the mark and used for zeroizing of galvanometer.

Photocolorimetry was conducted with a blue colour filter.

Determinations of content of zinc were conducted using an inverse voltamperometric method with the use of analyzers of ABA- 1, ABA-2.

For verification of capacity of the measuring electrochemical system, readiness of operator to realization of this methodology, and also for audit of quality of base-line solution, cleanness of electrodes and cell a trial test was carried out .

Preparation of base-line solution. As base-line solution an acetate buffer is used, pH=4,6 0,1M that is got, mixing up 102 ml of 0,2-molar acetic acid and 98 ml of 0,2-molar solution of potassium acetate .

An acetic acid was cleared in bottletight desiccator, in the underbody of which was poured the concentrated acetic acid ,which was subject of cleaning, and on porcelain insert was put the quartz evaporated cup with the twice-distilled water by volume of 200ml. After 2–5 twenty-four hours a cup was reached, determined the closeness of the got solution of acetic acid on an aerometer. Distilled at that way acid was kept in a vessel from the polyethylene of high-pressure and use for preparation of buffer solution.

Preparation of redistillate. The distilled water was additionally out-distanced with alkaline solution of potassium manganate , periodically adding to the distillation retort of 2.3 ml of solution of otassium manganate to appearance of the pink colouring.

Preparation of potassium manganate .The solution of potassium manganate was prepared by dissolution of 10 g solid salt in 100ml of solution of caustic soda with concentration of 1moles/l (40g of caustic soda on 1 l of water).

Preparation of salt of gallium is from nitric acid salt of gallium. In a volumetric flask on 500ml brought in a batch of 1,999g of gallium nitrate, added 1,5 ml of HNO (2:3) and after dissolution of salt the solution was conducted by redistillate to the mark. The solution

had a concentration of ions of gallium on the level of 0,01moles/l. During the use of waterless nitrate of gallium the batch folded 1,279g.

Carrying out a trial test. The operating volume of cell was 10–25 ml.

The operating volume was filled by 10–25ml of solution of acetated buffer (pH=4,6) and added 1–2 drops of solution 10 g/l of Hg and 0,2-1,0 ml of solution of Ga (III) respectively. The cell was fixed in a holder, and made sure that auxiliary, basic and comparison electrodes are submerged in the solution.

Before the measuring we checked up the absence of break in the chain of "basic electrode-electrode of comparison" (for example, through appearance of air bubble), impermeability of insulating shell basic (indicatory electrode).

Control of impermeability was carry out in the next way: in prepared to work cell with the base-line solution inundated in it measured stationary potential of basic electrode in relation to the electrode of comparison. If impermeability of insulating shell is broken, then potential of basic electrode takes on a negative value instead of values of order from 0,15 to 0,4. Three cycles were conducted by measuring on the solution of background. As was mentioned higher, every cycle includes 4 stages: regeneration of electrode at potential 0.3-0.5 during 30.60 s, accumulation at potential – 1,3–1,45 during 30–300 s, acceleration of solution at the same potential – 1,3.-1,45 during 10–30 s [6].

Carrying out a basic test. After carrying out a trial test from cell was deleted solution of background and by a pipette brought portion of analysing solution a capacity even to the swept volume of cell and added solution to gallium (III) in an amount that provides 20-multiple surplus of ions of Ga (III) in relation to the concentration of ions of zinc in cell and 1-2 drops of solution 10 g/l of Hg (II).

The cell was fastened and the cycles of measuring led to 4 on this solution at the same electric modes and temporal intervals, similarly as for solution of background.

We entered addition of solution of comparison of zinc, the amount of that gets out so that the concentration of it in initial solution increased in 2 times. A volume of additive must not be large, not to do an error as a result of dilution of analysing solution.

The cycles of measuring conducted 3-4 times using the solution with additive.

Treatment with using the voltamperogram.

1. We identified the peak of measureable component (zinc), going out of the values of his potential of dissolution (-0,95B). Also a peak height was measured, by measuring of length of perpendicular from the top of peak on axis of potentials from a peak-point to the base-line line. A contribution was conducted in millimetres. If the different scales of registration of corn-floor are used, then the size of corn-floor is enumerated in microammeters.
2. We calculated the mean arithmetic value of peak height, casting aside the first value and, determining average from the next recreated heights of peak of corn-floor. An operator fixes in a working magazine the value of analytical signal and value of sizes which are necessary for a calculation.

h_1 – AV arithmetic values of height of peak of zinc in solution of background, mm or мкА;

h_2 – AV arithmetic values of height of peak of metal in solution of background, mm or мкА;

h_3 - AV arithmetic values of height of peak of metal in analysingsolution with addition of solution of comparison, mm or мкА;

V_x – volume of analysing solution, ml; C_1 – concentration of solution of comparison, mg/l; V_3 – volume of addition of solution ofcomparison, ml.

The size of concentration of ions of zinc in analysing solution (in mcg/l) was determined with the use of formula:

$$C_x = \frac{C_1 \times V_3 \times (h_1 - h_2)}{V_x \times (h_3 - h_1) + V_3 \times (h_3 - h_2)} \quad (1)$$

Methodology of research of infra-red spectrums of meat consists in the following: the samples of meat prepare preliminary,the pieces of meat are ground down with the help of meat cutter machines whereupon yield to drying in a drying closet at the temperature of 1500C to permanent mass, they are dried out then. The got dry powder is sifted on homogeneous sieves [3].

The farther sifted samples of meat are placed in cuvettes and make more compact.The process of determination of infra-red spectrums goes next with the help of "Infrapid", that gives an opportunity to conduct research in the interval of lengths of waves of 1330–2370 nanometers. On the finishing of determination of infra-red spectrums of meat the computer processing of the obtained data is conducted and the chart of spectrums of reflection is built.

Results and discussion

The amino acid composition of meat of wild boar was investigated. In a table 1 amino acid composition of meat of wild boar is given in comparing to pork.

By amino acid composition meat of wild boar does not yield to pork, and by such amino acids, as a valine, isoleucine, leucine, threonine and tryptophane considerably prevails it. Also it prevails pork by the total amount of irreplaceable and replaceable amino acids on 2,45 and 0,81 g/100 g of protein accordingly, and owns a higher albuminous quality index (correlation is a tryptophane/hydroxy-proline) that prevails pork on 0,35 g/100 g of protein.

In our work the infra-red spectrums of reflection were investigational in a near area. As objects the specially prepared samples of meat of venison, wild and domestic pork were used.

The feature of measuring of powdery samples was that all of them must have an identical degree of grinding with the next sifting on one sieve. Samples must be kept at equal terms. As an analyzer of infra-red spectrums the device of "Infrarapid", that gave an opportunity to conduct research in the interval of lengths of waves – 1330–2370 nm, was used.

Table 1

Amino acid composition of meat of wild boar in comparing with pork, g/100 of protein

Sample	Wild boar meat	Lean meat	Scale FAO / WHO, g/100 g of protein
Valine	4,81±0,23	4,74±0,25	5
Isoleucine	5,1±0,15	4,48±0,14	4
Leucinum	8,7±0,18	8,25±0,20	7
Lysin	7,82±0,32	8,07±0,34	5,5
Methionine	2,37±0,14	2,34±0,13	3,5
Threonine	5,56±0,13	4,36±0,18	4
Tryptophane	1,37±0,05	1,10±0,04	1
Phenylalanine	3,52±0,13	3,46±0,10	6
Totally	39,25	36,8	
Totally	46,29	45,48	-
Alanin	5,72±0,27	5,34±0,26	-
Arginine	6,52±0,35	6,67±0,31	-
Aspartic	7,81±0,22	7,45±0,23	-
Histidinum	1,57±0,06	1,49±0,04	-
Glycine	7,38±0,21	7,21±0,20	-
Glutamic acid	16,54±0,35	16,52±0,31	-
Hydroxy-proline	0,75±0,05	0,74±0,04	-
Correlation tryptophane/ hydroxy-proline	1,83	1,48	-

On the presented chart the brought spectrums of reflection of three powdery samples of meat of the above-mentioned animals. As we see from the Figure 1, all of them in a complete measure repeat each other for most stripes of reflection. But it's important to notice that reflective ability of samples is different. The spectrum of reflection of powder of meat of wild boar has the greatest reflective ability in this spectral range, and spectrum of reflection of powder from meat of venison – has the least reflective ability. The analysis of spectrums shows that inspite of the fact that chemical composition of standards obviously differs one from other, however in the spectrums of reflection in the investigated spectral region these differences do not appear. It is explained by the fact that it is necessary to prepare standards with the greater degree of growing shallow for the exposure of individual descriptions. In addition, on forming of spectrums considerable influence finds out humidity of standards, that constantly it follows to control in a process of measurement.

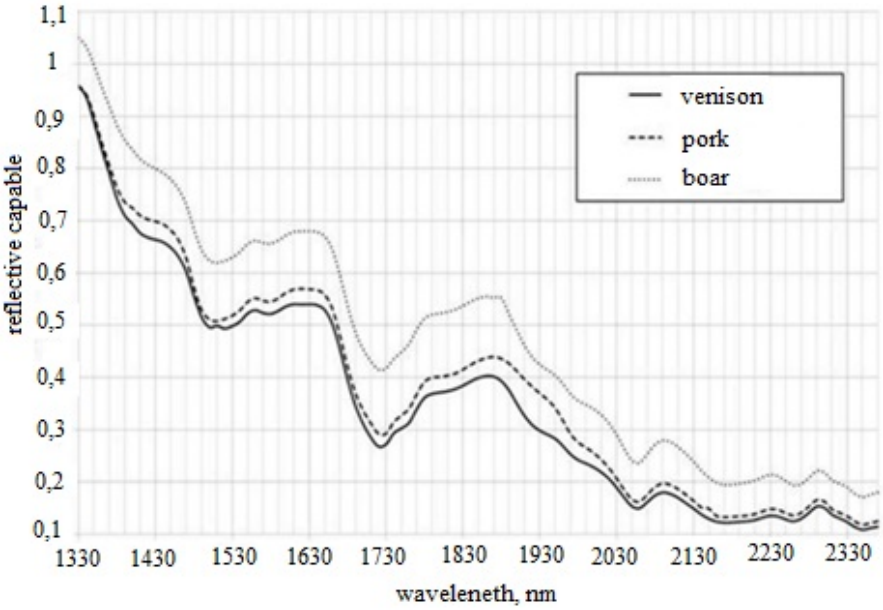

Figure 1. Spectrums of reflection of meat of different types of animals

Mineral composition of meat of wild boar surpass the meat of pork on maintenance of a row micro- and macronutrients. High maintenance of iron – 1500 mcg/100 g in meat of wild boar – is able to satisfy the amount close to the 20% of daily ration. This content of iron is also related to enhanceable maintenance in it to the myoglobin that is needed for more rapid motion of oxidizing processes for actively movable animals. High maintenance of iron influences on the color of meat of wild animals, giving to it more intensive crimson colouring in comparing with meat of agricultural animals.

The comparative estimation of influence of different methods of thermal treatment on the outcome of barbecue educed advantages of the use of steam converter and microwave radiation before traditional frying and processing on a steam. Decline of losses of content of moisture in the prepared product after processing in steam converter serves as reason of increase of outcome of barbecue. Also there is reduction of losses of mass of ready-to-cook foods at microwave radiation heating in comparison with frying.

The increase of outcome of finished products at thermal processing in steam converter is explained, by more moderate temperature conditions of heating of samples, than in a traditional method. It causes less deep physical and chemical changes at albuminous system of products, that results in reduction of losses of mass. By a significant index that characterizes the change of mass of meat products during thermal treatment, their succulence and consistency we mean is water-binding capacity. Property of meat products to hold moisture during heating depends on content in them the adsorption-bound water, so as a loss of moisture during thermal treatment is related mainly to the selection of weakly bound water, as the adsorption is more firmly contained by the polar groups of proteins of meat. But during the heating of foods part of the adsorption-bound moisture diminishes however, as a result there is side-shifting of equilibrium to increasing of content ofweakly bound moisture that results in the change of water-binding capacity.

Table 2

Loss of mass and water-binding capacity of finished product after thermal treatment in different ways

Thermal treatment method	Outcome, %	Losses, %	WBC_a, %	WBC_m, %	pH
Frying	50,0±1,2	50,0	55,3±1,8	23,4±0,9	5,7±0,09
Microwave radiation heating	54,2±0,9	45,8	66,8±1,7	26,34±1,2	5,55±0,04
Processing with the help of steam	51,2±1,6	48,8	58,7±1,5	25,3±0,7	5,75±0,07
Processing in steam converter	68,0±0,75	32,0	75,0±1,2	49,7±1,4	5,65±0,03

The data that are given in the table 2 specify on the differences of WBC of the prepared product treated by the investigated methods. The best indexes are marked at microwave radiation heating and at processing in steam converter, other methods of thermal processing do not result in the substantial increase of WBC.

The changes of mass at thermal treatment of meat products are related mainly with the losses of moisture, water soluble organic and mineral substances and predefined by a high temperature that causes denaturation of albuminous substances and substantial reduction to water holding capacity.

Potentiometric determination of active acidity of the prepared samples did not educe noticeable differences in the dynamics of this index depending on the applied method of thermal treatment of product.

Reductions of losses of mass, increase of WBC result in the improvement of tenderness and succulence of the finished product.

Preparation of foods in steam converter comes true due to the convection of hot air which was formed due to heating of electric tubular heaters or gas. Permanent circulation of hot air provides the equable baking of foods in stoves and speed of their preparation. In steam converter sprayers system of moistening is set, that is why humidity of air in a working chamber is able to be managed.

In a table 3 these researches over of barbecue are given which was prepared by thermal processing in steam converter at the different modes.

Table 3

Comparative description of functionally-technological properties of barbecue from game meat during processing at the different modes

Temperature of processing	Outcome, %	Losses, %	WBC_a, %	WBC_m, %	pH
220^0C	67,1±1,1	32,9	67,9±1,1	55,0±1,1	5,6±0,08
240^0C	69,0±0,5	31,0	68,9±0,4	54,1±0,4	5,65±0,05
260^0C	61,5±1,2	38,5	59,7±0,9	35,8±1,2	5,7±0,09

Analysing these dates of tables 3, the method of thermal processing of barbecue was recommended in steam converter for the temperatures of 240℃, both functionally-technological indexes and organoleptical estimation of the investigated foods were taken into account.

Conclusions

1. The infra-red spectrums of reflection of meat of wild boar, pork and venison showed in a near area, that the spectrum of reflection of powder of meat of wild boar had the greatest reflective ability, and spectrum of reflection of venison – the least, in spite of the fact that chemical composition of standards differs one from other.
2. The technological mode is recommended for processing of barbecue in steam converter by t=220-260℃, φ=15 during 9 minutes
3. Mineral composition of meat of wild boar excels meat of pork on maintenance a row micro- and macronutrients. High maintenance of iron – 1500 mcg/100 g in meat of wild boar – is able to satisfy to the 20% of daily ration.

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Determination of biologically active substances in protein-berry concentrates

Olena Grek, Olena Onopriichuk, Tetiana Pshenychna, Alla Tymchuk

National University of Food Technologies, Kyiv, Ukraine

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Corresponding author:

E-mail:

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Abstract

Introduction. Research of the polyphenolic compounds and amino acid composition of proteins, including the content of free and bound amino acids, in protein-berry concentrates (PBC), obtained by thermo acid coagulation are an actual direction.

Materials and methods. Protein-berry concentrates were obtained by thermo acid coagulation of milk proteins using blackcurrant paste as a coagulant, which is a source of biologically active substances – vitamins, minerals, polyphenols and others. Amino acid composition and polyphenolic compounds were determined by high performance liquid chromatography followed by the identification of individual compounds in the studied extracts of protein-berry concentrates.

Results and discussion. The research results of polyphenol composition were analyzed compared with the control (blackcurrant paste) and the degree of their transition to protein-berry concentrates was determined, which is about 55.31 % of polyphenols, including anthocyanins.

Proteins in concentrates have a full amino acid composition and contain all essential amino acids, the content of which from amount is 41.97 % and 43.96 %, respectively, for protein-berry and milk-protein. A quantitative content of 18 free amino acids and 16 bound amino acids has determined in protein-berry and milk-protein concentrates, of which glutamic acid, histidine, methionine, leucine and proline are dominated.

The nonessential amino acids were determined, the content of which is 58.03 % and 56.04 % from the sum of total amino acids in the PBC and MPC (control). The content of essential amino acids in protein-berry concentrate has increased by 14.75 % and the nonessential amino acids by 24.45 % by the following amino acids: threonine at 0.156 mg%, lysine at 0.21 mg%, tryptophan at 0.221 mg%, phenylalanine at 0.525 mg% compared with the control sample.

Conclusions. The protein-berry concentrates had a polyphenolic compound content of 331.86 mg / 100 g, which characterizes their natural violet color. The amino acid composition in PBC has increased by 20.18 % compared with the classic milk-protein concentrate, as a result of complex coagulation of casein and whey proteins.

Introduction

Dairy industry needs new approaches and solutions for the processing of milk for products with multifunctional composition. The modern food products have to supply human organism not only with proteins, milk fat and lactose, but also biologically active substances and other essential for normal functioning substances.

The above substances include vitamins, minerals, amino acids, polyphenols and other. The lattest are the most common group of natural antioxidants. They regulate the capillary permeability, strengthen the walls of blood vessels, are synergists of vitamin C, and also have the ability to determine the color and taste characteristics of products. By their antioxidant activity, these substances are dominated carotenoids and vitamins C and E by ten folds. Polyphenols are contained in vegetables, fruits, berries, and the products of their processing - juices and puree [1-2].

Black currant – one of the most widespread berry crops that grow in Ukraine. Medicinal-and-prophylactic properties are determine by fact that the berries contain vitamins, polyphenols, macro- and microelements, polysaccharides including pectin, and others which are necessary for a humans. Berries contain big amount of iron, phosphorus and calcium salts in the form of organic compounds, which are easily digestible by the human body [3].

Black currant berries may be realized in the native state, frozen and in the form of paste. Jam, jelly, syrup, wine etc. are widely used in the food production. Blackcurrant puree is recommended for use as an additional source of biologically active substances.

The development of cheese products technology based on thermo acid coagulation of milk proteins in the presence of functional nutrients is relevant. The source of nutrient can be black currant, which in the form of paste is compliant on the organoleptic level with milk base. In particular thermo acid method of milk processing, which is based on the simultaneous coagulation of milk casein and whey proteins under the influence of acid and high temperature, ensures the formation of a clot with maximum protein content and increased biological value. Amino acids in free and bound states are one of the important organic compounds involved in formation of secondary biosynthesis substances. According to the literature [4], after proteopepsis, proteins form a “free amino acids fund” which can be spent on the formation of new body tissues or on energy. The more of them in the product, the easier they are absorbed by the body. Moreover, free amino acids may experience further metabolic transformations to other low molecular weight compounds that have protective properties [5].

Nutrition and energy value of the homogenized puree LiQberry per 100 g of the product, not less than: proteins – 1.0 g; carbohydrates – 8.0 g, fiber – 3.0 g; 36.0 kcal/150.6 k. Physical-chemical indicators of the homogenized black currant puree are given in Table 1 [6].

Table 1

Physical-chemical indicators of the homogenized black currant puree

Dry soluble substanses, % not less than	pH value, no more than	Polyphenols, mg/100 g	Organic acids, g/100 g	Vitamin C, mg/100 g	Pectins, g/100 g
10.0	3.0	535–597	2.0–2.5	173–233	0.9–1.1

In our opinion, the use of blackcurrant paste as a coagulant during thermo acid coagulation of milk proteins is a promising direction of fortification with biologically active substances of milk-protein products and requires additional research.

The aim of this work is determination the content of biologically active substances - polyphenolic compounds and amino acid composition in protein-berry concentrates, obtained by thermo acid coagulation of milk proteins using blackcurrant paste as a coagulant.

Materials and methods

Materials

Object of research is a protein-berry concentrate (PBC) obtained by thermo acid coagulation of milk proteins using a black currant homogenized paste as a coagulant. This paste was produced in the industrial conditions by advanced technology using hydrodynamic (cavitation) processing of raw materials on a TEK-SM devices, that minimizes the loss of some biologically active substances in raw materials and their biochemical conversion. The berries were treated in the said above setup according to designed regime to a necessary level of homogenization and industrial sterility.

Method of producing protein-berry concentrates

Berry coagulant was introduced into the milk mixture with pH of 6.9 in the amount of 7 % with an active acidity of 2.8. This amount of berry coagulant changes the active acidity in the mixture to provide a balanced isoelectric state of milk proteins in the entire volume at pH 4.6-4.7 and leads to their active coagulation. Thermal conditioning of the milk mixture and proteins coagulation were realized according to the classical technology with optimization of schedule of thermo acid coagulation (t = 75±2 ºC duration 2±1 min) based on the results of previous studies [7]. The thermo acid coagulation allows more complete use of milk proteins and especially whey proteins – the most biologically complete with the contents of essential amino acids.

Performance liquid chromatography method

Determination of the polyphenolic composition in protein-berry concentrates was carried out by high-performance liquid chromatography using a Promimaence LC-20 Shimadzu liquid chromatographic system (Japan). For the extraction of polyphenols, the weight of the protein-berry concentrate was well mix up and 25 cm^3 of isopropyl alcohol were added to 10 g of PBC. The extraction was carried out in hermetic containers for 5 days at room temperature with occasional mixing. Identification of substances in the studied extracts was determined by comparing the retention time and the spectral characteristics of studied substances with similar characteristics of standards in accordance with the method of polyphenols identification. Chromatography was performed at a wave-length of 225, 255, 286 and 350 nm [8].

The determination of substances content with established affiliation to specific groups of polyphenols was carried out using standards, the degree of similarity with which was the most, taking into account the chemical form of the substance (aglycone, glycoside). Affiliation of substances in anthocyanins was established with peaks in chromatograms obtained at 530 nm. Identification of glycosides delphinidin, cyanidine, petunidin, peonidin

and malvidin was performed by the similarity of time, the content of studied anthocyanins with similar parameters of listed glycosides in Cabernet Sauvignon wine according to the method [9]. Identification of galactoside and arabinosidantocyanins was carried out on the basis of known sequence of glycoside peaks of anthocyanins in black currant berries on chromatograms taking into account the location of glycoside peaks [10]. The content of identified and unidentified anthocyanins was determined by the cyanidine standard. The total content of polyphenols was determined by summing the content of substances, that found in the peak range of flavonoids and phenolic acids in the chromatogram.

Determination of the amino acid composition in protein-berry concentrate was realized by ion-exchange chromatography. The meaning of method is hydrolysis of the sample to the amino acids with the following their identification by method of high-performance liquid chromatography on the amino acid analyzer LC 3000 of the company «Eppendorf-Biotronic» (Germany). Hydrolysis of the sample was realized with a solution of 6N hydrochloric acid, at a temperature (120±2) ºC for 24 hours. This method allows to determine with accuracy to ± (5-10) % the presence of up to 18 amino acids with a minimum level of their content in solution (0,500±0,006) μmol/ml. Quantitative evaluation of the content of individual amino acids was realized comparing the peak areas on the aminograms calculated using the Winpeak integration systems of the company "Eppendorf-Biotronic" (Germany) to a similar level, with peak areas obtained by analyzing a standard mixture of amino acids containing 2.5 μmol each amino acids in 1 cm^3 of standard solution.

The amino acid content in the protein-berry concentrate was compared with their content in the control sample – the milk-protein concentrate (MPC) obtained according to the classical technology (t = 90±2 ºC during 5 min), using an acid whey with titrated acidity 160–180 °T as a coagulant, in the amount of 10 % from the mass of milk.

Results and discussion

At the first stage of research, the transition degree of polyphenol composition, including anthocyanins, into protein-berry concentrates was determined, taking into account their content in blackcurrant paste. Black currant anthocyanin complex is determined by a set of main components: 3 glycosides and 3-rutinoside delphinidin and cyanidin, which is unchanged for fruits of all varieties with black color [11]. Dye-ware colors of berry raw materials are low molecular weight phenolic compounds, that refer to bioflavonoids, in particular anthocyanins, which in plants are in the form of glycosides. In addition, the berries contain flavones, flavonols, catechins, hydroxy-cinnamic acids, which led to the natural purple color of protein-berry concentrates. In order to determine the transition degree of biologically active substances, the polyphenolic composition in blackcurrant paste, protein-berry concentrate and colored whey were analyzed. The chromatogram of the alcoholic extract of protein-berry concentrate is shown in Figure.1.

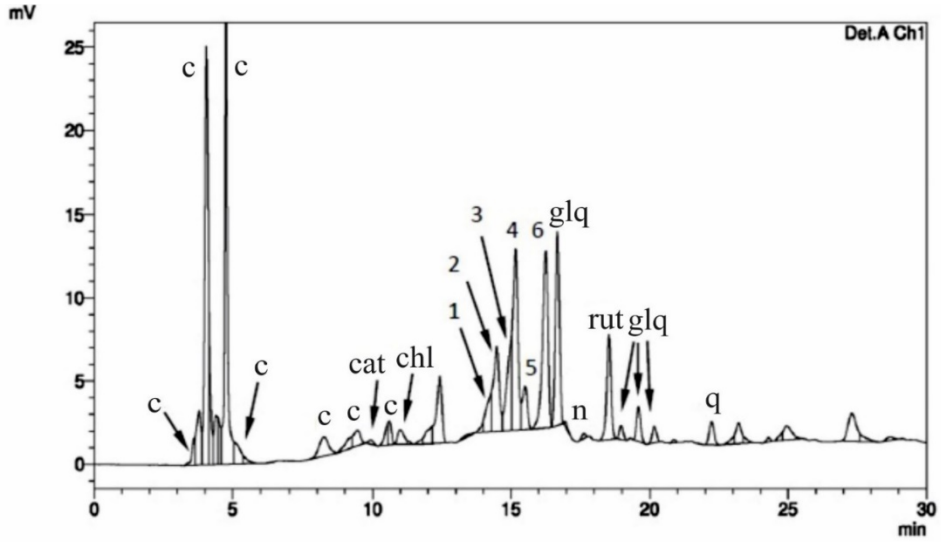


Figure 1. Chromatogram of the alcoholic extract of protein-berry concentrate at 255 nm:
c – catechins, cat – catechin, chl – chlorogenic acid, n – naringin, rut – rutin,
glq – quercetin glycosides, q – quercetin,
1 – delphinidin-galactoside, 2 – delphinidin-glucoside, 3 – cyanidin-galactoside,
4 – delphinide-arabinoside, 5 – cyanidin-glucoside,
6 – petunidine-galactoside + cyanidine-arabinoside + petunidine-glucoside + peonidin-galactoside.

The polyphenolic composition of protein-berry concentrate is presented in Table 2 correlated with the composition of a specially-processed blackcurrant paste (control) [6].

Table 2

Polyphenolic composition of protein-berry concentrate

Polyphenol group	Content, mg / 100 g	Individual substances	Content, mg / 100 g
Phenolic acids	0.18	Chlorogenic acid	0.18
Catechins	57.65	Catechin	4.83
Flavonols	34.10	Rutin	24.00
		Quercetine	1.10
Flavanones	38.38	Naringin	1.50
Anthocyanins	187.02	Delphinidin-3-O-galactoside	15.70
		Delphinidin-3-O-glucoside	26.35
		Cyanidin-3-O-galactoside	19.83
		Delphinidin-3-O-arabinoside	45.48
		Cyanidin-3-O-glucoside	13.48
		Pet-gal + Cyan-arab + + Pet-gluc + Peon-gal	54.30
		Peon-gluc + Mal-gal	0.30
Unidentified	14.53	Peon-arab + Mal-gluc	0.65
Amount of polyphenols	331.86	Malvidin-3-O-arabinoside	0.28

The content of polyphenolic substances in the obtained protein-berry concentrates is 331.86 mg / 100 g. For comparison, the content of polyphenols in blackcurrant paste ranged from 535 to 597 mg / 100 g. Probably, PBC are full-fledged ingredients for use in recipes of cheese products for health purposes, which have antioxidant, tonic effect.

About 55.31 % of polyphenolic compounds, including anthocyanins, stay in protein-berry concentrates. The transition degree of polyphenolic compounds into the colored whey is 34.47 % of their total amount. This fact is caused by the fact that anthocyanins are sensitive to temperature regimes of milk protein coagulation, which leads to their destruction.

At the next stage, the amino acid composition of protein-berry and milk-protein concentrates (control) was investigated and it has shown that the protein fractions contain a full set of amino acids, including essential, – this confirms their high biological value.

In protein-berry and milk-protein concentrates the free and bound amino acids content, including essential (EAA) and nonessential (NEAA), was calculated and shown in Figures 3 and 4, respectively.

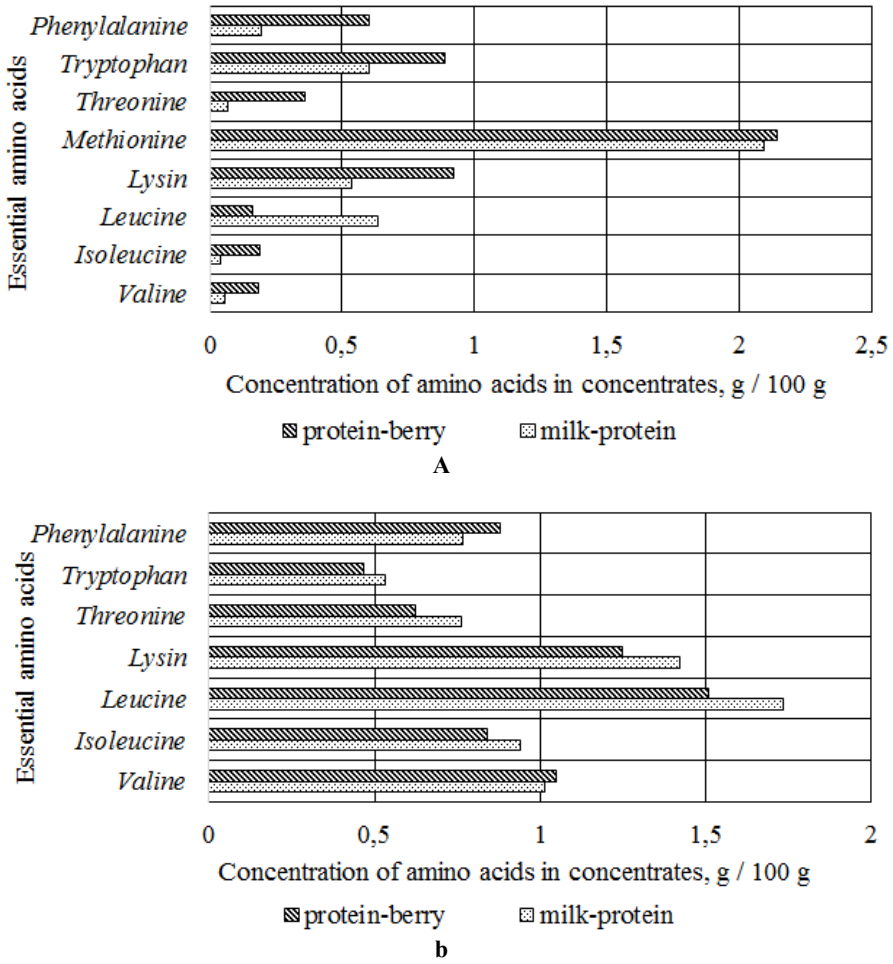
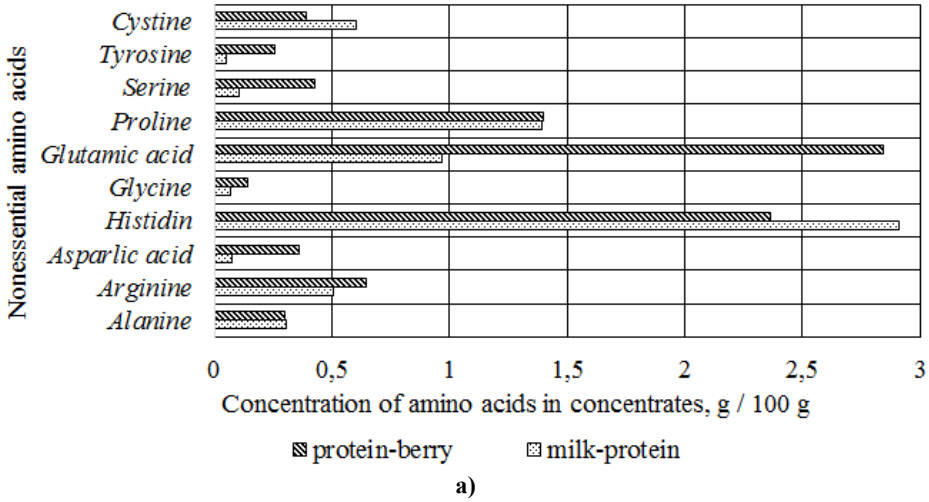
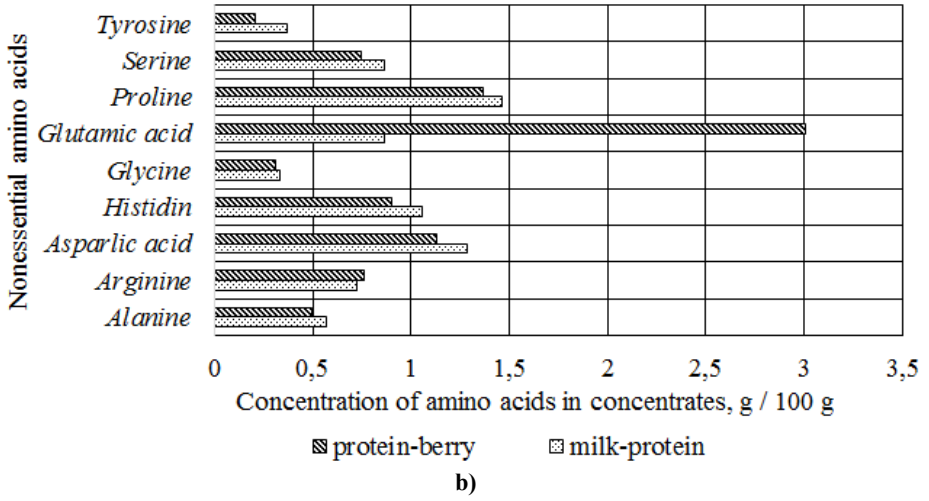


Figure 3. The content of free (a) and bound (b) essential amino acids in protein-berry and milk-protein concentrates (n = 3, p≤0.05)



a)



b)

Figure 4. The content of free (a) and bound (b) nonessential amino acids in protein-berry and milk-protein concentrates (n = 3, p≤0.05)

According to the results (Figures 3 and 4), the total amino acids content in PBC increased by 20,18 % compared with the control. This is characterized by an increase in the transition degree of casein and the maximum amount of whey proteins in the concentrate, as a result of organic blackcurrant paste action during thermo acid processing.

The maximum amount of glutamic acid in all samples was recorded. 18 free amino acids, among which histidine and methionine predominate, and 16 bound amino acids (leucine and proline prevail) were identified in concentrates. All essential amino acids are identified in the PBC and MPC. Their importance is due to the fact that they are not synthesized by the body, and the deficiency affects the protein regeneration. The content of the above amino acids from the total amount is 41,97 % and 43,96 %, respectively.

In addition, glutamic acid in a bound state accumulates in large quantities in protein-berry concentrates at the level of 3,007 / 100 g, due to its high content in black currant (34,7 g / 100 g, of which 33.2 g / 100 g in a bound state [12]). The above amino acid plays an important role in nitrogen metabolism, supports respiration of brain cells and performs the function of a neurotransmitter in the human body [13]. Leucine prevails in the milk-protein concentrare (1.732 g / 100 g), methionine and cystine were not detected in all samples. In the free state, histidine which is involved in the formation of proteins and affects metabolic reactions, is present in large quantities (2.362 and 2.909 g / 100 g, respectively) in concentrates.

Nonessential amino acids are performed important functions in the body – glucose synthesis (alanine), take part in enzymatic processes (arginine), improve the skin structure (proline), and some of them (cystine, tyrosine, glutamic acid) play a physiological role, no less than essential amino acids [14]. Glutamic acid, proline and histidine are dominant in concentrates, among essential amino acids that perform the functions of precursors in the protein synthesis and other biologically active compounds. According to the results (Figure 4), the content of NEAA from the amount of total amino acids in the PBC and MPC is 58.03 % and 56.04 %, respectively.

Analyzing the results, we can say about the increase in the amount of EAA in the protein-berry concentrate by 14.75 % and NEAA by 24.45 % in the following amino acids: threonine by 0.156 g %, lysine by 0.21 g %, tryptophan by 0.221 g %, phenylalanine – 0.525 g % compared with the control sample.

Important is the fact that the protein-berry concentrate contains 50.06 % of amino acids in the free state, including the content of essential amino acids is 41.44 %. The resulting patterns indicate that the protein-berry concentrate has a more easily digested form than the classical concentrate obtained by thermo acid coagulation of milk proteins by acid whey.

Conclusion

The resulting thermo acid coagulation of milk proteins, PBC are characterized by a content of polyphenolic compounds at the level of 331.86 mg / 100 g and amino acids – 31.14 g/100 g. This has a positive effect on the biological value of products based on them and organoleptic characteristics. As a result, protein-berry concentrates were characterized by the presence of violet color, that characteristic for raw materials containing anthocyanins. The use of colored PBC as a basis for cheese products will ensure the exclusion of food colors and flavors of artificial origin, and also will prolong their storage life.

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Impact of germination conditions on antioxidant properties and protein content in lentils (Lens culinaris) of Ukrainian cultivars

Iryna Yasinska, Viktoriia Ivanova

National University of Food Technologies, Kyiv, Ukraine

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Corresponding author:

Iryna Yasinska
E-mail: yasinskaya.ira@gmail.com

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Abstract

Introduction. Changes in the free radical scavenging activity, the yield of phenolic compounds, ascorbic acid and proteins content in lentil seeds of two Ukrainian cultivars were determined during the germination period under different light conditions.

Materials and methods. Were studied the effect of germination on two Ukrainian varieties of lentils namely Luganchanka and Svitanok. The total phenolics content (TPC) in samples was determined using Folin-Ciocalteu assay, the ascorbic acid level was determined by a colorimetric assay, free radical scavenging activity was elucidated using DPPH assay, changes of proteins content were found out according to Kjeldahl`s method.

Results and discussion. Results of the research have shown that during germination in seeds highly increased levels of the total phenolics, ascorbic acid and free radical scavenging activity, especially under day-night photoperiod light conditions. The proteins content in seeds at the end of germination was a little lower comparing with ungerminated seeds under both of light conditions.

The highest rise of TPC was fixed in lentils var. Luganchanka on the 3–4th germination day. The increase was about 65%.

A similar situation was with changing of ascorbic acid level. It was higher 6 times if compare germinated and ungerminated samples of lentils var. Luganchanka, obtained under day-night conditions.

The antiradical activity of germinated seeds was the highest at the end of the germination process. However, germinating after the 5th day under studied conditions is unacceptable, because the rotting of sprouts happened. The lowest increase near 60% had germinated materials of var. Svitanok that were obtained in dark conditions. The highest increase of antioxidant activity was near 550% in samples var. Luganchanka after germinating in day-night conditions.

Conclusions. Our results demonstrate that germinated lentil seeds both cultivars have advantages over non-germinated and can be useful in functional food technologies.

Introduction

Legumes play an important role in human nutrition in many diets. Lentil is one of the most valuable species of legumes. Its seeds are an excellent source of protein, rich in important vitamins, minerals, dietary fiber. According to recent studies [1–5], lentil could be considered as a prophylactic and therapeutic functional ingredient due to it sizable content of essential micronutrients as well as phytochemicals. These components can provide anti-inflammatory, hepatoprotective, antioxidant effects, lead to the prevention of heart diseases, diabetes, DNA damage and other disorders [4, 5].

Germination is inexpensive and effective bioengineering process that can highly increase the nutritional value of lentil seeds by intensive synthesis of bioactive compounds [6, 7], desirable changes in the nutrient availability [8] and decreasing of anti-nutritional components (phytic acid, tannins) [9]. During the germination period, the content of low-molecular weight antioxidants such as polyphenols [10, 11], ascorbic acid, tocopherols grows up, that provides increasing the antioxidant properties of seeds [7, 12]. The qualitative and quantitative composition of the functional components in germinated seeds depends on many variables, which includes soaking time, humidity, temperature, germination time, presence of chemical elicitors [13, 14] and other biotic and abiotic factors [15, 16]. Numerous studies have shown that the content of the synthesized components also depends on seeds variety and places of plant cultivation [17].

The aim of our study was to determine the dynamic of free radical scavenging activity changes, the yield of total phenolic compounds and ascorbic acid in lentils of Ukrainian cultivars depending on the germination time, light conditions (dark or day-night photoperiod) and the plant variety. Also changes of the crude protein content, as one of the main component of lentil seeds were monitored.

Materials and methods

Raw materials of two Ukranian varieties of lentil (*Lens culinaris*) namely Luganchanka and Svitanok were used in the study. Plants had been grown under the same environmental conditions in the Mykolaiv region, Ukraine. Seeds were collected during summer and autumn months of 2014 and handpicked to ensure usage of unbroken material.

Germination was done according to procedure written below**.** Dry seeds were cleaned and disinfected with 1% potassium hypochlorite for 5 min, washed with distilled water to neutral pH, soaked in distilled water for 4 h at 20 ºC and placed in Petri dishes with an adsorbent paper. Seeds were germinated for 5 days at 20 ºC in two different light conditions: in dark (D) and day-night (DN) (day – 16 h, night – 8 h) photoperiod. Seeds were kept moist by spraying them with distilled water. The germination process was done in triplicate. The percentage of germinated seeds was evaluated.

Experimental parameters of seeds were assayed every day during the period of germination. Before that, seeds were air-dried at 35 ºC for 8 h and milled.

The total phenolics content (TPC) of extracts was determined using Folin-Ciocalteu assay [18]. Seeds and sprouts were subjected to extraction using 70% aqueous-ethanolic solution. The ratio of raw material : extractant was 1:10. The extraction process had been continued for 4 h at room temperature with intense shaking. Extracts were centrifuged at 4000 rpm for 15 min and filtered through the filter paper. Supernatants were used for further analysis.

Ungerminated seeds were prepared as noted above to serve as a control.

Briefly, 0.1 ml of the extract or ultra-pure water or gallic acid standard solution (0-0.2 mg/ml) was diluted with 1 ml of ultra-pure water, 0,1 ml of Folin-Ciocalteu reagent and left standing at room temperature for 5 min. Then 2 ml of 2% sodium carbonate was added and the mixture was incubated at room temperature for 20 min. The absorbance was measured at 765 nm with the spectrophotometer BioMate 5 (Thermo electron corporation, USA). Gallic acid solution was used for the construction of a calibration curve as a standard. The total phenolic content was expressed as mg gallic acid equivalent (GAE) per 100 g dry weight of seeds.

Ascorbic acid was extracted with ultra-pure water acidified 2% meta-phosphoric acid according to our latest procedure [19] and determined by a colorimetric assay [20].

Free radical scavenging activity of aqueous and 70% aqueous-ethanolic extracts was determined using DPPH assay based on the activity of the stable 1,1-diphenyl-2-2-picrylhydrazyl (DPPH) free radical as described by Brand-Williams et al. [21].

Briefly, the alcoholic solution of DPPH (1.8 ml) was added to 0.2 ml of extracts obtained from plant materials. Samples were incubated in the dark place at room temperature for 30 min. The decrease in absorbance was measured at 517 nm by UV-VIS spectrophotometer for all samples. The absorbance of the DPPH radical solution without antioxidant was measured as the control (Ac). The percentage of inhibition of the DPPH radical by samples was calculated according to the equation:

$$\% \text{ Inhibition} = [(Ac-As)/Ac]\ 100,$$

where: Ac - absorbance of the control, As - absorbance of the solution of DPPH radical with extract or standard after the reaction.

Blank samples contained 1.8 ml of ethanol and 0.2 ml of plant extract; control sample contained 1.8 ml of 0.04 mM DPPH and 0.2 ml of ethanol. The synthetic antioxidant ascorbic acid was used as a standard. Antiradical activity of samples was presented as ascorbic acid equivalent capacity and expressed as mM of the ascorbic acid equivalent (AAE) antioxidant capacity per 1 g of seeds dry weight (mM AAE/g DW).

Total nitrogen was determined according to Kjeldahl`s method [22]. Crude protein was calculated as Nitrogen content multiply on 6,25.

Experimental results were expressed as mean ±standard deviation of three replicates. Where applicable, the data were subjected to one-way analysis of variance (ANOVA) and the differences among samples were determined using the statistical analysis system Statgraphics. P-value of < 0.05 was regarded as significant.

Results and discussion

The dynamic of the lentil sprouts length changing were evaluated under different germination conditions (Table 1).

Sprouts that had been obtained under day-night photoperiod light conditions were significantly longer than sprouts had grown in the dark. They were stronger and thicker. Their green color was conditioned by the photosynthesis process.

The sprout's length of the var. Luganchanka and var. Svitanok under the same germination conditions did not differ significantly.

Table 1

The length of sprouts grown under different conditions [mm]

Germination day	Lentil seeds varieties			
	Luganchanka		Svitanok	
	Light condition			
	D	DN	D	DN
1	3.5 ±0.15	4 ±0.2	3 ±0.18	4 ±0.22
2	13 ±0.85	38 ±1.8	11.5 ±0.7	32 ±1.65
3	19 ±1.05	52 ±3.5	18 ±1.0	50 ±3.8
4	25 ±1.4	68 ±4	24 ±1.5	65 ±4
5	34 ±1.8	97 ±5.5	32 ±2	89 ±4.5

After the 5th day of germination under both of conditions, the rotting of sprouts happened. Therefore, germination after the 5th day under these conditions is unacceptable.

Results have shown that under day-night photoperiod it occurs the increasing of the TPC level (Figure 1).

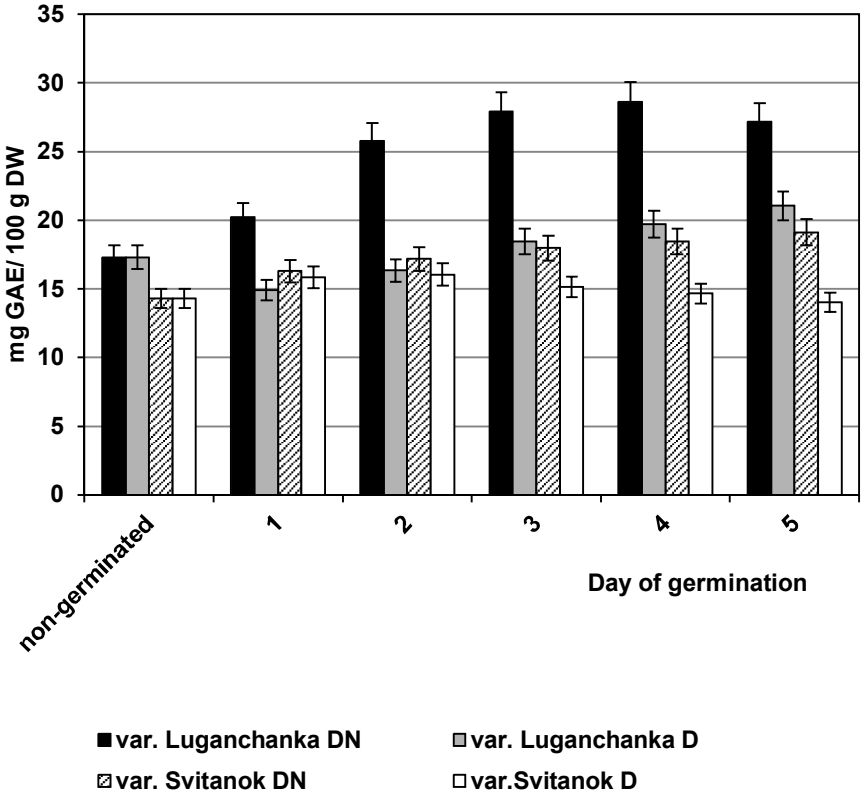

Figure 1. The total phenolics content of germinated seeds obtained under different light conditions (D, DN)

The visible increase of TPC during germination time had lentil sprouts var. Luganchanka, which were growing under the day-night photoperiod condition. The maximum value of total phenolics in this seeds was on the 3–4th germination days and it was higher than in ungerminated material on 65%. Obtained results are in agreement with those were given in similar studies [10, 23]. Sprouts of lentil seeds var. Svitanok demonstrated a decrease of TPC in darkness and increase under the day-night photoperiod condition.

Investigated samples, which were germinated under the day light, demonstrated more significant increase of the TPC level in comparison to sprouts obtained in dark conditions. This can be explained by the fact that different light conditions influence on activating prolin-linked phentose phosphate and shikimate pathways for phenols synthesis [24].

In the similar studies [25] were shown that the level of TPC in lentil sprouts during germination period was in a steady decline. The distinction in results can be explained by different cultivars and environment conditions in regions of cultivation of plants. On the other hand, authors didn't take into consideration changes of moisture content in the investigating samples during germination.

As in the case of polyphenols, better production of ascorbic acid was under the day-night photoperiod condition that in the dark. But in contrast to polyphenols a maximal increase of the ascorbic acid content was observed on the 1st day of germination (Figure 2).

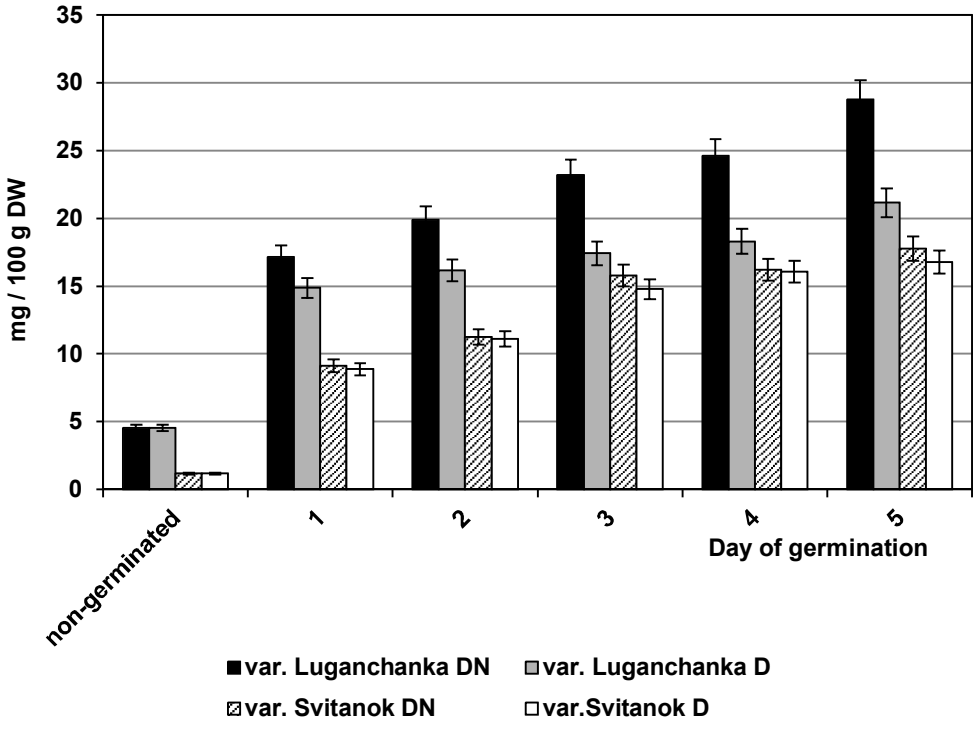

Figure 2. Ascorbic acid content in samples obtained under different light condition (D, DN)

The ascorbic acid content in sprouts of var. Luganchanka was significantly higher than in var. Svitanok. Also the differences in the vitamin C content in materials prepared under the darkness and day-night conditions in var. Luganchanka was differ significantly, however, this indexes for var. Svitanok was not considerable.

The research of two types of extracts from lentil sprouts (aqua (A) and aqueous-ethanolic (AE)) on their antiradical activity has showed dynamics similar to results previously described (Table 2).

Table 2

Free radical scavenging activity of aqueous-ethanolic and aqueous extracts of lentil seeds [mM AAE/g DW]

Germination day	Varieties of lentil seeds							
	Luganchanka				Svitanok			
	Light condition							
	D		DN		D		DN	
	Types of extracts from lentil seeds and sprouts							
	AE	A	AE	A	AE	A	AE	A
1	34,85 ±1,02	19,91 ±0,86	42,56 ±2,61	25,56 ±1,08	22,18 ±1,89	11,87 ±0,57	23,45 ±1,09	14,93 ±0,66
2	39,43 ±1,71	27,99 ±1,12	54,33 ±1,99	34,19 ±1,78	24,56 ±1,64	14,12 ±0,82	25,11 ±1,34	19,61 ±0,87
3	46,78 ±2,89	34,34 ±1,76	68,48 ±1,66	41,04 ±2,27	25,17 ±1,34	18,19 ±0,63	27,12 ±1,08	23,11 ±1,32
4	54,61 ±1,99	38,12 ±1,96	76,92 ±2,47	52,47 ±2,51	23,52 ±2,22	21,16 ±1,21	30,02 ±1,46	27,08 ±1,41
5	52,46 ±2,13	41,82 ±2,26	78,63 ±3,49	61,71 ±2,87	21,18 ±2,79	22,88 ±1,02	31,41 ±1,62	28,12 ±1,22
non-germinated	31,79 ±2,01	11,07 ±0,63	31,79 ±2,01	11,07 ±0,63	19,77 ±0,46	6,67 ±0,28	19,77 ±0,46	6,67 ±0,28

During the germination process the antiradical activity level of sprouts gradually increased. As in the case with the content of phenols and ascorbic acid, higher activity had sprouts which were cultivated under the day-night photoperiod condition.

By contrast to changes in levels of low-molecular compounds with antioxidant activity, the level of crude protein content in sprouts was decline during the germination period (Table 3).

Bigger protein value had lentil of var. Luganchanka. On the 7^{th} germination day the protein content in both varieties were almost equal. Samples of lentil sprouts which were obtained in the darkness had a less the protein content.

Reducing of the protein amount during germination can be explained by their biotransformation in structural components of sprout and using as an energy source for growth.

Table 3

Crude protein content in seeds and sprouts during germination [g/100g]

Germination day	Varieties of lentil seeds			
	Luganchanka		Svitanok	
	Light condition			
	D	DN	D	DN
1	33,87 ±0,89	34,17 ±1,84	28,96 ±1,21	29,32 ±1,12
2	33,18 ±1,76	32,13 ±0,99	28,33 ±1,08	29,06 ±1,33
3	31,96 ±1,12	30,83 ±1,51	28,01 ±1,67	28,61 ±0,89
4	28,08 ±0,87	29,77 ±0,78	27,69 ±0,87	28,08 ±1,19
5	27,87 ±0,81	29,1 ±1,43	27,17 ±1,33	27,95 ±1,34
non-germinated	35,21 ±1,56	35,21 ±1,34	30,76 ±0,91	30,76 ±1,64

Conclusions

Results have shown that the germination process provided increasing the content of total phenolics, ascorbic acid, and antiradical activity in investigated samples of lentil seeds.

Maximum values of experimental indexes were determined in seeds that were germinated under day-night light conditions.

During the germination period, the content of low molecular weight components with antioxidant activity was highly increased; whereas the content of such valuable component as protein was a little decreased. Definitely, germinated seeds can be used as sources of valuable components for preparing functional foods and supplements for oxidation-associated diseases prevention.

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Dietary calcium intake and bone mineral density among Macedonian women

Daniela Nikolovska Nedelkoska, Tanja Tefova, Zora Uzunoska

St. Kliment Ohridski University, Veles, Republic of Macedonia

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Corresponding author:

Daniela Nikolovska Nedelkoska
E-mail: daniela.nedelkoska@uklo.edu.mk

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Abstract

Introduction. Osteoporosis is a complex, multi-factorial bone disease leading to increased risk of fracture. Calcium as a nutrient is associated with the formation and metabolism of bone. The inadequate calcium intake leads to decreased bone mineralization and consequently an increased risk of osteoporosis.

Materials and methods. The study group was constituted by 104 postmenopausal women. Bone mineral density (BMD) at the participants' lumbar spin and hip was measured by dual-energy X-ray absorptiometry (DXA). The daily calcium intake (DCI) was assessed using a validated quantitative food frequency questionnaire (FFQ). Each participant also completed a core questionnaire that included general demographic data as well as questions about personal and family history of fractures, menopause onset, lifestyle behaviors, and corticosteroids use.

Results and discussion. The mean daily calcium intake among our study participants was 854.3±260.4 mg which is below the calcium recommended nutrient intake (RNI) for postmenopausal women. This study's findings confirmed that the reduction of the bone mineral density (BMD), reported using T-scores, depends on age and choice of measurement site. Our results also showed that higher body mass and body mass index (BMI) in participants are associated with higher BMD. The reduced bone density among postmenopausal women was related with the existence of previous personal fractures and the family history of fractures in diagnosed persons. The insight into exogenous risk factors of osteoporosis in this study showed that the most of the participants consume caffeine every day and have insufficient physical activity and sun exposure.

Conclusions. Education on the importance of calcium in the diet and knowledge on the lifestyle factors that affect bone loss are needed toward decreasing risk for osteoporosis and related fractures in postmenopausal women.

Introduction

Osteoporosis is a metabolic bone disease characterized by low bone mineral density (BMD) and deteriorated microarchitecture of the bone tissue, with a consequent increase in bone fragility and susceptibility to bone fractures [1]. The disease affects approximately 200 million people worldwide [2] and takes a huge personal and economic toll. Osteoporosis can not be cured but results can be reached in the context of its prevention and delayed progression [3].

The World Health Organization (WHO) classifies osteoporosis as one of the ten most important diseases connected with the progress of civilization in the modern world. It is a disease whose incidence increases with age. Osteoporosis can occur in different life periods; however, women in the postmenopausal age and the elderly persons (over 70 years old) are the riskiest population groups for its development [4]. Osteoporosis is a big public health problem associated with age-related fracture, most frequently of the hip, vertebrae, distal forearm and humerus [5]. The measurement of bone mineral density by dual-energy X-ray absorptiometry (DXA) is widely used in assessing bone strength and predicting the risk of fracture [6]. Many factors, including genetics, age, gender, endocrine system, as well as other modifiable risk factors such as nutrition, physical activity, smoking and alcohol intake affect bone density and can therefore influence the onset of the disease [3].

Calcium is a nutrient that is associated with the formation and metabolism of bone [7]. In the last decades, the role of calcium in bone health has been comprehensively examined but unfortunately, there is a significant proportion of some population groups in the western countries who fail to reach the recommended calcium intake [8]. Although adequate calcium intake is important throughout the whole life, it is especially important in childhood and adolescence (because of fast skeleton growth), and for postmenopausal women and elderly persons (whose rate of bone mass loss is high) [9] . Therefore, ensuring adequate calcium intake throughout lifetime leads to decreased risk for osteoporosis and related fractures in adults [10].

The objectives of our study were to screen the bone mineral density and to assess the daily calcium intake among Macedonian postmenopausal women. Also, this study was aimed to gain insight into the risk factors that affect bone density and can therefore influence the onset and the progression of osteoporosis.

Materials and methods

The study group was constituted by 104 postmenopausal women at the age from 49 to 82. Arithmetic mean of the examined women's age was 64,7±7,6 years. Women were informed about voluntary and anonymous participation in the study, and that the obtained results were collected only for scientific purposes. Eligibility criteria for the participants were: being postmenopausal, free of serious medical conditions and have clinical symptoms of osteoporosis. All women underwent anthropometric measurements (body mass, height, the calculation of body mass index (BMI)).

Bone mineral density (BMD) assessment. BMD at the participants' lumbar spin and hip was measured by dual-energy X-ray absorptiometry (DXA) at the Department for Radiological Diagnostics within PHI Clinical hospital 'Dr. Trifun Panovski' in Bitola. Dual energy X-ray absorptiometry is considered as a golden standard for measuring bone mineral density and it is most common method for diagnosing *primary* osteoporosis which is usually

related to age and postmenstrual period, as well as for diagnosing *secondary* osteoporosis (osteoporosis caused by other factors such as hormonal imbalance, certain diseases or taking medications) [11]. The bone mineral density measurement results were interpreted in accordance with the operational definition of osteoporosis given by WHO [6]. BMD was reported as a T-score, defined as the difference in number of standard deviations (SD) from the mean BMD of a normally distributed young adult reference population. WHO proposes four categories for women: *Normal* - BMD higher than 1 SD below the young adult reference mean (T-score ≥ -1); *Low bone mass (osteopenia)* - BMD between 1 and 2.5 SD below the young adult mean (T-score < -1 and > -2.5); *Osteoporosis* - BMD lower than and equal to 2.5 SD below the young adult mean (T-score ≤ -2.5); and *Severe osteoporosis* - BMD lower than 2.5 SD below the young adult mean and the presence of one or more fragility fractures.

Questionnaires. Each participant completed a core questionnaire that included general demographic data as well as questions about personal and family history of fracture, menopause onset, lifestyle behaviors, and corticosteroids use. The daily calcium intake (DCI) was assessed using a validated quantitative food frequency questionnaire (FFQ), that was originally developed for measuring dietary calcium intake in Croatian postmenopausal women [12]. The questionnaires were given to participants by researchers in person before the participants' X-ray absorptiometry examination.

Statistical analysis. The statistical analyses were performed with SPSS statistical software program (SPSS version 11.0.1 PC, USA, IL). All statistical tests were considered significant at $p \leq 0.05$.

Results and discussion

Of the total population group in this study (n=104), in accordance with the obtained results for the T-score of the lumbar spine and T-score of the hip, 53 participants (50.96%) showed osteoporotic, 42 participants (40.38%) osteopenic, whereas 9 participants (8.65%) normal BMD. Personal fragility fractures were reported by 19.23%, while 8.65% of the participants had a history of family fractures.

Descriptive characteristics of the participants, the T-score values and their DCI (mean ± SD) are presented in Table 1. It was determined that the average daily calcium intake in the female respondents is 854.3±260.4 mg, whereas the average body mass index (BMI) has reference 27.7±3.6 kg/m^2. In average, female respondents enter menopause from the age of 47.5±4.9. The obtained results from the BMD measurement showed that at the level of the whole population group, the average reference of T-score of the hip is -1.73±1.01 whereas the average reference of T-score of the lumbar spine is -1.83±1.30. None of the participants had reference BMI<18,5 kg/m^2.

Table 1

Descriptive characteristics of participants, T-score values and DCI

	Min	Max	$\bar{x}$	SD
Age (*years*)	49	82	64.7	7.6
Body mass (*kg*)	50	95	71.46	9.67
Height (*m*)	1.5	1.75	1.61	0.05
BMI (kg/m^2)	20.28	39.73	27.7	3.6
Menopause onset (*years*)	35	58	47.5	4.9
Hip T-score	-4.1	1.4	-1.73	1.01
Lumbar spine T-score	-4.7	2.6	-1.83	1.30
DCI (*mg/day*)	366.4	1689.01	854.3	260.4

n =104, $\bar{x}$ – mean, SD – standard deviation

Pearson's correlation coefficients were used to assess associations between T-score and DCI, body mass, height, age and menopause onset. The results of statistical analysis are shown in Table 2. Present results demonstrated that correlation between DCI and T-score of the spine (*r=-0.153, p=0.*120), as well as the T-score of the hip (*r=-0.155, p=0.115*) is not statistically significant. It was also observed that there is no significant relationship between parameters such as participants' age and menopause onset with T-score.

Table 2

Pearson's correlation coefficients between T-score and participants' age, body mass, height, menopause onset and DCI

		Lumbar spine **T-score**	***Hip*** **T-score**
DCI	*r*	-0.153	-0.155
	p	0.120	0.115
Age	*r*	-0.106	-0.105
	p	0.285	0.264
Height	*r*	0.033	0.020
	p	0.739	0.838
Body mass	*r*	0.255**	0.377***
	p	0.009	0.000
BMI	*r*	0.245*	0.383***
	p	0.012	0.000
Menopause onset	*r*	0.029	-0.058
	p	0.771	0.556

n=104; r – Pearson's correlation coefficients; p – probability value;
* significance level at $p \leq 0.05$; ** significance level at $p \leq 0.01$; *** significance level at $p \leq 0.001$

The significant positive correlation was found between the body mass and T-score of the spine (*r=0.255**, p=0.009*), as well as T-score of the hip (*r=0.377***, p=0.000*). There was no statistically significant association between the height of the participants and T-score of the spine (*r=0.033, p=0.739*); and between the height and T-score of the hip (*r=0.020, p=0.838*).

The significant correlation was also observed between BMI and T-score of the spine (*r=0.245*, p=0.012*), as well as T-score of the hip (*r=0.383***, p=0.000*).

Aiming to get insight into the changes of the bone density in the course of the age, the data were rearranged to demonstrate a possible difference in the T-score values between age groups. We divided the participants into 3 age groups: (1) from 49 to 58 years old, (2) from 59 to 68 years old and (3) 69 and older. The data are presented in Table 3.

Table 3

T-score of the lumbar spine and hip in different participants' age groups

		Hip **T-score**	***Spine*** **T-score**
Age range	**n**	$\bar{x}$	
49-58	28	-1.679	-1.657
59-68	41	-1.566	-1.824
69+	35	-1.951	-1.983

n – number of participants, $\bar{x}$ *– mean*

In order to get insight into the occurrence of (1) participants' previous fractures and (2) fractures among close family members, we also grouped data on the grounds of bone density findings: participants with osteoporosis, osteopenia and normal bone mass (Table 4). It was concluded that 20 participants had previous fractures, and 9 participants reported history of family fractures. The data analysis showed that the majority of previous fractures occurred in respondents with diagnosed osteoporosis (65% of the total number of reported previous fractures). The same group of participants also reported the biggest number of fractures among close family members (67% of the total number of fracture histories).

Table 4

Personal and family history of fracture of the participants

	Previous personal fractures	**Family history of fractures**
Osteoporosis	13 (65%)	6 (67%)
Low bone mass (osteopenia)	6 (30%)	3 (33%)
Normal bone mass	1 (5%)	0 (0%)
Total *(n=104)*	**20**	**9**

The data regarding the risk factors of osteoporosis among the participants are shown in Table 5. The results showed that most of the participants i.e. 76.92% consume caffeine on regular daily basis, 88.46% do not consume alcohol at all, and 69.23% do not consume food with high amounts of salt. A relatively small number of the respondents are smokers (12.5%), and 4.81% take corticosteroids therapy. 74.04% stated that they did not often have physical activity, and 40.38% stated that they were often exposed to sun.

Nutrition is consider to be an important modifiable factor in the development and preservation of bone mass and the prevention and treatment of osteoporosis [13]. In addition, calcium is a key element in the formation of bones and in reaching peak bone mass, and as a result its role is very important in the primary prevention of osteoporosis [14]. Calcium intake in adulthood and postmenopause influences the level of age-related bone loss. Therefore, ensuring adequate calcium intake in postmenopausal women is an important step in prevention and treatment of osteoporosis. The mean daily calcium intake among our study participants, assessed using a validated FFQ, was 854.3±260.4 mg, which is below the Recommended nutrient intakes (RNIs): the RNI of 1000 mg/day for premenopausal women, and the RNI of 1300 mg/day for menopausal women over 50 years old [15]. The lowest determined daily calcium intake among participants was 366 mg/day, while the highest was 1686 mg/day. According to the previously reported data calcium intake can effectively postpone the tendency of BMD decrease in postmenopausal women [16]. Several studies have demonstrated that a calcium intake dose less than 800 mg/day is associated with increased BMD loss in post- and perimenopausal women, and daily 1200 mg calcium is suggested as a beneficial dosage [14, 16].

Table 5

Risk factors of osteoporosis among the participants

Previous personal fractures	Yes	20 (19.23%)
	No	84 (80.77%)
History of family fractures	Yes	9 (8.65%)
	No	95 (91.35%)
Corticosteroids therapy	Yes	5 (4.81%)
	No	99 (95.19%)
Physical exercise	Daily	2 (1.92%)
	1-2 times a week	6 (5.77%)
	Sometimes	19 (18.27%)
	No	77 (74.04%)
Sun exposure	Yes	42 (40.38%)
	No	62 (59.62%)
Smoking	Up to 10 cigarettes a day	6 (5.77%)
	Up to 20 cigarettes a day	6 (5.77%)
	Up to 30 cigarettes a day	1 (0.96%)
	Non-smoking persons	91 (87.50%)
Alcoholic drinks	Daily	4 (3.85%)
	1-2 times a week	1 (0.96%)
	Sometimes	7 (6.73%)
	No	92 (88.46%)
Caffeinated beverages	Daily	80 (76.92%)
	3-5 times a week	1 (0.96%)
	Sometimes	4 (3.85%)
	No	19 (18.27%)
Food with high amounts of salt	Yes	32 (30.77%)
	No	72 (69.23%)

The results obtained in our study showed that the highest calcium amount consumed through diet in participants comes from milk and dairy products. The drinking water was another significant source of dietary calcium. The important source of calcium in their diets from the vegetable group was spinach, and from the fruit group it was oranges. Also, participants consume tinned sardines (with bones) which are a rich source of calcium. Our results suggest that education about the importance of dietary calcium in prevention of osteoporosis is necessary as well as gaining knowledge of the food supplies which are rich sources of calcium, in order to improve the dietary calcium intake. Education is especially important if taken into consideration that the persons with poor knowledge and with low social economic status are four to five times at larger risk to consume less calcium through nutrition compared to others [17].

The results obtained in this study confirmed that higher body mass and BMI in participants are associated with higher bone density, reported using T-scores. These findings are consistent with other studies emphasing the bone mass and the BMI as a powerful determinants of bone loss. Namely, in the research of Igić and Zvekić-Svorcan [18] it is confirmed that there is statistically significant association between the body mass and the T-score of the hip, as well as the T-score of the spine. Finkelstein et al. [19] have found that during the late peri- and postmenopause, rates of spine and hip bone loss was approximately 35–55% slower in women in the top *vs.* the bottom tertile of body mass. It is possible that the reasons why higher body weight is associated with slower rates of bone loss are the increased production of estrogens by adipose tissue or/and the regulatory role of osteocytes in order to reduce bone resorption as response to greater mechanical loading [19].

Low BMI values are considered to be a risk determinant for osteoporosis occurrence. In our research, none of the female respondents had BMI value <18,5 kg/m^2. The statistically significant association between the BMI and the T-score of the hip, as well as the T-score of the spine that was identified in our study is also confirmed in the research of Zvekić-Svorcan et al. [20], showing that there is a relationship between persons' BMI and their lumbar spine and hip T-scores i.e. there is association between the decreased BMD and the low BMI [20]. Kang et al. [21] found that the hip bone strength deteriorated with aging and enhanced with higher BMI and longer time of years of menstruation in Chinese postmenopausal women. The results from their study supported that BMD is in positive relationship with BMI which means that higher BMI values are associated with stronger and more powerful hip bones. In addition, low body mass index (BMI) is a well-determined risk factor for fractures, and fracture risk differs according to fracture site [22]. De Laet et al. [23] have found that the relationship between BMI and the fracture risk is non-linear, and the highest risk rate is at BMI values <20 kg/m^2 and slight decrease of the risk is noticed at the level > 25 kg/m^2. Based on these results, special attention should be given to thin women who are at increased risk of bone loss.

The majority of previous fractures in our study occurred in women with diagnosed osteoporosis (65% of the total number of reported previous fractures), compared with the participants with osteopenia (30%) and with normal bone mass (5%). The participants with osteoporosis also reported the biggest number of fractures in their close family (67% of the total number of fracture histories registered in the research). These results are consistent with literature data and demonstrated that reduced bone density among women is related with existence of previous personal fractures, as well as with family history of fracture in diagnosed persons. De Laet et al. [24] showed that the family history of fracture is strongly connected with the risk of fracture occurrence. Also, Invernizzi et al. [25] found an increased risk of fractures in women with a positive family history of fragility fractures. In the research

of Vasic et al. [26] the authors concluded that the presence of vertebral fractures is a risk factor for future fracture occurrence. Nevertheless, this dependence is not always present, and in a research which involved 122 respondents with average age 66.85±8.42, the authors Igić and Zvekić-Svorcan [18] emphasize that they had not determined statistically significant difference between the respondents with or without history of family fractures and the occurrence of osteoporosis/osteopenia.

The rearranging of the obtained T-score values in our study within age groups confirmed that the bone density decreases from the youngest to the oldest age group of participants; only exception was found for the hip T-score in the age group 59 to 68. This study's findings are generally consistent with studies that have found that the reduction of BMD depends on age and choice of measurement site [27, 28].

Women in our study reported to experience natural menopause fairly early, at about mean age 47.5. From the total of 104 participants, 76% entered menopause before reaching 50. The statistical analysis of our results showed that there is no significant relationship between the menopause onset and the BMD, reported in the T-score at the lumbar spine ($r=0.029$, $p=0.771$) or hip ($r=-0.058$, $p=0.556$). Contrary to our results, Zvekić-Svorcan et al. [29] observed statistically high connection between menopause onset and bone mineral density, as well as between menopause duration and bone mineral density. Other authors also reported that early menopause is an important risk factor for osteoporosis occurrence [30, 31]. We can speculate that the reason why our results didn't demonstrate significant correlation between the menopause onset and the BMD could be the low average age at menopause onset among the selected women in our study group.

The insight into exogenous risk factors of osteoporosis in this study showed that a small percentage of the participants: were smokers (12,5%), used corticosteroids therapy (4.81%) and consumed alcohol (11.54%), but the percentage of participants who consume caffeine on daily basis was rather high i.e. 76.92%. Smoking, corticosteroids therapy and alcohol and caffeine consumption are well-known risk factors that may be associated with low bone density and increased risk of osteoporotic fractures [32, 33, 34, 18]. Identifying major exogenous risk factors on national level and understanding their impact on bone loss in postmenopausal women need to be further elucidated.

Most of the participants in our study reported insufficient physical activity and sun exposure. Insufficient activity was defined as person not meeting the WHO recommendations on physical activity for health [35]. Among participants, 74.04% (n=77) reported to never exercise. Only two women (1.92%) reported they practise physical exercise every day. Studies have shown that poor dairy calcium intake, along with low physical activity are key risk determinants of osteoporosis and fracture [17]. Regular physical activity that maintains or increases muscle strength, coordination and balance is universal recommendation for the prevention and treatment of osteoporosis, as well as for reducing the risk of falls and fractures. Many authors reported that increased physical activity levels are associated with reduced risk for low bone density in postmenopausal women [36, 37]. In order to change the physical inactivity profile of Macedonian postmenopausal women determined in our study, strategies should be created to address this group of patients.

Conclusion

The mean daily calcium intake among our study participants was 854.3±260.4 mg which is below the calcium recommended nutrient intake (RNI) for postmenopausal women. This study's findings confirmed that the reduction of the bone mineral density (BMD), reported

using T-scores, depends on age and choice of measurement site. Education on the importance of calcium in the diet and knowledge on the lifestyle factors that affect bone loss are needed toward decreasing risk for osteoporosis and related fractures in postmenopausal women. The education should cover different age categories of women because the bone mass in later life depends on the peak bone mass achieved during growth and the rate of subsequent age-related bone loss. In order to change the physical inactivity profile of Macedonian postmenopausal women and their nutritional habits, preventive strategies should be created to address this group of patients.

Identifying major exogenous risk factors on national level and understanding their impact on bone loss in postmenopausal women need to be further elucidated.

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Formation of intelligent agents of the information and analytical system of enterprise safety management

Olga Yevtushenko, Alina Siryk

National University of Food Technologies, Kyiv, Ukraine

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Corresponding author:

Olga Yevtushenko
E-mail:
0677389857@ukr.net

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Abstract

Introduction. Research has been conducted to form a conceptual model of the intellectual information and analytical labor protection management system of food industry enterprise.

Materials and methods. For solving the tasks, methods of system analysis, basic classes of architecture of agent systems, mathematical logic, the theory of formal systems and calculations characteristic of traumatic processes at industry enterprises have been used.

Results and discussion. It is determined that the proposed complex automation system of labor protection management for companies in food industry, can be used to improve project management decisions on operational analysis of working conditions in the enterprise, definition of areas to prevent occupational injuries and organizational measures for the protection of labor basis. The paper proposes an intelligent agent model in the structure of an information-analytical management system of industry enterprises, which is different due to the way the information space of intelligent agents is formed, the availability of a model for behavior selection mechanism and the contents of intelligent agent's goal definition model, which allows to determine the dynamics of development of multi-agent environment, complicated hierarchy of goals in the information and analytical labor protection management system at enterprises and form various operation strategies for intelligent agents. The results of work contribute to the principle application development of occupational safety as far as the diagnosis and modeling of extreme situations and evaluate their consequences.

Conclusions. The most rational solution is to improve the safety of work of the enterprise by introducing elements such as data elements and intelligent agents into the information and analytical labor protection management system.

Introduction

Based on the analysis of information and analytical systems used in the labor safety field, depending on the purpose of their functioning, the tasks to be solved, and the specifics of data collection and processing, it is possible to single out information-reference, information-calculation, information-control and intelligent analytics platform [1, 2, 3].

The task of increasing the safety of labor in food industry enterprises is most rationally solved by introducing such components as data elements and intelligent agents into the information management system.

The paper proposes an intelligent agent model in the structure of an information management system in food industry enterprises, which is different due to the way the information space of intelligent agents is formed, the availability of a model for behavior selection mechanism and the contents of intelligent agent's goal definition model, which allows to determine the dynamics of development of multi-agent environment, complicated hierarchy of goals in the information management system at enterprises and form various operation strategies for intelligent agents.

The legislation of Ukraine on labor safety management provides for the following division of responsibilities for the labor safety management at any enterprise: in general, director (employer) and his/her deputies carry out the labor safety management at the production facility; in the divisions – their heads; organizational and methodological and supervisory activities in the field of labor protection, management decisions preparation and control over their implementation is carried out by the work safety service, which is directly responsible to the director.

During day-to-day operations, specialist services (divisions) of the food production facility are processed, systematized, stored large information volumes. Unfortunately, as practice shows, due consideration is not given to the use of accumulated data for decision analysis and operational management. Remain unresolved issues of structuring data, categorized (production factors and working conditions, instructions, regulations, etc.) and the choice of valuable information.

First, the issue is that we have to analyze and predict the manufacturing situations of labor safety, and this is a significant amount of information that cannot be analyzed in a timely manner without modern information technology (IT). Information technology is an integral part of our modernity, in particular its main component with a high level of development of introducing a new management style into our lives. The information distribution of and information support construction for labor safety in most ways characterizes the art of management. The introduction of new models and principles in the information provision of labor safety in a food production facility with the use of modern information technologies, plays a decisive role in the validity and timeliness of management decisions taken on the basis of monitoring labor conditions, occupational disease and injury statistics, the production risks analysis and the effectiveness of measures to limit and reduce them [4].

Therefore, a modern information and analytical system for health and safety management at a food production facility should be organized taking into account the clear interaction of the head of the health and safety department with the heads of all structural subdivisions of the food production facility for adequate and constant management, taking into account all factors affecting the health and safety management state, and provide heads of structural units with an optimal measures set to ensure labor safety.

The problems of ensuring the stability of operation of difficult intelligent information and control systems, which include of the industry enterprises, was first staged in the works of national scientists.

Key stages of stability theory lately was developed in the work of O.V. Barabash [5] and others. The overview of the issue of verification items base knowledge of management information systems was in the next works [6, 7].

The analytics platforms evaluation existing in the labor safety field shows that there is a positive experience of their use for solving problems of injury rates administrative monitoring and so on. Despite the considerable advantages that the use of information analysis systems provides, it should be noted that they are limited. Traditionally, there are no functions for developing managerial decisions in information analysis systems, this leads to irrational use of available data, and in some cases – to the insufficiently substantiated managerial decisions adoption. [14, 15, 16, 17].

Materials and methods

A research object is to ensure safety labour at the food industry enterprise.

The subject of the research is an increase safety of labour of food industry enterprise on the basis of the worked out conceptual model of intellectual agent in the structure of information-analytical system of labor protection management at the enterprise, institution, organization.

For the construction of information-analytical system control system by labor protection at the of the food industry enterprise is chosen the object-oriented programming [21, 22], methods of system analysis [30, 31, 32], mathematical logic and the theory of formal systems and numerals [33] for reducing an occupational injuries [3, 18, 19, 20].

Results and discussion

Modern analytical platforms [22, 23, 24] should be focused on supporting management activities [25, 26]. The creation of such systems involves the application of decision-making theory methods [27], mathematical modeling and forecasting methods, decision-making theory and expert judgment [28]. The main task to be solved by modern IIS is to transform the accumulated data on the status of the object of management of labor safety (the activities of functional services and structural units to ensure safe and healthy working conditions at workplaces, production sites, workshops and industry enterprises in general) in a form that allows the head (the labor safety department head) to adequately assess the labor safety object state, assess the situation development and make a sound management decision [29]. That is, the well-known state of the management object of labor safety should be aligned with such a management strategy, which is the physical implementation of management decisions, from the admissible set. In this case, the chosen solution is optimal based on a definite list of criteria for decision-making and restrictions.

A combined model of an intelligent agent information management system. Based on the analysis of the characteristics and shortcomings of known models of IA, it is proposed to define IA as the structure of the form

$$IA = <NIA, SA, VIA, MVB, VO>,$$

where NIA – intelligent agent's name; SA – structure of attribute, which is defined similarly to the structure of attributes of information objects (IO); VIA = {IA} –plenty of attachments

IA; MVB – the mechanism of the model of functioning selection, VO = {O} –plenty of information objects, that implement the scenarios of IA work.

Intelligent agent based on the criteria select the model of functioning inherent in the MVB, makes a decision about implementation in a given time a certain scenario and the corresponding appropriative IO.

Intelligent agents, which have only the name (IA = <NIA,∅ , ∅ , ∅ , ∅ >), can be called nominal, similarly to nominal IO. By the content nominal IA are not differ to nominal IO. Similar situation is also with the parametric IA rank (IA =<NIA, SA, ∅ , ∅ , ∅ >). By the feature of presence of mechanism behavior of IA is possible to allot them in 2 classes: active (MVB ≠∅ & VO≠∅) and passive (MVB = ∅ & VO = ∅). The passive IA class have subclass of passive agents – cover, which are used for connecting the objects inside the (IA = <NIA, ∅ , VIA, ∅ , ∅ >). Passive IA (IA = <NIA, SA, VIA, ∅ , ∅ >) have attribute, which can be constant and it allows them to create an intermediate level of the hierarchy. The active IA class has a subclass of unclear IA (IA = <NIA, ∅ ,∅ , MVB, VO> ∪ <NIA, ∅ , VIA, MVB; VO>), which can predict the manipulation with internal structure of attribute Classification IA is performed in tables 1 and 2.

Table 1

Classification IA

Rank of intelligent agent	Change of an intelligent agent model				
	NIA	SA	VIA	MVB	VO
Empty	-	-	-	-	-
Nominal	+	-	-	-	-
Parametric	+	+	-	-	-
Passive – cover	+	-	+	-	-
Passive	+	+	+	-	-
Active unclear	+	-	-	+	+
Active terminal	+	+	-	+	+
Active	+	+	+	+	+

If imagine, that the attributes structure SA is a general representation of the knowledge spaces of IA, it is possible to consider this structure on a conceptual level. Most famous work make functional separation of a knowledge of IA (knowledge about the environment, knowledge about yourself, knowledge about other agents and etc. Here "–" means empty condition (∅), "+" means the presence in IA model.

Table 2

Classification IA

<table>
<tr><th colspan="4">Intelligent agents</th></tr>
<tr><td colspan="2">passive
<NIA, SA, {IA}, 0, 0></td><td colspan="2">active
<NIA, SA, {IA}, MVB, 0></td></tr>
<tr><td rowspan="3">Passive cover
<nia, 0, {ia}, 0, 0></td><td>parametric
<nia, sa, 0, 0, 0></td><td rowspan="3">terminal
<nia, sa, 0, mvb, {0}></td><td rowspan="3">Active unclear
<nia, 0, 0, mvb, {0}>
u <nia, 0, {ia}, mvb, {0}></td></tr>
<tr><td>nominal
<NIA, 0, 0, 0, 0></td></tr>
<tr><td>empty
<0, 0, 0, 0, 0></td></tr>
</table>

Functional separation is not universal, because it depends on the features of industry enterprises is related with exact area. Conceptual review allows you to create more General models of intelligent agents as necessary to specify and clarifying the structure of the space of knowledge IA , that related to this intellectual component, as if to form the “near edge” space of the subject area and define its behavior using certain mechanisms of social behavior in this localized group. IA can use the logical mechanism and by methods of consistency, which are located on the intelligent components. Intelligent component will be more resistant structure, “strictly” localized logical and spacely. IA faster, they can move like in a network environmnet. As IA use general mechanism of logical method, then it is not necessary to copy it in every agent, that can increase the action and to reduce memory overhead.

Let’s find an informational space, as a sum of intelligent agents, that surround IA_i and interact with it; a sum of IO, that surround IA_i and interact with it, and a plenty of attributes, which are necessary IA_i to assess the condition of an environment.

$$V_{IA_i} = (AR^i_{IA}, AR^i_{IO}),$$

$$AR^i_{IA} = (N_{IAj}, A^{\xi}_{IA_j}, ..., A^{\psi}_{IA_j}, N_{IAI}, A^{\xi}_{IA_I}, ..., A^{\psi}_{IA_I}),$$

$$AR^i_{IO} = (N_{IOj}, A^{\xi}_{IO_j}, ..., A^{\psi}_{IO_j}, N_{IOI}, A^{\xi}_{IO_I}, ..., A^{\psi}_{IO_I}).$$

Condition of informational space IA_i we call the sum of AR^i_{IA}, AR^i_{IO} in the moment of time – t:

$$SV_{IA_i} = (< A^{\xi}_{IA_j} >, ..., < A^{\psi}_{IA_j} >, ..., < A^{\xi}_{IA_I} >, ..., < A^{\psi}_{IA_I} >,$$

$$< A^{\xi}_{IO_j} >, ..., < A^{\psi}_{IO_j} >, ..., < A^{\xi}_{IO_I} >, ..., < A^{\psi}_{IO_I} >),$$

where <A...> – meaning of attribute in the moment of time *t* from the side of perfomanced intelligent. Information about the condition of informational space IA_i cannot get at the same moment from all the corners of this space, because there is a delay in the exchange of information between agents.

The information space of the agent can be formed in two ways:

a. Static – AR_{IA}^{i}, AR_{IO}^{i} determined at the design stage IA and in the process information management system can't be changed;

b. Dynamic– AR_{IA}^{i}, AR_{IO}^{i} can be changed .

So, informational space model IAi you can find in such way

$$MIS_{IA_i} = (V_{IA_i}(t), SV_{IA_i}(t), FV_{IA_i}(t+1)),$$

where FV – function of formation of information space.

A model of the mechanism of choice behavior of IA can be as follows:

MVB = (MIS, MG, MSR, MA),

where MG – model of goal setting, MSR – model of solution research (direction research, methods how to reach a goal), MA – active actions model, means the activation mechanism of IO, that influences on the environment.

For such IA model of goal setting can be built the next way

$$MG_{IA_i} = (SS_{IA_i}, FSS_{IA_i}, GS_{IA_i}, G_{IA_i}^{top}, G_{IA_i}^{down}, FG_{IA_i}^{D}, FG_{IA_i}^{S}, FAG_{IA_i}, SMA_{IA_i}(t))$$

Then the subscripts can be omitted where it causes no ambiguity. Here SS –plural of stratigies, that means like methods of making choice of an aim $SS = (S_i \,|\, i = 1,...,n)$, FSS – a function selection strategy; GS –plural of static targets, G^{top} – plenty of goals, that got by an IA from the agents with a higher level of the hierarchy, G^{down} – plenty of goals which can be transmitted to IA at lower levels FG^{D} – function of creating the dynamic targets, FG^{S} – selection static target function; FAG – active goals selection function, means goals, taken to implement; SMA – condition of multi-agent environment.

In contrast to existing agent-based models the state of MA places more appropriate to take into account the dynamics of its development, taking into account both past history and expected future. Condition of MA-environment can be viewed from the position of exact intelligent agent IA_i, that's why

$$SMA_{IA_i}(t) = (Pa_{IA_i}(t), Rt_{IA_i}(t), Fu_{IA_i}(t)).$$

Past MA- environment is $Pa_{IA_i}(t) = \bigcup_{0}^{t} (V_{IA_i}(t-1), SV_{IA_i}(t-1))$, means the unification of the information space and state of the totality of previous points in time.

Current condition MA-environment

$$Rt_{IA_i}(t) = (V_{IA_i}(t), SV_{IA_i}(t)).$$

Predictable future condition

$$Fu_{IA_i}(t) = (V_{IA_i}(t+1), SV_{IA_i}(t+1))$$

is an evaluation of the information space and its condition, that was made in exact moment t–1 means at the previous step of IA. And to make this evaluation, it is necessary to have a future function of MA-environment $FP(Rt_{IA_i}(t), MA)$ as a result it will be $Fu_{IA_i}(t)$.

Strategy selection function determines the current strategy of depending on the previous strategy, the state of MA-environment, plenty of currently active goals. So $FSS: s(t) \times SMA \times GA \to s(t)$.

If notice static goals as *gs*, then goals that are taken from other higher agents like *gt*, goals that are taken from lower levels like, how *gd* then relevant plural will be: $GS_{IA_i} = \{gs^i \,|\, i = 1,...,m\}$, $G_{IA_i}^{top} = \{gt^i \,|\, i = 1,...,l\}$, $G_{IA_i}^{down} = \{gd^i \,|\, i = 1,...,k\}$.

Function of creating the dynamic targets be determined by functional transformation $h_{IA_i}^D$ above the condition of MA-environment, by current strategy, be plenty of $G^{AVT(D)}(t)$, $GA(t)$ and a sum of formula with a logic from the first above the elements MA-environment:

$$FG_{IA_i}^D = h^D(SMA_{IA_i}(t), s^i(t), G^{AVT(D)}(t), GA(t), U),$$

where $U = \left\{U^j(SMA(t)) \,|\, j = 1,...,k\right\}$. The result of work $h_{IA_i}^D$ is $G_{IA_i}^{AVT(D)}(t+1)$.

Selection static goals function can be determined by functional transformation above the condition of MA- environment, by current strategy, plenty of static goals at an exact period of time– $G^{AVT(D)}(t)$, plenty of active goals, that were taken to implementation and a sum of formula with a logic from the first above the elements MA-environment:

$$FG_{IA_i}^S = h^S(SMA_{IA_i}(t), s^i(t), G^{AVT(S)}(t), GA(t), W),$$

where $W = \left\{ W^j(SMA(t)) \,|\, j = 1,...,k \right\}$.

The result of work $h_{IA_i}^S$ is $G_{IA_i}^{AVT(S)}(t+1)$.

For effective operation of an intelligent analytics platform, it is crucial to establish timely receipt of reliable information about the actual values of harmful and dangerous factors that are monitored at workplaces. Data base carriers, as well as primary documents in the system of accounting and analysis of this condition can use data on the certification of workplaces at the food production facilities.

It is suggested to choose the XML type for documents storage that makes it possible to use it as a universal language for requests to information repositories. The XML type also allows you to control the correctness of data stored in documents, perform checks on hierarchical relationships within a document, and establish a single standard on the documents structure, the content of which may be various data. This means that it can be used in the construction of complex information systems, in which the information issue exchange between different applications running on the same system is very important.

The organization of the data entry system is adapted to the existing methods of data accumulation [6] in the general work of the intelligent analytics platform. The labor safety service (department) head of the food production facility receives the output.

Conclusion

The task of increasing the safety of labor in industry enterprises is most rationally solved by introducing such components as data elements and intelligent agents into the information and analytical labor protection management system.

Comparative analysis of the main types of agent models in terms of their applicability to the task of building the information and analytical labor protection management system of the industry enterprises has shown that till nowadays there was not developed sufficiently generic model of an intelligent agent that can take into account the hierarchy of intelligent agents in multy-agent system, the structural hierarchy of goals and, at the same time, it would be focused on the technical implementation within the framework of existing technical facilities in information and analytical labor protection management system of industry enterprises.

It is proposed an intelligent agent model in the structure of an information and analytical labor protection management system of power facilities in industry enterprises, which is different due to the way the information space of intelligent agents is formed, the availability of a model for behavior selection mechanism and the contents of intelligent agent's goal definition model, which allows to determine the dynamics of development of multi-agent environment, complicated hierarchy of goals in the information and analytical labor protection management system of power facilities at enterprises and form various operation strategies for intelligent agents.

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Problems of innovative development of the system of Ukraine

Tamara Berezianko

National University of Food Technologies, Kyiv, Ukraine

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Corresponding author:

Tamara Berezianko
E-mail: berezianko-2016@bigmir.net

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Abstract

Introduction. The aim of this recearch is to identify the main disproportions of the development management of the national innovation system.

Materials and methods. The materials of the research contain the analysis of development state of the Ukrainian innovation system. The national innovation system is considered in the context of compliance with the international measurements and the concept of transition to the formation of knowledge society. It have been used the method of comparison, system analysis as well as survey. A logical-abstract method was used to group national and international analytical results.

Result and discussion. It is proved, that the main restrictive factor while forming of comprehensive whole and developing of its breakthroughs is inconsistent, and sometimes destructive management, insufficient activity of public administration and residual financing of needs. In the state administration and research environment of Ukraine there are somewhat opposite ideas about the state and needs of further innovation development. Public officials consider it necessary to put science at the service of the immediate business needs in order to strengthen the country's position on the international market and increase overall competitiveness. This, in turn, serves the purpose of implementing the tasks entrusted to the government by international financial donors. For its part, the scientific environment defends the long-term goals of preserving the country's scientific, technological and innovative potential. Support for fundamental research does not bring a quick result, but it preserves opportunities for development for future generations. In view of this, it is critical to address the call of functionaries to reformat the directions of the market to meet market demand and the current needs of the real sector of the economy. The discrepancy in approaches to scientific innovations and the directions of their implementation is reflected in the scope of state financial and organizational support. To fund the innovation development fund in 2018, only $ 2 million has been allocated. The second issue of the country's innovation development is the lack of development of national legislation, especially in modern areas, such as the creation of innovative ecosystems. In general, this can be diagnosed as a consequence of an institutional destructive policy at the state level. The scientific activity is not included into the list of state priorities: there is a constant reduction of funding both for institutions and scientific research.

Conclusions. Forming of an effective and competitive national innovation system requires the legislative and tool consolidation of innovative development of the country, creation and structuring of the innovation market under national control.

Introduction

The world market community has began to focus on the convergence of the public and business interest since the 90's. At first the society had such tasks and motivations as: creation of favourable climate for the entire business; soft investments in the infrastructure (personnel training, improvement of regulations); development of partnership between the state and private sector; private sector invests in the common weal; priority of target domestic investments, strengthening of competitive advantages in the corporate sector (priority of public sector). According to the tasks the state used the following tools: global strategy of competitive development and stimulation of increase in local firms; support of inter-community network consolidation and cooperation; promotion of economic interdependence of corporate groups; improvement of quality of labor resources; efforts to improve the quality of life of the society.

The purpose of the study consists in identification of problems of creation and implementation of scientific knowledge, technologies, provision of innovation process and functioning of national innovation system.

The above-mentioned conditioned consideration and critical analysis of the following tasks: efficiency of state regulation of innovations; problems of implementation of innovations in the national education; the quality of knowledge generation and their direction; research of innovation infrastructure; as well as the level of innovation of national production. Object of the study. The components of the national innovation system.

Materials and methods

In the process of preparation of the article scientific and analytical researches of national and foreign statistical, financial and rating organizations were used, as well as the results of their own interviews and questionnaires were processed.

The methodology of the study included statistical analysis, grouping, systematization, sociological surveys, questionnaires and special tools for processing personal data. The logic of presentation of the material follows the structure of the national innovation system. The logic of the study is subordinated to the task of analyzing the constituent parts of the national innovation system.

Results and discussion

The national innovation system includes the following elements:

1. State regulation (legislative, structural and functional institutions);
2. Education (institutions of higher education and scientific production enterprises);
3. Generation of knowledge (research institutions and organizations);
4. Innovative infrastructure (production, technological, financial, informational, analytical, expert and consulting components, including industrial parks, technopolises, innovation centers, technology transfer centers, etc.);
5. Production.

However, due to the development of human capital Ukraine received the 31st place, that corresponds to the level of development of developed market countries. Productivity is one of the most effective tools of increase and development. And the best tool of its accumulation is the use of innovative tools for the development of potential.

According to the Global innovation index Ukraine ranked the 50th place among 127 countries in 2017 [1-3]. Human capital is the main part of national competitiveness: the country ranked the 41st place. The main restraining element is the low of R&D expenditures (54th place in the ranking) that cause the migration of existing and potential scientists outside Ukraine.

According to the index of "Institutions" Ukraine received the 101st place, according to the level of development of infrastructure – 90th place, according to the indicators of markets effectiveness– 43.2 or 81st place (trade and competition – 48, credits – 71, investment – 107), according to the "business experience" index - 51st place (according to the number of brain workers – 41st place, according to the innovative knowledge – 72d, according to the knowledge perception – 63d place). At the same time the country demonstrates a high level of research efficiency – 32nd place and a low-impact of its implementation – 77. Quite high is the index value of "creativity" - 49th place, online creativity - 47th place. According to the global competitiveness index Ukraine has received the 82nd place between Brazil and Bhutan.

According to the criteria, the score of Ukraine is: the share of expenditures on research activities in GDP - 47; the effectiveness of industry – 48; growth of GDP per capita of the adult population for three years – 50; percentage of local high-tech companies in the business of the country as a whole – 32; the effectiveness of higher education – 21; concentration of scientists – 46; patent activity – 27 [4].

For reference: the effectiveness of education is calculated as the proportion of graduates graduating from higher education institutions to the share of graduates with engineering and technical education. In the western market countries university education is considered to be a part of academic one and humanities. And the competitive advantage of the country is mainly obtained by technical and technological advantage. Then the methodical approach becomes clear. There was the period of 1990-95's in the history of market economy of Ukraine, when namely the market transformation caused the situation, when the engineering specialists were not engaged into the non-specialized employment. For 20 years it was impossible to get actual and decent employment in the engineering profession. As a result people are not interested in technical education in the country (in 2017 only 3 applications were submitted to the Faculty of Mechanics at the National University of Food Technologies). This situation reflects the structural changes in the economy and resulted in to the country's de-industrialization. The lack of attention to the technical professions is formed in society and is reflected in family education (parental attitude, negative public experience and media neglect) and schools (lower quality of teaching of exact sciences, especially in towns and villages, lack of out-of-school encouragement through public circles of technical development and lack of material and technical base for their functioning).

This conclusion agrees with the data of sociological research conducted by the leading national agencies. The destruction of social growth through education and ability to use skills in working practice force youth to focus on the societies with a defined and formalized program for acquiring a high social status.

Ukraine received the 35th place according to the rating of compulsory education, the 45th place according to the number of researchers, according to the quality of scientific institutions – the 41st place, according to the employment – the 27th, but legal regulation of labor market remains to be the the main problem - the 103rd place.

Table 1

Guidelines of social growth,%

Response	Ukraine			EU		
	2009	**2012**	**2016**	**2009**	**2012**	**2016**
High intelligence	30.3	31.8	36.6	56.1	60.8	60.1
Ability to circumvent the law	33.1	33.1	29.2	5.3	5.5	4.7
Social status of the family (origin)	37.9	38.6	33.9	24.2	22.5	14.9
Good education	25.8	26.4	20.7	49.0	48.4	52.2
Focus on enrichment, individualism	46	45	42	47	43	42
Possibility of self-realization in own country	66	56	32	83	86	88
Confidence in government	23.3	28.8	10.6	63.1	67.6	55.3
Importance of science in society	35	48	34	67.3	70.2	78.3
Authority take into account the recommendations of national science	33	35	33	58	67	72

Based on the sources [5]

The position of Ukraine in the "Innovation" rating became worse, except for the index of "Availability of scientists and engineers." The worst position is in category "Government procurement of high technologies and products" - from the 86th place to the 92nd, as well as in the category of "Relations between university and industry" - from the 57th to the 73rd place. And the only positive trend is in the category "access to the Internet per 100 people".

In general, this is a consequence of an institutional destructive policy at the state level.

Meanwhile, Ukraine has exclusive positive examples that have been implemented counter to the situation: 7 Ukrainians are among the top 100 of the best innovators in Europe in robotics, biosensories and computer literacy, production of power efficient homes, HR technologies, media and Internet tools [3].

Analysts note the lack of an integral management system of the national innovation system: the functions are allocated between the Ministry of Education and Science of Ukraine and the Ministry of Economic Development and Trade of Ukraine. As a result, there is no coordination between the investment policy and innovation projects. Moreover, a significant number of restrictive measures of the Ministry of Finance of Ukraine hinders the implementation of innovations and hinders the development of scientific and technical capacity.

However, there are positive improvements: in 2016 a separate National Committee for Industrial Development was created, in 2017 the National Council of Ukraine for Science and Technology Development and the Council for Development of Innovation were formed. However, their activities are not coordinated. As a result, it is not possible to ensure effective impact on the Government's decisions on the development of innovations.

The identified problems become worse at the regional level.

Many elements of the innovation infrastructure don't work, innovation parks and incubators are closed (in 2005 the system of scientific and technological preferences has been suspended in terms of legislation). Legislative proposals on improvement and development of innovation activities have been refined and marked up for many years.

According to the index of Global talent Ukraine has got a high rating. Human resources are always characterized by a high level of qualification. Perhaps, therefore, Ukraine has become one of the largest exporters of labor (more than 2 million citizens work abroad). The number of students and institutions of higher education is decreasing: in 2017 only 1369,4 students studied at 287 institutions of higher education. These indexes are 35% and 17% respectively less than the same indexes in 2010. For many years no more than 10% of the national investments are allocated to the university science (15 million a year).

In 2016 an external audit of the Ukrainian innovation and research system was launched in Brussels. International experts observed an extremely unsatisfactory state of national innovation system. The participation of the private sector at the level of 20% of the total expenditure in the state on science is very low in comparison with its corporate capabilities. Basic machine building has turned from development driver into a deterrent factor, that hinders innovation mechanisms.

Experts underlined, that Ukraine belongs to the countries with the highest level of "superfluous education": in the final document they wrote, that 80% of young people study at universities. And it is too much for Ukraine. This document was approved by the Ministry of Education and Science of Ukraine. The level of "superfluous education" is the highest in economic and legal sciences. At the same time the entrants are not interested in natural and technical sciences. In addition, the national economy is not able to admit such a large number of highly skilled people, on the contrary, there is lack of semiskilled specialists with technical qualifications. At the same time, the percentage of students, who continue their postgraduate study is too low in accordance with the European standards [6].

During the independence years, nobody has created proper conditions for the development of science and for the introduction of innovations. Expenditures of the state budget for research make only 0,22% of GDP. Although the developments of domestic scientists are annually sent to the Cabinet of Ministers of Ukraine and ministries only a few inventions are realized practically. However, world experience shows, that the results of scientific research are not able to be effectively and quickly realized only on the market basis without significant state support.

National science operates within the 6th technological paradigm, and 94% of production consist of the 3rd paradigm with the elements of the 4th and 5th ones. It is impossible to change this situation without active intervention and strategic purposeful work of the state, because business (both large and small) exploit the natural raw material base of the country and is aimed at getting maximum results in a short time.

The enterprises producing food products, beverages and tobacco products carried out the most active innovative activities – 21,6%.

These industries are interested in the wide range of products, expansion of markets, improvement of quality, introduction of new technologies, receipts and equipment. The enterprises of these industries focus on private investment opportunities with a rare involvement of international loans from foreign co-owners. The leading industry experts think, that it is necessary to create more scientific and technical centers, provide access to favorable financing in order to activate innovation activity. The food industry as well as other industries mainly use own resources at the level of 75%.

Analysts note, that a significant share of innovative activities involves marketing and management technologies. The trade and service sector applies marketing and management technologies rather than technological innovation. First of all, it is about the means of product promotion, PR and HR activities, electronic commerce, logistics and motivation of personnel. 5,6% of funds allocated for innovation were spent on financing of this direction.

Over the last 5 years budget financing of strategic priorities of innovative activity was carried out in the following areas: technological innovation and development of agro-industrial complex – 59,4%; the smallest financing was in the direction of the introduction of new technologies and equipment for quality medical service, treatment and pharmaceutics – 2,6%. At the same time, the total funding budget was fulfilled only by 75,5%. The funding of medium-term priorities was fulfilled by 74,2%. At the same time, the funding was reduced by 40% of the annual volume in 2014.

For the period of 2012-2016 5671 technologies were created at research institutions for budget funds. Only 10.8% of these technologies were transferred to industrial enterprises and 0,8% were sold on the external markets. During this period 36 advanced technologies were purchased for budget funds. 97,5% of these technologies were purchased in 2012. It should be noted a significant deterioration in the relationship between the number of implemented technologies and innovative products. In 2000 this ratio averaged 1:10,92, in 2005 – only 1:1,74, and in 2017 – only 1:1,09 [7].

For almost 20 years there were two peaks of innovative financing in Ukraine: in 2007 due to the external borrowings of the owner and in 2011 due to external arrangements, partnerships and external investment. The latter allowed us to double the level of funding of innovation activities in the industry. But in the period of 2006-2016 the share of innovative enterprises in industry was steadily decreasing. Such situation proves, that there are no necessary prerequisites for the functioning of the investment-innovative model of development in Ukraine. The reason for this is the fact, that the realization of competitive advantages created due to the high-tech products in the domestic industry is almost absent. At the same time, this situation leads to a high risk of investment in innovation. As a result the cash flows decrease. Investors choose the less risky traditional industries: today 75% of investments in Ukraine are in the industry of the 3rd paradigm, 20% in the 4th paradigm and 4,5 % in the 5th paradigm. The industries of the 3rd technological paradigm have the highest level of re-equipment and modernization - 83%, and the industries of the 4th paradigm - only 10%.

In the period of 2000-2004 the State Statistics Service of Ukraine conducted surveys of managers of industrial enterprises regarding the reasons for low innovation activity. We have carried out own research in the period of 2007-2016. But our sample was significantly smaller.

Having analyzed the results of the survey and the data of scientific observations and statistics, we reached the following conclusion:

1. In the entire period from 2000 to 2016 the matter of financing was not settled. Attraction of venture, loan and other market resources was limited and speculative, and ensured only "skimming". The received profit was taken out of the country regardless of the source of income (80% of the revenues came from offshore sources for short-term funding of developments that are complete by 80%).
2. Legislation and public administration are situational and preferential. The author has investigated this question in many publications.
3. Non-market forms of restraint became barriers: opportunism of the owner, greed effect, resource orientation of the markets in the country.

Table 2

Main obstacles to the innovation activity of enterprises (survey results),%

Factors of negative influence	According to the IFC		The answers of managers of enterprises	
	2000-2004	2007-2016	2000-2004	2007-2016
The lack of funding	75	23	86	92
Customers don't have enough money	50	12	40	50
Underdevelopment of finance and credit system/high credit rates	42	22	39	50
Imperfect legislation	25	15	32	38
Undeveloped raw materials base	15	15	29	29
High economic risk	30	18	24	28
Low demand	8	10	15	34
Lack of international relations	25	12	11	12
Strict/preferential state regulation	28	10	15	29
Corruption	10	38	12	22
Bad public administration	36	22	12	28
Owner's/investor's reluctance	6	6	15	34

Based on statistics and own surveys

The process of basic adjustment and modernization of the enterprises requires the use of special means of support : government support, tax and procedural benefits, creation of special zones and incubators. All developed countries did everything in the same way. However, the international community has called Ukraine for structural changes, modernization of equipment and production technologies and simultaneously it ha strongly demanded abolition of preferences and economic support measures: the World Bank, rating agencies, intergovernmental meetings, the International Monetary Fund have repeatedly emphasized these demands in their documents. The severest demands were in the periods, when Ukraine tried to join the global funding at the state level (IMF requirements on the eve of the receipt of loans), to enter the international market organizations (2005 WTO and 2014 the Association agreement with the EU). Because of such leverage Ukraine has reorganized the State innovation Fund into the State innovation credit institution (2000); suspended, the adopted in 1999 law of Ukraine "On special regime of innovation activity of technological parks" has been abrogated (2005). Thus Ukraine doesn't have own tools to support the national innovation production. But the industrial parks started to operate. They were based on foreign investment and foreign control of selection of directions of innovations and areas of application of innovative production (2006). At the same time the innovative developments were implemented with help of business incubator (creation of prototype, current engineering model) through financing of venture and private investment funds. The objective "organization of development, production and put science intensive, high-tech products on Ukrainian and foreign markets" [8]. The change of economic orientation of the country made it possible to restart the activities of industrial parks (2012), to create jobs, to

development modern production infrastructure. At that time, there were more than 30 industrial parks.

In recent years the number of institutions of scientific and technical information has been substantially reduced, the number of regional centers of scientific and technical information has been reduced or their subordination has been changed, the Ukrainian Center for Scientific and Technical Information has been reorganized, its resource support has been weakened, therefore the information resource does not conceptually and organizationally meet the needs of the innovative economy.

The integrity of the development of the National innovation system. The issues of formation and development of national innovation system periodically become the object of consideration at the Parliamentary hearings. In 2007 such hearing was held for the first time. In 2009 the "Strategy of innovation development of Ukraine for the period of 2010-2020 under the conditions of globalization challenges" was discussed and the Concept of development of the national innovation system for 2009-2013 was approved. Even at the level of higher state authorities this period is recognized as the most productive. This period is characterized by a consolidated governmental approach to the needs of innovative development of the economy.

At present, there are two programs documents on innovation development in Ukraine: Sustainable Development Strategy "Ukraine 2020", the program of activities of the Cabinet of Ministers of Ukraine on implementation of the Association Agreement between Ukraine and the EU. The Plan of measures on the implementation of the Concept of reformation of the state policy in the innovation sector for 2015-2019 is aimed at the realization of these directions. In accordance with the Plan it is necessary to develop strategies for the development of high-tech industries, as well as a number of specified laws. The process of approval of the bills continues for more than two years. The National Academy of Sciences is trying to compensate for sluggishness or inactivity: there was a report "Civilizational Choice of Ukraine: Paradigm of Understanding and Action Strategy", "Innovative Ukraine 2020". The program "Foresight" has been developed. It is a program of innovation and investment development of NAAS for 2016-2020. And the Mechanism of implementation of this Program has been also developed. All these data were submitted to the Cabinet of Ministers of Ukraine. These documents are being processed since 2016.

Meanwhile, Ukraine continues to lose its competitive position in the markets of high-tech goods and services. According to the State statistics service of Ukraine 75% of patents of national owners are no longer valid because of non-payment of fees to maintain efficiency, only 7% of patents are used in the economy. The reason is the lack of incentives, long-term and resource consuming method of registration. As a result, there is a process of "patent migration", which is annually at the rate of 10–12%. This process is particularly characteristic for the direction of development of medicines, IT technologies and for pharmacology [7,9].

Moreover the imbalances in the training of specialists are increasing: there are three times more lawyers and economists than specialists, that are able to generate new knowledge, specialists in physics, mathematics and advanced technology and specialists, that are able to provide innovative development of economy.

Conclusions

Having analyzed the state of the national innovation system we have found a number of negative factors that hamper its development. These negative factors include slippery political decisions, reduction of governmental attention. These factors have influenced the

type of managerial decisions, prioritization, funding, legislative support. Particularly urgent is the inadequate regulation in the area of intellectual property. There are also problems of commercial implementation of scientific research results. It is caused by disinterest of rental business, poor infrastructure and lack of support in the processes of international registrations of intellectual property rights to the inventions.

The vast majority of innovative solutions are considered without regard for the prospects. Only business aspect and the rate of recoupment of investments are mostly taking into account. Unfortunately, the scientific activity is not included into the list of state priorities: there is a constant reduction of funding both for institutions and scientific research. At the same time, this situation leads to negative shifts in personnel, promotes the outflow out of the country of talented young people and well-known experts. The scientific potential of Ukraine is almost excluded from the economic and management process of the society – the science intensive capacity of industrial production is at the rate of only 0,3%, the knowledge management capacity of commercial structures – 2%, public administration – 5%. This situation creates a steady lag in technical and technological directions of development and establishes the raw material orientation of the national economy for the future [9].

The revival of scientific and technological power of Ukraine, strengthening of its competitiveness and formation of powerful national innovation system is observed in several directions:

- renewal of the value of science and innovation at the level of state policy, including the formation of the strategy of innovative development, activities, execution of tasks in form of Program with independent funding;
- implementation, legislative and instrumental securing of innovative development of the state on the basis of formation of innovative market under the control and accountability of the executive power of the country, region, industry.

Implementation and realization of these tasks requires not only political will, continuity of governmental policies but also creation of systemic approach based on strategic vision, development prospects and international cooperation, legislative regulation. Fulfillment of tasks requires improvement of the state management of innovation processes in the state, proper economic support, improvement of forecasting system for long-term outlook, target priorities and improvement of education srystem, preservation and support of scientific personnel of the state.

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Object-oriented design of packaging machines on the principles of mechatronics

Oleksandr Gavva, Liudmyla Kryvopiias-Volodina, Olena Kokhan

National University of Food Technologies, Kiev, Ukraine

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Corresponding author:

Oleksandr Gavva
E-mail:
gavvaoleksandr@gmail.com

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Abstract

Introduction. The research purpose is to formulate the basic principles of object-oriented designing of packaging machines on the basis of mechatronics.

Materials and methods. The object of the study is machines for the formation of increased cargo units from group packages. The research method is an object decomposition with the development of logical, physical, static and dynamic models of the projected machine and its object-oriented analysis and synthesis.

Results and discussion. Modern multifunctional, high-performance automatic packaging machines are mechatronic systems that consist of four main components: technological, power, information and mechatronic. The development of modern mechatronic packaging machines requires the solving of complex problems, which take into account the interconnections between different components, their reaction to external and internal destabilizing factors.

To solve such problems applying of object-oriented design methods was proposed. The topology of the object-oriented design and technological design of a packaging machine on the basis of mechatronics was developed. In the first stage of the design, the analysis of the technological process of transport package formation was carried out, the basis of the SADT basis was formed the hierarchical structure of the machine, the functional and structural models were developed, the decomposition of the service function of the machine was made, the functional and structural scheme of the machine was developed. Functional-structural scheme of the machine for conducting parametric synthesis with the choice of the best or optimal values of geometric, kinematic, dynamic and energy parameters.

Conclusions. The proposed methodology of interactive technologies for designing packaging machines allows to save time on design (up to 45%), to reduce capital costs and to obtain a functionally reliable machine.

Introduction

Since the advent of a new programming ideology, the object-oriented programming languages and object-oriented operating systems have been created. On their base, modern object-oriented automatic design systems (CAD) for solid-state programming (CAD-systems) and for visual design (Visual-system) [1] were developed. The transfer of the ideology of object-oriented programming and the basics of constructing object-oriented CAD systems on traditional designing fields of complex mechanical and technological systems with computer control, which include packaging machines, are not just supplementation. That requires rethinking their design tasks, as at the stage of setting task of designing the system and at all following stages of real design, including at the final stage on the selection of an optimal solution [2].

The most effective solution can be obtained after developing and comparing several variants of mechanical and technological systems. Mostly, the criterion for decision choice is to ensure the minimum cost of the product. At the same time, in today's global society, the need for targeted orientation of scientific research, design and production of packaging equipment of a high level of competitiveness and quality throughout the life cycle of products, are observed. Thus, the development of competitive packaging machines requires the implementation of object-oriented design technology in mechanical engineering industry.

In scientific works [3-5] the actual problem of creating packaging machines based on the functional-modular principle was formulated and currently is solved. But the issue of object-oriented designing machines for the food products packaging previously was not considered by other authors.

The purpose of these research is to form the basic principles of object-oriented design of packaging machines on the basis of mechatronics. According to the purpose, the task is as following :

- to perform analysis of the hierarchical structure of packaging machines as a design object;
- on the basis of SADT design, to construct functionally modular equipment structures in the form of a system description of models: functional (f-model) and structural (s-model);
- to develop a generalized functional-structural scheme of the packaging machine.

Materials and methods

Modern multifunctional, high-performance automatic packaging machines are mechatronic systems which include four main components: mechatronic, energetic, informational and technological (functional). When designing mechatronic packaging machines, more attention is paid to the first three components [6], and the functional purpose of such machines remains at the level of developing a technological scheme of the packaging process. The task of metric synthesis of packaging machines is the determination of the necessary technological moving of the working parts for the realization of the functional purpose of the machine and for the purpose of automating the main and additional operations.

The development of mechatronic packaging machines requires their modeling. That makes it possible to take into account the interrelations between different components, to investigate the operation of the machine and its reaction to external and internal destabilizing factors without making the physical model of the machine.

To solve such problems it is appropriate to use methods of object-oriented design.

Object = product	Object = capture device	Object = section	Object = power source
Object = packing material	Object = measuring containers	Object = dedicated mechanism	Object = executive mechanism
Object = container	Object = pushing device	Object = drive system	Object = sensor
Object = auxiliary packaging	Object = transportation device		Object = distributor
	Object = feeder or hopper		Object = controller
	Object = guiding parts		
	Object = container		
	. . .		
Base class Object = raw materials	Base class Object = working member	Base class Object = executive mechanism	Base class Object = mechatronics

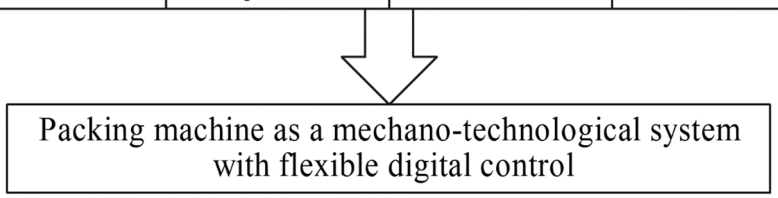


Figure 1. Topology diagram of object-oriented structural and technological design on the principles of mechatronics

Object-oriented design (OOP) is a method for designing, combining the process of object decomposition and the reception of the representation of logical and physical, as well as static and dynamic models of the projected packaging machine.

The OOP is based on the models which are formed as a result of object-oriented analysis and synthesis.

Object-oriented analysis is a methodology aimed at creating models using an object-oriented approach based on concepts, classes, and objects.

The main way to solve complex problems in OOP is abstraction. Relations between classes of objects generate hierarchical links.

The OOP process can be summarized as the following sequence:

- Identification of classes and objects of a particular level of abstraction;
- Identification of the semantics of classes and objects;
- Identify the relationships between classes and objects;
- Using classes and objects

For the effective implementation of object-oriented design approach, a Unified Modeling Language (UML) has been developed. UML refers to SADT (Structure Analysis

and Design Technique) - a technology for constructing a functional model for an certain area of objects (packaging machines) [1]. The main purpose of SADT technology is to describe complex objects as hierarchical, multilevel modular systems with a small set of typical elements.

Along with the analysis, object-oriented design involves the implementation of a series of consistent interconnected stages, not iterative descendant structural-parametric synthesis.

Figure 1 shows the scheme of the object-oriented design and technological design of packaging machines on the basis of mechatronics.

Figure 2 shows the topology of object-oriented design and technological design of mechatronic systems of packaging machines.

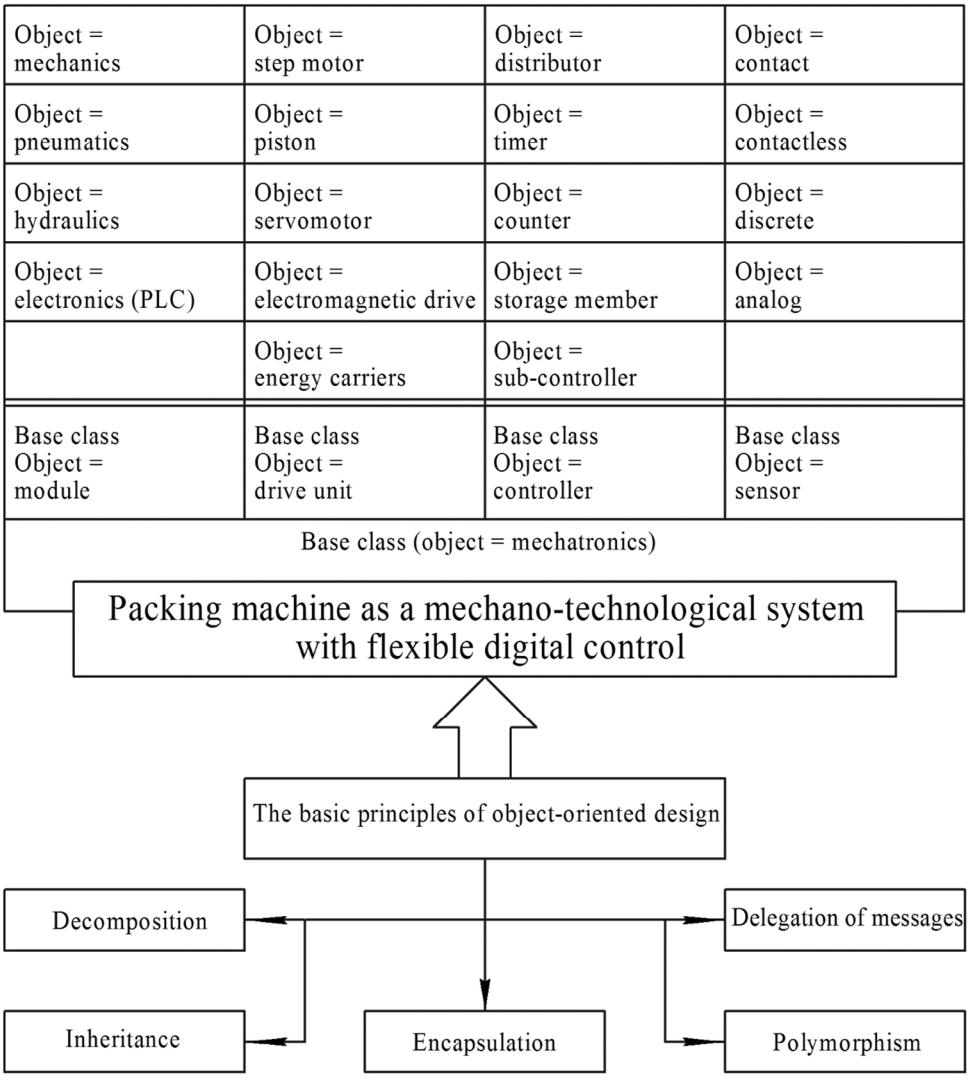


Figure 2. Topology diagram of object-oriented structural and technological design mechatronic systems of packing machines

Result and discussion

Modern models of packaging machines are complex mechanical and technological systems. They perform a considerable amount of technological processes of packaging. Depending on the technological processes and operations performed, they are divided into classes, subclasses, groups, etc. [4]. Algorithms of object-oriented design are considered on the example of designing a machine for the formation of unit loads from individual items. At the first stage of the design process analysis is carried out, further on the basis of SADT principles the hierarchical structure of the machine is formed, functional and structural models are designed, the operational functions of the machine are decomposed, the hierarchical structure and the functional block diagram of the machine are developed. On the basis of the functional-structural scheme, parametric synthesis is carried out with the choice of the best or optimal values of geometrical, kinematic, dynamic, energy parameters.

Technological process of packaging of unit loads includes the following characteristic operations (by the levels of the graph):

1.1. Delivery of single items to the supply conveyor of the batching machine;

2.1. Moving items by conveyor;

3.1. Profiling of soft transport containers (paper, linen and polymer bags with friable products);

4.1. Individual items orientation;

5. Formation of a row or stop of loads;

5.1. Formation of a line of loads;

5.2. Forming of items pile;

6. Formation of a layer or stack of items;

6.1. Formation of a layer of individual items;

6.2. Formation of a layer from a series of loads;

6.3. Formation of a stack from lines;

6.4. Formation of a stack from piles;

7. Reorientation of the layer or stack;

7.1. Reorientation of the cargo layer to the stack;

7.2. Reorientation of a stack of goods into a layer;

8.1. Separation of a single pallet from the stack of the pallets (performed before laying the first in a package of layer or piles of goods);

9.1. Move the unit pallet to the position of the accumulation of the unit load, or to the platform of the lift mechanism.

10.1. Installing or applying auxiliary means of packing (laying of gaskets, applying glue between layers of cargoes, etc.).

11. Formation of the unit load;

11.1 Landing on a stationary pallet or a previously laid layer;

11.2. Stacking of loads in a package;

12.1. Fastening of unit load (slings);

13.1. Move the formed unit load from the machine.

The above graph covers all possible ways of forming unit load from the most diverse single consignments. It is pertinent to note that the horizontal method of packet formation is more technologically more efficient for unit load. Therefore, among the many variants of the technological process of the formation of transport packages from tare cargoes, it is possible to distinguish two main groups, the most applied are the groups of processes, the principal difference between these processes is in the method of packing goods in the

package. In the variants of the process carried out for item 11.1, the package itself moves, and in those that pass through position 11.2 only a layer of cargo transactions moves.

After analyzing the structural graph of the technological process of forming the unit load from individual items, the closest to the universal scheme for most individual items and the optimal functional indicators and the cost of the process scheme, the following sequence of operations can be taken:

1. 1.1-2.1-3.0-4.1-5.1-6.1(6.2)-7.0-8.1-9.1-10.0-11.1-12.0-13.1.

This sequence corresponds to the technological process in which the following operations are carried out: overloading the load on the feed conveyor of the palletizer; loading of cargo by a conveyor; the orientation of the cargo; formation of a line of loads; forming a layer of individual items; allocation of a single pallet from a pallet stack and transporting it to the area of the accumulation of the unit load; laying of a layer of goods on an elevating and lowering platform; moving the unit load from the machine:

2. 1.1-2.1-3.0-4.1-5.1-6.1(6.2)-7.0-8.1-9.1-10.0-11.2-12.0-13.1.

The difference of this process is the presence of the operation 11.2 which is stacking of the cargo layer on a fixed pallet or pre-laid layer.

On the basis of the synthesis of the variants of technological processes, it is possible, if necessary, to exclude or replace certain operations, to create the desired type of technological process. So the operation 3.1. is performed only during the packaging of bags with bulk products. In other cases, the process passes through the "3.0" position. The next segment of the chain "4.1-5.1-6.2" corresponds to the case when the cargo is first formed by a row, and then from a row-layer. If in the process of forming a series of cargo orientation is unnecessary, the segment has the form "4.0-5.1-6.2". In the case when the layer is formed immediately from the oriented single items, the process passes through the positions "4.1-5.0-6.1". As for operations "8.1" and "9.1", in most cases they are combined, since the separation of a single pallet from a pallet stack is usually carried out by removing the pallet from the stack and moving its bottom of the formation of the unit load. During forming a unit load without a pallet, the process passes through the positions "8.0" and "9.0" Again, if there is no need for auxiliary means of packaging, the "10.1" position is executed and so on.

Implementation of the technological process of packaging by a robot manipulator is displayed in the following sequence:

1.1-2.1-3.0-4.1-5.0(5.1)-6.0(6.1, 6.2)-7.0-8.1-9.1-10.0-11.2-12.0-13.1.

The structure of this process differs from processes 1 and 2 in that the unit load is formed by a robot for individual items (there are no operations 5, 6 and 7). Such process has significant drawbacks-the productivity constraints as a result of the kinematic constraints on the movement of working bodies, the importance of the kinematic and technological cycle of the process and the increased requirements for the deviations of the geometric parameters of the transport packaging.

From the analysis of the design of palletizer, implementing the horizontal method of forming the package, it was established that depending on the design of the hoist of the machine can be divided into three groups: with frame four-column, portal-two-column and single-column complectation.

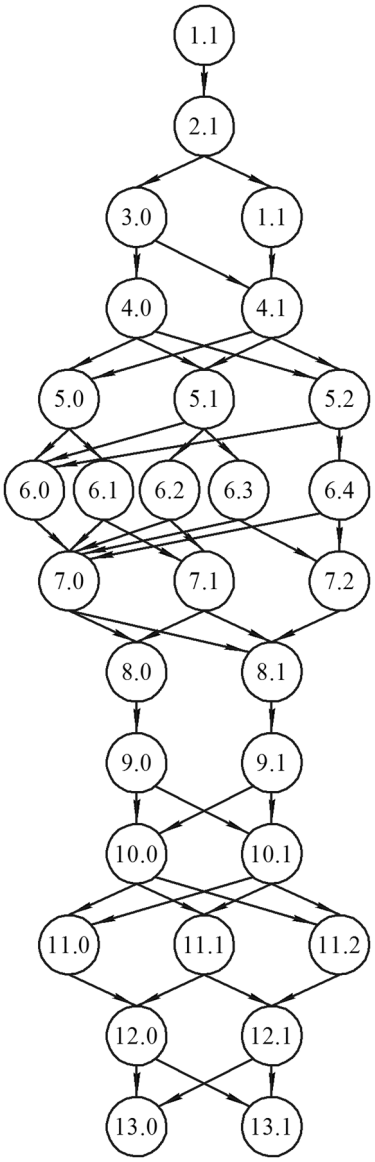


Figure 3. Structurally-technologic graph of the process of forming a unit load from individual items

The most wide spread due to its mobility was the frame four-column complectation of palletizer. This complectation provides a straightforward and similar location of the main functional modules. An important characteristic of the machine complectation is the direction of input and output material flows. They can be: direct-current, opposite directed and mutually perpendicular.

The complectation of palletizer using functional modules based on the four-column frame construction can fulfill requirements for all directions of cargo flows.

Module as an aggregate unit palletizer is an independent device that performs one or more specific operations of the manufacturing process of the package, fully assembled , functionally verified and ready for installation. The modules can be easily connected by creating complex palletizer schemes, disassembling and modifying them in order to obtain machines of different configurations and with different characteristics.

During the synthesis of structural and design schemes of palletizer, along with the productivity and quality of the package formation, one of the important criteria is the minimal cost of both the equipment itself and its operation. The cost of equipment is proportional to its metal capacity and energy supply. One of the main components of operating costs is the power consumption by equipment, its reliability and flexibility to re-adjust.

That is, the task of structural synthesis is to find such a set of functional modules, so that all technological operations and their elements are performed in a given sequence, and the reliability of the machine should be as high as possible, and the cost does not exceed the maximum permissible value. When designing a machine, it's necessary to take into account that all modules are interconnected, since one and the same function must be carried out by a single module within the machine [6]. The graph of logical connections between the functional modules accepted for consideration is shown in Figure 4

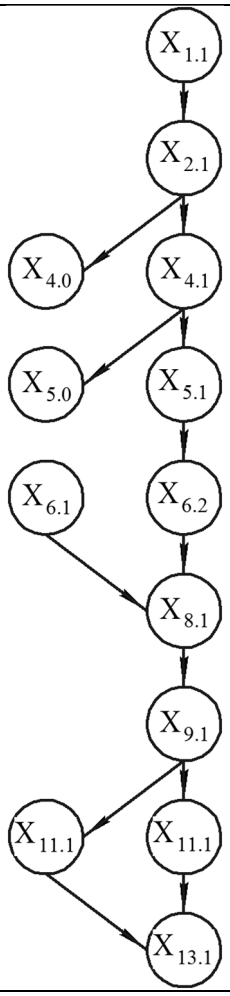
Function modules	Technological operations
	Delivery of single items to the supply conveyor of the batching machine
	Moving items by conveyor
	Orientation individual items
	Formation of a row or stop of loads
	Formation of a layer of items
	Separation of a single pallet from the stack of the pallets
	Move the unit pallet to the position of the accumulation of the unit load
	Formation of the unit load
	Move the formed unit load from the machine

Figure 4. Graph of logical connections between the functional modules of machines for the formation of transport packages from tare cargoes.

Formalized representation of the graph is expressed as follows:

$$S : m_1(x_{1.1}) \wedge m_2(x_{2.1}) \vee m_3(x_{3.1}) \wedge m_4(x_{4.0} \vee x_{4.1}) \wedge m_5(x_{5.0} \vee x_{5.1}) \wedge m_6(x_{6.1} \vee x_{6.2}) \wedge$$
$$\wedge m_7(x_{7.1} \vee x_{7.2}) \wedge m_8(x_{8.1}) \wedge m_9(x_{9.1}) \vee m_{10}(x_{10.1}) \wedge m_{11}(x_{11.1} \vee x_{11.2}) \vee m_{12}(x_{12.1}) \wedge m_{13}(x_{13.1})$$

where S - realization of the service function of palletizer (execution of technological operations of packaging); m - technological operations performed by the corresponding functional modules.

On the basis of the developed structural graph of the processes of formation of unit loads from single items and using methods of synthesis and analysis, a rational sequence of

execution of technological operations, functional modules for their realization and logical connections between them are established (Figure 5).

The analysis of the design of palletizer made it possible to develop typical structures of machines corresponding to the structure of the technological process and include functional modules, a system of actuators of executive mechanisms of working parts and the synthesis of control over their work (Figure 6).

The control of the work of all functional modules is provided by the general electronic system, which synchronizes their work in accordance with this packaging process.

In order to implement the latest requirements for the design of palletizer it is appropriate to use an algorithm for constructing a conceptual model based on SADT principles. The algorithm includes the construction of a functional (f - model) and structural (s - model) models [5].

The graph of the decomposition of the function of the palletizer is shown in Figure 7.

An in-depth description of the conceptual model of palletizer is the construction of S-models. The block diagram of palletizer for unit load is given in the form of "I-OR" trees (Figure 8).

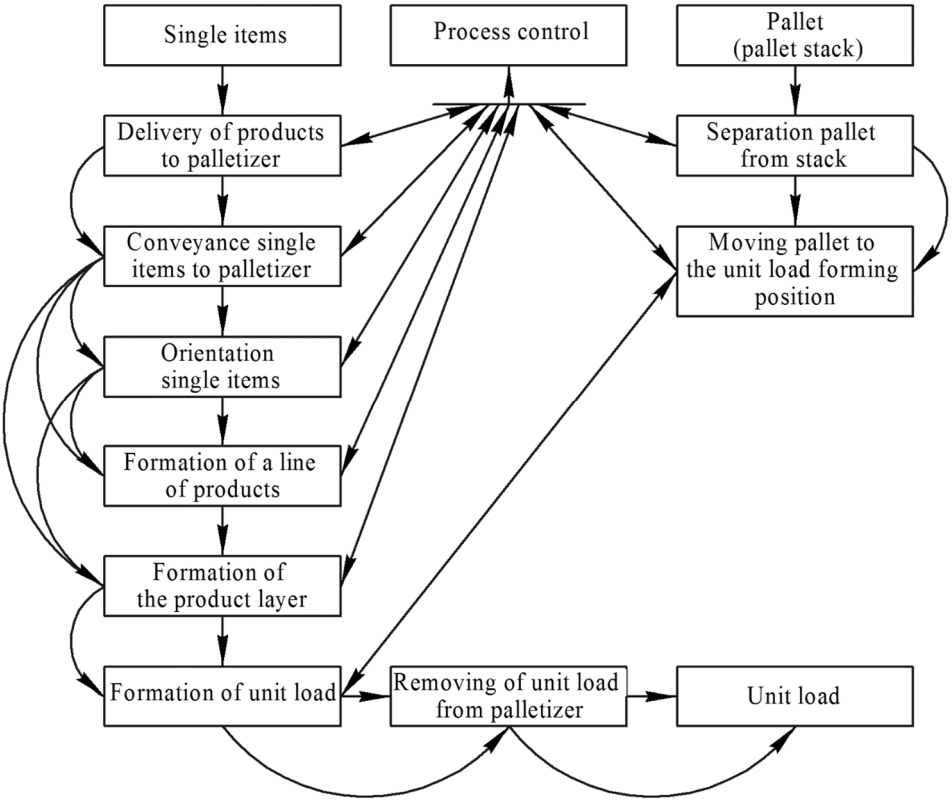


Figure 5. Logical connections between functional modules in the machines for forming unit load from single items

On the basis of the developed *f* and S modules, the generalized functional-modular structural schemes of palletizer for various frames constructions, implementing the horizontal method of forming transport packages (Figures 9-11), were developed.

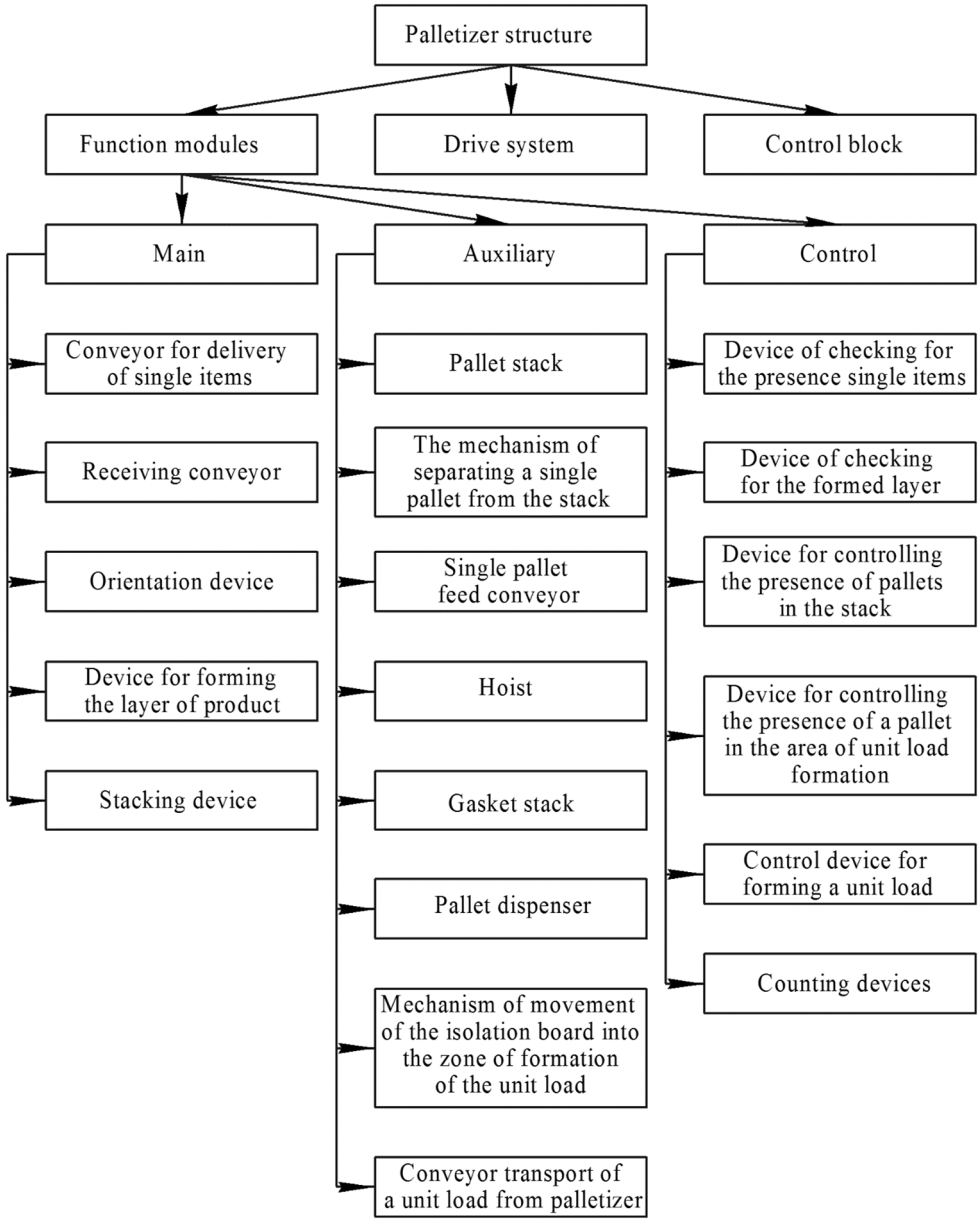


Figure 6. General structure of the machine for the formation of unit load from single items

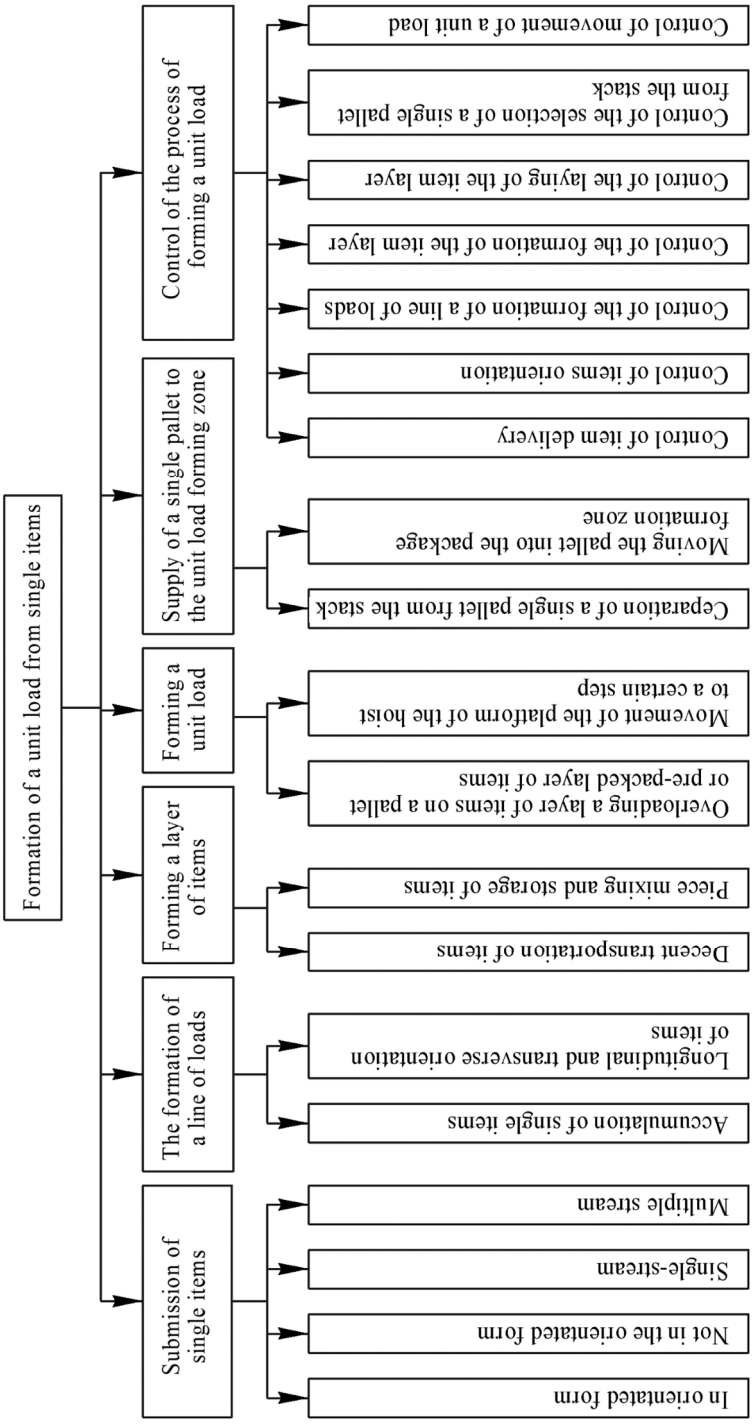


Figure 7. Scheme of decomposition of the service function of the machine for the formation of unit load from single item

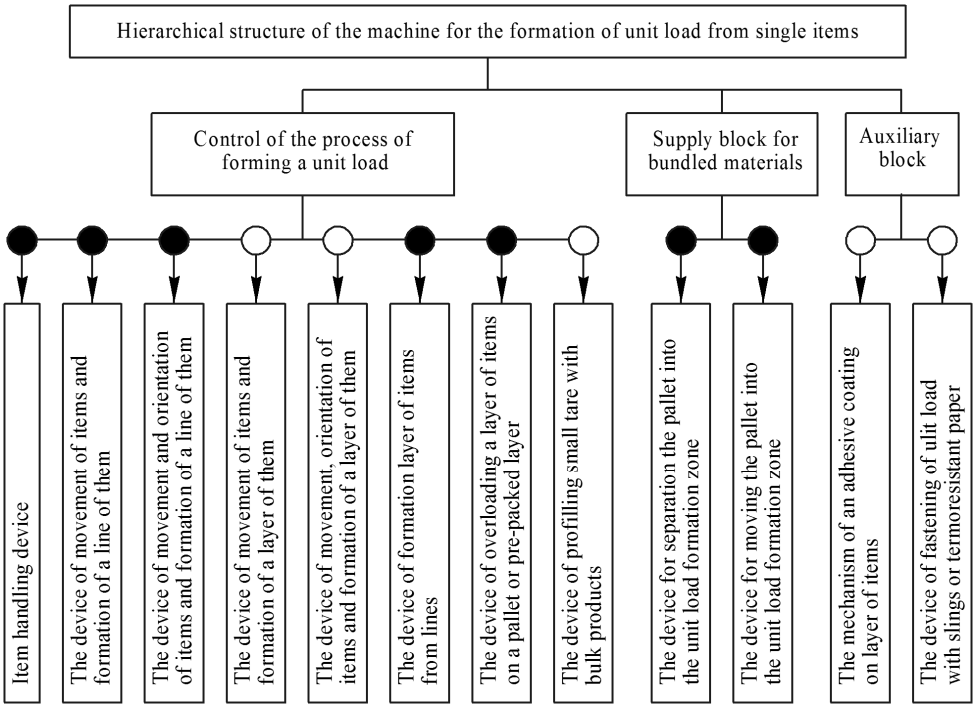


Figure 8. Hierarchical structure of the machine for the formation of unit load from single items:
● - the vertices are connected "and"; ○- vertices linked by "or"

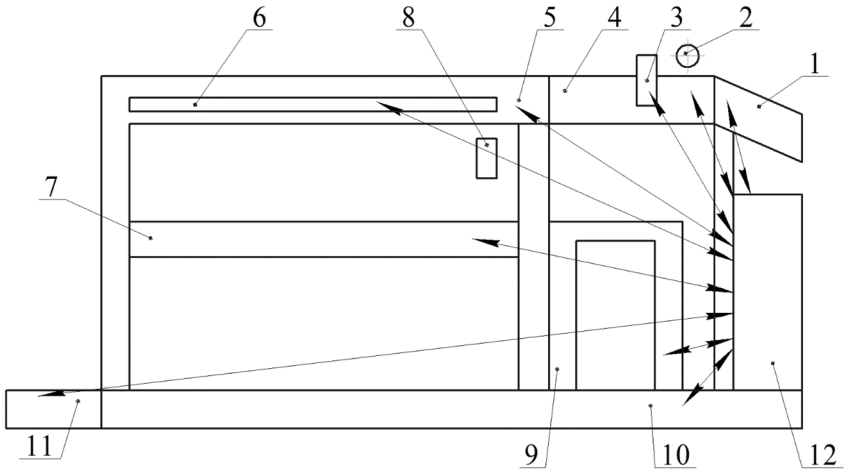


Figure 9. Generalized functional and structural scheme of the machine for the formation of transport packages from containerized cargo with a four-column frame:
1-conveyor of delivery of freight cargoes; 2 - a device for profiling soft containers; 3 - the device of orientation of tare cargo; 4- conveyor of the formation of a number of loads; 5-device for forming the layer of items; 6-device of collision of a number of loads and packing of a layer of cargoes; 7- lifting and lowering gear; 8. mechanism of applying adhesives to layers of goods; 9- store with pallets; 10 - the conveyor of supply of a single pallet to the lifting gear; 11 - the conveyor of transportation of the formed unit load from the car; 12-block control

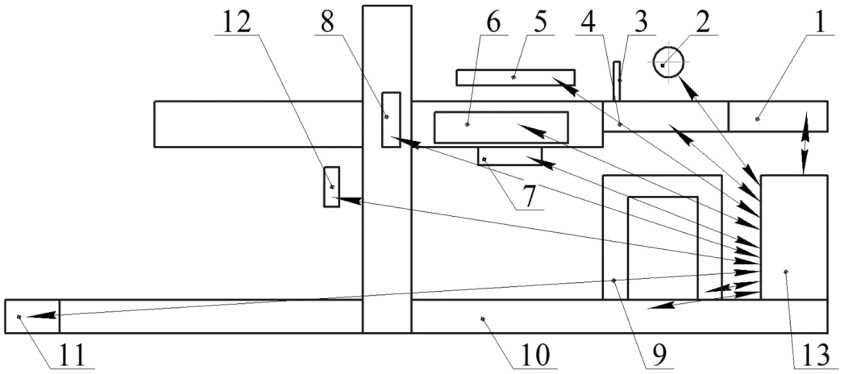


Figure 10. Generalized functional and structural scheme of the machine for the formation of transport packages from tare cargoes with a two-column frame:
1-conveyor of delivery of tare cargoes; 2 - a device for profiling soft containers; 3-pointing device for tare cargo; 4-conveyor forming a number of loads; 5 - device of collision of a number of loads and packing of a layer of cargoes; 6. device for forming the layer of goods; 7. The mechanism of horizontal movement of the items layer; 8. lifting and lowering gear; 9- store with pallets; 10 - the conveyor of supply of a single pallet to the lifting gear; 11 - the conveyor of transportation of the formed unit load from the car; 12 - the mechanism of application of adhesives on the layers of items; 13-control unit

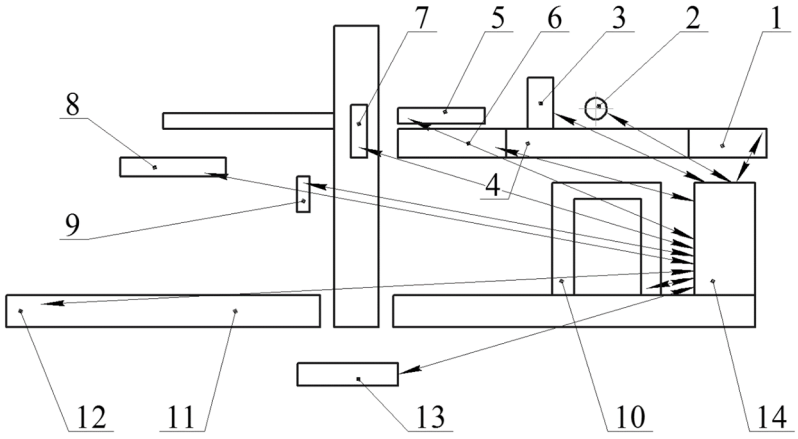


Figure 11. Generalized functional and structural scheme of the machine for the formation of transport packages of containerized cargo with a single-column frame:
1-conveyor of delivery of freight cargoes; 2 - a device for profiling soft containers; 3 - the device of orientation of tare cargo; 4- conveyor of the formation of a number of loads; 5 - a device for pushing and sealing a number of loads in a layer; 6-device for forming the layer of goods; 7 - lifting and lowering gear; 8-capture device; 9 - the mechanism of applying adhesives on the layers of items; 10-store with pallets; 11 - the conveyor of delivery of a single pallet to the zone of formation of the unit load; 12 - conveyor of transport of the formed transport package; 13 - the mechanism of rotation of the column; 14 control unit.

To select the optimal structure of the machine for the formation of unit load from single items, consider the sequence of actions of such machines from mechatronic modules in accordance with the functional structure diagram shown in Figure 8

The parametric series of mechatronic modules, forming a functional library, is characterized by execution of the same number of technological operations of the type:

$$L_k = \left(x_{k1}, x_{k2}, x_{k3}, ..., x_{kn}\right)$$

where x_{kn} - module-elements of different nature.

We assume that the structure of equipment for the formation of unit load will consist of a limited set of different types of mechatronic modules, which are subdivided into functional subsystems. The condition for the formation of equipment is as follows:

$$L^{(1n)} = \bigcup_{i=1}^{m} L_i = \left\{x / x_{1n} \in L_1 \wedge x_{2n} \in L_2 \vee x_{3n} \in L_3 \vee ... \wedge x_{mn} \in L_m\right\}$$

The formation of the structure of a machine for the formation of unit load is carried out by combinatorics, permutations and layouts of various mechatronic modules, forming a set of variants of the same functional scheme of forming a unit load and different structures:

$$N = \left(L^{(1n)}, L^{(1n)}, L^{(1n)}, ..., L^{(in)}\right)$$

The search for the optimal variant of the machine complectation, which best corresponds the initial design conditions, involves solving the one-stage or multi-stage optimization synthesis problem by applying well-known techniques [6,7]. For its conduct, an important step is the choice of parameters, or parameters of efficiency and optimization.

Conclusions

1. On the basis of objectively-oriented design, a topological scheme of a packing machine was developed on the basis of mechatronics. Based on of this scheme, the basic for design structural and control objects of packaging machines was defined.

2. Analysis of mechatronic systems of packaging machines allowed to adapt the basic principles of object-oriented design.

3. Based on the example of formation of unit load from single items, an analysis of their hierarchical structure with the definition of basic, auxiliary, and additional operations was performed.

4. On the basis of SADT principals the functional-modular structures of machines for the formation of cargo unit in the form of functional and structural model were developed.

5. Analysis of functional and structural models of packet forming machines made it possible to perform an optimization synthesis of their combinations .

6. Implementation of the following design stages with the use of interactive technologies allows you to significantly reduce the time spent on design, capital costs and obtain a reliable operation of the machine.

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Анотації

Харчові технології

Закономірності структуроутворення мармеладу желейного на агарових полісахаридах і пектинах з низьким вмістом цукрів

Дарія Матяс[1], Юлія Камбулова[1], Олена Гончарук[2]
1 – Національний університет харчових технологій, Київ, Україна
2 – Інститут хімії поверхні ім. О.О. Чуйка НАН України, Київ, Україна

Вступ. Актуальною науковою задачею є встановлення закономірностей структуроутворення мармеладу на агарових полісахаридах і пектинах з низьким вмістом цукрів (сахарозою, глюкозою, фруктозою).

Матеріали і методи. Реологічні властивостів досліджували методом ротаційної віскозометрії. Структурно-механічні характеристики досліджували методом пенетрації. У дослідженнях використано мармелад з пониженим вмістом сахарози, глюкози, фруктози з корегуванням вмісту цукрів додаванням полідекстрози і з внесенням натуральних смако-ароматичних добавок у вигляді плодово-ягідного пюре.

Результати і обговорення. Встановлено, що солодкий смак мармеладу при використанні будь-якого структуроутворювача забезпечується дозуванням сахарози і глюкози по 35 г/100г продукції, а фруктози – по 25 г/100г. Проте зменшення кількості цукрів в системі відображається на збільшені показника загальної деформації і доводить, що структурно-механічні властивості суттєвим чином залежать від їх вмісту. Реологічними дослідженнями кожної мармеладної маси виділено діапазон значень градієнту зсуву, за якими рекомендовано її транспортування в технологічному процесі. Так, для мармеладної маси на агарі з глюкозою і сахарозою $\gamma = 10–20$ c^{-1}($t = 55±3°C$), з фруктозою – $\gamma = 5,4–10$ c^{-1}, або можливо застосування нижчих температур ($t = 50±3°C$); на k-каррагінані – для всіх видів цукрів $\gamma = 5,4–10$ c^{-1} ($t = 77±3°C$), для мас з фруктозою і сахарозою допускаються нижчі температуру ($t = 72±3°C$); на Н-пектині – $\gamma = 5,4–8$ c^{-1}($t = 85±3°C$), для мас з глюкозою і з фруктозою ($t = 88±3°C$); на L-пектині – з глюкозою $\gamma = 2–8$ c^{-1} ($t = 80±3°C$), для мас з сахарозою і з фруктозою – $\gamma = 5...10$ c^{-1} ($t = 85±3°C$). Встановлений час структурування мармеладу, який подовжується порівняно з традиційними виробами, (на агарі з 60 хв до 120 хв, на k-каррагінані з 15 хв до 60 хв, на Н-пектині з 12 хв до 20 хв. Більшою мірою такі зміни пов'язані із внесенням значної кількості полідекстрози на заміну цукру, яка володіє вищою гідратаційною здатністю. Найбільш пружними властивостями відрізняється мармелад на агарі і к-каррагінані, на пектинах – характеризуються більшою пластичністю.

Висновки. Встановлені та рекомендовані наступні параметри: максимальна швидкість обертового руху під час перекачування; температура транспортування та темперування мас; тривалість охолодження та вистоювання готового мармеладу.

Ключові слова: *желе, мармелад, агар, к-каррагінан, пектин, цукри.*

Оцінка якості та антиоксидантної активності відновленого чорного чаю та комерційного чаю (Camellia sinensis), доступного в Бангладеш

Тасліма Ахмед, Назмул Сарвар
Читтагонський університет ветеринарних та зоологічних наук, Читтагонг, Бангладеш

Вступ. Проведені дослідженян з метою удосконалення технології для виробництва сухого поршкового чорного чаю, збагаченого антиоксидантами.

Матеріали та методи. Антиоксидантний розчинний чорний чай був отриманий методом розпилювального сушіння концентрованої заварки оброблюваного чайного листя з включенням БАР з фруктів і овочів. Якість отриманого сухого (відновленого) чаю було порівняно з іншими комерційними сухими видами чаю і чайними гранулами.

Результати і обговорення. Розроблений сухий чорний чай мав добрі характеристики в'язкості, решта показників були також у прийнятному діапазоні. Вміст кофеїну був загалом високим у всіх зразках чаю і становив від 2,2% до 3,1% . Вміст поліфенолів змінювався від 17,38% до 22,67%, а розроблений сухий чорний чай має вищу кількість поліфенолів у порівнянні з іншими зразками. Вміст танінів у всіх зразках коливався від 7,42 до 10,43%, тоді як розроблений сухий чорний чай мав найменший вміст поживних речовин, ніж інші зразки. Розроблений розчинний чорний чай показав найбільшу активність за методом радикального очищення DPPH (1, 1diphenyl-2-picryl hydrazyl) а потім – комерційний миттєвий зелений чай і гранули чорного чаю.

Висновки. Розроблений сухий чорний чай мав більш високу антиоксидантну здатність та кількість поліфенолів, ніж інші бангладешські чаї, і може бути замінником природних антиоксидантів і як перспективний агент для сприятливого впливу на здоров'я людини.

Ключові слова: *чай, антиоксидант, кофеїн, поліфенол, танін, Бангладеш.*

Вплив термічної обробки пароконвектоматом на мариноване м'ясо диких тварин

Людмила Пешук, Олександр Горбач, Олег Галенко, Ніна Буднік
Національний університет харчових технологій, Київ, Україна

Вступ. Метою досліджень було обґрунтування можливості використання різних способів термічного обробляння в технології маринованих напівфабрикатів з м'яса диких тварин та визначення його оптимальних режимів.

Матеріали та методи. Досліджується технологія теплового обробляння маринованого напівфабрикату, м'ясо дикого кабана, маринади, шашлик після різних способів теплового обробляння. Для визначення вмісту заліза використано сульфосаліциловий метод визначення оксиду заліза, а для вмісту цинку інверсійний вольтамперометричний метод. В роботі також використаний метод визначення інфрачервоних спектрів за допомогою приладу «Інфрапід».

Результати і обговорення. Харчову цінність м'яса диких тварин оцінили за фізико-хімічними показниками. Встановлено, що за фізико-хімічними показниками м'ясо диких тварин нічим не поступається м'ясу сільськогосподарських тварин – свинині та яловичині, а навпаки по вмісту білку переважає на 2,9–6,8 %.

Доведено, що за амінокислотним складом м'ясо дикого кабана не поступається свинині, а за такими амінокислотами, як валін, ізолейцин, лейцин, треонін та триптофан значно переважає його. Також воно переважає свинину за сумарною кількістю незамінних та замінних амінокислот на 2,45 та 0,81 г/100 г білка відповідно, і володіє вищим білковим якісним показником на 0,35 г/100 г білка.

Порівняльна оцінка впливу різних методів теплової обробки на вихід шашлику виявила переваги використання пароконвектомату та НВЧ перед традиційним жарінням і обробкою на пару. Зниження втрат вмісту вологи в готовому продукті на 23% після обробляння в пароконвектоматі слугує причиною збільшення виходу шашлику.

Приготування продуктів в пароконвектоматі здійснювали завдяки конвекції гарячого повітря, утвореного за рахунок нагрівання електричних ТЕНів або газу. Постійна циркуляція гарячого повітря забезпечувала рівномірне пропікання продуктів в печі і швидкість їх приготування. У пароконвектоматі встановлено форсункова система зволоження, тому вологість повітря в робочій камері була регульованою.

Висновки. Рекомендовано технологічний режим для обробки шашлику в пароконвектоматі t=220-260 °С, φ=15% протягом 9 хвилин. Мінеральний склад м'яса дикого кабана перевершує м'ясо свинини за вмістом ряду мікро- і макроелементів. Високий вміст заліза – 1500 мкг/100 г в м'ясі дикого кабана – здатний задовольнити 20% добового раціону людини.

Ключові слова: *напівфабрикат, шашлик, дичина, пароконвектомат.*

Визначення біологічно-активних речовин у концентратах білково-ягідних

Грек Олена, Онопрійчук Олена, Пшенична Тетяна, Тимчук Алла
Національний університет харчових технологій, Київ, Україна

Вступ. Актуальним є дослідження поліфенольних сполук та амінокислотного складу білків, у тому числі вмісту вільних і зв'язаних амінокислот, в концентратах білково-ягідних, отриманих термокислотним осадженням.

Матеріали і методи. Концентрати білково-ягідні отримували термокислотним осадженням білків молока із використанням в якості коагулянту – пасти чорносмородинової, що є джерелом біологічно-активних речовин – вітамінів, мінералів, поліфенолів та ін. Амінокислотний склад та поліфенольні сполуки визначали методом високоефективної рідинної хроматографії з наступною ідентифікацією окремих сполук в досліджуваних екстрактах концентратів білково-ягідних шляхом порівняння часу утримування і спектральних характеристик досліджуваних речовин з аналогічними характеристиками стандартів.

Результати і обговорення. Результати отриманих досліджень поліфенольного складу були проаналізовані порівняно з контролем (пастою чорносмородиновою) та визначено ступінь їх переходу в концентрати білково-ягідні, що складає близько 55,31 % поліфенольних сполук, в тому числі антоціанів.

Білки концентратів мають повноцінний амінокислотний склад і містять всі незамінні амінокислоти, вміст яких від загальної суми становить для білково-ягідних та молочно-білкових – 41,97 % та 43,96 % відповідно. В концентратах ідентифіковано 18 вільних та 16 зв'язаних амінокислот, із яких переважають глютамінова кислота, гістидин, метіонін, лейцин та пролін.

Визначено замінні амінокислоти, вміст яких від суми загальних амінокислот в КБЯ та КМБ (контроль) становить 58,03 % та 56,04 %. Збільшується вміст НАК в

концентратах білково-ягідних на 14,75 % та ЗАК на 24,45 % за наступними амінокислотами: треонін на 0,156 мг%, лізин на 0,21 мг%, триптофан на 0,221 мг%, фенілаланін – 0,525 мг% порівняно з контрольним зразком.

Висновки. Концентрати білково-ягідні мали вміст поліфенольних сполук на рівні 331,86 мг / 100 г, що характеризує їх природнє фіолетове забарвлення. Амінокислотний склад в КБЯ збільшився на 20,18 % порівняно з класичним молочно-білковим концентратом, як результат комплексного осадження казеїну та сироваткових білків.

Ключові слова: *концентрати, коагуляція, поліфеноли, амінокислоти, хроматографія.*

Вплив умов пророщування на антиоксидантні властивості та вміст білку у сочевиці (Lens culinaris) українських сортів

Ірина Ясінська, Вікторія Іванова
Національний університет харчових технологій, Київ, Україна

Вступ. Проведено дослідження зміни антирадикальної активності, вмісту фенольних сполук, аскорбінової кислоти та білку у зерні сочевиці в процесі пророщування за різних умов освітлення.

Матеріали і методи. У якості дослідних об'єктів виступали два українські сорти сочевиці – Луганчанка і Світанок. Загальний вміст фенольних сполук у зразках визначали за методом Фоліна-Чокальтеу, рівень аскорбінової кислоти – колориметрично, антирадикальну активність – з використанням дифенілпікрилгідразилу (ДФПГ), вміст білку аналізували методом К'єльдаля.

Результати і обговорення. Результати досліджень показали, що під час пророщування в сочевиці збільшується вміст фенольних сполук, аскорбінової кислоти та зростає антирадикальна активність, особливо при пророщуванні за умов освітлення день/ніч. Вміст білку у сочевиці протягом пророщування за обох режимів освітлення поступово знижувався.

Найбільший приріст фенольних сполук було зафіксовано у сочевиці сорту Луганчанка на 3–4-й день пророщування за умов освітлення день/ніч, де приріст склав близько 65%.

Аналогічна ситуація була зафіксована при визначенні вмісту аскорбінової кислоти. ЇЇ рівень у сочевиці сорту Луганчанка, пророщеної за умов освітлення день/ніч, був вищим у 6 разів, порівняно зі зразками не пророщеної сочевиці цього сорту.

Найвища антирадикальна активність була у сочевиці наприкінці процесу пророщування. Однак встановлено, що пророщування після 5-го дня в досліджуваних умовах є неприпустимим, оскільки відбувалося псування паростків. Найнижчий рівень збільшення антирадикальної активності (близько 60 %) зафіксовано у сочевиці сорту Світанок, пророщеної у темноті. Найбільше підвищення антирадикальної активності становило близько 550% у зразках сорту Луганчанка за умов освітлення день/ніч.

Висновки. Результати показали, що пророщені зразки сочевиці обох сортів мали кращі антиоксидантні властивості, порівняно з непророщеною сировиною. Одержані результати можуть бути корисними при розробленні функціональних харчових продуктів.

Ключові слова: *Сочевиця, пророщування, антиоксидант,білок, освітлення.*

Харчування і здоров'я

Приймання харчового кальцію і мінеральна щільність кісткової тканини у македонських жінок у постменопаузі

Даніела Ніколовська Неделковська, Таня Тефова, Зора Узуноска
Університет Св. Климента Охрідського, Велес, Республіка Македонія

Вступ. Недостатнє споживання кальцію призводить до зниження мінералізації кісткової тканини і, отже, до підвищеного ризику остеопорозу.

Матеріали і методи. Дослідну групу склали 104 жінки в постменопаузі. Мінеральна щільність кісткової тканини (МЩТ) на поперековому відділі хребта і стегнах учасників вимірювалася методом рентгенівської абсорбціометрії (DXA). Добове споживання кальцію (DCI) оцінювали за кількісним опитуванням частоти продуктів (FFQ). Учасники заповнювали анкету, яка включала загальні демографічні дані та питання про особисту і сімейну історію переломів, настання менопаузи, спосіб життя і використання кортикостероїдів.

Результати і обговорення. Середньодобове споживання кальцію серед учасників дослідження становило 854,3±260,4 мг, що нижче кальцієвого споживання (RNI) для жінок у постменопаузі. Результати цього дослідження підтвердили, що зниження мінеральної щільності кісткової тканини (МЩТ), зафіксованої за допомогою Т-балів, залежить від віку та вибору місця вимірювання.

Більш висока маса тіла і індекс маси тіла (ІМТ) у учасників асоціюються з більш високою МЩТ. Зниження щільності кісткової тканини серед жінок у постменопаузі було пов'язано з наявністю попередніх особистих переломів та сімейним анамнезом переломів у діагностованих осіб, недостатньою фізичною активністю і перебуванням на сонці.

Висновки. Вивчено необхідність кальцію в раціоні та отримано знання про фактори способу життя, які впливають на втрату кісткової тканини, необхідні для зменшення ризику остеопорозу та пов'язаних з ним переломів у жінок у постменопаузі.

Ключові слова: *остеопороз, жінка, кальцій, кістка, мінерал, посменопауза.*

Безпека життєдіяльності

Формування інтелектуальних агентів інформаційно-аналітичної системи управління безпекою на підприємстві

Ольга Євтушенко, Аліна Сірик
Національний університет харчових технологій, Київ, Україна

Вступ. Проведено дослідження з метою формування концептуальної моделі інтелектуально-інформаційної та аналітичної системи управління охороною праці підприємств харчової промисловості.

Матеріали і методи. Для вирішення поставлених завдань використовувалися методи системного аналізу, основні класи архітектури систем інтелектуальних агентів, математична логіка, теорія формальних систем і числень, що характерні для травматичних процесів на підприємствах харчової промисловості.

Результати і обговорення. Встановлено, що запропонована комплексна система автоматизації управління охороною праці для підприємств харчової промисловості може бути використана для удосконалення управлінських рішень щодо оперативного аналізу умов праці на підприємстві, визначення напрямів запобігання виробничому травматизму та організаційних заходів щодо захисту працівників. Запропоновано модель інтелектуального агента в структурі інформаційно-аналітичної системи управління галузевих підприємств, яка відрізняється тим, що формується інформаційний простір інтелектуальних агентів, враховано модель механізму вибору поведінки та зміст моделі визначення мети інтелектуального агента, що дозволяє визначити динаміку розвитку мультиагентного середовища, впорядкувати ієрархію цілей в інформаційно-аналітичній системі управління охороною праці на підприємствах і сформувати різні стратегії роботи інтелектуальних агентів. Результати роботи сприяють принципу застосування розвитку охорони праці як діагностики та моделювання небезпечних ситуацій, так і оцінки їх наслідків.

Висновки. Найбільш раціональним рішенням для підвищення безпеки праці підприємства шляхом впровадження в інформаційно-аналітичну систему управління охороною праці таких елементів, як інтелектуальні агенти.

Ключові слова: *безпека, підприємство, праця.*

Процеси і обладнання

Об'єктно-орієнтоване проектування пакувальних машинна засадах мехатноніки

Олександр Гавва, Людмила Кривопляс-Володіна, Олена Кохан
Національний університет харчових технологій, Київ, Україна

Вступ. Дослідження проведено з метою формування основних принципів об'єктно-орієнтованого проектування пакувальних машин на засадах мехатроніки.

Матеріали і методи. Об'єктом дослідження є машини для формування збільшених вантажних одиниць із групових упаковок. Методом дослідження є об'єктна декомпозиція із розробленням логічної, фізичної, статичної й динамічної моделей проектованої машини та її об'єктно-орієнтованої аналіз і синтез.

Результати і обговорення. Сучасні багатофункціональні, високопродуктивні пакувальні машини автоматичної дії це мехатронні системи, що мають чотири основні складові: технологічну, енергетичну, інформаційну та мехатронну. Розроблення сучасних мехатронних пакувальних машин потребує розв'язання складних задач в яких враховуються взаємозв'язки між різними складовими, їх реакцію на зовнішні та внутрішні дестабілізуючи фактори. Для розв'язання таких задач запропоновано застосувати методи об'єктно-орієнтованого проектування. Розроблено топологію об'єктно-орієнтованого конструкційно-технологічного проектування пакувальної машини на засадах мехатроніки. На першому етапі проектування проведено аналіз технологічного процесу формування транспортного пакета в подальшому на основі засад SADT сформовано ієрархічна структура машини, побудовані фукціональні та структурні моделі, проведено декомпозицію службової функції машини, розроблена функціонально-структурна схема машини. Функціонально- структурна схема машини ведення параметричного синтезу із вибором найкращих або оптимальних значень геометричних, кінематичних, динамічних та енергетичних параметрів.

Висновки. Запропонована методологія інтерактивних технологій проектування пакувальних машин дає можливість зменшити витрати часу (до 45%) на проектування, капітальні витрати та одержати функціонально надійну в експлуатації машину.

Ключові слова: *упаковка, машина, мехатроніка, модуль, граф.*

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7. The information about the author (Name, surname, scientific degree, place of work, email and contact phone number).

All Figure s should be made in graphic editor, the font size 14.

The background of the graphs and charts should be only in white colour. The colour of the Figure elements (lines, grid, text) – in black colour.

Figure s and EXCEL format files with graphs additionally should submit in separate files.

Photos are not appropriate to use.

Extended articles should be sent by email to:
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Ukrainian Journal of Food Science публікує оригінальні наукові статті, короткі повідомлення, оглядові статті, новини та огляди літератури.

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Харчова інженерія
Харчова хімія
Мікробіологія
Властивості харчових продуктів
Якість та безпека харчових продуктів
Нанотехнології
Процеси та обладнання
Економіка та управління
Автоматизація процесів
Упаковка для харчових продуктів
Здоров'я

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Результати досліджень, представлені в журналі, повинні бути новими, мати зв'язок з харчовою наукою і представляти інтерес для міжнародного наукового співтовариства.

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Ukrainian Journal of Food Science включено у перелік наукових фахових видань України з технічних наук, в якому можуть публікуватися результати дисертаційних робіт на здобуття наукових ступенів доктора і кандидата наук (Наказ Міністерства освіти і науки України № 793 від 04.07.2014)

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Мова статті – англійська.

Рекомендований обсяг статті – **8–15 сторінок** (для оглядових статей – 20–30 сторінок) формату А4.

Для всіх (!) елементів статті шрифт – **Times New Roman**, кегль – **14**, інтервал – 1, абзац – 1 см.

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1. **Назва статті.**
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3. *Установа, в якій виконана робота.*
4. Анотація. Рекомендований обсяг анотації – пів сторінки. Анотація повинна відповідати структурі статті та містити розділи Вступ (2–3 рядки), Матеріали і методи (до 5 рядків), Результати та обговорення (пів сторінки), Висновки (2–3 рядки).
5. Ключові слова, 3–5 слів, **але не** словосполучень (!).

Пункти 1–5 виконати англійською і українською мовами.

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За необхідності можна додавати інші розділи та розбивати їх на підрозділи.

7. Авторська довідка (Прізвище, ім'я та по батькові, вчений ступінь та звання, місце роботи, електронна адреса або телефон).
8. Контактні дані автора, до якого за необхідності буде звертатись редакція журналу (телефон та електронна адреса).

Розмір тексту на рисунках повинен бути **співрозмірним** (!) основному тексту статті. Скановані рисунки не приймаються.

Фон графіків, діаграм – лише білий (!). Колір елементів рисунку (лінії, сітка, текст) – лише чорний (не сірий).

Оригінали рисунків (файли графічних редакторів), а також файли формату EXCEL з графіками обовязково подаються в окремих файлах.

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Скорочені назви фізичних величин в тексті та на графіках позначаються латинськими літерами відповідно до системи СІ.

В списку літератури повинні переважати англомовні статті та монографії, які опубліковані після 2000 року.

Детальні інструкції для авторів розміщені на сайті

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Оформлення списку літератури

Посилання на статтю

Автори (рік видання), Назва статті, *Назва журналу (курсивом)*, том (номер), сторінки.

Всі елементи після року видання розділяються **комами**.

Приклади:

1. Yannick Fayolle, Sylvie Gillot, Arnaud Cockx, Laetitia Bensimhon, Michel Roustan, Alain Heduit (2010), In situ characterization of local hydrodynamic parameters in closed-loop aeration tanks, *Chemical Engineering Journal*, 158(2), pp. 207–212.
2. Carlo Tocchi, Ermanno Federici, Laura Fidati, Rodolfo Manzi, Vittorio Vincigurerra, Maurizio Petruccioli (2012), Aerobic treatment of dairy wastewater in an industrial three-reactor plant: Effect of aeration regime on performances and on protozoan and bacterial communities, *Water Research*, 46(10), pp. 3334–3344.

Приклад оформлення статті, оригінал якої українською мовою:

1. Pyroh T.P., Konon A.D., Skochko A.B. (2011), Vykorystannia mikrobnykh poverkhnevo-aktyvnykh rechovyn u biolohii ta medytsyni, *Biotekhnolohiia*, 4(2), pp. 24–38.

За бажання після транслітерованої назви статті або журналу в {фігурних дужках можна дати переклад англійською мовою}.

Посилання на книгу

Автори (рік), *Назва книги (курсивом)*, Видавництво, Місто.

Всі елементи після року видання розділяються комами.

Приклади:

1. Harris L. (1991), *Money theory*, McGraw-Hill Companies, Hardcover
2. Rob Steele (2004), *Understanding and measuring the shelf-life of food*, CRC Press.

Приклад оформлення статті, оригінал якої українською або російською мовою:

1. Donchenko L.V. (2000), Tekhnologiya pektina i pektinoproduktov, Deli, Moscow
2. Kirianova H.A. (2008), Udoskonalennia tekhnolohii termostabilnykh zheleinykh nachynok shliakhom ratsionalnoho vykorystannia hidrokoloidiv roslynnoho ta mikrobnoho pokhodzhennia: PhD tethis, NUHT, Kyiv.
3. Zalutskyi I.R., Tsymbaliuk V.M., Shevchenko C. H. (2009), Planuvannia i diahnostyka diialnosti pidpryiemstva, Novyi svit, Lviv.

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Посилання на електронний ресурс

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Приклад посилання на статтю із електронного видання:

1. Barbara Chmielewska. (2012), Differentiation of the standard of living of families in countries of the European Union, *Ukrainian Food Journal*, 2(2), pp. 230–241, available at: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202013%20V.2%20Is.2.pdf
2. (2013), *Svitovi naukovometrychni bazy*, available at: http://www1.nas.gov.ua/publications/q_a/Pages/scopus.aspx

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Національний університет
харчових технологій
Вул. Володимирська, 68
Київ
01601
Україна

E-mail:

Ukrfoodscience@meta.ua

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