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JUSTIFICATION OF THE COMPOSITION AND TECHNOLOGY OF COMBINED TABLETS FOR THE TREATMENT OF TYPE II DIABETES

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The aim. *The aim of the work was to establish the feasibility of development, determine the optimal composition and technology, and confirm the pharmacological effectiveness of combined tablets for treating type II diabetes.*
Materials and methods. *Analytical research of the pharmaceutical market of drugs used for the treatment of type II diabetes was carried out using content analysis of official sources of information. The subjects of the study were medicinal products used to treat type II diabetes. A set of physicochemical and technological research methods was used to determine the quality parameters of the tabletting mass and tablets based on them.*
Results*. According to the results of previous studies, similarities in the approaches to the pharmacotherapy of type II diabetes in the countries of Southeast Asia, the Western Pacific region, and Ukraine were established, which became the basis for conducting a market study of drugs with a sugar-lowering effect, namely, based on voglibose, with the aim of further including such drugs in the range of Ukrainian manufacturers. Furthermore, according to the results of physicochemical and technological studies, the composition and rational technology of obtaining tablets were established. Also, pharmacological studies have established that tablets with voglibose and solid dispersion of quercetin significantly prevent the development of glucose metabolism disorders caused by a high-sugar diet. In terms of the expressiveness of the hypocholesterolemic effect of the tablets and their constituent components, they are reliably superior to the comparison drug – metformin.*
Conclusions*. According to the research results, the feasibility and relevance of the development of combined tablets with voglibose and solid dispersion of quercetin have been established. Furthermore, based on the investigated physicochemical and technological indicators, combined tablets' composition and rational technology were developed, and their specific pharmacological activity was proven*
Keywords*: type II diabetes therapy, derivatives of alpha-glucosidase inhibitors, voglibose, quercetin, solid dispersion, technology*

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1. Introduction

According to statistics, the increase in the number of diabetes patients has become a pandemic. If at the beginning of the 80s of the last century, the number of patients with DM was about 30 million, then today it is more than 366 million, and according to the forecasts of experts of the International Diabetes Federation (IDF) and WHO, more than 552 million are expected by 2030 [1]. The prevalence of diabetes in Ukraine has increased by half over the past 10 years. Almost 3 % of the primary disability of the adult population in Ukraine is a consequence of diabetes. The results of the analysis of literature data on the drug therapy of diabetes indicate that over the past 5 years, the range of hypoglycemic drugs aimed at the correction of hyperglycemia, dyslipidemia, and the prevention of microangiopathy in patients with type 2 diabetes (DM II), which is one of the main medical and social problems, has expanded and economic problems of modern medicine [2, 3].

It is known that DM II leads to loss of working capacity, early disability and premature mortality. At the same time, the main cause of mortality is the development of heart attacks and strokes. The use of modern drugs, the therapeutic effect of which is aimed at preventing and correcting hyperglycemia, dyslipidemia, microangiopathy and other complications of DM, allows to improve the results of treatment of such patients.

The tactics of treatment of type II DM should be aimed at normalizing the pathogenetic processes underlying the disease: reducing insulin resistance and improving cell function. Drug therapy is prescribed in cases where dietary measures and increased physical activity within 3 months do not allow to achieve the goal of treatment. The general directions of DM therapy include prevention (at the stage of impaired glucose tolerance) and treatment tactics aimed at the early achievement of glycemic target values, preferential use of combined therapy, and active insulin therapy to achieve compensation of carbohydrate metabolism.

According to the recommendations of the American Diabetes Association, the choice of antidiabetic drugs should meet 5 main criteria: effectiveness, fre-

quency of hypoglycemia, impact on body weight, side effects, and cost. It is noted that the cost of drug therapy is only part of the total costs, including additional costs for monitoring, treatment of hypoglycemia, correction of body weight and side effects. Therefore, the use of drugs with safe and effective glycemic control and minimal risk of hypoglycemia without gaining body weight is a decisive factor when choosing therapy for type II diabetes.

And although today, according to the recommendations of the adapted clinical guideline, metformin remains the most studied in terms of effectiveness and safety of monotherapy, the American Association of Clinical Endocrinologists recommends α-glucosidase inhibitor drugs for the treatment of DM. In the multicenter, randomized, placebo-controlled STOP-NIDDM Trial, it was shown that α-glucosidase inhibitors contribute to the normalization of glucose tolerance and prevent the occurrence of type II DM. Furthermore, according to literature analysis, it was found that taking α-glucosidase inhibitors improves the level of glycemic control and decreases triglycerides, body weight, and systolic blood pressure. These observations show that the prevention of postprandial hyperglycemia is a promising therapeutic strategy for reducing the risk of DM, hypertension, dyslipidemia, obesity, and CVD in patients with metabolic syndrome.

Thus**,** the aim of the research was to establish the expediency and development of the composition and technology of combined tablets for the treatment of type II diabetes.

2. Planning (methodology) of research

The National Pharmaceutical University (NUPH) has already obtained a standardized solid dispersion (SD) of quercetin with polyethylene oxide-6000, microcrystalline cellulose and neusilin. Therefore, at the next stage, it is planned to prove the feasibility of its combination with voglibose, to develop the composition and technology of combined tablets, to conduct their pharmacological screening for antihyperglycemic action, which will become the rationale for the creation of a drug for the treatment of type II diabetes [4].

Stages:

1. Conducting market research on drugs used in the treatment of type II diabetes, in particular, the group of α-glucosidase inhibitors.

2. Research on the development of the composition and technology of combined tablets.

3. Determination of the specific activity of the developed tablets.

Thus, this work combines the results of studying the assortment of voglibose preparations in the pharmaceutical market of Ukraine, Southeast Asia and the Western Pacific region, establishing the physicochemical and technological parameters of the mass for tabletting and tablets based on them, determining the specificity of the pharmacological action of the drug.

3. Material and methods

3. 1. Marketing researches

Analytical research of the pharmaceutical market of drugs used for treating type II diabetes was carried out using content analysis of official sources of information [1, 5–9]. The subjects of the study were medicinal products used to treat type II diabetes.

3. 2. Research of technological parameters samples

Determination of flowability, bulk density, slope angle and other technological parameters was carried out according to SPhU 2.1 methods [10].

Calculation of the pressing pressure by modifying the equation of H. M. Zhdanovich, which reflects the tablet densities from the efforts of forming powders in the moulds

$$P = P_{\max}\frac{\rho^n - \rho_p^n}{1-\rho_p^n},$$

where $P_{\max}$ [MPa] is the pressing pressure required to obtain a core with a minimum number of pores; physically, it is equal to the yield pressure of the material and corresponds to its hardness. $P_{\max}$=250 MPa; n is the form factor (formula 2.11). For medicinal substances, it is 4.1; Π_p – porosity:

$$n = 1 + \frac{2}{\Pi_p}.$$

Porosity is calculated using the formula:

$$\Pi_p = \frac{\gamma_k - \gamma_{press}}{\gamma_k}100\ \%.$$

The coefficient of vibration compaction is one of the flowability assessment indicators, which is determined by the formula:

$$k_v = \frac{p_{\max} - p}{p},$$

where p is bulk density, $p_{\max}$ – maximum bulk density.

A characteristic property of masses for tabletting is the coefficient of heterogeneity (R_0) [11]. For its calculation, the results of sieve analysis are used: the ratio of the size of the sieve opening through which 60 % of the mass passed (R_{60}) to the size of the sieve opening through which 10 % of the material passed (R_{10}):

$$R_0 = \frac{R_{60}}{R_{10}}.$$

3. 3. Research of the pharmacological activity of a drug

The study of the antihyperglycemic and antidiabetic properties of the drugs was carried out following the methodological recommendations for the experimental study of new hypoglycemic agents. To determine the insulin resistance of the developed drug, its activity was studied on the model of experimental metabolic syndrome (MS), which was reproduced on 18-month-old male rats weighing 270–300 g by means of a high-sucrose diet

(HSD), which was provided by replacing drinking water with a 30 % sucrose solution during 8 weeks.

Six groups of animals were used in the experiment: 1 – intact control; 2 – control pathology; 3 – control pathology+Glykverin at a dose of 50 mg/kg; 4 – control pathology+comparator (quercetin substance) at a dose of 0.02 mg/kg; 5 – control pathology+comparator (voglibose substance) at a dose of 50 mg/kg; 6 – control pathology+comparator (Metformin tablets) at a dose of 200 mg/kg. The state of glucose homeostasis was evaluated in a short insulin test based on the level of basal glycemia and the degree of sensitivity of the liver and peripheral tissues to the action of insulin. In addition, glycerin's hypoglycemic activity was determined during the intraperitoneal glucose tolerance test (IGTT) [12, 13].

3. 4. Statistical processing of results

Determination of the statistical reliability of the results of experiments on the development of the composition and technology of solid dispersions and solid dosage forms based on them was carried out using the Statistica 6.0 program.

4. Results

It was established that only metformin and voglibose positively affect indicators of weight fluctuations. Compared to the group of sulfonylurea derivatives, they have a number of advantages and a minimal number of side effects. Preparations of groups A10B A, A10B B, A10B F, and A10B G have a relatively low cost of packaging, which significantly affects the cost of treatment. New generation drugs: groups A10B H, A10B J, and A10B X (excluding guar gum) have appropriate efficacy compared to biguanidines, but have an insufficient safety profile. The high cost of drugs for these groups reduces their availability to the general population, so the demand for them is the lowest.

Of the α-glucosidase inhibitors, only acarbose, miglitol, and voglibose are currently available. These drugs delay the absorption of glucose, thereby reducing the degree of postprandial hyperglycemia. For a long time, the widespread introduction of α-glucosidase inhibitors (acarbose, miglitol) into clinical practice was limited by a low glucose-lowering effect and pronounced side effects from the gastrointestinal tract, which led to low patient adherence to treatment. However, the new drug voglibose's entry into the pharmaceutical market can significantly change the situation. This drug causes 15 times fewer side effects than acarbose and can reduce the HbA1c level by 1–2 %. In Japan, voglibose is approved for the treatment of impaired glucose tolerance. It became the first oral antidiabetic drug to be approved for this indication. This class of drugs is widely used in Asian countries; in other countries, its use is limited due to the lack of voglibose drugs on the market [14].

It is the wide presence of voglibose medicinal products in the pharmaceutical markets of Southeast Asian and Western Pacific countries and the experience of its successful use in pharmacotherapy schemes for type II diabetes that led to the marketing research of these markets.

According to the results of the study of the assortment of drugs, it was established that among 76 trade names of drugs, without taking into account the forms of release, the majority of drugs are represented by monocomponent forms of voglibose (80.3 %), which are produced mainly by pharmaceutical companies from Japan and India [15, 16] (Fig. 1).

In the segment of drugs represented by combinations of voglibose with metformin or voglibose with

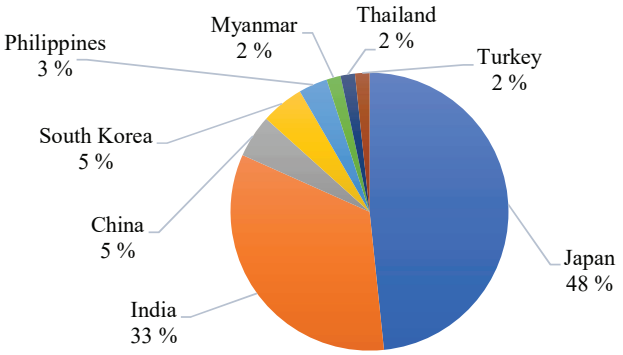

Fig. 1. Distribution of the shares of the producing countries of single-component drugs voglibose in the pharmaceutical market of the Western Pacific region

metformin and glimepiride, the dominant number of drugs is produced by Indian pharmaceutical companies (almost 90 %) (Fig. 2).

Taking into account the results of the previous stage of analysis regarding the recommendations in the pharmacotherapy of DM and the data of scientific publications on the effectiveness of the inclusion in the treatment of combined forms of drugs for the treatment of type 2 DM, as well as the fact that the main manufacturer of the voglibose substance and drugs based on it are Indian pharmaceutical companies, the next stage was analyzed range of drugs based on voglibose on the Indian market. Thus, it was established that among 186 trade names of drugs, taking into account the forms of release, 70.43 % are voglibose monopreparations with a dosage of 0.2 mg and 0.3 mg in almost equal quantities. The segment of combined forms includes the drug voglibose with metformin and glimepiride or pioglitazone. Thus, 56 % of combined drugs are represented by voglibose and metformin, and 44 %, respectively, are three-component drugs. Fig. 3 shows the results of the structural analysis of the segment of combined forms of drugs with voglibose on the Indian market.

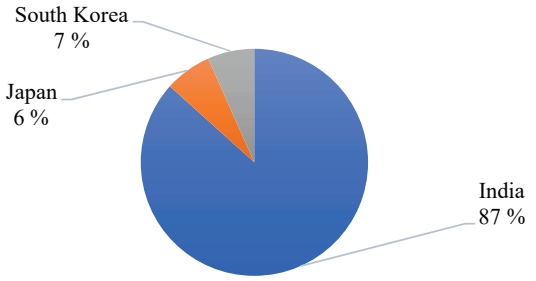

Fig. 2. Distribution of shares of countries producing combined drugs with voglibose in the pharmaceutical market of the Western Pacific region

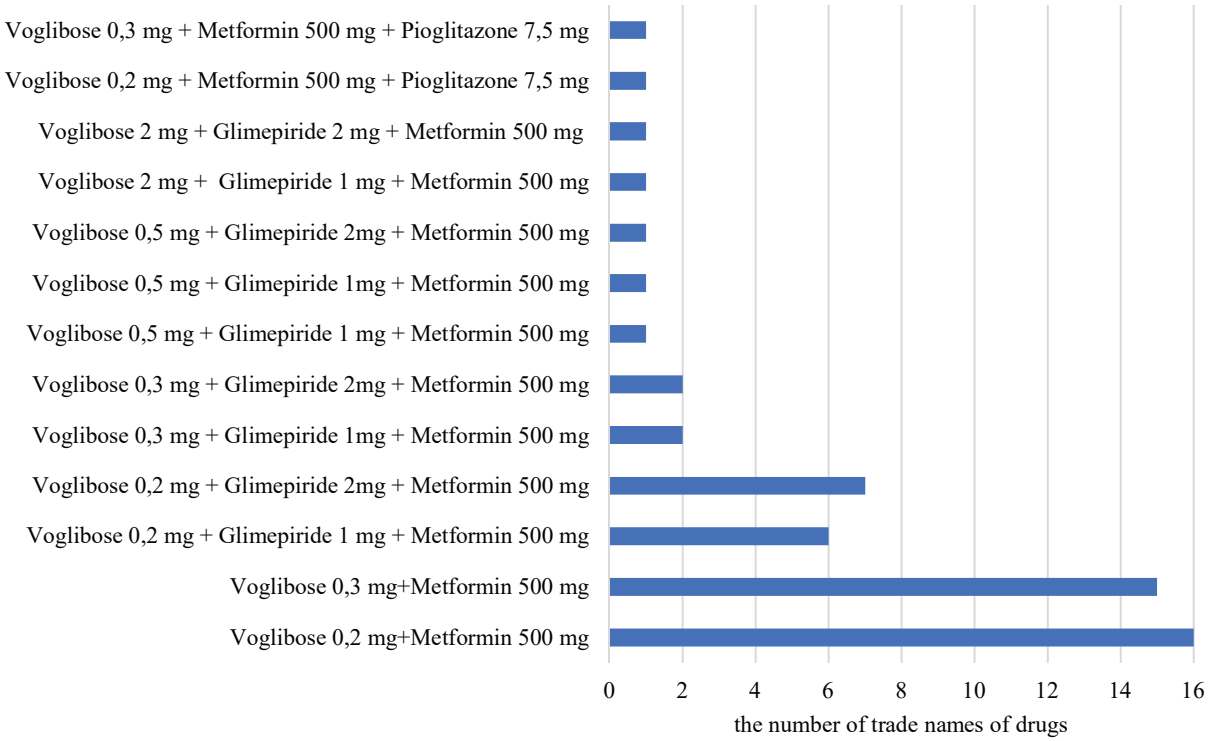

Fig. 3. The range of combined forms of drugs with voglibose on the Indian market

According to the results of the analysis of the assortment of combined drugs of voglibose by dosage forms, it was determined that the majority of drugs are produced in the form of tablets (89 % of the assortment). Medicines from three manufacturers - Emenox Healthcare, Glenmark Pharmaceuticals Ltd. (Zoltan), Ahaan Healthcare Pvt. Ltd – presented in the form of buccal tablets: 2 preparations each of the combinations Voglibose 0.2 mg+Metformin 500 mg and Voglibose 0.3 mg+Metformin 500 mg; and 1 drug each with the active substances Glimepiride 1 mg+Metformin 500 mg+Voglibose 0.2 mg and Glimepiride 2 mg+Metformin 500 mg+Voglibose 0.2 mg.

In the next stage, we analyzed the Ukrainian market for the drug voglibose. According to the State Register of Medicines of Ukraine, as of July 12, 2022, 2 single-component medicines, "Voksid" in the form of tablets with a voglibose dosage of 0.2 mg and 0.3 mg manufactured by Kusum Pharm LLC (Ukraine) were registered, as well as one substance in vials for pharmaceutical use produced by Shanghai Techvel Biopharmaceutical Co. Ltd. (China) [17].

Accordingly, taking into account the global experience of the production and use in the schemes of pharmacotherapy of DM 2 type of combined forms of drugs with voglibose and the presence of such drugs in national recommendations, it is expedient to develop the formulation and production technology of combined drugs for introduction into production by Ukrainian pharmaceutical companies.

Therefore, the development of drugs with voglibose is a promising direction for expanding the range of anti-diabetic drugs and increasing the effectiveness of treatment. Therefore, on the basis of marketing and pharmacological research, it was decided to create a multicomponent drug with a complex effect based on a combination of voglibose and quercetin.

Previous studies established the rational composition of the solid dispersion of quercetin physicochemical and technological properties of voglibose [18].

At the stage of developing the composition and technology of combined tablets with quercetin and voglibose, attention was paid to the choice of disintegrant and lubricant. The addition of excipients that have the property of loosening – disintegrators makes it possible to reduce the side effects of tablets, as well as increase the bioavailability of medicines. According to the requirements of good manufacturing practice, disintegrants should have low solubility, low gel formation, good hydration, satisfactory forming properties and flowability. Sodium starch glycolate is used for tablets obtained by direct pressing. In this case, the disintegration of the drug occurs due to the rapid absorption of water, which leads to a significant increase in the volume of the granules, and this, in turn, causes rapid and uniform disintegration. Another substance that has been used is crospovidone, which is not soluble in water and is also used in a concentration of 2–5 % in the manufacture of tablets by direct pressing. Crospovidone has a rapid high capillary action and hydration capacity with little tendency to form gels. To determine the type and concentration of disintegrant, samples of tablets with a concentration of 2 %, 3 %, 4 %, 5 % of crospovidone (CP) or sodium starch glycolate (SSG) were obtained. The study of the decay time was carried out according to the requirements of the SPhU, II edition (Fig. 4).

As can be seen from Fig. 6, both substances have high rates of decay. But sodium starch glycolate at a concentration of 3 % has the minimum disintegration time.

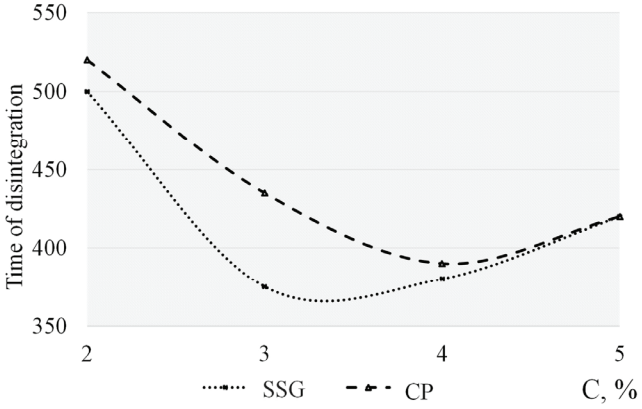

Fig. 4. Dependence of the disintegration time on the concentration of the disintegrant

At the next stage, the type of lubricant and its amount in the tablets were determined. Aerosil, Neusilin, and magnesium stearate have recently been widely used as glidants and anti-adhesives. All substances are moisture regulators at the same time, which is important when creating tablets with solid dispersions. As neuselin is part of the solid dispersion, the effect on the characteristics of the tabletting mass of magnesium stearate and aerosol was investigated (Table 1).

According to the data given in Table 4, it can be seen that the flowability indicators with the addition of magnesium stearate and Aerosil are almost the same. But Aerosil, with a content of 1 % of the total mass for tabletting, approaches the calculated indicator. At the same time, the disintegration time of the obtained tablet samples was determined. According to the results, it was established that the addition of aerosol does not increase the time of decay of the samples. Also, when receiving tablet samples, sticking to the punches was observed in the case of using magnesium stearate. When using Aerosil as a lubricant, in concentrations of 0.5 % and 1.0 %, sticking to punches and the appearance of external defects do not occur. Therefore, to ensure the optimal speed and minimum time of disintegration, it is advisable to add to the composition of tablets the combined composition of sodium starch glycolate – 3 % and Aerosil – 1 %. So, based on the conducted research, the rational composition of the tablets was established: voglibose, solid dispersion of quercetin, sodium starch glycolate, and Aerosil.

Table 1

Flowability and disintegration time indicators depending on the type and concentration of the lubricant

Sample	Indicator	
	Flowability, g/s	Time of disintegration, s
No lubricant	4.0±0.02	375±5.6
Aerosil 0.5 %	6.2±0.04	377±4.2
Magnesium stearate 0.5 %	6.1±0.06	423±8.3
Aerosil 1.0 %	6.6±0.03	375±6.1
Magnesium stearate 1.0 %	6.9±0.06	456±9.4

To develop the optimal technology of combined tablets, the coefficient of vibration compaction was studied, which is determined based on the values of the bulk density; the higher it is, the lower the flowability of the sample under study. It also characterizes the homogeneity of the shape and size of the particles, the degree of deformation, and cohesive properties (Fig. 5).

At the same time, the slope angle and collapse angle were determined (Table 2) to establish the flowability class, which is a universal school of flowability assessment in points (Car method) applicable to any flowable materials.

Taking into account the angle of collapse and the angle of inclination, the mass of the solid dispersion of quercetin, which was obtained at a temperature of 45–50 °C, has a value of 94 points.

Therefore, the resulting mass can be attributed to the I class of flowability, which does not require excipients and additional equipment.

Taking into account the multicomponent composition of the mixture for tabletting, the pressure was calculated – 170 MPa. The quality indicators of tablet mass and tablets based on it are given in Table 3.

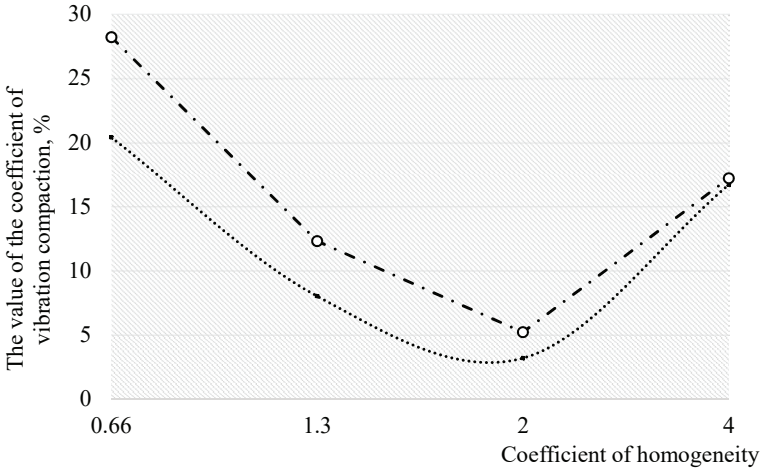

Fig. 5. The value of the coefficient of vibration compaction depending on the coefficient of inhomogeneity

Table 2

Technological indicators of samples of solid dispersions

Indicator	Optimal value/points	Indicators of TD samples/points
		No. 1
Coefficient of vibration compaction	not more than 8 %/23	3.17/23
Coefficient of homogeneity	2/23	2/23
Slope angle	not more than 25°/25	27.0±0.6/23
The angle of collapse	not more than 40°/25	30±2/25

So, according to the results of the conducted research, the composition and technology of obtaining combined tablets was developed:

– voglibose: 0.2 mg;
– quercetin: 50 mg;
– PEO-6000: 100 mg;

– MCC: 25.2 mg;
– neuselin: 26.1 mg;
– sodium starch glycolate: 6.1 mg;
– aerosil: 2.1 mg;
– Total: 210.0 mg.

To determine the insulin resistance of the developed drug, its activity was studied on the model of experimental metabolic syndrome (MS), which was reproduced on 18-month-old male rats weighing 270–300 g, by means of a high-sucrose diet (HSD), which was provided by replacing drinking water with a 30 % sucrose solution for 8 weeks (Table 4).

From the given data, it is clear that long-term maintenance of animals on HSD did not cause changes in basal glycemia, probably due to the presence of compensatory hyperinsulinemia. However, an increase in the area under the glycemic curves (AUCglu) by 1.6 times compared to the indicator of the intact control group indicates a violation of glucose tolerance in rats with control pathology, a significant decrease in the insulin sensitivity coefficient – a significant deterioration in the sensitivity of peripheral tissues to insulin.

It was also established by pharmacological studies that a sample of combined tablets significantly prevents the development of glucose metabolism disorders caused by HSD: glucose tolerance increases in rats, as evidenced by a 1.8-fold decrease in the integral glycemic index AUC_{glu}, and insulin resistance significantly decreases. In terms of effectiveness, the sample of combined tablets is significantly superior to the comparative drugs voglibose and metformin.

The antiatherogenic effect of samples of combined tablets was determined by the content of cholesterol (CL), triglycerides (TG), low-density lipoprotein (LDL), and high-density lipoprotein (HDL) in the blood serum of experimental animals (Table 5).

The analysis of the data presented in Tab. 8 showed that against the background of HSD in control pathology animals, manifestations of dyslipidemia were observed, which indicated the initial processes of atherogenesis: a 2.4-fold increase in the level of triglycerides, LDL – almost 2-fold, an increase in the content of total cholesterol and tendency to decrease HDL.

The sample of combined tablets significantly reduces the level of total cholesterol by 2.2 times, TG – by 2.5 times and LDL – by 1.9 times, and the content of HDL increases by 1.3 times compared to the parameters of the control pathology.

Therefore, in terms of the expressiveness of the hypocholesterolemic effect, the combined tablets and their constituent components are significantly superior to the comparison drug – metformin, however, probable antiatherogenic properties were found only in the tablets.

Table 3

Pharmacotechnological indicators of combined tablets

Indicator	Values
Disintegration time, min	4±0.1
Crushing strength, N	192±5
Abrasion, %	0.25±0.001
Deviation from the average mass, %	3 %
The density of mass for tabletting, g/cm^3	0.54
The density of the tablet sample, g/cm^3	0.10
The porosity of the mass for tabletting	0.25

Table 4

The effect of combined tablets and comparator drugs on the parameters of glucose metabolism in rats under conditions of metabolic syndrome induced by a high-sucrose diet

Groups of animals	Indicators		
	Basal glycemia, mmol/l	AUK_{glu}, mmol/l·min (IGTT)	ISC, %
Intact control	4.84±0.22	783.62±19.79	51.4±2.8
Control pathology	5.12±0.38	1290.24±55.02*	18.2±3.3*
Experimental sample of combined tablets	4.24±0.73	733.65±15.32**$^{/v/m}$	49.6±7.7*
Quercetin	4.68±0.25	768.21±29.44**	46.6±3.8*
Voglibose	4.37±0.24	900.21±40.43**	42.3±5.4*
Metformin	4.09±0.06	848.83±43.33**	45.9±3.2*

*Note: * – differences are significant compared to the values of the intact control, p<0.05; ** – differences are significant in relation to the values of the control pathology, p<0.05; v – the differences are significant with respect to the values of the voglibose substance, p<0.05; m – the differences are significant with respect to metformin values, p<0.05; ISC – insulin sensitivity coefficient*

Table 5

Antiatherogenic effect of combined tablets and comparative drugs under conditions of metabolic syndrome induced by a high-sugar diet

Groups of animals	Blood serum indicators			
	Cholesterol, mmol/l	HDL, mmol/l	LDL, g/l	TG, mmol/l
IC	0.82±0.04	0.71±0.05	6.79±0.52	1.25±0.10
CP	2.17±0.13*	0.92±0.11	12.98±0.35*	2.96±0.25*
Experimental sample of combined tablets	0.97±0.12**$^{/m}$	0.64±0.03**	6.70±0.33**	1.18±0.12**
Quercetin	1.11±0.12**$^{/m}$	0.77±0.05	6.13±0.56**	1.51±0.05**
Voglibose	1.16±0.12**$^{/m}$	0.69±0.07	7.74±0.36*	1.65±0.10**
Metformin	1.91±0.13*	0.65±0.02**	6.71±0.53**	1.48±0.10**

*Note: * – differences are significant compared to the values of the intact control, p<0.05; ** – differences are significant in relation to the values of the control pathology, p<0.05; m – deviations are reliable with respect to metformin values, p<0.05*

5. Discussion of research results

High-quality medical and pharmaceutical care requires all participants in the process of its provision to take successive interrelated actions, which involve the use of modern approaches in pharmacotherapy, assessment of the urgent needs of the population for medicinal products, development and introduction to the market of modern high-quality, safe and effective medicines. In recent years, at the global level, the relevance of developing optimal and effective approaches in the prevention and treatment of socially significant diseases, including diabetes [19–21], has been increasingly emphasized. Taking into account the above, the conducted studies will allow us to avoid the use

of an irrational scheme of pharmacotherapy and to identify the main groups of drugs that are proposed to be used to ensure an effective, rational and long-term hypoglycemic effect in patients with type II DM. This study is a continuation of a complex marketing analysis of hypoglycemic drugs, which allows us to conclude about the similarity of approaches in the pharmacotherapy of type 2 diabetes in different countries and about the relevance of including antioxidants in the treatment regimens of combined forms of hypoglycemic drugs, namely, based on biguanides, sulfonylurea derivatives and α-glycosidase inhibitors.

According to the prediction of antidiabetic activity, the use of quercetin may provide a potential new treatment for type II diabetes. And using it as an antioxidant will help reduce the degree of oxidative stress, which in turn will reduce the risk of progression of diabetic angiopathy and improve hypoglycemic control and insulin sensitivity. But due to poor bioavailability, it is not possible to achieve the necessary therapeutic activity when taking it.

In the course of the research, the composition and rational technology of obtaining complex tablets with voglibose and solid dispersion of quercetin were established. Pharmacological studies have determined that they significantly prevent the development of glucose metabolism disorders caused by a high-sugar diet, and in terms of the expressiveness of the hypocholesterolemic effect of the tablets and their constituent components, they reliably outperform the comparison drug - metformin.

Study limitations. Since the bioavailability of the active substance in a solid medicinal product may depend on the duration of passage through the gastrointestinal tract and the intensity of regional blood flow, in order to save resources in the early stages of research, it is advisable to use in silico methods. This will help during the pharmaceutical development of solid dosage forms to conduct a scientific search for the optimal composition and technology by predicting and evaluating the pharmacokinetic parameters of poorly soluble substances in environments close to physiological ones.

Prospects for further research. Based on the results of the research, it is possible to assert the feasibility of further research on the development of a complex preparation with voglibose and solid dispersion of quercetin, with the aim of further including such drugs in the range of Ukrainian manufacturers.

6. Conclusion

The comprehensive analysis of approaches to the pharmacotherapy of type II DM and the results of the market research of hypoglycemic drugs allows us to conclude about the similarity of approaches in the treatment of type 2 diabetes in the countries of Southeast Asia, the Western Pacific region and Ukraine, and about the relevance of including in the assortment portfolio of manufacturers of combined forms drugs with a sugar-lowering effect, namely based on α-glycosidase inhibitors.

Based on the coefficients of homogeneity, vibrational compaction, slope angle and collapse angle, a rational technology for obtaining tablets was established. According to the results of pharmacotechnological studies of the density of the mass for tabletting, its porosity, the density of the tablets and their quality indicators, a technology for obtaining combined tablets with voglibose and a solid dispersion of quercetin was developed.

In the model of insulin resistance caused by dexamethasone, the use of experimental samples of combined tablets reduces intolerance to carbohydrates and prevents the development of postprandial hyperglycemia (reduction of AUCglu to 885.90 mmol/l·min vs 1368.73 mmol/l·min in the group of control pathology), normalizes lipid metabolism (decrease in the content of total lipids and triglycerides by 1.9 and 2.8 times, respectively, compared to the level of intact animals) and LPO processes (normalization of the level of TBC-active substances and increase of the level of reduced glutathione). Due to the additive summation of the effects of voglibose and quercetin, the test sample outperforms the comparison drugs metformin and acarbose in terms of antihyperglycemic.

An antidiabetic effect of the sample of experimental tablets in the conditions of experimental type II DM, induced by the administration of streptozotocin, was established, which is confirmed by a 2.7-fold increase in the insulin sensitivity coefficient compared to control animals, a 1.8-fold decrease in the area under the glycemic curves, and a restoration of the balance of LPO/AOS, which exceeded the antidiabetic effect of individual components and metformin. The obtained data correlate with the results of a morphological study of the pancreas regarding the pancreatic protective effect of a sample of experimental combined tablets.

Conflict of interests

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this article.

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