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Development of Entero Sorbent Technology for Agriculture Based on Mechanically Activated Hydrolytic Lignin

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Abstract

In this article, one of the possible options for the use of a complex nano sorbent based on hydrolytic lignin is considered - the prevention of mycotoxicoses in farm animals and is described in its production technology.

Agricultural feeds are produced and exported in Uzbekistan and most of the raw materials for their production are contaminated with mycotoxins. Mycotoxins are waste products of microscopic molds. They enter the gastrointestinal tract of farm animals with contaminated feed and cause poisoning - mycotoxicosis.

According to the test results (mycotoxins at a concentration of 200 µg/kg were added to the feed and adsorbents at the level of 0.5% of the feed), the maximum absorption rate of zearalenone was 58%, ochratoxin A - 54%, deoxynivalenol - no more than 40%, T-2 toxin - not more than 30%. Currently, there is no single drug that has universal adsorption and inactivating activity against all major mycotoxins.

Keywords: ***Deoxynivalenol (DON), T-2 toxin, zearalenone, ochratoxin A, mycotoxin, optimization***

Introduction

Mycotoxicoses cause billions in losses to the agricultural industry worldwide every year. The group of mycotoxins includes more than a hundred low molecular weight compounds, however, about 20 of them are of practical importance as feed contaminants for farm animals. The following can be an example of them; Deoxynivalenol (DON), T-2 toxin, zearalenone, and ochratoxin A. They can cause the development of tumors, damage the immune system, and disrupt the functioning of the liver and kidneys [1,2].

The main method of removing mycotoxins from the feed is neutralization using entero sorbents included in the mixed feed. Enterosorption is a treatment method based on the ability of sorbents to bind and remove from the body various exogenous substances, microorganisms, and their toxins, intermediate and end products of metabolism when they enter the gastrointestinal tract. The effectiveness against different mycotoxins varies significantly due to the diversity of their chemical structure and properties [3,4].

Nowadays, the demand for adsorbents in the pharmaceutical, oil and gas, cosmetology, oil and gas processing industries, also, the demand for highly selective, efficient, and environmentally safe adsorbents in various sectors of the national economy is increasing [5-10]. Preparation of adsorbent that meets such requirements, research of colloidal-chemical properties of adsorbents, and mechanism of adsorption processes in them was studied. New scientific approaches, as well as setting urgent tasks for the scientists and researchers of the field.

Currently, activated charcoal is used in the food industry, medicine, and other industries to treat gases, wastewater and other waters [11-12]. The use of charcoal, for example for water purification, allows drinking water to fulfill basic requirements, their use as electrodes of supercapacitors makes it possible to create inexpensive rechargeable electrochemical devices with high power and energetic properties [13-18]. Therefore, the study of the base of raw materials to obtain activated charcoal and increase its physical and technical characteristics is of particular interest [19]. Its black ash, obtained by burning walnut pods in the absence of oxygen, has sorption activity.

Materials and Methods

To optimize the composition of the complex nano sorbent for use in agriculture, it is necessary to draw up "content-property" diagrams that reflect the dependence of the sorption capacity on typical exogenous toxins common in our country. It is constructed using experimental design methods. There is a "composition-property" diagram in the implementation of the simplex lattice plan of the experiment to study the dependences of the sorption capacity on the composition of the complex nano sorbent[20-23].

Content - sorption capacity" polynomial models were calculated using the statistica 12 program.

Mathematical models obtained in the form of diagrams of three-dimensional graphs are presented in **FIG. 1 (a,b,c and d) and 2 (a,b,c and d)**.

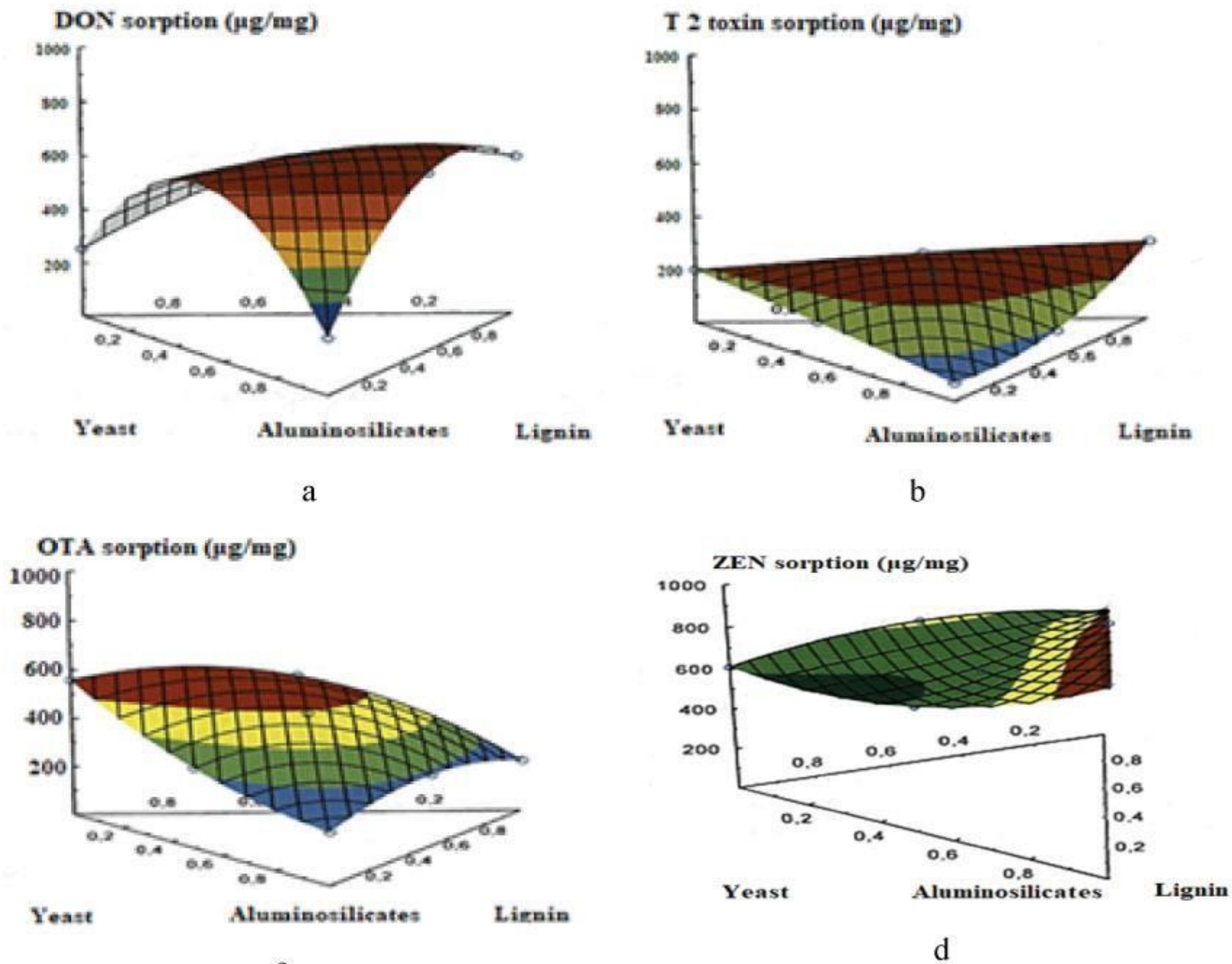
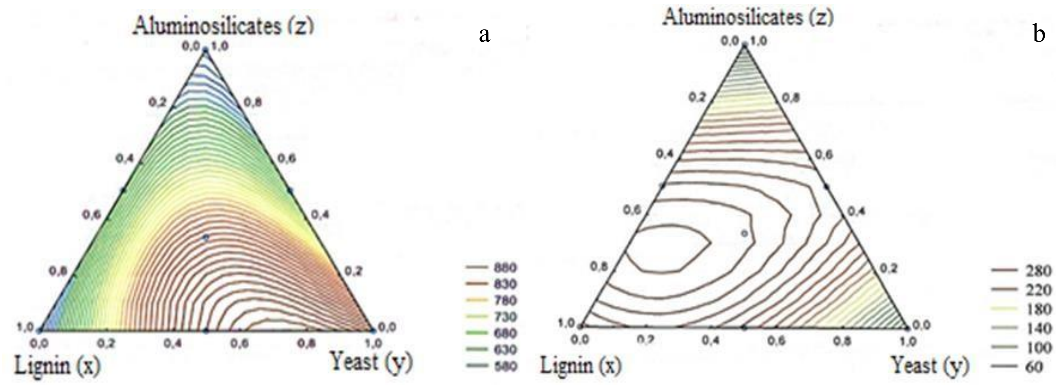
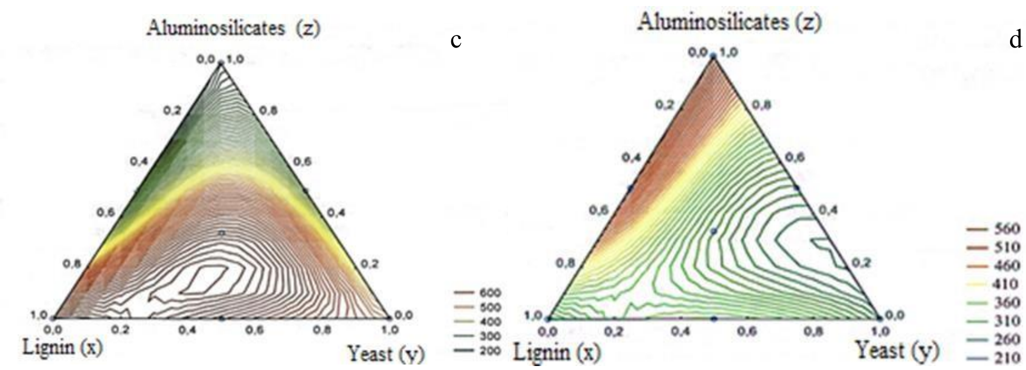


FIG. 1**. a) Deoxynivalenol (DON) b) T 2 toxin c) Ochratoxin A (OTA) d) 3D graph of the dependence of the sorption capacity of the complex nano sorbent on the component of the sorbent concerning zearalenone**



DON sorption =293*x+253*y+199*z+ 608*x*y+992*x*z+1544*y*z-828*x*y*z	T-2 toxin sorption =295*x+199*y+63*z+ 40*x*y +324*x*z+28*y*z+2883*x*y*z



Ochratoxin A sorption =210*x+558*y+204*z+ 744*x*y+316*x*z-244*y*z+2115*x*y*z	Zearalenone sorption =633*x+610*y+915*z+ 358*x*y+ 468*x*z-582*y*z-2901*x*y*z

FIG. 2 **a) DON b) T-2 toxin c) Ochratoxin A d) Zearalenone composition-property diagram for sorption**

Testing the adequacy of the models by Student's criterion showed a good approximation of the calculated and experimental data. All built models are compatible.

After constructing mathematical models of sorption capacity for various toxic substances, it is necessary to solve the problem of multi-criteria optimization[24-27]. Usually, to solve such problems, the method of selecting the main criterion is used, after which the problem of optimization for the selected criterion is solved.

In the case under consideration, it is difficult to choose the main criterion, and the mathematical solution to the problem causes great difficulties. Therefore, it is appropriate to use a graphical method to solve the given optimization problem. The obtained result is shown in **FIG 3**.

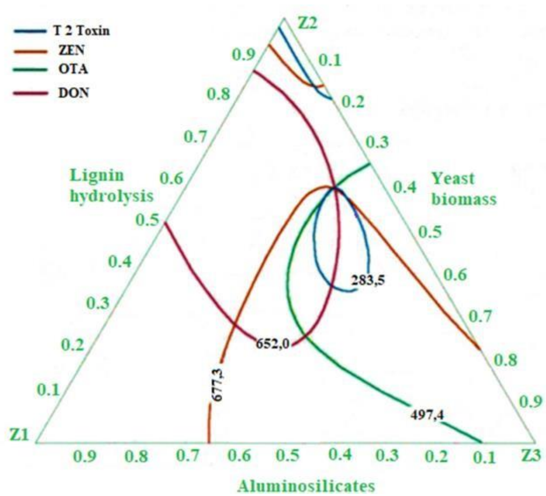


FIG 3. **Composition-property diagram for 4 toxin sorptions**

As can be seen from **FIG.3**, the composition with optimal sorption capacity for all studied toxins (in mass percentage): 60% mechanically activated hydrolytic lignin, 30% mechanically activated nutritional yeast biomass, and 10% mechanically activated bentonite clay.

Results and Discussion

The matrix of the simplex-fence construction of the unfinished third-order experiment and the experimental data for calculating the mathematical models are presented in **TABLE 1**.

TABLE 1**. A matrix of experimental data and experimental data are needed to construct mathematical models**

Experiment №	Composition of the mixture (in parts of one)			response	Sorption capacity experimental data (μg/mg)			
	Mechanically activated hydrolysis lignin, (x)	Mechanically activated nutritional yeast biomass (y)	Mechanically activated bentonite clay (z)		Mechanically activated hydrolysis lignin, (x)	Mechanically activated nutritional yeast biomass (y)	Mechanically activated bentonite clay (z)	Zearalenone
1	1	0	0	1	1	0	0	1
2	0	1	0	2	0	1	0	2
3	0	0	1	3	0	0	1	3

As can be seen from **TABLE 1**, each of the studied components has a high sorption capacity for certain types of toxins. First of all, it depends on the structural features of the sorbents themselves and the toxins they adsorb.

Experimental determination of the sorption capacity of the above composition showed a good convergence of theoretical and experimental data **FIG. 3**. The results are presented in **FIG 4**.

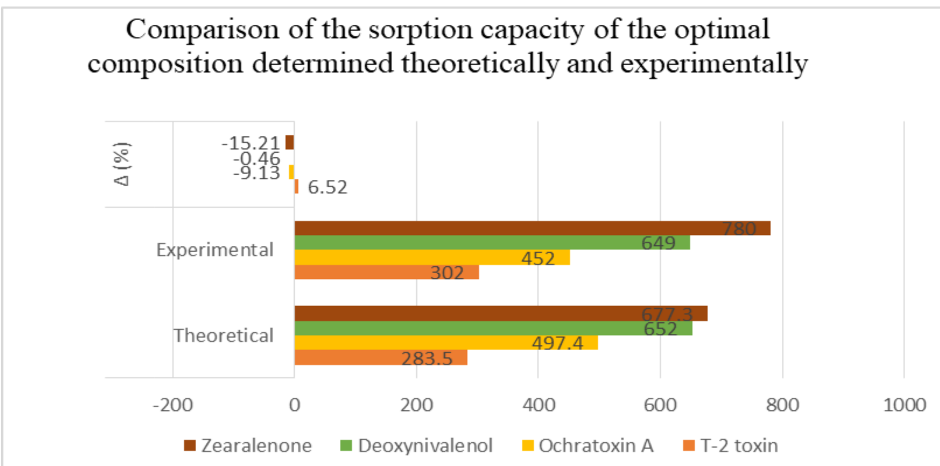


FIG 4. **This composite allows efficient absorption of hydrophilic and hydrophobic mycotoxins**

During the research tests of the developed technology, 3 batches of complex nanosorbent samples of 1 kg each were taken. The material balance of nanosorbent production (per unit of goods) is presented in **TABLE 2**.

Analytical studies of the properties of the complex nanosorbent formed for each received batch of the target product were carried out.

TABLE 2. **Material balance for obtaining 1 kg of complex nanosorbent**

Raw material			Product		
Naming	Mass, g	%	Naming	Mass, g	%
Hydrolytic lignin (from landfill), *including:* hydrolytic lignin water	1890 510,3 1379,7	58,0	Target product *including:* lignin yeast clay	1000 510,3 255,2 85,1	30,7
Yeast biomass	277,4	8,5	Na-CMC	50	

including: yeast water	 255,2 22,2		water	99,4	
Bentonite clay *including:* clay water	91,5 85,1 6,4	2,8	water vapor	2258,9	69,3
R-r binder component *Including:* Na-CMC water	1000 50 950	30,7			
Total:	3258,9		Total:	3258,9	

In laboratory conditions, it was found that the usual equipment for micro granulation is not suitable for obtaining a product with the desired properties, the granules are obtained in different sizes, which makes it impossible to dose them uniformly. In addition, up to 40%, additional binding components should be included in the composition of the granules, which reduce the sorption properties of the nano sorbent. The bench used in the work allows the modeling of micro granulation processes and provides scaling without loss of product quality indicators in plants with a loading volume of granulated components up to 800 liters. In the course of further research, the possibility of significant (up to 5%) reduction in the rate of access to the binder was found.

To optimize the composition of the complex nano sorbent, we studied the effect of different types of binders on the sorption capacity for different mycotoxins.

Binders are included in the composition in the amount of 5% of the mass of the final product. Sucrose, sodium carboxymethylcellulose (Na-CMC), and potato starch were tested as binders. The expediency of using one or another binder was evaluated by changing the sorption capacity for mycotoxins.

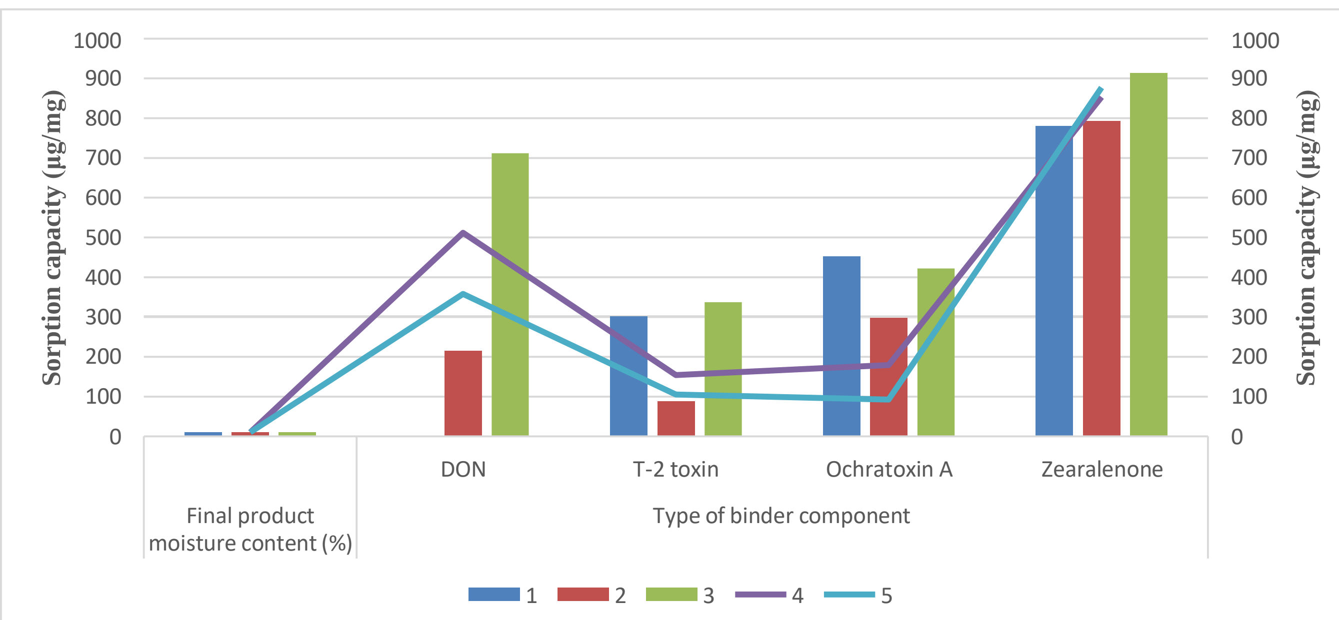


FIG 5. **Variation of the sorption capacity of complex Nano sorbent depending on the type of binder used**

As a result of the research, it was found that the sorption capacity of the complex nano sorbent depends significantly on the type of binder used. When potato starch was used as a binder, the greatest decrease in sorption capacity was noted compared to the non-granular mixture. This effect was, in our opinion, due to the poor disintegration of the granules in the aqueous environment.

The use of sucrose to obtain micro granules also led to the deterioration of the sorption properties of the target product. Despite the good destruction of granules in an aqueous medium, the efficiency of mycotoxin sorption decreased significantly.

The sodium salt of carboxymethylcellulose can be recognized as an optimal binder. Its use provided the granules with sufficient strength, and good disintegration ability in the aqueous medium, and practically did not affect the sorption properties of the nano sorbent in the form of granules.

Attempts to additionally enrich the nano sorbent with minerals in a bioavailable form did not give the desired results. The addition of water-soluble chelate compounds of microelements with the introduction of a binding solution led to a sharp decrease in the sorption capacity index compared to the use of Na-CMC **FIG 5**.

CONCLUSION

1. As a result of the research, a complex nano sorbent production technology for agriculture was developed.
2. The optimal commercial form of complex nano sorbent for agricultural use is microgranules with a size of 0.2-0.8 mm, their composition (in mass percentage) is 60% hydrolytic lignin, 25% fodder yeast biomass, 10% aluminosilicates and 5% Na-CMC. The mass fraction of moisture in the obtained product does not exceed 10%.
3. According to the results of analytical studies of the properties of the target product, it is possible to talk about the stability of the complex nano sorbent production technology for farm animals and its high entero sorption capacity.
4. Information obtained during research tests can serve as a basis for creating technical conditions and technological regulations.

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