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THEORETICAL AND EXPERIMENTAL SUBSTANTIATION OF PREPARATION OF BIOACTIVE SUBSTANCES FOR PRODUCTION OF HIGHLY HOMOGENEOUS MIXTURES

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Abstract. The paper supplies a theoretical base for the preparation of bioactive substances used to produce highly homogeneous mixtures. It presents theoretical and experimental data on the physical, technological, and chemical properties of vitamin preparations, carbonic and sulphuric acid salts of trace elements. The study has considered the interrelation, compatibility, and manifestations of the effects of synergism and antagonism, the one-sided and mutual influence of major and minor elements, vitamin preparations and minerals. It has been analysed how the composition of the premix, the filler, its properties affect the activity of bioactive substances. Besides, data are presented on how the moisture content, pH, temperature, and physical properties determine the degree of bioavailability of substances. It has been studied how big the particles are and how homogeneously bioactive substances are distributed when mixed with a premix filler. The size and shape of particles have been established to be essential factors when obtaining homogeneous mixtures. The characteristics of bioactive substances have been summarised, and their physical, technological, and chemical properties, the features of their preparation, and the technological stages of manufacturing premixes have been analysed. Based on this, classifications of bioactive substances have been developed for vitamin preparations and salts of trace elements. The step-by-step structure of the compound feed technological system that produces premixes has been described and compared with the earlier technologies. Based on the theoretical and experimental studies, reasons have been given for the classification of bioactive substances into three groups and for their proper preparation during premix production, depending on their bulk density, particle size, and percentage in the composition of premixes: 0.1–2.0 kg/t, 2.0–30.0 kg/t, 30.0–100.0, and more. It has been determined how particles of the premix components range in size (0.04–0.6 mm), and it has been established that the size of the filler particles should not exceed 0.8 mm. The problems of preparing bioactive substances in the premix production have been analysed, and it has been recommended how to solve them in order to obtain homogeneous mixtures, premixes, protein-vitamin supplements, and protein-mineral-vitamin supplements.

Key words: bioactive substances, vitamin preparations, salts of trace elements, properties, technological system, classification, premix, homogeneity.

Introduction. Formulation of the problem

Scientific bases of the technology of premixes and making preparations of bioactive substances (BAS) to produce highly homogeneous mixtures call for new requirements to the physical and technological properties of BAS, to their share in the composition of premixes. Aspects that need consideration are the compatibility and the quality of the carrier and the filler in a premix, peculiarities of calculating recipes of premixes, features of production processes, the homogeneity of distribution of vitamins and other BAS mixed with the filler, the conditions of transportation and storage.

Information on the physical, technological, and chemical properties of raw materials for animal feed affects the selection and use of technological equipment and transport, technological modes of the processes involved in the production of premixes, enrichment mixtures, and animal feed, determines the storage conditions and application of these products [1-5].

Analysis of recent research and publications

The activity of additives in the composition of premixes is influenced by a number of factors. They include the composition of a premix (in particular, its filler), its humidity, pH, temperature, physicochemical properties of salts and other compounds of macro- and micronutrients [6-11]. Other important factors are the degree of bioavailability [12,13], which, in turn, depends on the particle size, form of BAS, and solubility, the degree of homogeneity of the distribution of vitamins and other BAS mixed with the filler, the storage conditions and shelf life of both BAS and premixes [2,3,6-10,12,14-16].

From literary sources, it is known that the effect of some BAS on others is determined by the composition of the premixes themselves, namely the set of BAS and the properties of the filler [2,3,8,9,13]. In the production of premixes, one should take into account the interaction between their components, such as the compatibility and interrelationship of vitamin preparations, macro- and micronutrients presented in Table 1 and Fig. 1a. It is required to use protected forms of BAS, to classify them into groups to ensure accurate dosage, and to prepare pre-enrichment mixtures in the production of premixes. The level of interaction of BAS is extremely enhanced when premixes, protein-vitamin supplements (PVS), and protein-mineral-vitamin supplements (PMVS), together with feed, enter the gastrointestinal tract of animals and poultry. Variants of how BAS present in the composition of feed and premixes interact after entering the gastrointestinal tract of animals and poultry are shown in Fig. 1b.

For example, vitamins E, D, B_{12}, and B_4 are known to improve the absorption of vitamin A and carotene. Vitamin E complements the action of antioxidants, and suspends the destruction of fat-soluble vitamins in feed. The introduction of selenium premixes enhances the antioxidant effect and reduces animals' and poultry's need in vitamin E [1-3,8-10,12].

Vitamin B_{12} stimulates the synthesis of such an important amino acid as methionine. Vitamin B_{12} is in a state of synergy with vitamin Bc [3,12].

Vitamin A increases the effectiveness of feed antibiotics. Vitamins D and C promote the absorption of iron in animals and poultry [7]. Vitamin B_2 stimulates the absorption of tryptophan and fat.

Table 1 – Compatibility of vitamin preparations, macronutrients, and trace elements [10,12]

BAS		Vitamins													Macronutrients and trace elements							
		A	D	E	K	B_1	B_2	B_3	B_4	B_5	B_6	B_{12}	Bc	C	Ca	P	Mg	Fe	Zn	Cu	Se	Mn
Vitamins	A	–																				
	D		–																			
	E			–																		
	K				–																	
	B_1					–																
	B_2						–															
	B_3							–														
	B_4								–													
	B_5									–												
	B_6										–											
	B_{12}											–										
	Bc												–									
	C													–								
Macronutrients and trace elements	Ca														–							
	P															–						
	Mg																–					
	Fe																	–				
	Zn																		–			
	Cu																			–		
	Se																				–	
	Mn																					–

Note: – incompatible; – compatible; – neutral.

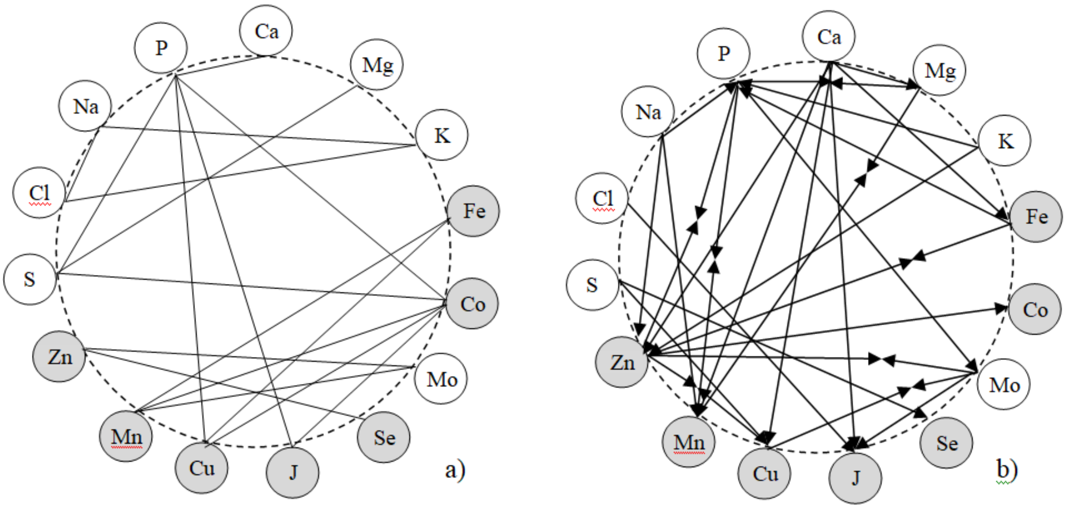


Fig. 1. Interrelationship between macro- and micronutrients [2, 11]

a – synergism, b – antagonism, →– one-sided, →← – mutual

Vitamin B_5 stimulates the activity of the digestive glands and, above all, the pancreas. Excess in vitamin B_5 increases methionine deficiency [1-3,6,7].

Vitamins and micronutrient salts interact with each other during storage of premixes, which often leads to loss of vitamins. Thus, between the preservation of vitamins A and C and the content of salts of zinc, iron, and copper in premixes, an antagonistic effect was observed [4,5,8].

The preservation of vitamins and other BAS is significantly affected by the moisture content of a premix.

With an increase in the mass fraction of moisture in a premix over 10%, the rate of destruction of vitamins increases. An increase in the moisture content of premixes leads to an increase in the rate of redox reactions, activation of viable microorganisms, deterioration of the physical properties of a premix (reduced flowability, caking, possible biochemical changes in the filler, etc.). That is why 13% is considered the critical mass fraction of moisture in a premix. Its shelf life should be significantly reduced and not exceed 1.5 months [2,3,12].

In the presence of oxidants and reducing agents, vitamins behave differently depending on the pH of the medium. For example, calcium pantothenate has a stable state at pH 6 to 8, and the presence of acidic components (niacin, ascorbic acid, etc.) leads to a decrease in its activity [3,9,12].

Some feeds, such as shellfish flour, whey powder, sucrose are quite aggressive towards vitamin D. As a result, it is inactivated during storage. However, fillers like oatmeal, oilseeds have a positive effect on the stability of vitamin D [1,3,12].

Purpose and objectives of the study.

The **purpose** of the study was the theoretical and practical substantiation of the preparation of bioactive substances for the production of highly homogeneous mixtures.

To achieve this purpose, the following **objectives** were set:

– to determine the physical, technological, and chemical properties of vitamin preparations, sulphuric and carbonic salts of trace elements;

– to consider theoretically the relationship, compatibility, and manifestation of the effects of synergy and antagonism, one-sided and mutual influence between macro- and micronutrients, vitamins and minerals;

– to improve the classification of vitamin preparations and salts of trace elements for the production of premixes;

– to develop a phased structure of compound feed technological system for the production of premixes in comparison with previous technologies;

– to substantiate the preparation of bioactive substances in groups in the production of premixes depending on the physical properties and the percentage of premixes;

– to determine the ranges of optimal particle sizes of premix components;

– to develop recommendations for obtaining homogeneous mixtures.

Research materials and methods

The object of examination was dry powdered and microgranular protected forms of fat (A, D, E, K) and dry protected forms of water-soluble (B_1, B_2, B_3, B_4, B_5, B_6, B_{12}, B_c, H, C) vitamin preparations, of the trademark Mikrovit produced by DSM (France) and Rovimix™ (Hoffman-La-Roche, Switzerland), sulphuric acid and carbon dioxide salts of trace elements produced by JSC DOIREA (Institute of Chemical Reagents, Dnepropetrovsk, Ukraine). Wheat bran (DSTU (State Standard of Ukraine) 3016-95) and limestone flour (GOST (State Standard) 26826-86) were studied as the fillers of premixes.

All experiments to determine the physicochemical properties of bioactive substances were conducted at the Department of Compound Feed and Biofuel Technology of the Odessa National Academy of Food Technologies, in accordance with standard methods accepted for bulk materials according to DSTU 4482:2005. Premix fillers and bioactive substances were assessed by the following physical properties: mass fraction of moisture, bulk density, particle size, flowability, angle of repose.

The mass fraction of moisture was determined by drying the sample of the product in the weighing cup in the drying oven at 130 °C for 40 min, and was calculated using the formula:

$$W = \frac{q_1 - q_2}{q_1 - q_0} * 100, \% \qquad (1)$$

where q_0 – weight of the empty weighing cup, g;
q_1 – weight of the weighing cup with a sample before drying, g;
q_2 – weight of the weighing cup with a sample after drying, g.

The angle of repose was determined by pouring the product out of the filler onto a horizontal surface. The product was poured through a metal funnel that had the cone angle 60°, until the top of the pile reached the height of the vertical walls of the device. The angle was measured with a protractor. To this end, the protractor was applied to the cone generatrix, and the angle β was determined with a plumb bob. Then the angle of repose α was calculated as: α = 90 - β.

The flowability was determined by pouring the product through a hole of a certain size (4 cm in diameter). The product was poured into a box with an outlet closed with a latch. To determine the product's flowability, the latch was opened and the time of pouring of the product through the outlet onto a horizontal surface was noted. The volume of the product poured was measured with a cylinder. The flowability was determined from the formula:

$$V = \frac{q}{S * t}, cm/s \qquad (2)$$

where q – volume of the product that passed through the hopper outlet, cm^3;
t – duration of pouring of the product, s;
S – cross-section area of the outlet, cm^2.

Size modulus determination has been carried out with the help of the laboratory diffuser. Sample of the product was placed on the top sieve of the laboratory diffuser, then it was closed with the lid and sieved for 5 minutes at 190...210 sieve oscillations per minute. After sifting remaining residue on each sieve were weighed.

The average size of particles was determined from the formula:

$$M = \frac{3.5 * m_1 + 2.5 * m_2 + 1.5 * m_3 + 0.78 * m_4 + 0.28 * m_5}{100}, \ mm \qquad (3)$$

where m_1, m_2, m_3, m_4 – weight of the residue on the sieves with holes Ø 3, Ø 2, Ø 1, Ø 0.56 mm, g;

m_5 – weight of the undersize material sifted through holes Ø 0,56 mm, g;

3.5; 2.5; 1.5; 0.78 – average size of the particles remaining on the sieves with holes Ø 3, Ø 2, Ø 1, Ø 0.56 mm respectively, mm;

0.28 – average size of the particles which passed through a sieve with holes Ø 0.56 mm;

100 – weight of the sample taken for the analysis, g.

The density was determined by the pycnometric method, by weighing the pycnometer with liquid (toluene) and the sample, followed by calculation according to the formula:

$$\rho = \frac{m}{V}, \quad g/cm^3 \qquad (4)$$

where m – weight of the product, g;
V – volume of displaced liquid (toluene), cm^3.

The solubility of bioactive substances is based on their ability to dissolve in water and 0.1 M HCl without the formation of sediment [17, 18]. The pH value was determined using a pH meter by immersing the electrodes in a hydrogen solution of bioactive substances [17, 18]. Sensitivity to oxidation, reduction, light, temperature, moisture, with the determination of the retention of the activity of drugs of the bioactive substances were determined according to [17, 18]. The aggressiveness was determined by the manifestation of the aggressive action of the bioactive substances and their hydrogen solutions on various materials (metal, polyethylene) [18]. The toxicity was classed by mineralisation to determine toxic elements according to GOST 26929-94.

All tests were performed in triplicate, and the experimental results were processed by the software Mathcad Professional from Mathsoft, Inc. (USA) [3].

Results of the research and their discussion

The results of the theoretical [1–5] and experimental studies of the physical, technological and chemical properties of vitamin preparations are given in Table 2, those of salts of micronutrient preparations in Table 3.

The homogeneity of the premix and its resistance to demixing directly depend on the physical properties of the BAS and the filler. Taking it as a theoretical basis that the bulk density of the i-th component of the mixture is a function of the density of their particles $\gamma_i = f(\rho_i)$, which has the biggest effect on the conditions for obtaining homogeneous mixtures, as well as their average particle size, all BAS preparations can be classified into three groups: macro, medium, and microgroup. The comparative characteristics of the physical properties of BAS drugs and their grouping are presented in Fig. 2 and Fig. 3.

Table 2 – Physical, technological, and chemical properties of vitamin preparations

Vitamins	Mass fraction of moisture, W, %	Average size of particles, M, mm	Angle of repose, α, deg.	Bulk density, γ, kg/m^3	Density, ρ, g/cm^3	Solubility in water, mg/cm^3	pH optimum	Flowability	Sensitivity to					Aggressiveness	Shelf life, months
									oxidation	reduction	light	temperature	moisture		
A	3.7	0.20	33	450	1.35	–	6–9	III	III	–	I	II	I	–	12
D_3	6.2	0.71	39	624	1.40	–	6–9	III	II	–	I	II	II	–	12
E	0.5	0.32	37	263	1.10	–	6–7	III	–	–	I	II	II	–	12
K_3	2.6	0.23	37	621	1.52	–	6–9	II	–	II	I	III	III	–	24
B_1	2.0	0.32	36	300	1.19	1000	5–7	I	III	III	II	II	I	–	48
B_2	1.5	0.17	50	106	1.49	0.12	6–8	II	I	I	II	I	II	–	12
B_3	1.2	0.24	44	577	1.48	356	6–9	III	–	–	–	II	–	I	36
B_5	0.5	0.02	50	427	1.35	17	2–7	III	–	–	–	–	I	I	36
B_6	2.0	0.17	41	620	1.30	222	3–7	I	–	–	II	II	II	–	24
B_{12}	5.7	0.12	36	372	1.50	12	3–9	III	–	II	III	I	–	–	24
B_c	5.9	0.65	48	250	1.19	0.02	3–8	I	II	II	III	I	I	I	36
H	3.4	0.53	38	500	1.50	0.20	5–9	II	–	–	I	I	I	–	12
C	0.3	0.27	37	722	1.61	330	3–7.5	II	III	III	II	III	–	III	36
B_4	9.3	0.73	58	365	1.22	–	–	I	–	–	–	–	III	III	24

Note: sensitivity group: I – weakly sensitive; II – medium sensitivity; III – high sensitivity; – insensitive [2, 4].

Table 3 – Physical and chemical properties of compounds of salts of trace elements

Compounds of trace elements	Mass fraction of the element, %	Mass fraction of moisture, W, %	Average size of particles, M, mm	Density, ρ, g/cm^3	Angle of repose, α, deg.	Bulk density, γ, kg/m^3	Solubility in 0,1 M HCl	Hygroscopicity	Sensitivity	Aggressiveness	Toxicity class [2, 4]	Shelf life, months
$FeSO_4 \cdot 7H_2O$	20.1	40.0	0.78	1.898	55	839	90	II	II	III	3	6
$FeSO_4 \cdot 1H_2O$	32.8	9.2	0.25	1.730	–	–	81	III	II	I	3	6
$FeCO_3$	48.2	1.5	–	5.700	–	–	65	–	III	–	3	6
$CuSO_4 \cdot 5H_2O$	25.4	28.8	0.64	2.284	36	1232	100	I	III	III	2	24
$CuSO_4$	54.8	0.9	–	–	–	–	100	I	III	I	2	24
CuO	77.5	0.5	–	6.400	–	–	40	–	III	–	2	24
$ZnSO_4 \cdot 7H_2O$	22.7	25.9	0.32	1.957	41	1196	100	I	III	II	3	12
$ZnSO_4 \cdot 1H2O$	36.4	9.5	0.80	5.700	–	–	100	II	III	I	3	12
ZnO	80.0	0.2	0.21		42	440	95	I	III		2	12
$MnSO_4 \cdot 7H_2O$	22.4	26.8	0.28	2.103	40	1083	100	I	III	III	3	12
$MnSO_4 \cdot 1H_2O$	32.5	8.0	0.86	1.870	–	–	100	I	III	I	3	12
MnO	77.0	1.1	–	5.180	–	–	13	–	III	–	2	12
MnO_2	62.5	1.7	–	5.360	–	–	15	–	III	–	2	12
$CoSO_4 \cdot 7H_2O$	20.7	34.9	0.80	1.948	47	956	100	II	III	II	1	12
$CoSO_4 \cdot 1H_2O$	34.1	7.5	0.78	1.900	–	–	100	I	III	I	1	12
$CoSO_3$	45.0	12.1	–	4.130	–	–	85	I	III	I	2	12
KlO_3	59.0	1.00	–	–	–	–	100	–	II	II	2	36
Kl	75.3	0.07	0.62	3.115	41	1250	100	I	I	III	3	36
Na_2SeO_3	45.7	1.10	0.32	3.070	50	1242	100	I	II	I	1	12
Na_2SeO_4	41.4	1.50	0.33	3.100	48	1250	100	II	II	I	1	12

Note: sensitivity group: I – weakly sensitive; II – medium sensitivity; III – high sensitivity; – insensitive [2, 4]

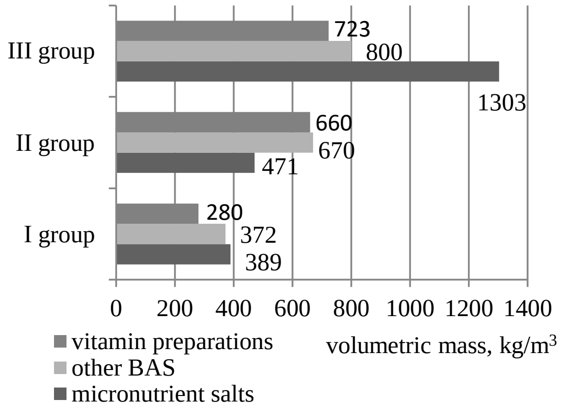


Fig. 2. Grouping of BAS in the production of premixes depending on the bulk density

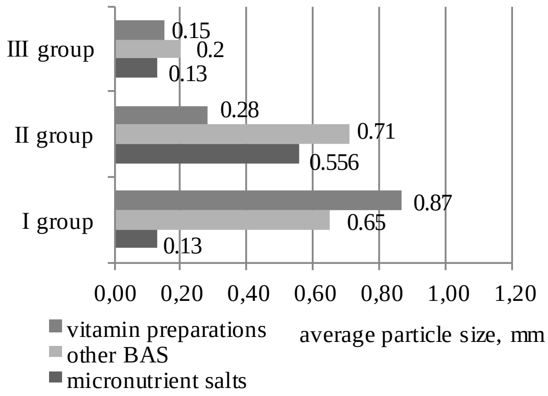


Fig. 3. Grouping of BAS in the production of premixes depending on the particle size

In the works by foreign and domestic scientists [12,19-22], it was found that the maximum particle size to obtain a homogeneous 1-% premix should be within 0.6–0.7 mm. However, it should be noted that in the production environment to prepare all the components with this size of particles is impossible, because only 60–65% of the particles of BAS are within the optimal size range. Besides, the filler of premixes according to DSTU 4482:2005 is characterised by the undersize material fitting through a sieve with the mesh size 1.2 mm.

As the particle size of the BAS and the premix filler increases, the ability of the finished mixture to self-sort increases too, especially during its subsequent movement and transportation.

Based on this, the optimal size of the premix components, with deviations taken into account, can be presented in Fig. 4. In terms of size, the optimal BAS are those obtained in the form of microgranules and including the vitamin preparations A, D, E, granules of amino acids, enzyme preparations. Of all the preparations of BAS, the most careful granulometric preparation in the production of premixes requires micronutrient salts.

In addition, when preparing BAS for the production of homogeneous premixes, special attention should be paid to the concentration of the *i*-th component in the premix and its purpose.

By the mass fraction of BAS drugs in the premix for poultry, they can be divided into three groups [23]:

– Group I – from 0.1 to 2.0 kg/t, it includes vitamin preparations B_{12}, H, and preparations or salts of selenium (Se);

– Group II – from 2.0 to 30.0 kg/t, it includes vitamin preparations B_1, B_6, B_C, K, and preparations of iodine (I), cobalt (Co);

– Group III – from 30.0 to 100.0 and more kg/t, it includes vitamin preparations A, D, C, B_2, B_3, B_4, B_5, and preparations of salts of iron (Fe), manganese (Mn), zinc (Zn), copper (Cu).

Then, according to the structure of the compound feed technological system for premix (FTSP), the production of premixes, in contrast to previous technologies (Fig. 5a), will include: particle size distribution of components; preparation of three preliminary mixtures; mixing the previous mixtures in one or two stages (Fig. 5b).

Based on summarising the characteristics of BAS, it is possible to analyse the physical, technological, and chemical properties of BAS drugs, the peculiarities of their preparation, and the technological stages of production of premixes, and to develop classifications of BAS for: vitamin preparations (Fig. 6); micronutrient salts (Fig. 7). Manufacturers of premixes try to use components of the highest quality, but still there are problems related to both quality and technology (Table 4), which today can be solved through a comprehensive analysis and systematic approach to the production of premixes and other enrichment mixtures.

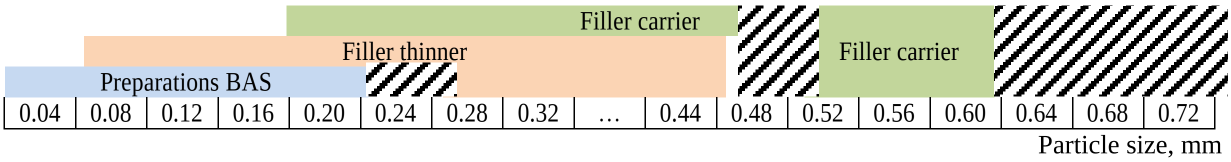
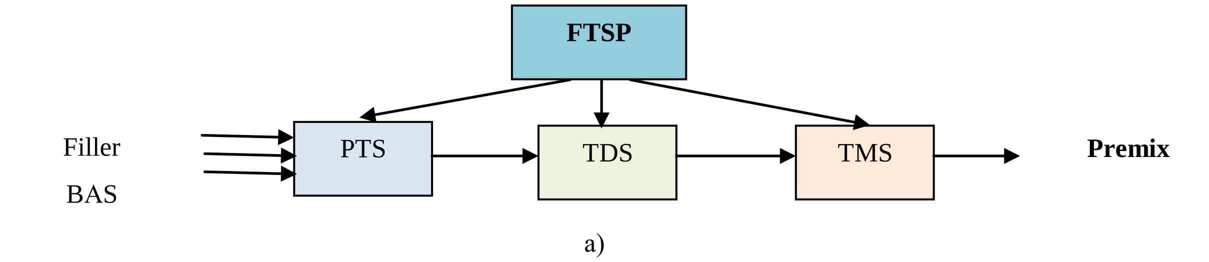


Fig. 4. Range of optimal particle sizes of the premix components

- maximum deviation (20%)



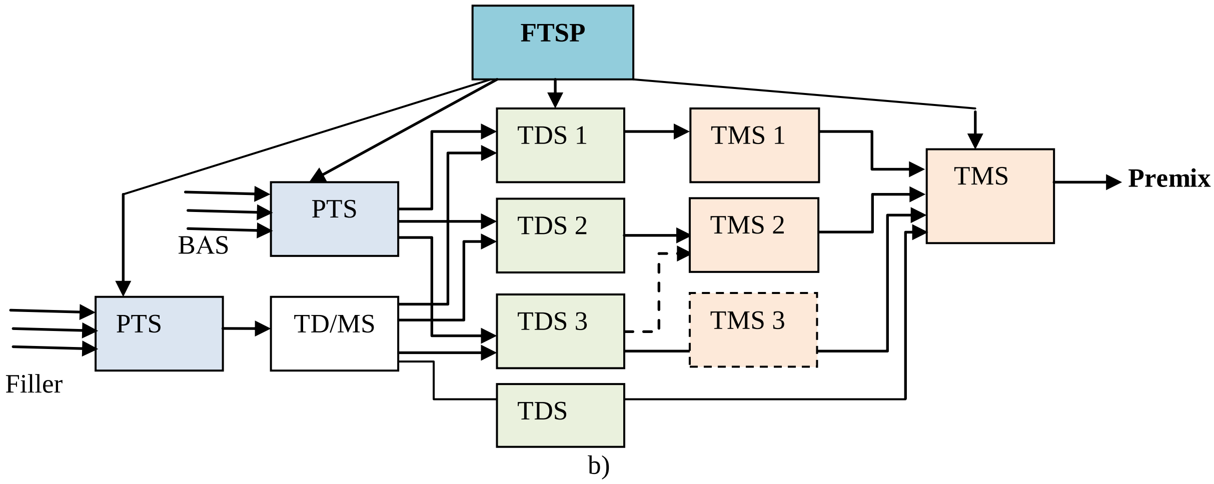


Fig. 5. Structure of FTSP:
PTS – preparatory technological systems, TDS – technological dosing system, TMS – technological mixing system; TD/MS – technological dosing and mixing system complex filler

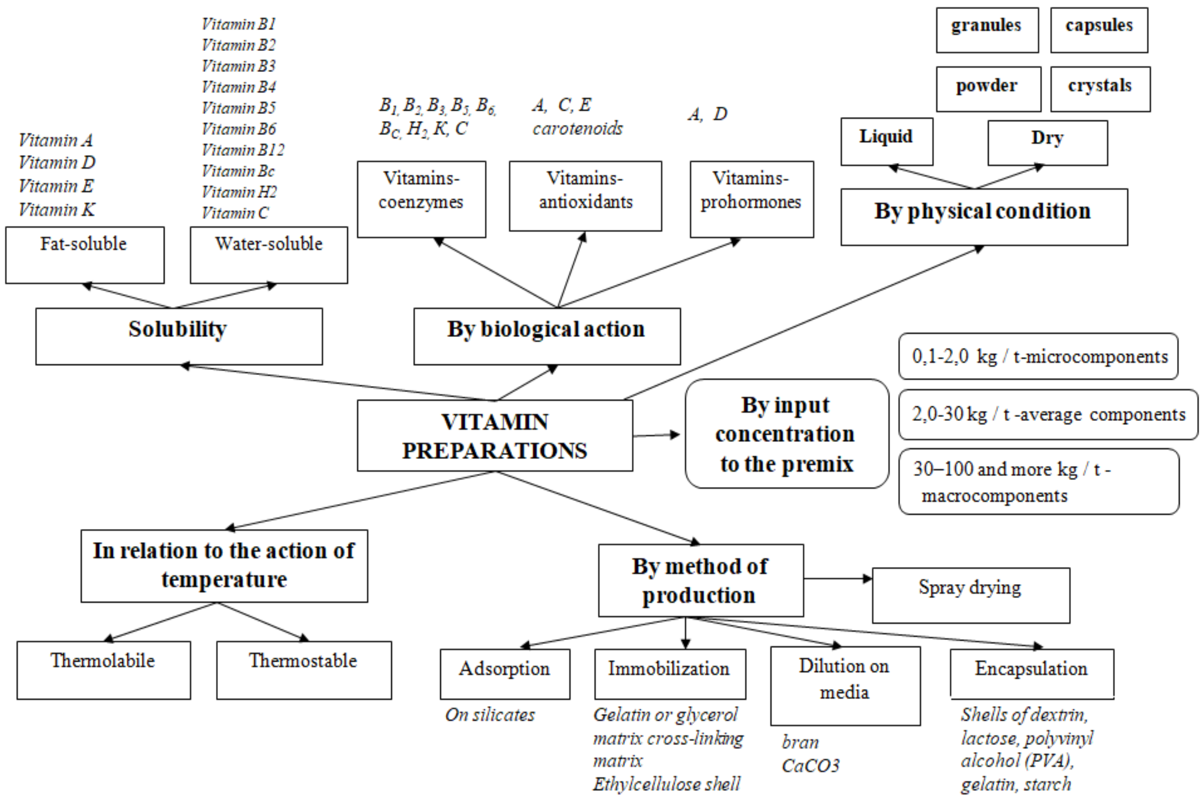


Fig. 6. Classification of vitamin preparations for the production of premixes

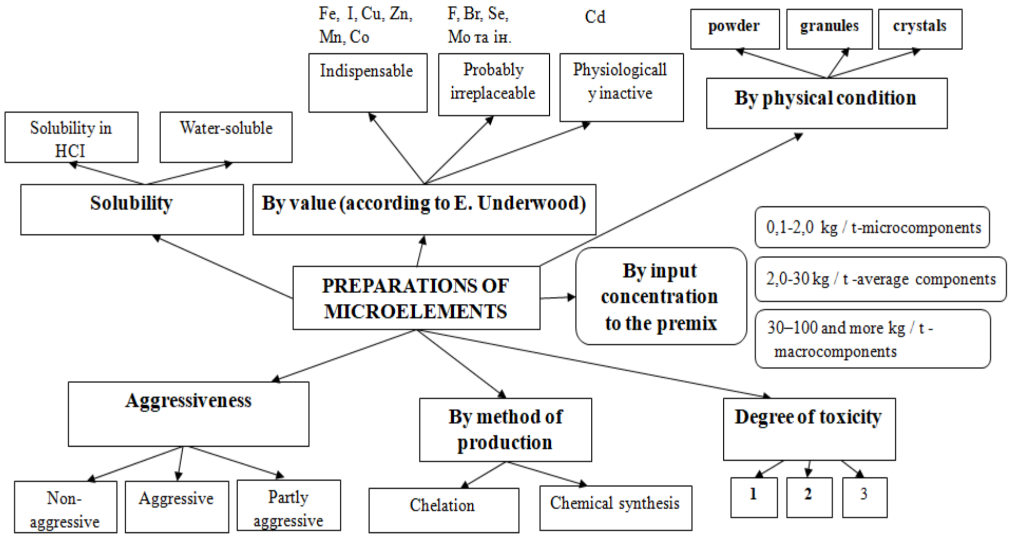


Fig. 7. Classification of preparations of salts of trace elements for the production of premixes

Table 4 – Problems and ways to solve them in the preparation of BAS in the production of premixes

No.	Problem	Consequences	Solutions
1	Difference in the physical properties of BAS (particle size, density, bulk density).	Self-sorting of the mixture during movement and transportation, demixing while loading/unloading containers and hoppers during storage.	Particle size distribution of components taking into account the norms of particle size for farm animals and poultry. Application of complex fillers.
2	Bioavailability	Reduced productive action of premixes.	Use of stabilised forms of BAS. Technological methods of preparation and introduction of BAS.
3	Use of liquid and dry forms of BAS drugs.	Reduced activity of BAS in the composition of finished premixes and feed. `	Use of protected forms of BAS drugs. Special technological methods and technological equipment for introduction at different stages of production.
4	Number of particles in a single dose	Decrease in the productive action of premixes, inequality in a herd, diseases, death of farm animals and poultry.	Careful particle size preparation of components. Preparation of premixes and high-efficiency technological equipment for mixing.
5	Homogeneity of BAS distribution in premixes.	Decrease in the productive action of premixes, inequality in a herd, diseases, death of farm animals and poultry.	Application of special technologies for preparation of premixes and highly efficient technological equipment for mixing.
6	Compatibility of components in the composition of premixes, especially in the composition of concentrated blends (re-premixes).	Destruction of the active components of a blend (pre-premix). Reduced productive action of premixes.	Separate preparation of BAS by groups, the introduction of choline chloride at the final stage of production. Production of enrichment mixture with a minimum concentration of all BAS depending on the species of farm animals and poultry. Application of special feeding programs.
7	Non-compliance with the premix formulation.	Decrease in the productive action of premixes, inequality in a herd, diseases, death of farm animals and poultry.	Calculating the content of vitamins, trace elements, and other BAS, mechanical losses during production. Control over technological processes of production. Application of high-precision dosing and technological methods of mixing components in several stages. Application of feeding programs.
8	Toxicity	Reduced productive action of compound feeds. Diseases of animals, staff.	Granulometric preparation of components, application of preliminary mixes. Dilution with one of the components of feed.
9	Use of blends	It is economically feasible due to lower transport costs of delivery, but reduces the quality of premixes due to the interaction and results in the production of inactive (“dead”) premixes. Adverse effects on the health of employees.	Application of special microdosing and mixing units. Preliminary preparation by diluting the concentration before the main mixing with other components of the feed. Production of PVS, PMVS.
10	Transportation, relocation, storage	Reduction in the homogeneity, self-sorting and demixing of premixes, reduction in BAS activity.	Compliance with the conditions of transportation and storage (ambient temperature from –5 to +25 °C, humidity not more than 70%, special transport). Formation of premixes. Use within 1 month.

Conclusion

Thus, based on summarising the results obtained, classifications of bioactive substances for the production of premixes have been developed. These classifications take into account the peculiarities of the production technology. In the production of highly homogeneous enrichment mixtures, premixes, protein-vitamin supplements, and protein-mineral-vitamin supplements should be based on proper calculation of interrelation and interaction of BAS with each other within a complex, since not every mixture gives the desired result of feeding. While making micronutrient feed preparations, special attention should be paid to the particle size and the degree of bioavailability of micronutrients. Preference should be given to chelated compounds of micronutrients, as they are more bioavailable. When making a premix, the particle size in the preparation of the filler should not be more than 0.8 mm. During the production process, to ensure a more uniform distribution of bioactive substances in a premix, its components should be pre-grouped into three groups depending on their content in the premix and bulk density: 0.1–2.0 kg/t; 2.0–30.0 kg/t, 30.0–100.0 and more kg/t, and two-stage and three-stage dosing and mixing should be used. Pre-enrichment of mixtures will reduce the cost of raw materials and the specific cost of electricity for production, as well as ensure the homogeneity of the components in the premixes and in the composition of ready-made feed.

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ТЕОРЕТИЧНЕ ТА ЕКСПЕРИМЕНТАЛЬНЕ ОБҐРУНТУВАННЯ ПІДГОТУВАННЯ БІОЛОГІЧНО АКТИВНИХ РЕЧОВИН ДО ВИРОБНИЦТВА ВИСОКООДНОРІДНИХ СУМІШЕЙ

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Анотація. У статті наведено теоретичне обґрунтування підготовки препаратів біологічно активних речовин для виробництва високооднорідних сумішей. Представлено теоретичні та експериментальні дані з визначення фізичних, технологічних та хімічних властивостей вітамінних препаратів, сірчанокислих та вуглекислих солей мікроелементів. Розглянуто питання взаємозв'язку, сумісності та прояву ефектів синергізму і антагонізму, одностороннього та взаємного впливу між макро- і мікроелементами, вітамінними препаратами та мінеральними речовинами. В роботі проаналізовано вплив складу преміксу, наповнювача, його властивостей на активність біологічно активних речовин. Також наведено данні впливу вологості, значення pH, температури, фізичних властивостей на ступінь біодоступності речовин. Досліджено розмір частинок, ступінь однорідності розподілення біологічно активних речовин при змішуванні з наповнювачем преміксів. Встановлено, що суттєвий вплив для одержання однорідних сумішей оказує розмір та форма частинок. На основі узагальнення характеристик біологічно активних речовин, аналізу фізичних, технологічних та хімічних властивостей препаратів біологічно активних речовин, а також особливостей їхньої підготовки і технологічних етапів виробництва преміксів розроблені класифікації біологічно активних речовин для: вітамінних препаратів та солей мікроелементів. Наведено поетапну структуру комбікормової технологічної системи з виробництва преміксів у порівнянні з попередніми технологіями. На основі теоретичних та експериментальних досліджень обґрунтовано розділення біологічно активних речовин на три групи та їхню підготовку при виробництві преміксів в залежності від об'ємної маси, розміру частинок, відсоткового вмісту в складі преміксів: 0,1 до 2,0 кг/т; 2,0 до 30,0 кг/т, 30,0 до 100,0 і більше кг/т. Визначено діапазони розмірів частинок компонентів премікса, який знаходиться у межах 0,04–0,6 мм, при цьому розмір частинок наповнювача не повинен перевищувати 0,8 мм. Проаналізовано проблеми підготовки біологічно активних речовин при виробництві преміксів та запропоновано рекомендації для їх вирішення з метою одержання однорідних сумішей, преміксів, білково-вітамінних добавок, білково-мінерально-вітамінних добавок.

Ключові слова: біологічно активні речовини, вітамінні препарати, солі мікроелементів, властивості, технологічна система, класифікація, премікс, однорідність.