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Research Article

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Preparation and application of fodder vitamin additive choline chloride B4 on the basis of dried beet pulp in premix composition

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ABSTRACT

At present, almost all factories producing premixes switched to the use of imported dry products due to technological reasons related to the difficulties of input of liquid choline chloride. However, these expensive preparations have a high adsorption and capillary-osmotic activity, their use leads to premature hydration of choline chloride, loss of its free-flowing properties and to the reduction of storage time. In this regard, cheaper domestic products and innovative production technologies are needed. This research is devoted to this direction. The main goal of the research is to expand the assortment of feed preparations based on the creation of an energy-saving and environmentally friendly technology for the production and storage of powdered choline chloride based on beet pulp as filler. The objectives of the study included: development of a method for the production of choline chloride based on beet pulp; study of quality indicators of premixes containing powdered choline chloride based on beet pulp. Materials and methods. Experimental line for the production of choline chloride based on beet pulp. Quality indicators of premixes with choline chloride content based on beet pulp (humidity, pH of aqueous extract, vitamins A, E, B1, B2, B4, volumetric weight and angle of repose) were determined according to GOST-approved methods. Findings. An energy efficient method of obtaining a finished product due to the fact that the spent superheated steam after the vibration drier is sent to heat the atmospheric air taken from the environment and, therefore, its thermal potential is used more fully, is developed. High quality choline chloride powder based on sugar beet pulp was obtained.

Keywords*: choline chloride, dried beet pulp, feeding, steam drying*

INTRODUCTION

The organization of high-grade feeding and the development of the formula of mixed fodders is based on the wide use of additives of the medical and preventive direction and requires an understanding of the needs of various species and age groups of farm animals and poultry in basic nutritional elements, and first of all in choline chloride (vitamin B4) [1, 2]. Choline is a part of the phospholipid lecithin and is one of the main representatives of lipotropic substances that prevent fatty liver infiltration. It also serves as an important source of methyl groups necessary for the biochemical processes occurring in the body [3, 4].

In farms using diets with vitamin and mineral complexes without choline chloride, there are many problems that often are not associated to the lack of this valuable vitamin. Vitamin B4 is absent in vitamin complexes, because it is impossible to ensure the safety of vitamins if choline is introduced in the composition of vitamin complex [5-7]. In addition, choline at a high dosage negatively affects the stability of vitamins present in premixes and mixed fodders during storage, which also makes it difficult to use it in the composition of highly concentrated mixtures [8]. The best solution to this problem is the use of full premixes, the production technology of which will allow the introduction of vitamin B4 into the mixture without affecting other components [9-12].

At present, almost all factories producing premixes refused input of liquid choline chloride and transferred to the use of dry preparations from Germany, France, Holland, Hungary, the USA, Canada of such major companies as BASF, Rhone-Poulenc, Akzo Nobel. In the opinion of these producers, the use of liquid choline chloride in feed production is associated with technological difficulties in storing, transporting and inputting it into the premix, as it is unevenly distributed over the volume of the mixture that can lead to overdose and death of animals and birds [13-16]. In this regard, the development of innovative technologies for the production of powder choline chloride and the study of its effect on the quality of premixes is of current importance.

At the present stage of production development, choline chloride is obtained on the basis of fillers with high adsorption and capillary-osmotic activity [17]. Preference is given to fillers that do not lead to premature hydration of the product, increase the accuracy of dosing and can have a long-term shelf life and free-flowing properties [18]. Zeolite, chalk, bran, corn cobs, etc., can be a carrier in the production of free-flowing choline chloride.

The possibility and expediency of using beet pulp as filler, which is a waste of sugar production and at the same time contains carbohydrates, proteins, biologically active and mineral substances, has been studied in this paper. Pulp is cheap, but at the same time valuable and highly digestible forage. About 20 kg of cellulose, 30-35 kg of hemicellulose, about the same amount of pectin, 8-10 kg of proteins, 2-3 kg of sugar, and about 2 kg of mineral substances contained in 100 kg of fresh pulp dry matter. 100 kg contains 85 feed units. In the composition of mixed fodders, it can replace in pigs' diets 20-30%, in cattle up to 50% of barley or oats.

The combination of a 70% aqueous solution of choline chloride and dry beet pulp as a filler will make it possible to obtain a feed additive in the composition of full-feed for agricultural and domestic animals and poultry, which has such pronounced functional properties as hepatoprotective, antioxidant, lipotropic and probiotic activity during their feeding [19, 20].

MATERIALS AND METHODS

The developed line for the production of powdered choline-chloride based on beet pulp is presented in the work. The resulting product was added to the premix according to the P1-1 recipe based on bran for the breeding stock of laying hens. Choline chloride based on beet pulp was added to the pilot batches of premixes in the amount of 80, 120, 160 and 200 kg/t, respectively. The quality of premixes was assessed by the following indicators: humidity according to GOST 13496.3-92. "Mixed fodder, feed forage. Method for determining moisture."; pH of the water extract according to GOST R 51637-2000. "Premixes. Methods for determining the mass fraction of microelements (manganese, iron, copper, zinc, cobalt)."; vitamins A and E according to GOST R 50928-96. "Premixes. Methods for the determination of vitamins A, D, E." ; vitamins B1, B2, B4 according to GOST R 50929-96. "Premixes. Method for the determination of B vitamins"; vitamin C according to the methods developed by the All-Russian Research Institute of the Feed Mixed Industry; volumetric weight and angle of repose according to GOST 28254-89. "Mixed fodder, feed forage. Method for determining the volumetric weight and angle of repose.".

RESULTS

The main object of the study was a 70% aqueous solution of choline chloride, the quality of which (Table 1) allows it to be effectively used in the composition of mixed fodders.

The experimental batch of the product was made on the experimental line for the production of powdered choline chloride from its aqueous solution based on dry beet pulp (Figure 1).

The line included the following equipment: 1 - crusher, 2 - sifter, 3 - mixer (screw conveyor), 4 - nozzles, 5 - heat exchanger, 6.1 - vibration dryer for drying beet pulp with superheated steam, 6.2 - dryer for drying loose choline chloride with atmospheric air, 7 - cyclones for cleaning spent superheated steam and spent air, respectively, 8 - steam superheater, 9 - fan, 10 - pump, 11 - duct heater.

Wet pulp with a solids content of 16-18% was fed to the dryer 6.1, where it was dried with superheated steam of atmospheric pressure at a temperature of 150-155 ° C in a pulse vibro-boiling layer [21]. In the working chamber of the dryer, every 60 seconds, the product layer was brought into a vibro-boiling condition for 3 seconds; the amplitude and frequency of the oscillations were 7 mm and 12.5 Hz, respectively. At the same time, the superheated steam velocity was constant - 2 m/s.

The drying was carried out in alternating fluidized and vibro-boiling regimes to a solids content of 87-88% in the finished product.

The spent superheated steam from dryer 6.1 was sent for cleaning to cyclone 7, and then divided into two streams. A part of the spent superheated steam with t = 110 ° C was supplied to the duct heater 11 where condensation occurred. At the same time, atmospheric air was heated to a temperature of 65-70 ° C, which was then fed to an experimental dryer 6.2 by a fan 9.

Another part of the spent superheated steam through the recirculation loop was supplied to the steam superheater 8 by fan 9 for heating steam to a temperature of 150-155 ° C and further to the dryer 6.1.

Beet pulp, dried to a moisture content of 12-13%, was crushed on a grinder 1 (working gap of 1 mm).

The milled product was fractionated on a sifter 2 with sieve cell diameter of 1.0 mm. The coarse fraction was sent for regrinding to the crusher 1, and the fine fraction, characterized by passage through a sieve of not less than 95%, was fed to the mixer 3, where it was mixed in a ratio of 2:3 with the initial 70% aqueous solution of choline chloride that was fed into the mixer by nozzles 4 at a pressure of 0.2-0.3 MPa.

The resulting mixture with a humidity of 47-50% was sent to a vibration drier 6.2. The heat carrier was atmospheric air heated in the duct heater 11 to a temperature of 65-70 ° C.

The spent atmospheric air with a temperature of 40-45 ° C from the dryer 6.2 was supplied to the heater 5 to preheat the initial solution of choline chloride in order to reduce its viscosity. This creates favorable conditions for uniform spraying of choline chloride into the mixer 3, ensures reliable operation of the nozzles 4 and reduces the load on the pump 10.

To study the effect of the obtained choline chloride on product quality, four pilot batches of premixes of prescription P1-1 on the basis of bran for the breeding population of laying hens with different contents of choline chloride were developed.

In pilot batches, choline chloride based on beet pulp was introduced in an amount of 80, 120, 160 and 200 kg/t, respectively.

Experimental batches of premixes weighing 10 kg were prepared on an experimental basis of JSC "Voronezh Experimental Feed Mill." In laboratory conditions, samples of experimental batches of premixes were stored under various artificially created regimes: in a refrigerator and in a thermostat. In the refrigerator and the thermostat, the preset temperature and the certain humidity of the air are constantly maintained. Specified humidity of air in desiccators was created by aqueous solutions of sulfuric acid, which were in them.

During the entire storage period, once a month, the acidity was determined by the method of N.K. Florenskaya, pH - on the potentiometer pH-340 and the activity of vitamins.

In connection with the existing problem of loss of vitamin activity in premixes containing choline chloride, experiments of their storage were conducted.

The storage was carried out in the warehouse of the experimental base of the JSC "Voronezh Experimental Feed Mill" during the period from August to December. The average temperature varied from +19.2 ° C to +0.6 ° C. Relative air humidity was within the range of φ = 66-79%.

DISCUSSION

The data obtained in the study of premixes quality indicators based on bran with different contents of powdered choline chloride based on beet pulp is presented in Table 2 and 3.

During the experiment, the active acidity of the premixes did not change significantly and the pH value was within the range of 4.7-5.1.

It is known that vitamin C is the most labile component to the action of the prooxidative system of choline in combination with iron and copper ions. In our experiment, storage of products within one month resulted in a decrease of vitamin C content. Its activity in the studied variants was 32.4-78.9 %. After two months of storage, further significant destruction of the vitamin was noted, especially in experimental batches containing high amount of choline chloride. After three months, the content of vitamin C in premixes decreased by 3-5 times and by the end of the experiment only its traces were found.

Vitamins B1 and B2 were characterized by higher stability and their loss after five months of storage in the experimental and control variants did not exceed 10%.

During the entire shelf life, premixes containing choline chloride in the amount of 80 and 120 kg/t were not caked, kept flowability and appearance without signs of spoilage, their volumetric mass did not change significantly. The premix containing choline chloride in the amount of 160 kg/t by the end of the fourth month of storage was caked, and the premix containing 200 kg/t of choline chloride was caked by the end of the first month of storage.

In a premix containing 160 kg/t of choline chloride, an increase in the angle of repose was observed after 3 months of storage. Consequently, the introduction of a large amount of choline chloride into the premixes results in a reduction in the period of their safe storage.

The results of the study of the hygroscopic properties of premixes with different contents of the new choline chloride preparation are presented in Table 4.

The obtained data indicate that premixes with high choline chloride content should be stored in paper bags in accordance with GOST 2226-88.

High hygroscopicity of the product is retained when it is added to premixes. It, as well as other components of premixes of organic and mineral origin, is able to absorb (sorb) from the environment and to exude (desorb) water vapor into it. The amount of moisture retained by the premix depends on its chemical composition, physico-mechanical properties, as well as on the relative humidity and temperature of the ambient air [22, 23].

A comparative study of the quality influence of new (variant 2) and used (variant 1) of choline chloride on the quality of premixes during storage was also carried out. The content of vitamin B4 in the production was 120 kg/t (Table 4). In this table, the content in % of the vitamin to its initial content in the premix is indicated in brackets.

There was no significant discrepancy in the results during the comparative analysis.

CONCLUSION

The proposed experimental line has revealed the following advantages:

- to obtain powdery choline chloride of high quality due to the use in the scheme of an effective method for drying beet pulp by superheated steam of atmospheric pressure;
- to ensure the preservation of vitamin B4 in the finished product, because the drying of powdered choline chloride is carried out by atmospheric air at a low temperature of 65-70 ° C;
- to eliminate the thermal destruction of vitamin B4 in the initial aqueous 70% choline chloride solution due to its heating by spent atmospheric air with a sufficient low temperature of 40-45 ° C;
- to increase the energy efficiency of the method for obtaining the finished product due to the fact that the spent superheated steam after the vibration dryer is sent to heat the atmospheric air taken from the environment and, therefore, to make fuller use of its thermal potential.

The results of studying the quality indicators of choline chloride based on beet pulp in the premix make it possible to recommend it for mass production. Adding it in quantities provided by the majority of approved recipes does not adversely affect the quality of the products during storage.

An effective way to increase the shelf life of premixes with a high content of choline chloride is the use of bags with a film liner in accordance with GOST 19360-74 or polyethylene bags in accordance with GOST 17811-78 when packing products, instead of paper bags in accordance with GOST 2226-88.

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Table 1. Quality indicators of 70% aqueous choline chloride solution

Indicator	**Value**
Mass fraction of choline chloride, %, within the limits of	68.00–72.00
Colority in units of optical density, not more than	0.20
Mass fraction of hydrochloric acid salts in terms of hydrochloric trimethylamine, %, not more than	0.25
Harmlessness in the test dose: per rat, mg/kg or per mouse, mg/kg	 2000.00 3000.00
Appearance	Transparent liquid without mechanical impurities

Table 2. pH change of the premixes of recipe P1-1 during storage

Premix variant	**pH at the beginning of storage**	**Shelf life, months**				
		1	**2**	**3**	**4**	**5**
1 (80 kg/t)	5	5.1	5	5.1	5.2	5.1
2 (120 kg/t)	5	5	5.1	5.1	5	5
3 (160 kg/t)	4.9	4.9	4.9	4.9	4.9	4.8
4 (200 kg/t)	4.8	4.8	4.9	4.8	4.9	4.7

Table 3. Variation in the content of vitamins in premixes with different amounts of choline chloride during storage

Premix variant	Original content	Shelf life, months				
		1	2	3	4	5
	million M.U./t	**Vitamin A, % to the original**				
1	1402.7	93.6	93.3	85.2	80.8	77.1
2	1383.8	93.4	87	82.2	80.4	71.2
3	1320.3	91.8	82.1	72.4	63.4	48.7
4	1350.8	73.4	–	–	–	–
	g/t	**Vitamin E, % to the original**				
1	573.3	93.6	91.8	85.3	81.4	80.3
2	524.8	91.4	89.3	80.9	75.6	70.8
3	507.8	92.8	83.5	73.6	69.7	53.3
4	550.4	80.2	–	–	–	–
	g/t	**Vitamin B1, % to the original**				
1	211.6	98.9	95.4	91.2	96.1	85.5
2	175.5	100	95	94.8	94.3	87.1
3	207.6	100	93.7	93.6	91	85.6
4	203.4	85.2	–	–	–	–
	g/t	**Vitamin B2, % to the original**				
1	585.7	100	94.5	91.2	96.4	93.3
2	526.8	97.9	99.4	94.6	92.7	94.7
3	518.7	98.4	94.5	91.8	91.3	92.7
4	513.3	85.6	–	–	–	–
	kg/t	**Vitamin B4, % to the original**				
1	80.9	99.2	99	98.2	98.9	97.5
2	119.8	98.6	96.7	97.8	97.3	96
3	161.5	98.6	99	99.8	99.5	96.6
4	203.4	99	–	–	–	–
	kg/t	**Vitamin C, % to the original**				
1	5.45	78.9	71.6	58.3	31.4	traces
2	5.37	71.3	66.5	36.5	17.8	traces
3	5.31	75	71.4	40.3	22.4	traces
4	5.23	32.4	–	–	–	–

Table 4. Results of a study of the hygroscopic properties of premixes containing a different amount of choline chloride

Premix variant	The amount of added choline chloride, kg/t	Relative humidity, %	The equilibrium moisture content of premixes, %	Nature of moisture exchange
1	80	40	8.3	Desorption
		50	9.8	Desorption
		60	10.1	Desorption
		70	12.2	Sorption
		80	13.5	Sorption
		90	14.5	Sorption
2	120	40	8.3	Desorption
		50	9.9	Desorption
		60	11.2	Sorption
		70	12.3	Sorption
		80	13.6	Sorption
		90	15.1	Sorption
3	160	40	8.3	Desorption
		50	11	Sorption
		60	11.8	Sorption
		70	12.6	Sorption
		80	13.8	Sorption
		90	15.8	Sorption
4	200	40	10	Desorption
		50	12.2	Sorption
		60	13.3	Sorption
		70	15.1	Sorption
		80	16.3	Sorption
		90	17.8	Sorption

Table 5. Changes in the activity of vitamins in premixes with a new and used form of choline chloride under storage conditions

Premixes variants	Original content	Shelf life, months			
		1	2	3	4
	M ± m	M ± m	M ± m	M ± m	M ± m
Vitamin A, M.U./g					
1	1 493.9 ± 10.7 (100.0)	1 478.3 ± 7.9 (99.0)	1 368.3 ± 10.3 (91.6)	1 312.6 ± 12.0 (87.9)	1 248.5 ± 7.6 (83.6)
2	1 501.6 ± 9.6 (100.0)	1 450.9 ±6.78 (96.6)	1 374.3 ± 10.5 (91.5)	1 309.7 ± 8.4 (87.2)	1 249.0 ± 10.6 (83.2)
Vitamin E, g/t					
1	504.9 ± 4.7 (100.0)	489.7 ± 2.3 (97.0)	477.7 ± 4.4 (94.6)	457.1 ± 2.9 (90.5)	445.2 ±2.4 (88.2)
2	503.8 ± 3.9 (100.0)	490.5 ± 2.5 (97.4)	484.9 ± 5.6 (96.2)	468.7 ± 2.7 (93.0)	453.6 ± 2.4 (90.0)
Vitamin B1, g/t					
1	202.7 ± 2.1 (100.0)	199.5 ± 1.9 (98.4)	197.8 ± 1.6 (97.6)	191.7 ± 1.6 (94.6)	182.7 ± 2.5 (90.1)
2	201.9 ± 1.9 (100.0)	191.3 ± 1.9 (94.7)	190.2 ± 1.6 (94.2)	184.9 ± 1.9 (91.6)	181.3 ± 1.6 (89.8)
Vitamin B2, g/t					
1	396.7 ± 2.4 (100.0)	390.7 ± 2.2 (98.5)	383.3 ± 1.7 (96.6)	373.8 ± 1.4 (94.2)	366.4 ± 2.9 (92.4)
2	394.9 ± 1.7 (100.0)	391.2 ± 1.4 (99.1)	383.7 ± 1.7 (97.2)	377.3 ± 1.8 (95.5)	365.3 ± 1.7 (92.5)

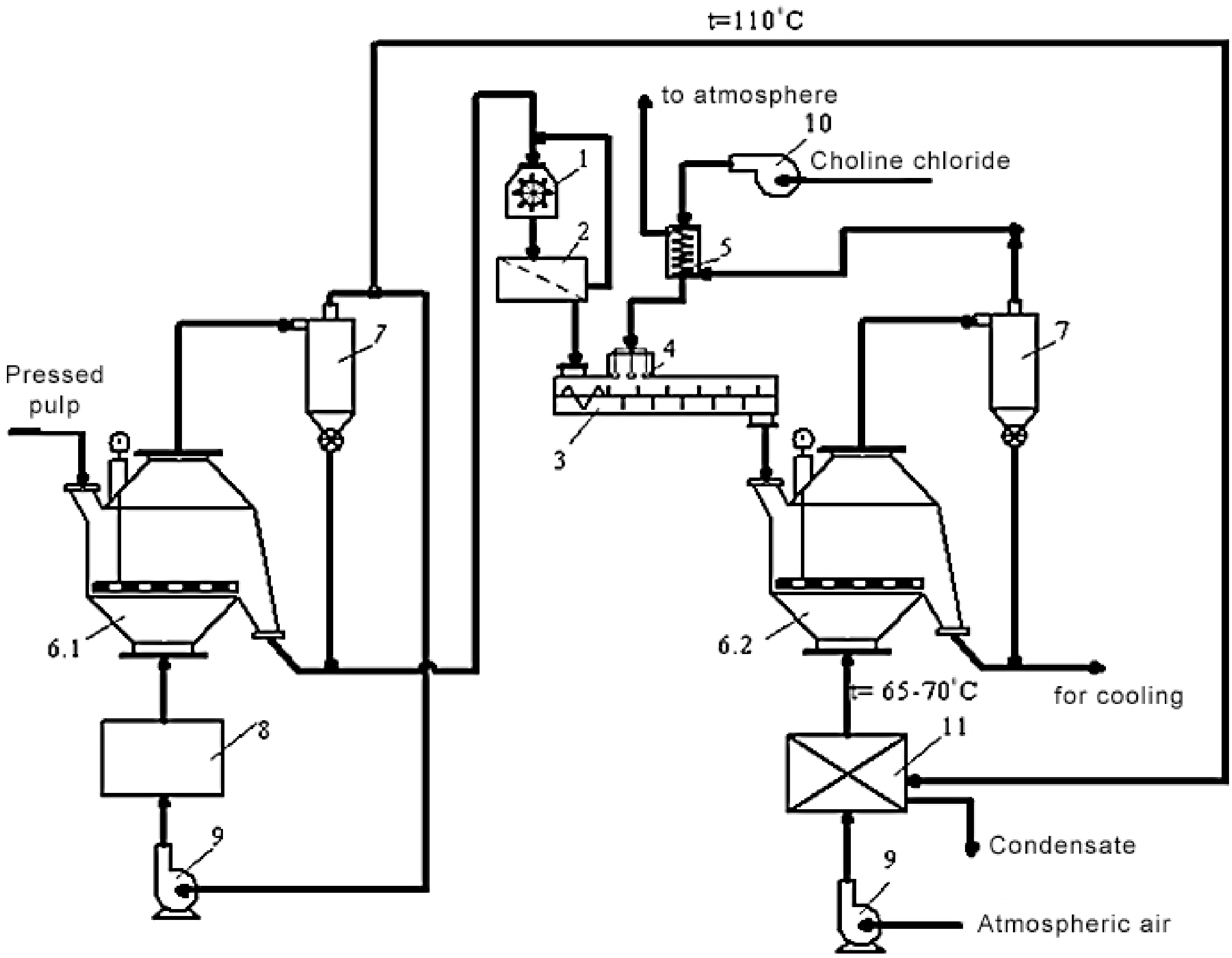

Figure 1. Experimental production line of powdered choline chloride based on dry beet pulp