Bulgarian Journal of Agricultural Science, 21 (No 4) 2015, 872-876
Agricultural Academy

STUDY OF PRODUCTION PROCESSES OF FEED ADDITIVES USING NATURAL MINERALS AND PLANT BY-PRODUCTS

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Abstract

ALIMKULOV, Z. S., S. T. ZHIYENBAYEVA, N. B. BATYRBAYEVA and A. P. KRASTEVA, 2015. Study of production processes of feed additives using natural minerals and plant by-products. *Bulg. J. Agric. Sci.*, 21: 872–876

We suggested optimum composition of feed additives for young stock which contains the following: 12.0% grape pomace feedmeal, 10% tomato waste feedmeal, 8% dehydrated potato feedmeal, 11% wheat germ, 10% maize germ, 13% maize gluten, 23% wheat middling, 4.0% feed schungite, 6.0% feed chalk, 3.0% salt. Feed additive nutritive value: crude protein – 18.02%, crude fat – 4.52%, crude fiber – 16.06%, crude ash – 7.14%, nitrogen-free extractive substances – 45.82%, dry matter (solids) – 88.3%, total sugar – 17.2%, vitamin C content – 0.75 g/1t, carotene content – 3.15 g/1t, fodder unit per 100 kg feed – 102.6. The ratio of components in the recipes defines balancing supplement animal feed, based on the resources of the formation of byproducts and creates the condition for receiving the feed additive tech and stable form. Study the process of grinding the components of the feed additive A comparison size distribution milled mixture byproducts at one and twostage grinding method revealed that the average particle size of the milled premix was more aligned and larger after a two-stage grinding. Investigate the process of mixing the feed additive, the coefficient of variation of salt - 7.06%, crude protein - 1.39%, crude fiber – 7.37%, the quality of the mixing process is satisfactory. Natural schungite impact on granulation process of feed additives was studied. Introduction of granulation of feed additives for calves that contain 4% schungite at optimal parameters allow obtaining a quality product.

Key words: grape waste meal, tomato waste meal, dehydrated potato feedmeal, schungite feed additive, feed additive, formula

Introduction

In Kazakhstan, most feed-milling establishments are mainly located in administrative centres and towns, with food and processing industry enterprises located nearby. Introduction of non-waste technologies of production of additives suitable for mixed feed in the enterprises will substantially expand a raw material base of their production (Alimkulov and Zhiyenbayeva, 2012).

In the CIS states, over 80% of the by-products and vegetable and fruit waste, either fresh or preserved, are fed down to animals. It was found that the protein contained in fruit and vegetable wet residues is limited for all farm animals. For this reason, fresh feeding is only possible provided that feeding stations are located at short distance away from the enterprises (Gryss, 1974).

For nutrient index, fruit waste equals most foodstuff of plant origin. For instance, the pomace left after processing of apples for juice excels other succulent feeds, including alfalfa and beet, per its nutrient content. For energy value and general nutrition, the pomace is of equal value to green feed; due to this, it can, either fresh or dry, be fed to animals and fowl (Zgardan, 1978).

Results of the research into digestibility of vegetable and fruit waste meal showed that it exceeds conventional rough feed digestibility considerably.

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Meal produced from tomato, grape and apple waste is characterized by a high content of crude fiber. Cellulose content of tomato polyuria, grape and apple pomace is lower than that of grass meal.

Meal produced from tomato polyuria, grape and apple pomace contains essential amino acids. Apple pomace meal is rich in amino acids such as tryptophane and arginine.

Per lysine content, grape pomace meal excels wheat and corn/maize 1.38 and 1.8 times, respectively; it is rich in amino acids such as tryptophane, isoleucine and threonine. Per tryptophane content, tomato polyuria meal excels wheat 2.3 times (Shumansky, 1994).

In terms of physical characteristics, vegetable and fruit (waste) meal has a number of disadvantages that negate the effectiveness of its use as a feed ingredient. Feed meal is hygroscopic; upon storage it is exposed to spontaneous heating (Mixed Feed Industry Abroad, 1984).

Studies conducted in the field suggest that feed value of these wastes can be enhanced at accurate application of manufacturing methods.

Currently, scholars are paying ever more attention to the use of locally-found natural minerals for feeding farm animals and fowl. Natural minerals like zeolites, bentonites, schungites, and vermiculites have a positive impact on digestibility of the used feed nutrients; and consequently, they improve conversion and increase production (performance) of animals and fowl.

In this view, natural schungite represents the greatest scientific and practical significance; large deposits of the mineral were found in Koksu field, Almaty Region. Occurrence of a lot of essential mineral substances (calcium, potassium, silicium, iron, manganese, zinc etc.) in schungite and unique catalytic, ion-exchange and bactericidal properties enable its use as an environmentally sound natural mineral additive in animal and fowl ration.

Veterinarian and toxicological evaluation of Koksu field schungites on laboratory animals has shown that the mineral is nontoxic and it can be applied as a feed additive and various hygiene products in veterinary (Sarsembayeva, 2006).

Materials and Methods

Quality parameters of a raw material, feed additives and mixed feed had been determined by the following methods: moisture content – as per GOST 13496.3-92; crude protein and nitrogen content – as per GOST 13496.4-93; crude fat content – as per GOST 13496.15-97; crude fiber content – as per GOST 13496.2-91; crude ash content – as per GOST 26226-95; total acidity – as per GOST 13496.12-92; weight by volume and natural angle of slope – as per GOST 28254-89; flowability – according to V.E. Pestov, schungites' chemical composition – in compliance with the Instructions 246-Ñ; total sugar – as per GOST 8756.13-87; vitamin C content – as per GOST 24556 – 89; pectin content – as per GOST 29059-91.

Experimental research of manufacturing methods for production of feed additives from grape and vegetable wastes and mixed feed thereof for young stock was carried out, and process technologies were tested with application of an experimental line of the Kazakh Scientific Research Institute of Processing and Food Industry LLP and a feed plant of Otes Bio Asia LLP.

Results and Discussion

In fruit and vegetable processing, primarily the following by-products are obtained: grape pomace feed meal, tomato waste feed meal and dehydrated potato feed meal.

Fruit and vegetable by-products have an adequate feed value and are partly applied in farm animals' ration. Use of the products is associated with a number of complications. For example, grape pomace and tomato waste feed meal becomes rancid rapidly, is difficult to transport; dehydrated potato feed meal has high caking ability, low nutrient index and high ash content.

There is Koksu field in the Almaty region. Resources of schungite containing formations to a depth of 100 m by the category of $Ð_3$ make 50.22 million tons with the average content of C_{org} – 10%. A processing plant for schungite raw materials was constructed in 2002 on this territory. Schungite samples with the fineness of 1.0 mm were taken from the Koksu plant for schungite raw materials to be studied.

In per cent terms Koksu field schungite contains: CaO – 6.0; MgO – 2.0; Fe_2O_3 – 6.0; Al_2O_3 – 10.0; SiO_2 > 60.0; Na_2O – 0.3; K_2O – 2.0; Co – 0.002; Zn – 0.08; Cu – 0.015; P – 0.15; Mn – 0.20; C_{org} – 10.0 (test certificate is enclosed). Heavy metal and radionuclide content is not more than the limit of use of the mineral in feeding farm animals.

Physical and mechanical properties of feed additive ingredients are presented in Table 1. Chemical composition of plant by-products is represented in Table 2.

It becomes obvious from the above-given data in Table 2 that each type of plant by-products contains nutrients per which feed value of mixed feed stock is assessed; at this, protein content in grape pomace, tomato waste and dehydrated potato feed meal accounts for 9.82%, 8.77% and 6.22% respectively.

There are 6 recipes prepared to make feed additives for cattle. These recipes are distinguished by the proportion of feed flour made of grape polyuria - from 6 to 16%, feed flour made of tomato waste products - from 6 to 16%, feed flour made of dehydrated potatoes waste products - from 6 to 16%; the con-

Table 1
Physical and Mechanical Properties of Feed Additive Ingredients

Indices	Plant By-Products					
	Grape Pomace Feedmeal	Tomato Waste Feedmeal	Dehydrated Potato Feedmeal	Wheat Germ	Maize	
Moisture, %	9.82	9.77	6.22	11.2	11.74	10.76
Natural Angle of Slope, degree	40	42	38	43	42	44
Weight by Volume, kg/m3	410	420	480	510	500	520
Flowability, kg/cm2.sec.	0.052	0.054	0.65	0.061	0.06	0.058
Mean Particle Size, mm	2.32	2.02	1.76	2.02	1.98	1.96
Caking Ability	Non- Caked					
Acidity, pH	5.2	6.4	4.2	4.4	5	4.4

Table 2
Chemical Composition of Plant By-Products

Indices	Grape Pomace Feedmeal	Tomato Waste Feedmeal	Dehydrated Potato Feedmeal
Crude Protein, %	9.82	8.77	6.22
Crude Fat, %	2.12	2.02	1.14
Crude Fiber, %	17.8	13.72	12.64
Total Sugar Content, %	26.4	19.3	21.2
Metabolic Energy, mJ/kg	9.3	8.24	7.72

tent of wheat and corn corcles, corn gluten, wheat middlings, feeding schungite, chalk and fine salt remains changeless.

Studies of pilot batches with feed additives, according to the developed recipes, showed that the introduction of feed flour, made of grape polyuria and tomato waste products, over 12% is undesirable because of the impoverishment of protein and fat and the increase of cellulose and ash content. Feed additives, where the content of flour made of grape polyuria and tomato waste products exceeds 15%, lead to the deterioration of organoleptic indicators and the reduction of technological properties. Therefore, their introduction to the content of feed additives should be limited to 12%, and to 10% - for flour made of dehydrated potatoes waste products.

We suggested optimum composition of feed additives for young stock which contains the following: 12.0% grape pomace feed meal, 10% tomato waste feed meal, 8% dehydrated potato feed meal, 11% wheat germ, 10% maize germ, 13% maize gluten, 23% wheat middling, 4.0% feed schungite, 6.0% feed chalk, 3.0% salt. Feed additive nutritive value: crude protein – 18.02%, crude fat – 4.52%, crude fibre – 16.06%, crude ash – 7.14%, nitrogen-free extractive substances – 45.82%, dry matter (solids) – 88.3%, total sugar – 17.2%, vitamin C content – 0.75 $g.t^{-1}$, carotene content –3.15 $g.t^{-1}$, fodder unit per 100 kg feed – 102.6. Ingredient ratio in formula defines a balancing mixed feed additive on the assumption of resources for by-products and establishes a condition for producing a technological and stable form of a feed additive.

Feed additive preparation technology consists of the following processes: dosing of feed additive free-running ingredients in volumetric measurers according to a formula and their delivery to a mixer; two-phase co-milling of meal mixture, pelleting of crumbled feed additives in a pelleting press and cooling of pellets in a tray cooler; dressing/sieving of pelleted feed additives for separation of small particles and stockpiling of a finished product.

It is common knowledge that the two-phase milling of stock with interim sieving is an advanced manufacturing method; it promotes an increase in productivity of milling equipment, saving energy costs and ensures manufacture of products of required fineness.

It has been established through laboratory researches carried out by KazSRI PFI that the required fineness and granulometric characteristics of feed additives may be best obtained via two-phase refinement of ingredients using 2-speed hammer mills. The mentioned milling method had been tested on experimental processing line of the Institute.

Efficiency of various milling methods was examined per the following key parameters: machine capacity, specific energy consumption and fineness of milled products. Upon running experiments on mills, screens with opening diameter of 2, 3, 4, 5 mm were set. Other operative parts and operating conditions of the mills complied with the rated values. Separator À1-DMP (Russia) was used for fractionation of a milled product; on sorting frames of the separator perforated screens with opening diameter of 2 mm were set.

Experiments were carried out using the stock – grape pomace, tomato polyuria, rough waste of dehydrated potato, maize and wheat germ and maize gluten and a mixture of the products according to a formula.

Analysis of one-phase and two-phase milling of separate ingredients using Ì-150 mill demonstrated that maximum output and the least specific energy consumption were observed while milling press residues. Mill capacity on screens with opening diameter of 2, 3, 4, 5 mm is 0.2, 0.3, 0.4, 0.5 $t.h^{-1}$, specific energy consumption is 1.6; 1.4; 1.2; 1.1 kWh. t^{-1}, respectively.

Upon milling dehydrated potato wastes, capacity fell, power consumption increased as compared to results received at milling tomato polyuria. Depending on screens' opening diameter, mill capacity shrank by 8-15.5%, and specific energy consumption increased by 5.0-14.5%.

The most energy consumption, and consequently the least mill capacity were observed in dehydrated potato milling; Energy consumption at milling 1t waste in the mill with screen opening diameters 2, 3, 4, 5 mm was 1.2; 1.05; 1.01; 0.7 $kWh.t^{-1}$, and mill capacity made 0.05; 0.1; 0.15; 0.3 $t.h^{-1}$, respectively.

Comparative results of the research into milling a mixture of plant by-products allow us to predetermine those technical and economic features of the mixture milling process are close to those of corn.

Comparison of technical and economic features of one-phase and two-phase milling methods showed that maximum effect is achieved when setting a screen with an opening diameter 4 mm. Thus, when milling dehydrated potato wastes with 4 mm screen, line speed (capacity) grew by 17.8% in comparison with one-phase milling; for press residues and a mixture of products, line capacity rose by 16.7 and 16.6% against 12.8 and 14.4% (one-phase milling), respectively.

At two-phase milling, each milled ingredient is attributed certain fineness (particle size). Thus, while particle size of milled grape pomace is the biggest with 0.93 - 1.2 mm, fineness of dehydrated potato wastes and the mixture ranged between 0.9 - 1.1 mm and 0.75 - 0.90 mm, respectively.

Comparison of the granulometric characteristics of the milled mixture of plant by-products at one-phase and two-phase methods demonstrated that mean particle size of the milled preliminary mixture was more even and larger after two-phase method.

Inclusion of required amount of ingredients into a feed additive structure is not sufficient to manufacture the feed additives. All the ingredients need to be well-distributed in the bulk of the mixed feed; it should be homogeneous. That is why providing effective distributive mixing is of primary importance.

Mixing efficiency in practice is evaluated per coefficient of variation (heterogeneity) V_c, which is a qualitative indicator of distribution of the assay value in the mixture:

$$V_c = \frac{100}{x}\sqrt{\frac{\sum(x_i - \overline{x}).^2}{n-1}},$$

where: $\overline{x}$ is the arithmetic average of the assay value (quantity content within the mixture), %; $\tilde{o}_i$ - the value of the studied quantity in the i-sample, %; n - the number of analysed samples.

Mixing efficiency of feed additive ingredients is, as a rule, determined through distribution of salt in it. However, crude protein, fibre, phosphorus or calcium may also be used as a key ingredient.

When making a feed additive, 20 spot samples 250 g each were selected at 15 sec interval by means of crossing jets. Mixing efficiency of feed additive ingredients for young stock was assessed per coefficient of variation of calcium, crude protein and crude fibre.

It can be seen from the quoted results that coefficient of variation of salt, calcium, crude protein and crude fibre ranges between 4.78 - 7.06%, 5.38 - 7.02%, 1.31 - 1.39% and 6.07 - 7.37% respectively. According to literature data, mixing quality of mixed feed at coefficient of variation of 7 -15% is deemed satisfactory.

Granulation (pelleting) is one of the advanced methods of mixed feed production for farm animals, fowl and fish; it allows preserve nutritive value of feedstuff, enhances tastiness and digestibility to animals, and improves physical and mechanical properties of mixed feed essentially.

To study the impact of schungite on granulation process at optimal values obtained at investigation with the use of experiment planning method, inspection lot of feed additives for calves without schungite and pre-production lot of feed additives for calves with 4% schungite had been worked out.

Feed additives' granulation had been performed on dies with a diameter of the hole of 7.7 mm. Clearance between press rolls and the die was 0.44 mm, steam pressure was 0.3 MPa.

Granulation efficiency was estimated per productivity of pelleting press, specific energy consumption and pellet durability. Results of experimental data related to granulation of feed additives with schungite are provided in Table 3.

Data obtained as a result of the conducted experiments illustrate that press machine capacity increased by 12.9% in preproduction lots as compared to inspection lots, specific

Table 3
Process indices of feed additives' granulation

Type of Feed Additive	Steam Pressure, MPa	Press-type machine capacity, t/h	Specific Energy Consumption, kWh/t	Temperature of the pressed mixture,	Moisture of the pressed mixture, %	Pellet quality			
						moisture, %	pellet diameter, mm	crumbling value of pellets, %	undersize Ø2mm,%
Feed additives for calves without schungite	0.3	5.4	9.6	74	17.2	14.3	7.7	7.7	6.7
Feed additives for calves with schungite	0.3	6.1	7.9	75	16.9	14.1	7.7	5.5	4.9

energy consumption was reduced by 17.7% and crumbling value of pellets fell by 29.6%.

Therefore, based upon the carried studies we can conclude that introduction of granulation of feed additives for calves that contain 4% schungite at optimal parameters allow obtaining a quality final product.

Conclusion

Examination of physical and mechanical properties of plant by-products showed that grape pomace feed meal has the least weight by volume and the biggest mean particle size. As contrasted to the other ingredients, tomato polyuria feed meal also has the worst physical properties; besides, at storage within 4-6 days acidity of the products rose by 18-22%. Analysis of chemical composition of plant by-products proved that they contain nutrients per which feed value of mixed feed stock is assessed; at this, protein content in grape pomace, tomato waste and dehydrated potato feed meal accounts for 9.82%, 8.77% and 6.22% respectively.

Optimum composition of feed additives for young stock which contains the following: 12.0% grape pomace feed meal, 10% tomato waste feed meal, 8% dehydrated potato feed meal, 11% wheat germ, 10% maize germ, 13% maize gluten, 23% wheat middling, 4.0% feed schungite, 6.0% feed chalk, 3.0% salt, has been suggested.

Milling, mixing and granulation processes of feed additives were studied. Comparison of granulometric characteristics of the milled mixture of plant by-products at one-phase and two-phase methods demonstrated that mean particle size of the milled preliminary mixture was more even and larger when the two-phase method was used.

Natural schungite impact on granulation process of feed additives was studied. Introduction of granulation of feed additives for calves that contain 4% schungite at optimal parameters allow obtaining a quality product.

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Received December, 15, 2014; accepted for printing May, 22, 2015