Development of technologies for the production of innovative phytobiotic and adaptogenic additives for animal nutrition

Vladimir Ermolaev[1]

Kuzbass State Agricultural Academy, Kemerovo, Russia

Abstract. The positive effects of phytogens on the growth, health, immunity and productivity of animals have been proven and they are often used in the form of essential oils and herbal extracts. There is evidence supporting the ability of phytogenic compounds, including extracts from alfalfa seeds, herbs, and essential oils, to influence the digestive system. We propose to study the innovative phytobiotic (Orthília secúnda) and adaptogenic (Velvet antlers) additives for animal nutrition. In this article we use a completely new technology of vacuum drying, which will allow phyto-additives to preserve all beneficial biological properties and be included in the diet of animals immediately after drying. Our new technology of vacuum drying will increase the shelf life of the supplemental product and receive the additives with predictable chemical composition and properties.

Keywords: phytobiotic, adaptogenic, Orthilia secunda, Velvet antlers, vacuum drying.

1 Introduction

The full realization of the genetic potential of the productivity of farm animals under industrial technologies is impossible without the inclusion into the diet of various biologically active additives that will increase productivity and normalize body homeostasis and provide proper functioning of the gastrointestinal tract. Earlier, such additives were represented by the feed antibiotics, which were used in the second half of the 20th century almost everywhere and in all branches of animal husbandry [17]. Also since the early 1990s zinc oxide (ZnO) has been used to control post-weaning diarrhea and promote growth in piglets [29]. However, it turned out that the excessive and uncontrolled use of antibiotic drugs adversely affected the body of animals and poultry. Therefore, from 2006 onwards the use of antibiotics for growth promotion purposes in the European Union was banned. Concerning ZnO, due to the fact that the use of zinc in feed

[1] Corresponding author: ermolaevvla@rambler.ru

contributes to environmental pollution, restrictions have been imposed on its use in feed. Currently, many EU countries have authorized the use of zinc oxide until 2022 to develop equally effective and safe feed additives to protect weaned piglets from digestive disorders.

In recent years, many scientists and practitioners working in the field of animal nutrition have paid attention to phytobiotics - biologically active substances formed in plants with antibiotic properties [8] and as well as to adaptogens - pharmacological drugs of natural origin [19].

Within the framework of the concept of sustainable development in the EU [18], phytogenic and adaptogenic compounds [9, 17, 27] can be used as a potential alternative to antibiotics in feed. The use of phytobiotic and adaptogenic additives fully complies with the ideology of environmentally friendly agricultural production and the objectives of improving the life quality of population [20, 21].

There are studies on the influence of individual representatives of phytobiotics and adaptogens on animals of various species. The positive effects of phytogens on the growth, health, immunity and productivity of animals have been proven and they are often used in the form of essential oils and herbal extracts [16]. There is evidence supporting the ability of phytogenic compounds, including extracts from alfalfa seeds [25], herbs [23], and essential oils [4, 28], to influence the digestive system.

A comprehensive study of the properties of plants and other valuable environmentally friendly additives containing phytobiotic and adaptogenic components neutralize such phenomena as the decrease in the immune and antioxidant status of animals, increase all types of productivity by improving consumption, digestibility, and accessibility of feed, normalization of intestinal microflora and homeostasis in general [15].

2 Conditions, materials and methods

There are numerous supplements that are given to animals but until now, there have been no sustainable additives ensuring a permanent therapeutic effect. Identification of optimal substances that would be effectively used in animal feed is necessary. So, in this article, we propose to study the innovative phytobiotic (Orthília secúnda) and adaptogenic (Velvet antlers) additives for animal nutrition.

Orthília secúnda is a perennial herb that grows in the forest zone of the Northern hemisphere; this species of the genus Orthília in the family Ericaceae is a phytobiotic supplement. Orthília secúnda is not listed on the Endangered-Species List, which allows it to be freely used without harming the environment [2, 12].

Orthilia secunda contains a very large amount of biologically active substances. For example, the plant contains arbutin – a phenolic glycoside; hydroquinone - an aromatic organic compound, a diatomic phenol; coumarins; vitamin C; flavonoids; resins; saponins; organic acids (tartaric and citric), as well as trace elements (titanium, copper, zinc, manganese). Many tannins were found in Orthilia secunda too [2, 14, 22, 26]. Moreover, Orthilia secunda contains phytoestrogens, which are similar in mechanism to female hormone functioning. Apparently, these phytohormones are able to stimulate reproductive processes in the body, which makes it possible to use Orthilia secunda in infertility treatment. In addition, flavanoids contained in Orthilia secunda have antioxidant activity and protect tissues from free radical damage. Orthilia secunda has immunostimulating properties. The hydroquinone found in this plant has antiseptic and anti-inflammatory properties. Currently, in traditional medicine, the use of biologically active additives with Orthilia secunda is allowed [22]. For example, the study [3] proved high efficiency of the use of such phytobiotics as Orthilia secunda on the regenerative functions of

protozoa. In general, Orthilia secunda is a very valuable phytobiotic [1, 7] containing many beneficial substances and trace elements, and it has anti-inflammatory, diuretic, and tonic properties [10]. However, little is known about its properties in animal nutrition and gastrointestinal functioning.

Considering our second biologically active additive - Velvet antlers, it should be pointed out that it has numerous useful properties. The first mention of maral antlers in the Chinese medicine refers to the manuscript discovered at the excavation of the Khan's tomb in 168 BC, it contains recipes for medicines based on them: powders, tablets, extracts, tinctures and ointments. Velvet antlers have a complex chemical composition, including about 40 chemical elements and about 400 complex chemical compounds. The composition of Velvet antlers is very diverse - there are a lot of amino acids, collagen, vitamins and macro- and microelements. Among these macronutrients there is iron, calcium, magnesium, sodium, phosphorus and potassium. Trace elements in Velvet antlers are represented by manganese, selenium, cobalt, copper and zinc, as well as iodine [14]. Moreover, the composition of Velvet antlers includes: 18 amino acids out of 22 naturally occurring, nucleosides (uracil, cytidine, hypoxanthine, xanthine, thymine, inosine, guanosine and adenosine), polysaccharides, peptides and hormones (testosterone, estradiol, dehydroepiandrosterone, erythropoietin, luteotropin) [11]. In eastern traditional healing systems, antlers are widely used to preserve human strength and youth, they are at the very top of the drugs used and are comparable only to ginseng, which is a scientifically proven fact [24]. Velvet antlers are known for their ability to maintain male strength even in old age. In the East, treatment with antlers concentrate in men is still considered the only effective means of prolonging youth, a folk remedy for longevity, which helps men live long without any urological diseases - prostatitis, impotence, urethritis and many others [14, 26].

Velvet antlers are deer antlers that grow annually as a natural phenomenon of these animals' development. Antlers have a tubular non-horny structure, they are filled with blood, covered with thin velvet skin with short soft hair, they have a life-giving force; thus, they present an adaptogenic supplement. Deer antlers are cut off from May to August, when males are most active, and antlers grow back easily. This procedure is harmless and painless for the animal because deer have a natural ability to shed and grow antlers annually. One deer can produce 8-9 kilograms of antlers per year [11, 12, 13].

After collecting Orthilia secunda and harvesting Velvet antlers, there is a problem with their correct preservation without loss of their useful initial properties. Traditionally, Orthilia secunda is subjected to the following processing: preparation of an alcohol solution, soaking in an alcohol solution, vacuum extraction, dewatering, drying, grinding by a rotary grinder. This technology is outdated, energy and time consuming and labor-intensive [11, 12]. According to the traditional technology of Velvet antlers preservation, they are boiled by alternating changing of boiling water scalding and sharp cooling, then they are fried in special ovens at a temperature of 60-80 oC and dried in the air. At the end of this process, the horns lose up to 20-40% of their original weight [13]. Traditional methods have several disadvantages: high-temperature effects, loss of useful properties of the product, and a decrease in quality.

In this article we are going to use a completely new technology of vacuum drying, which will allow phyto-additives to preserve all beneficial biological properties and be included in the diet of animals immediately after drying [5, 6]. The vacuum drying process will take place at a residual pressure of 2 to 10 kPa, the drying temperature of Orthilia secunda and Velvet antlers will not exceed 60 oC, as it can preserve all beneficial biological properties of these additives. Vacuum treatment will increase the shelf life of the supplemental product and receive the additives with predictable chemical composition and properties [5, 6]. Therefore, the aim of this

article is the development of technology for the production of chosen phytobiotic and adaptogenic additive for animal nutrition.

3 Results and discussion

Raw material for the experiment will be bought from certified producers located in eco-friendly regions of Siberia in Russia. Orthilia secunda will be supplied by the firm Genshen LTD, Khabarovsk http://dv-genshen.ru/kupit_borovaia_matka.html Velvet antlers will be supplied by the Maral Breeding Farm from the Altai Republic https://exportv.ru/zavod/roga-marala-ot-proizvoditelya.html

Before vacuum processing, the raw materials will be thoroughly washed in running water at a temperature of 40-50 °C. Then, Orthilia secunda will be chopped (cut) into pieces 8-10 mm long, but upper sections of Velvet antler - cut into slices 2-3 mm thick, and then dried.

Fig. 1 Appearance

Description of Vacuum drying processing

Orthilia secunda and Velvet antlers was vacuum dried with the following operating parameters (Table 1):

Table 1. Vacuum drying processing

(O1) – drying temperature 30 °C, residual pressure 2 kPa, heat flow density * kW/m^2, desublimator surface temperature * °C, drying time 300 min.
(O2) – drying temperature 40 °C, residual pressure 6 kPa, heat flow density * kW/m^2, desublimator surface temperature * °C, drying time 270 min.

(O3) – drying temperature 50 °C, residual pressure 10 kPa, heat flow density * kW/m^2, desublimator surface temperature * °C, drying time 240 min.
(V1) – drying temperature 40°C, residual pressure 3 kPa, heat flow density * kW/m^2, desublimator surface temperature * °C, drying time 240 min.
(V2) – drying temperature 50 °C, residual pressure 4 kPa, heat flow density * kW/m^2, desublimator surface temperature * °C, drying time 210 min.
(V3) – drying temperature 60 °C, residual pressure 11 kPa, heat flow density * kW/m^2, desublimator surface temperature * °C, drying time 180 min.

* - the parameters of the heat flow density and surface temperature of the desublimator are marked with the symbol due to the fact that we want to apply for a patent and do not want to disclose the know-how before registering this patent

After vacuum drying, we studied the kinetics of the process of vacuum drying of phytobiotic and adaptogenic additives. To study the processes of heat and mass transfer occurring in Orthilia secunda and Velvet antlers during vacuum drying, drying curves $U = f(\tau)$ and drying rate curves $dU/d\tau = f(U)$ were plotted. experiments. On the basis of drying curves and drying rate curves, a mathematical model of the process of vacuum drying of Orthilia secunda and Velvet velvet antlers was constructed using the methods of integral and differential calculus.

The method of raw material preparation proposed by us makes it possible to obtain additives with the required concentration of useful chemicals. It should be noticed that the raw material dried up to a moisture content of no more than 4-7% [6]. Then the dried Orthilia secunda and Velvet antlers will be cut in a rotary shredder to a fraction of no more than 50 microns and will be prepared for administration to animals. Before administration of the additives to animals the presence of impurities will be detected.

Planed research focuses on the significant and understudied problem of antibiotic replacement for farm animals and investigates the impact of phytobiotic and adaptogenic additives, that are prepared by unique technology. The invention of the best technologies for the production of novel substances will allow for preserving all beneficial biological properties of these additives. It will also allow us to use them in farm animals as potential alternatives to antibiotics. Also, our new technology of vacuum drying will increase the shelf life of the supplemental product and receive the additives with predictable chemical composition and properties. Moreover, our technology could be used for the preparation of other products, sush as starter cultures, hydrolysates, microbiological preparations, etc. Also, the obtained results can form the basis for starting research on farm animals (eg. pigs, poultry) and may be useful for both veterinary and human medicine.

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