

Use of bee products in livestock nutrition and therapy

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Received 09.05.2014

Accepted 16.09.2014

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Summary

Bee products, such as honey, propolis, pollen, bee bread, bee venom and royal jelly, are rich in vitamins, minerals and healthy fats. People often derive benefits from nature and apply these products as dietary supplements or therapeutics against various diseases. Until recently little has been known of their effects on animals. Recent years, however, have seen a growing interest in the possibility of using bee products in the nutrition and treatment of farm animals. This study collects and presents the current state of knowledge on the therapeutic and nutritional properties of these products in livestock, and summarizes the results of various experiments conducted in Poland and other countries.

Keywords: bee products, apitherapy, livestock

Highly developed societies are increasingly interested in organic products. Honey, propolis, pollen, bee venom, and royal jelly are often effectively used in nutrition, as well as in the treatment and prevention of various diseases. Few studies have focused on using apitherapy in animals.

Along with the growing interest in the protection of bees, bee products may also become more popular. An appropriate presentation of this subject matter among animal breeders could encourage them to introduce these products in the everyday diet of farm animals. The current problem of food safety and public health is the excessive use of antibiotics, even in animals. Through the preventive or therapeutic use of some bee products, synthetic antibiotics could be avoided, their time of administration could be shortened, or at least their dosage could be reduced. Bee products may also be an alternative to ineffective conventional therapy of antibiotic-resistant strains that occur with increasing frequency. Bee products as dietary supplements, rich in vitamins, minerals and healthy fats, may become better food supplements than popular mineral-vitamin mixes, or may be used as their complements in critical moments of breeding. It should be noted that the bioavailability of bee products is greater than that of artificially produced preparations. Many authors point out that bee products significantly affect the production performance and health of animals (4, 6, 7, 12, 15, 16, 21, 23-25).

Bee products as livestock dietary supplements

Research on the use of bee products as nutritional supplements for livestock has generally shown their positive impact on the health and productivity of animals. A wide range of research concentrated mainly on the propolis supplementation of layers and broilers, in various conditions and age groups. Research concerned primarily the immune response of the birds, physiological parameters and weight gain in broilers, as well as the parameters of egg-laying activity and the quality of eggs (9, 17, 27, 29). Some studies (27) evaluated the humoral immune response of poultry to diseases common in poultry production: poultry bronchitis, Newcastle disease, Gumboro disease and avian influenza. In order to determine the level of antibodies, a propolis product dissolved in vegetable oil was supplemented following vaccination against the above diseases. The authors compared the increase in the number of antibodies against different viruses measured by the ELISA method in 21- and 42-day-old broilers at different dosages of propolis. The studies confirmed a better adaptation of birds, but only at a low dose of propolis, i.e. 70 and 100 mg/kg fodder/day. ELISA tests also revealed resistance to avian influenza, a very common disease in poultry farming, in birds supplemented with 1,000 mg/kg fodder (27). Further studies, similar to the one above in terms of the subject, observed the immune response in broilers and

their productivity. Their results confirm earlier findings, proving the greater effectiveness in resistance building of small doses of propolis in the diet of birds (29). Supplementation with propolis in an amount of 70 mg or less per kg of fodder proved the most effective in increasing the number of antibodies against Newcastle disease – a higher dosage reduced the level of antibodies. However, propolis did not in any concentration improve the ratio of γ -globulin to the total protein in serum, which may be a measure of the state of health and of stress in birds. Large doses resulted in a high level of leukocytes in the intestine, increasing the number of lymphoid cells, which include T lymphocytes and NK cells. This proves that the level of antibodies becomes decreased and the cellular response is more decisive. The cell wall of blood vessels decreased in thickness in all experimental groups, which may have been caused by the anti-inflammatory effect of propolis. In the bursa of Fabricius, the main organ responsible for birds' immunity, a high dose (1,000 mg/kg fodder) caused strong cell proliferation, proving adverse action to the immune system. There was no increase in the productivity of birds fed with a propolis supplement, regardless of dosage. There was no favorable effect on the average daily gain, food intake, achieved body weight, or feed consumption per growth in kg, although the chickens fed with propolis showed a tendency to achieve better overall production results (29). A similar study, aimed at demonstrating the impact of propolis nutrition on broilers' performance, produced slightly different results (17). It was found that birds fed with high doses of propolis, i.e. 200-250 mg/kg of fodder, showed a significantly higher feed intake and daily weight gains, as well as decreased mortality. At lower doses, the effects were less pronounced. This may indicate actual benefits of higher doses of propolis, i.e. at least about 250 mg/kg of fodder, in poultry feeding. Studies on the effects of bee products as dietary supplements have also been conducted on laying hens. Intensive production leads to disorders caused by unnatural conditions and the associated stress, as well as a deterioration in the quality of eggs, in particular the shell, which leads to a higher number of broken eggs and economic losses. The weight and size of the eggs are important for the profitability of production. There are studies on the impact of propolis supplementation on the immune response and productivity of laying hens that have provided interesting results. It has been proved that the most effective dose of propolis is 100 and 150 mg/kg of fodder. With supplementation, feed intake by hens and the weight of eggs were improved, which directly resulted in lower feed consumption by birds. Such supplementation also had a positive impact on shell quality, increasing its thickness and strength, as well as generally raising the qualitative and quantitative production parameters of laying hens (9). With regard to hematological parameters, propolis had an influence on the increase of the hematocrit level, the overall amount of protein in blood and the level of globulins. It decreased cholesterol, and reduced the amount of

liver enzymes, which is due to the hepato-protective properties of bee products. Improvement in the activity of the immune system was manifested as a reduced level of heterophils (down to 30.27%) and an increased level of lymphocytes (69.73%), changing their ratios in a positive way. Cellular response was measured by the observation of wattle swelling after the injection of phytohemagglutinin (PHA-P), which leads to the agglutination of erythrocytes and is a potent mitogen for lymphocytes in a dissolved form. Immune response in animals increased proportionately to the dose of propolis. The largest swelling (1.1 cm) occurred 24 hours after the administration of 150 mg of propolis. A serious danger for laying hens in temperate and warm climates is posed by heat stress due to inefficient ventilation, interruptions in electricity supply or extreme temperatures. Breeders search for solutions to reduce losses caused by decreased production, health problems in chickens, and increased mortality (26). In the case of heat stress, a frequently used method is to add antibiotics to the feed or water to reduce the growth of bacterial flora in weakened birds. This supplement helps reduce the unavoidable loss of production. However, conventional antibiotics are also not indifferent to the beneficial bacterial flora in the gastrointestinal tract that protect birds from infection with strains of the genus *Salmonella*. Animal products are not free of antibiotic residues. Food manufacturers and breeders are therefore looking for alternatives to conventional antibiotic treatment. Research on heat stress in laying hens demonstrates that the addition of propolis to their diet has an equally beneficial effect as a preventive use of flavomycin (23). Experimental hens were kept in heat stress at 34°C alternately with the normal temperature, mimicking the conditions frequently occurring in overheated hencoops. A supplement of flavomycin or propolis significantly reduced the negative effects of heat stress. Compared to hens exposed to heat stress without any additional supplementation, it improved the daily gain and final weight of the hens, feed intake, egg weight and egg laying, and even egg quality parameters, such as the thickness and weight of the shell. In the control group, kept at a normal temperature, there were no fatalities, which occurred in groups exposed to heat stress. However, the supplementation with propolis and flavomycin reduced their percentage. The experiment also showed a beneficial effect on the digestibility of the fodder.

Research on the use of bee products in animal nutrition also includes studies on the supplementation of bee venom to chickens. The innovative character of this research consisted in a dietary application of bee venom, but not for preventing or reducing arthritis pain by injection, as had been done previously (11). The research studied two doses of 0.5 mg/l and 1 mg/l of drinking water. A positive effect was observed in a higher concentration of this preparation. Its beneficial effects included improved feed intake, higher final weight, better feed consumption and higher average daily weight gain. The parameters such as liver enzymes (alanine and as-

paragine aminotransferases), total cholesterol and blood protein, albumins and globulins remained unchanged. It should be noted, however, that the level of superoxide dismutase, which was a measure of antioxidant activity, increased significantly (11). From the above studies it can be concluded that supplementation with bee venom may be useful in rearing newborn chicks, especially broilers, and providing faster fattening and smaller losses of production (11).

Other livestock which may benefit from bee products as nutritional supplements are cattle (24). The production of cattle is quite specific in terms of digestive processes and energy balance in the bodies of ruminants. Many diseases associated with intensive milk and meat production are of metabolic origin, resulting from poor nutrition and high losses of energy and minerals in the process of milk production or fattening (10). The fermentation process in the rumen is based on the action of probiotic organisms, both bacteria and protozoa. Hence the importance of their number in stomach compartments, as well as their species composition and proper passage. Diseases may result from the reduced level of beneficial microflora and from the occurrence of undesirable or even pathogenic microorganisms (24). This is why the effect of flavonoids originating from ethanol extract of propolis on ruminal fermentation in ruminants was tested *in vitro* by the RUSITEC technique, which simulates ruminant digestion under laboratory conditions (20). Propolis extract administered at two concentrations (0.5 ml of 20% and 70% EEP) did not change the pH of ruminal fluid, did not significantly change the total amount of SCFA (short-chain fatty acids), including acetic acid and propionic acid, their ratio, or the total number of protozoa, or improve the digestibility of dry matter. At the same time, the higher dose of propolis extract (70% EEP) slightly decreased the production of propionic acid and increased the production of butyric acid. The level of butyric acid increased slightly even with a lower dose (20% EEP). In addition, the number of microorganisms changed, indicating a reduction in the number of bacteria and reducing their ratio to protozoa. In the case of ruminants, this may have a beneficial effect on the bioavailability of essential amino acids originating from animal proteins. There was also a significant decrease in the production of ammonia, especially with the higher dose of propolis extract. This study suggests that propolis in the form of EEP may find application in ruminant feeding as a means of preventing excessive nitrogen excretion into the environment by increasing its utilization in the rumen.

Tests were also conducted for the production of meat. The parameters examined by the researchers included gains, feed consumption and carcass quality. Some of these, possibly due to the small concentration of flavonoids used in the experiment, did not show better digestibility or improved bovine carcass parameters. Larger concentrations of flavonoids produced better results, particularly in the immune system of young calves. Flavonoids were proved to have a significant, dose-de-

pendent effect on the level of antibodies. After a longer time of usage, higher levels of IgG were observed in calves fed with high doses of flavonoids, compared to low and medium doses. A longer period of usage also showed a greater effect of high doses, whereas the IgG level decreased at the end of the study (eight weeks). IgM was significantly lower in calves receiving the highest and medium doses (28). The highest body weight was obtained in cows supplemented with the highest dose of flavonoids. Tests on the effect of propolis on the fattening of young bulls included the administration of propolis and antibiotics (monensin sodium). In the final stage of the experiment, weight, feed consumption and slaughtering characteristics were measured. Propolis was administered in the form of ethanol extract; however, the exact list of ingredients and their concentration in the solution was restricted by the manufacturer. It is known that it contained 0.054 mg of chrysin per 1 g of total flavonoids. The dosage included 300 mg monensin and 35 g of propolis extract per day (28). Propolis had no significant effect on slaughter parameters, i.e. hot and cold carcass mass, carcass quality and muscularity, proportions, color and pH. However, what is important, it increased weight in bulls and decreased feed consumption per kg of weight gain (28). The results of research on the actual improvement in cattle productivity after the application of bee products are not unequivocal. Milk cows have also been tested in order to demonstrate the effect of propolis on milk yield and milk characteristics (8). In this experiment, the total value of daily propolis intake was 19.2 g. The results showed that propolis-fed cows had a higher milk yield as well as protein content in milk. Propolis had no significant effect on feed intake or on fat content and the number of somatic cells in milk. In cows in the perinatal period, flavonoids may have a similar effect as milk thistle (*Silybum marianum*) silymarin (3-hydroxyflavone) – a hepatoprotector also used to treat liver diseases in humans (25). Experiments in which this hepatoprotector was administered to cows during the perinatal period demonstrated its positive impact on the energy balance and the postpartum condition of cows, as well as on productivity. The hepatoprotective and blood-fat lowering activity of propolis may find application in feeding cows during the perinatal period, which is a critical moment in cattle. An improvement in lipid administration and a better protection of liver cells may prevent many medical disorders in recently calved cows, such as the fat-cow syndrome or ketosis, which affect especially overnourished cows in a very good condition (10). Another supplement, even more promising than propolis, is bee pollen. Research on the use of pollen in laboratory animals has demonstrated its potential as a supplement in practical breeding and production, especially in ruminant nutrition. It may be particularly beneficial in young calves during the first three weeks of life when the rumen develops. Pollen has a positive influence on the digestive system, stimulating its function, regulating the passage of ingesta, and increasing appetite. All of these factors may contribute to a faster

transition of calves from milk or milk replacers to solid fodder, and generally improve feed intake, which results in faster growth. In addition to these benefits, pollen, like other bee products, improves immunity, contains many vitamins, as well as micro- and macro-elements, and can be considered as a high-quality feed because of its balanced content of proteins, carbohydrates and fats. It is rich in methionine, whose deficiency reduces the synthesis of milk proteins in cows (24).

Horses have a special place among farm animals. Their breeding for production, as a material for slaughter, is at present marginal, and most animals are saddle horses used for recreation and sport. The market value of individual horses, especially horses for sports and shows, is incomparably higher than that of other farm animals. Moreover, expenses incurred by the owners of horses as companion animals are much higher than the usual costs in typical animal production. This raises the possibility of introducing more expensive preparations, better adapted to the specific breed in which the emphasis is not put on production traits, but on physical fitness and health, in the case of sports horses, and on appearance, in the case of show horses. So far, research on the use of bee products in equine nutrition has only been conducted on bee pollen. Pollen constitutes 55% of Dynamic Trio 50/50, the rest being made up of herbs, but the specific composition is restricted by the manufacturer. This manufacturer also offers a preparation called Dynamic Trio, based on the composition of bee pollen and propolis, but no studies on its effectiveness are available. Horses were tested for digestibility, exercise capacity and blood parameters, such as the content of lactate, glucose, hematocrit, hemoglobin concentration and the level of immunoglobulins. Exercise capacity testing included the calculation of the speed of the animal at a heart rate of 160 (V160) and 200 (V200) beats per minute (bpm) (26). Horses on a pollen diet generally consumed more fodder, excreted less phosphorus, and retained more nitrogen. Dynamic Trio 50/50 also improved the digestibility of fiber. The study did not show large changes in endurance or blood parameters. However, in the experimental group of horses the level of lymphocytes tended to decrease in the 42nd day of study, compared to the control group. This raises the hope for developing a supplement based on bee products, which could effectively improve the athletic performance of horses and become a successful product on the market of sports horse nutrition.

Bee products for the treatment of internal animal diseases

A major problem in poultry production, both intensive and extensive, is the large size of herds, which carries the risk of the accumulation of pathogenic organisms and their rapid transfer to other birds. Among these organisms, some of the most common and equally harmful to humans are bacteria of the genus *Salmonella* (1). In a study on asymptomatic infection with *Salmonella enteritidis* in birds, poultry were administered propolis,

bee pollen, or both. Three groups of poultry received diets with different concentrations of propolis and bee pollen: the first group received propolis at 0.250 mg/kg of feed, the second were given pollen at 5 g/kg feed, and the third both pollen and propolis at the above doses. The fourth group, the control group, received a placebo (3). Surprisingly, the poultry fed with propolis showed poorer growth and a worse ratio of meat to bone. Better results were obtained in the groups receiving pollen, pollen with propolis, and even in the control group. These results may have been due to the short time of supplementation, which was only two weeks long (4). However, both bee pollen and propolis proved to have a positive effect on the structure of the liver. Pathogenic changes were significantly smaller in poultry that received these supplements.

Due to underdevelopment of forestomachs and nutrition based on milk or milk replacers, the resulting low resistance of young calves to neonatal diarrhea is a common disease occurring in breeding practice. Diarrhea is dangerous to the life and health of calves, and its origin is predominantly bacterial (24). In tests involving very young calves with clinical signs of diarrhea of bacterial origin, it was demonstrated that propolis had a positive effect on the health of the animals. The evaluation of the effect of the preparation included an organoleptic and microbiological examination of diarrhea, blood tests, including immunoproteins. The clinical evaluation of symptoms was performed on a 3-point scale, the highest value of which represented an acute course of the disease, whereas the lowest value meant a lightweight course. In all tested groups, the initial values were comparable and amounted to more than 2. Bacteria responsible for the nutritional gastrointestinal infections were identified as *Escherichia coli*, *Klebsiella oxytoca* and *Enterococcus faecalis*. After the experiment with the application of propolis, improvement was noted especially in the groups that received higher doses. At lower doses, longer supplementation was needed. It is also worth noting that calves fed with propolis demonstrated significantly higher daily gains, which produced the best results when administered at high doses for a long period. Blood parameters, especially those relating to the immune system, showed the best results in animals receiving propolis. Bacteriological studies of feces proved a significant reduction in the total bacteria level, from 42.93 to 77.46%. High values were recorded in the case of the most common cause of diarrhea in calves, namely *Escherichia coli*. In the case of the propolis-supplemented diet, hematocrit remained elevated.

Other studies on the efficacy of the ethanol extract of propolis in the treatment of diarrhea in calves showed identical beneficial effects. In addition to eliminating the symptoms of the disease, supplementation caused an overall improvement in the health of calves, their haematological parameters and blood biochemistry, particularly the concentrations of immunoglobulin α , β and γ , in serum, as well as a reduction in respiratory acidosis.

Higher daily gains were also characteristic. Tests were conducted on the control group, group 1, which received Humowitan (humus and a mineral medium with vitamins) at a dose of 50 g/day/animal, and group 2, which received 10% EEP at a dose of 400 mg/day/animal. Daily weight gains for these groups amounted to 0.392 kg, 0.425 kg and 0.432 kg, respectively.

In cattle, propolis has also proved helpful in the treatment of one of the most economically damaging diseases, namely *mastitis*. Given the bacteriostatic and bactericidal effect of propolis in the case of Gram-positive bacteria, including *Staphylococcus* and *Streptococcus*, as well as fungi, it may be useful in the treatment of mastitis of different origin (6). The therapy usually involves the use of antibiotic udder infusions. The experiments have confirmed the effectiveness of propolis in the treatment of *mastitis in vivo* during lactation and udder involution. Its effectiveness exceeded even the targeted antibiotic therapy, significantly reducing the number of pathogenic microorganisms in milk, particularly that of staphylococci and streptococci. Due to the anti-microbiological action of the formulation, it was also possible to reduce the number of subclinical and latent states. What is important, the propolis supplement accelerated the return to the level of 400,000 somatic cells per 1 ml of milk. It is also important that the administration of propolis gel to cows during udder involution improved their health in the postpartum period. There was a decrease in the number of *mastitis* cases and in the amount of microorganisms in milk samples; there were also fewer fungal or mixed infections (6). Propolis, when used as intramammary infusion, has the added advantage of a shorter withdrawal period after its application. The effect of propolis irritation, desirable to some extent in the treatment of chronic and subclinical mastitis, was less pronounced than when using mycostatics containing natamycin (7). In the case of propolis, the period of complete expulsion from milk was 4 days, whereas in the case of antibiotics it is a minimum of 5 days, and in some cases even three weeks. This fact has a significant impact on the profitability of animal production (7).

Bee products for treating external animal diseases

Bee honey has long been used as an ointment for wounds of various origin, and its efficacy is highly appreciated. Injuries that heal better after treatment with honey include all damages to the skin and deep tissues, mainly burns (14). These injuries include cut wounds, lacerations and hard-to-heal wounds infected by microorganisms (5). However, honey itself is fairly often contaminated with pathogens, such as bacteria of the genus *Bacillus* and *Proteus sp* (22). Therefore, especially when using honey for the treatment of open wounds, commercial honey should be avoided, since it has not been clinically tested, and its use may lead to a secondary infection and wound deterioration. In the treatment of burn wounds, honey has a much higher therapeutic efficacy when combined with sodium sulfadiazine salts. This refers to a faster beginning of the wound healing

process, as well as the overall duration of regenerative processes (13). Apitherapy may also greatly improve the appearance of the wound. The granulation process is faster and less exuberant, there is less inflammation and swelling of the wound, the crust forms faster, and the scars are less visible. The skin around the wound has a greater flexibility, and more collagen fibers can be seen. Complete healing typically occurs within 15-20 days of treatment, depending on the size and microbiological condition of the wounds, whereas for other agents or in the absence of treatment the healing period is longer. In some extreme cases, when the wounds treated with honey are already healed, the control wounds are only at the stage of not advanced granulation (13).

The development of animal behavior was also significant, as differences could be observed after 48 hours, when the analgesics stopped working. Pigs treated with honey were calmer, displayed no obvious signs of pain and did not show resistance when treatment was administered. Microbiologically, in non-extensive burn wounds the most common complications are caused by the bacteria *Staphylococcus aureus*, *Bacillus sp*, and *Enterococcus faecalis*, and by the fungus *Candida albicans*. In wounds covering more than 40% of body surface, the most commonly isolated bacteria are *Staphylococcus aureus* and *Pseudomonas*. Honey applied directly to the wound limited their growth in the initial phase and caused their rapid elimination. In the treatment of minor, clinically induced wounds with honey, the multiplication of bacteria was faster than for other treatment agents, and their presence was ascertained longer, but then rapidly decreased, resulting in a faster debridement and healing of the wound (13). Bee products have also proved efficient in the treatment of wounds in horses. Wounds that occur in horses, mostly in the lower parts of their legs, most frequently contain pathogens of the methicillin-resistant *Staphylococcus aureus* (MRSA), *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus equi*, *S. equi subsp. zooepidemicus*, *Enterococcus faecalis*, *Acinetobacter baumannii*, methicillin-resistant *Staphylococcus epidermis* (MRSE), *Staphylococcus sciuri* and *Pseudomonas aeruginosa*. Eight out of 11 varieties of honey tested showed efficacy against all strains, and the best results were achieved with manuka honey and with gently heated honey (22). Many studies confirm a high therapeutic efficacy of manuka honey (4, 19, 22). Another important factor is the duration of use, which should be continued until the wound has healed, and not stopped in the first stage of regeneration. Honey in a gel form, containing a high concentration of the active ingredient, appears to be more effective than pure honey. This may be explained by the fact that gel is easier to apply and more likely to remain on the skin (5).

Wounds contaminated with bacteria, in particular with fecal bacteria, are a serious problem in horses, as well as in other farm animals. When honey was used in the treatment of wounds infected by fecal bacteria, the healing process began later, but the recovery proceeded

so rapidly that at the end of the study those wounds were at the same stage of healing as the uninfected ones (5).

Honey is equally effective in the treatment of old and complicated wounds. In experiments, pure honey proved very effective in treating fresh and surgical wounds, whereas honey combined with other ingredients, such as cod liver oil, showed a beneficial effect on older and poorly healing injuries. This beneficial effect on older injuries may have been due to the combination of antibacterial and anti-inflammatory properties of honey and a high content of A and D vitamins, as well as omega-3 fatty acids from fish oil, which accelerate tissue regeneration. After cleaning and the removal of scabs displaying abnormal healing traits, a mixture was applied that made it possible to achieve faster and less exuberant tissue granulation, as well as a smaller and healthy scar. The entire healing process lasted from 3 to 6 weeks (18).

The present paper has aimed to demonstrate the broad applicability of bee products, such as honey, propolis, bee pollen, bee venom and bee wax in the nutrition and treatment of farm animals. Previous studies, though proving the beneficial results of using different formulations based on bee products, were quite limited in scope and left out many aspects that should be further analyzed. The studies often focus on the testing of only one product, and the literature on its use in different species of livestock or in other diseases may be insufficient. Nevertheless, thanks to the interest in natural medicine and organic farming, there is hope that more research is forthcoming. Two of the problems associated with the use of bee products are their high prices, due to the small amounts of substances produced by bees, and the effort necessary for their subsequent sterilization and transformation into final products, such as gels or extracts. However, a more widespread use of bee products may become profitable for beekeepers, thus increasing the number of apiaries. Obviously, environmental benefits from beekeeping, such as plant pollination, are invaluable. On the other hand, in order to obtain safe products of high quality, forage sources must be pollution-free, a condition difficult to meet in heavily populated areas.

Therefore, although the use of bee products in intensive farming could pose some difficulty, it may be a good solution in the case of organic farming, where the bred herds are less numerous. It is worth noting that the demand for healthy food is increasing, so its higher price may compensate for the cost of bee preparations used in its production.

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