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The Effect of Extruded Feed Additives with Balsamic Poplar Buds on Productivity of Dairy Goats

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ABSTRACT

Goats are important livestock species for meat and milk production. Meeting goat nutritional requirements is essential in maintaining goat health and the quality of derived food products. Dietary supplementation with certain bioactive compounds can improve the quality of diet and help to create a productive and economical nutrition program. The aim of this study was to evaluate the effect of several feed additives on the milk productivity of Saanen goats. According to the method of pairs of analogues, 72 dairy goats were distributed into four groups (18 goats/group): the control (CG) – the conventional diet with no additives: the experimental groups 1 (EG1) - the diet with 10% extract of balsamic poplar buds; the experimental groups 2 (EG2) – the diet with vegetable protein hydrolysate; the experimental groups 3 (EG3) – the diet with 10% extract of balsamic poplar buds with activated charcoal (EG3). Supplementation of feed with balsamic poplar buds increased goat's milk productivity by 34.2% without compromising milk quality, which was evaluated by the amount of milk and contents of milk fat and protein. Supplementation of feed with balsamic poplar bud extract and activated carbon contributed to an increase in milk yield by 25%. Such, using phytobiotic feed additives is a promising method in animal husbandry.

Key words: Feed additives, Goats, Milk production, Phitobiotic's, Saanen breed.

INTRODUCTION

Livestock production depends on various external factors, such as growing demand for livestock products and issues associated with the supply of feed raw materials caused by competition for natural resources and trade barriers (Bartl et al. 2009; Leroy et al. 2022; Shmatkovska et al. 2022). There is growing concern about food's impact on human health, as well as the impact of production systems on animal welfare and the environment (Artmann et al. 2020; Reissig and Lebendiker 2021; Cockshaw 2021). Animal feeding is an important part of animal husbandry. An innovative approach in science and technology, opens up many opportunities for improvements in feed production and animal feeding (den Hartog and Sijtsma 2013; Guo et al. 2022; Eugenio et al. 2022; Shah et al. 2022).

Currently, the food and feed industry are under enormous pressure, forcing to look for natural, environmentally friendly and safe compounds for animal nutrition. It applies to use resource-saving feeding technologies that allow saving feed and getting safe animal products of high quality.

In developing countries, they feed mainly cattle with inferior quality roughage feed, which is deficient in protein, energy, minerals and vitamins. Therefore, in order to avoid reducing the productivity of animals, it is necessary to include feed additives in the diets (Jouany and Morgavi 2007; Franz et al. 2020; Kholif et al. 2021). It introduced compounds of different groups to achieve a beneficial effect on animals' performance. The group of additives, which has been of increasing interest in recent years, comprises secondary plant metabolites and extracts of plant origin. Aromatic plants can serve as nutraceuticals with various applications, such as growth stimulants, antimicrobials, immunostimulant, antioxidants, flavourings, pigments and preservatives for animals, as well as alternatives to synthetic substances. It did not yet identify the mechanisms of action and exact compounds responsible for these effects, but the recent development of

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omics methods can provide more detailed information. It continuously tested medicinal plants as feed additive to improve animal health and productivity (Shahrajabian et al. 2021). Using traditional medicinal plants is cheaper, simpler and more stable compared to synthetic drugs and pharmaceuticals (Muhammed et al. 2018). Standardisation of the optimal dose of plant-based feed additives for a specific function is an urgent issue, therefore, there needed more research (Mendonça et al. 2021). In ruminants, plant compounds may be suitable agents to control microbial fermentation in the rumen and improve animal productivity, health and product quality. It also has a beneficial effect on the environment. Extracts are being studied as possible enhancers of farm animals' productivity, as well as an alternative to commonly used veterinary drugs based on their promising antimicrobial, antiparasitic, antioxidant, anti-inflammatory and immunostimulant properties (Giannenas et al. 2018; Beyene and Reshad 2020; Klyuchnikova et al. 2021). The aim of this study is to evaluate the effect of multifunctional feed additives on the productivity and quality indicators of goat's milk and to provide a scientific justification for the effectiveness of their use.

MATERIALS AND METHODS

Ethics?

The study had performed during summer 2021 in at LLP "Breeding goat farm Zerenda" Akmola Region, Kazakhstan. This farm has a full production cycle, from forage harvesting to the release of final products, which allows to control the quality of products at every stage. The structure of the farm "Zerenda" includes: dairy goat farm; production complex: dairy with refrigeration units, laboratory and cheese maturation chamber. Feeding has been manually, supplying feed additives once a day before morning milking. Then milk had collected and transported to the laboratory for analyzing.

Essential oils composition of balsamic poplar buds had been analyzing on gas chromatography–mass spectrometry (GC-MS) (Agilent 7890V/5977V, Agilent Technologies, United States) using HP-5MS 5% Phenyl Methyl Silox column (30m×0.25mm) with a helium carrier gas velocity of 1 mL/min. The evaporator temperature was 28°C. The column had been keeping by a temperature of 50℃ for 2min with a gradual increase to 280℃ (4℃/min). Then, the column had kept in an isothermal mode for 20min. Spitless injection mode was used (the sample was 0.2mL). Mass range was m/z 10-350 and the conditions for recording mass spectrum were 70eV. Essential oils components were identified by comparing their mass spectra and linear retention indices (relative to alkanes C7-C40). Quantitative analysis was performed by internal normalization method by the gas chromatographic peaks areas, calculated using the Agilent ChemStation package (Agilent Technologies, United States) without using correction factors. Peak areas sum of components with linear retention indices in the range 900-2200 was as 100%.

The nutritional value of feed and extruded feed additives was determined using the NIRS FOSS 2500 analyser (Foss Analytical A/S, Denmark). Milk productivity was determined by two control milking per month. Milk quality indicators were determined using the milk analyser "Expert Super Plem Combo" (NPP "Laboratory" LLC, Russia) (percentage of fat, protein, non-fat milk solids and lactose, acidity, density, temperature, freezing point, conductivity). This analyser also determined the number of somatic cells of milk. The principle of operation of the device is based on the interaction of milk with a lysogenic buffer, which destroys the cytoplasmic membrane of the somatic cell. The cell nuclei become available for the action of a fluorescent dye. The dye binds to the double-stranded DNA of somatic cells and forms a fluorescent substance that allows the identification of cells. Then the built-in microscope magnifies their image, the built-in data acquisition system camera takes photos, and the software counts their number. The operation of the Ekomilk Scan analyser corresponds to the method of determining somatic cells in milk using a viscometer. This device uses an optocoupler (infrared sensor) to measure the outflow time. The mastoprim (3.5g) had introduced into a 100cm measuring flask and topped up to the mark with distilled water heated to 30-35°C. Before using, the solution had shaken until evenly distributed the sediment. Into the analyser flask, had introduced 10mL of milk and 5mL of mastoprim while pressing the "Start" button with automatic stirring. The number of somatic cells in the milk under study is determined by the time the mixture flows out.

For statistical analysis, SAS version 9.1 was used (SAS Institute, Cary, NC, USA). Physico-chemical parameters in the studied groups had compared using the GLIMMIX model (SAS Institute, Cary, NC, USA) (generalised linear mixed model) with fixed factors: group, sampling time, interaction between group and time, and individual goat as a random factor.

RESULTS

By GC-MS had been detecting 59 components of balsamic poplar essential oil. Into balsamic poplar essential oil, got by hydro distillation, had been identifying 32 components. The key components were: 18.267% of 2-phenylethyl 2-methylbutanoate, 11.479% of prenyl 2-methylbutanoate, 6.573% - epi-α-bisabolol, 6.243% - ar-turmeric, 5.259% - elemol.

Feeding rations and their nutritional value for the period of the experiment are in Table 1. Replacing 200g of concentrated feed by extrudate with additives did not significantly affect the final nutritional value of the diet of goats. However, with the same dry matter content in the diet, the level of the following nutrients changed: metabolic energy increased in all experimental groups by 0.3mJ; digestible protein increased by 2g in EG3 group compared with the control group, and in EG1 and EG2 groups-by almost 3g; crude ash increased in all experimental groups by 0.3g.

Using extruded feed additives in the diet had a positive effect on the health condition of the goats and their external characteristics, so that the goats of the experimental groups had a visually different coat. With poor feeding, improper maintenance and diseases of animals, wool easily loses its natural shine (Kalaitsidis et al. 2021).

The main parameters studied were quantitative and qualitative indicators of goat's milk. Milk organoleptic parameters for the experiment entire period met the

Table 1: Feeding rations of the experiment goats

Feed	Daily ration, kg			
	Control group	EG1	EG2	EG3
Mixed grass hay, kg	2	2	2	2
Lucerne hay, kg	1	1	1	1
Concentrates, kg	0.5	0.3	0.3	0.3
Extrudate, kg	-	0.2	0.2	0.2
10% extract of balsamic poplar buds, mL	-	0.4	0.4	0.4
25% enzymatic hydrolysate of vegetable protein, mL	-	-	25	-
100% active coal, g	-	-	-	1
Diet composition				
Dry matter, g	2521.8	2519.2	2520.8	2520.8
Exchange energy, mJ	25.4	25.7	25.7	25.7
Digestible protein, g	184.7	187.6	187.9	186.5
Crude fat, g	9.2	9.2	9.2	9.2
Crude fibre, g	83.1	83.1	83.1	83.1
Crude ash, g	20.0	20.3	20.3	20.3

Table 2: Physico-chemical parameters of goat's milk

Group	Physico-chemical parameters of milk before feeding additives						
	Fat, %	Non-fat milk solids, %	Density, kg/м³	Protein, %	Salts, %	Lactose, %	Number of somatic cells, thousand/mL³
Standard	≤2.5	≤8.2	≤27-30	≤ 2.8	0.6-0.9	≤4.5	$1.0 \cdot 10^6$
Control group	4.23±0.62	8.41±0.34	28.24±0.87	3.09±0.12	0.71±0.03	4.57±0.18	803.5±85.0
EG 1	3.73±0.26	8.11±0.15	27.55±0.51	2.99±0.06	0.68±0.01	4.41±0.09	353±34.22
EG 2	4.79±1.05	7.73±0.21	25.26±1.55	2.84±0.08	0.65±0.02*	4.16±0.09	686±67.49
EG 3	4.54±0.73	7.73±0.21	25.48±1.32	2.84±0.08	0.64±0.02	4.21±0.12	627.8±95.96
Physico-chemical parameters of milk on the 30th day of feeding additives							
Standard	≤2.5	≤8.2	≤27-30	≤2.8	0.6-0.9	≤4.5	$1.0 \cdot 10^6$
Group	Fat, %	Nonfat milk solids, %	Density, kg/м³	Protein, %	Salts, %	Lactose, %	Number of somatic cells, thousand/mL³
Control group	3.78±0.25	8.22±0.16	27.94±0.66	3.03±0.06	0.68±0.01	4.47±0.09	493.1±36.87
EG 1	3.73±0.26	8.08±0.23	27.46±0.94	2.98±0.08*	0.67±0.028	4.40±0.13	543.7±82.08
EG 2	4.15±0.21	7.78±0.11	25.97±0.46	2.87±0.04	0.65±0.01	4.23±0.06	652.0±65.59
EG 3	3.31±0.32	8.0±0.16	27.51±0.82	2.95±0.06	0.67±0.01	4.35±0.08	863.5±47.71

*Statistically significant (P<0.05) differences in comparison with the control group.

requirements of TP TC 033/2013 "On the safety of milk and dairy products". The results of the physico-chemical parameters of milk are in Table 2.

Animals got feed additives during one month. On the 30th day of feeding, had been observing decreasing in the fat percentage in the second, third and control groups. In the group EG1, which was fed an extruded granulate containing 10% extract of balsamic poplar buds, the fat level remained at the same level as at the beginning of the experiment – 3.73%. In EG2, increase in the the protein percentage was observed at the end of the experiment by 7.1% compared to the beginning of the experiment, and by 1.3% compared to EG1, and by 5.3% compared to EG3. The percentage of protein decreased in the control group. The mineral content throughout the experiment ranged from 0.6 to 0.71%. There were no significant changes in the content of non-fat milk solids in milk.

There is often use somatic cells number in $1mL^3$ of milk as an indicator of udder health in lactating animals. For goats, this indicator is normally up to $1000/cm^3$. These studies showed that milk somatic cell counts in all groups were in the normal range throughout the experiment (Table 2). Milk secretion in goats and sheep is mainly apocrine, and cytoplasmic particles similar in size to somatic milk cells are normal constituents of their milk. The concentrations of cytoplasmic particles in goat's milk are on average of 150×10^3mL, while in sheep's milk on average of 15×10^3mL.

The percentage of lactose ranged from 4.16 to 4.57%. There had been observing the increase in lactose by 1.68% in EG2, and by 3.32% in EG3. In EG1, lactose decreased by 0.22%. One of the important indicators for assessing the impact of feed additives on dairy goats is the level of milk productivity. The results on milk productivity for the month are in Fig. 1.

There was an increase in milk productivity in all groups, including the control group. The goats of EG1 group had shown the largest increase in the productivity. In EG1, milk yield increased on the 30th day of feeding by 295.1g or 34.2%.

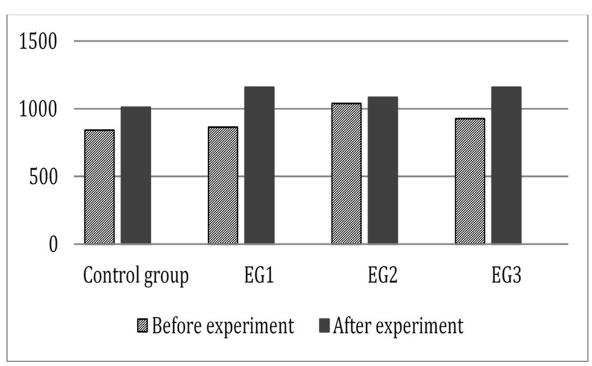

Fig. 1: Indicators of comparative milk productivity of dairy goats when using feed additives.

DISCUSSION

Dawod et al. (2020) observed similar pattern. The authors evaluated the effect of dietary supplements of extruded lint and soy (ELS) on milk yield, composition, and fatty acid profile of Holstein cows, and observed an increase in milk yield by 3.26% per day, and the addition of ELS led to a decrease in the content of saturated fatty acids (SFAs), and an increase in monounsaturated (MUFAs) and polyunsaturated fatty acids (PUFAs) in milk when adding 100g/kg of feed to the diet of lactating cows. As reported, after a month of feeding with an extruded feed additive; the productivity increased by 3.5kg per cow. When feeding extruded feed to animals, protein breakdown in the rumen decreases. This makes it possible to improve the amino acid composition of the chyme in the small intestine and reduce the formation of ammonia. This process makes it possible to keep additional nitrogen in the body of farm animals. As a result, there had increased protein synthesis - an increase in the weight gain of meat breeds and an increase in a lactation of dairy. With fortification of feed with phytobiotic additives, the immune status of the animal is further improved, which also contributes to an increase in milk productivity. In the studies of Balji and Knicky (2021), an extract of the buds of balsamic poplar was used to increase the meat productivity of young bulls. The effect of various phytobiotics on animal productivity was recently reviewed by Sultanayeva and Balji (2021).

Kholif et al. (2017) found that the addition of extract of *M. oleifera* in the diet of Nubian breed goats increased milk yield by approximately 6% and milk yield adjusted for energy by 12%. Similarly, supplements of lemongrass and rosemary in the diet of lactating Damascus goats with 10g per head daily increased the digestibility of nutrients and improved milk production (Kholif et al. 2017).

In EG2, at the end of the experiment, the increase in milk productivity was not significant, and amounted to an additional 44.7g or 4.3% higher compared to the period before the start of feeding feed additives. In EG3, which was given an extruded granulate containing 0.4mL of balsamic poplar buds extract and 100% activated charcoal at a dose of 3.0g/head per day, milk productivity increased by 25% or 231.2g at the end of the experiment. Recently, Burchacka et al. (2019) studied the role of activated coal as a feed additive. The carbon porous structure allows it to absorb substrates, products and catalysts from the environment, thus changing the bio-catalysis processes in the gastrointestinal tract. Active carbons can absorb toxins from the gastrointestinal tract and reduce the excessive accumulation of intestinal gas. Using properly changed activated carbon as a feed additive can have a beneficial effect on the development of animals. Biochar is widely using worldwide in Agro-ecological management, including animal husbandry, to improve the health and productivity of farm animals, such as weight gain, immune response, feed intake, feed conversion rate, carcass characteristics and the overall quality of animal products (Man et al. 2020).

Man et al. (2021) reported that a diet enriched with an active coal feed additive (biochar) at 800g per 1ton of compound feed contributes to an increase in milk productivity by 5-10%.

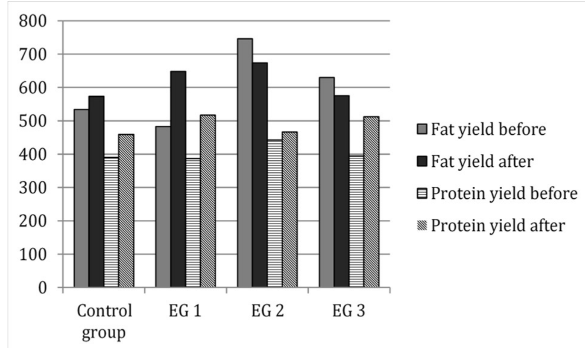

Fig. 2: Milk fat and protein yield in the experimental and control groups, g per day

In most studies and for all studied species of farm animals, the addition of biochar to the diet has a positive effect. This component affects various parameters, such as the adsorption of toxins, digestion, blood counts, the efficiency of digestion of feed, dairy and meat productivity, greenhouse gas emissions, etc (Schmidt et al. 2019).

However, it should be noticed, that, in goats of control group on the 30th day, milk productivity increased, but only by 9%. The fat and protein yield lets estimate milk productivity level (Fig. 2), that are important technological indicators. In addition, these nutrients determine its biological and nutritional value.

The fat yield at the beginning of the experiment was the highest in EG2 and was 746.1g, and the lowest in EG1 – 482.8g (Fig. 2). At the experiment end, in EG1 had observed an increase in fat yield by 34.2% or by 165.2g. In EG2 and EG3, the fat yield was lower at the beginning of the experiment, but higher than in the control group. Thus, the best result had animals of EG1 group. The farm received 9.720g instead of 7.242g of fat in milk.

Protein yield increased throughout the experiment in all groups, but the highest increase had animals of EG1 group. In this group, protein increased by 33.7% or 130.7g per day, which amounted to 7.766g per month.

Probiotics, plant extracts and their metabolites have a beneficial effect on both health and productivity of animals, influencing the stabilisation of the rumen environment, inhibition of the reproduction of pathogenic bacteria in the gastrointestinal tract, modulation of the immune response, increased degradation of fibre and fermentation, the use of nutrients, animal growth indicators, milk production, etc (Muhammed et al. 2018).

Kholif et al. (2019) described the use of phytogenic preparations identified in a mixture of additives in the amount of 3g PHY3 and 6g PHY6 based on menthol, levomentol, beta-linaloolm, anethol, hexadecanoic acid and p-mentane in the diet of lactating Friesian cows. Established that PHY3 and PHY6 increased ($p<0.01$) the ruminal pH, the total amount of volatile fatty acids propionate and acetate, increased the level of total protein and antioxidant capacity of blood serum and reduced the concentration of urea-N, triglycerides, total lipids, cholesterol and malondialdehyde in blood serum ($p<0.05$). Consumption of PHY3 leads to increase milk production and milk content of total solids, protein, lactose and fat (Mendel et al. 2017). Hence, including 3 g/cow per day of a mixture of feed additives in the diet of lactating Friesian cows increased milk production and feed consumption. But increasing mixture of additives to 6g/cow per day leads to negative effects. Kalaitsidis et al. (2021) studied the effect of Cornus essential oils and its mixture with oregano and thyme essential oils on the productivity of dairy sheep and the quality of milk, yogurt and cheese under heat stress. The results showed that including the plant extracts and essential oils increased milk production. A dietary supplement to corn extracts and essential oils reduced lipid and protein oxidation in milk, yogurt and cheese samples compared to the control. However, the dietary supplement with herbal extracts did not affect the fatty acid profile in milk, cheese and yogurt, as well as the biochemical parameters of blood serum. In conclusion, it should be noticing that an additive of corn to the diet in combination with oregano and thyme can improve the use of feed and productivity of dairy sheep of the Chian cross-bred breed raised under heat stress.

Leparmarai et al. (2019) compared the addition of phenolic grape seed extract in 11 East Friesian dairy sheep and 9 Saanen goats. The concentrate supplemented with grape seed extract 7.4g/100g of dry matter had an additional phenol content of 3.5g/100g of dry matter by compared with a control concentrate with a low phenol content. The effect of the extract on milk yield in sheep and goats was not the same. Goats consumed more feed and nutrients, had higher live weight and gave more milk. In addition, the milk protein and lactose content were lower, and the urea content in milk was higher in goats than in sheep. In conclusion, it should be noticed that the addition of grape seed extract to the diet of sheep and goats to a certain extent increased the concentration of phenols in milk and blood, but most of the phenols had lost in urine. The study provided another sign that goats have developed survival mechanisms, such as a higher ability of saliva to bind tannin because of specific tannin-binding proteins, mechanisms that are less pronounced in sheep.

There is insufficient information about using feed additives with plant extracts in the diet of dairy goats. The developed formulations of multifunctional feed additives as extruded granulate not only have a positive effect on the dairy productivity of goats but also allow to reduce the consumption of the main feed.

Conclusion

In this study, feeding goats with extruded granulate containing 10% extract of balsamic poplar buds increased milk productivity by 34.2% without adverse effects on milk yield and milk quality. Using feed supplements contributed to an increase in fat and protein yield. The highest increase had animals of EG1 group, in which protein growth was 33.7% or 130.7g per day, which amounted to 7766g per month; increasing in milk fat content on the 30th day consisted of 34.2% or 165.2g. Using phytobiotic feed additives is a promising method in animal husbandry.

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Authors' Contribution

Sultanayeva L.Z. conceived the presented idea; Balji Yu. A. developed the theory and performed the computations; Korotkiy V.P. Shantyz A.H. and Issabekova S.A. analyzed and interpreted the data, and edited the manuscript for important intellectual contents; Borovskiy A.Y., Maier Y.G. and Abakanova G.N. participated with data acquisition and critically revised the manuscript for improvements. All authors discussed the results and contributed to the final manuscript.

REFERENCES

Artmann M, Sartison K and Vávra J, 2020. The role of edible cities supporting sustainability transformation – A conceptual multi-dimensional framework tested on a case study in Germany. Journal of Cleaner Production 255: 120220. https://doi.org/10.1016/j.jclepro.2020.120220

Balji Y and Knicky M, 2022. Impact of feed supplementation with balsam poplar buds on performance of young bulls. Theory and Practice of Meat Processing 6: 294-299. https://doi.org/10.21323/2414-438X-2021-6-4-294-299

Bartl K, Mayer AC, Gómez CA, Muñoz E, Hess HD and Holmann F, 2009. Economic evaluation of current and alternative dual-purpose cattle systems for smallholder farms in the central Peruvian highlands. Agricultural Systems 101(3): 152-161. https://doi.org/10.1016/j.agsy.2009.05.003

Beyene A and Reshad M, 2020. The effect of *Acacia tortilis* and *Balanites aegyptica* trees on fodder quality: The case of Mieso District, West Hararghe, Oromia National Regional State, Ethiopia. Agriculture, Forestry and Fisheries 9(5): 142-147. https://doi.org/10.11648/j.aff.20200905.12

Burchacka E, Łukaszewic M and Kułażyński M, 2019. Determination of mechanisms of action of active carbons as a feed additive. Bioorganic Chemistry 93: 102804. https://doi.org/10.1016/j.bioorg.2019.02.029

Cockshaw R, 2021. The end of factory farming. Voices in Bioethics 7: 1-6. https://doi.org/10.52214/vib.v7i.8696.

Dawod A, Ahmed H, Abou-Elkhair R, Elbaz H, Taha A and Swelum A, 2020. Effects of extruded linseed and soybean dietary supplementation on lactation performance, first-service conception rate, and mastitis incidence in Holstein dairy cows. Animals 10: 436. https://doi.org/10.3390/ani10030436

Den Hartog LA and Sijtsma R, 2013. Challenges and opportunities in animal feed and nutrition. Paper presented at 11th World Conference on Animal Production. Beijing. China. 15.10.13–20.10.13 pp. 1-15. https://edepot.wur.nl/306279

Eugenio FA, van Milgen J, Duperray J, Sergheraert R and Le Floc'h N, 2022. Feeding intact proteins, peptides, or free amino acids to monogastric farm animals. Amino Acids 54: 157–168. https://doi.org/10.1007/s00726-021-03118-0

Franz Ch, Baser KHC and Hahn-Ramssl I, 2020. Chapter 3 - Herbs and aromatic plants as feed additives: Aspects of composition, safety, and registration rules. In book: Feed Additives, pp: 35-56. https://doi.org/10.1016/B978-0-12-814700-9.00003-0

Giannenas I, Bonos E, Christaki E and Florou-Paneri P, 2018. Oregano: A Feed Additive with Functional Properties. In book: Therapeutic Foods, pp: 179-208. https://doi.org/10.1016/B978-0-12-811517-6.00006-4

Guo Y, Ryan U, Feng Y and Xiao L, 2022. Association of common zoonotic pathogens with concentrated animal feeding operations. Frontiers in Microbiology 12: 810142. https://doi.org/10.3389/fmicb.2021.810142

Jouany J and Morgavi D, 2007. Use of 'natural' products as alternatives to antibiotic feed additives in ruminant

production. Animal 1(10): 1443-1466. https://doi.org/10.1017/S1751731107000742
Kalaitsidis K, Sidiropoulou E, Tsiftsoglou O, Mourtzinos I, Moschakis T, Basdagianni Z, Vasilopoulos S, Chatzigavriel S, Lazari D and Giannenas I, 2021. Effects of cornus and its mixture with oregano and thyme essential oils on dairy sheep performance and milk, yoghurt and cheese quality under heat stress, Animals 11: 1063. https://doi.org/10.3390/ani11041063
Kholif A, Gouda G, Galyean M, Anele, U and Morsy T, 2019. Extract of Moringa oleifera leaves increases milk production and enhances milk fatty acid profile of Nubian goats. Agroforestry Systems 93: 1877-1886. https://doi.org/10.1007/s10457-018-0292-9
Kholif A, Hassan A, El Ashry G, Bakr M, El-Zaiat H, Olafadehan O, Matloup O and Sallam S, 2021. Phytogenic feed additives mixture enhances the lactational performance, feed utilization and ruminal fermentation of Friesian cows. Animal Biotechnology 32: 708-718. https://doi.org/10.1080/10495398.2020.1746322
Kholif A, Matloup O, Morsy T, Abdo M, Elella A, Anele U and Swanson K, 2017. Rosemary and lemongrass herbs as phytogenic feed additives to improve efficient feed utilization, manipulate rumen fermentation and elevate milk production of Damascus goats. Livestock Science 204: 39-46. https://doi.org/10.1016/j.livsci.2017.08.001
Klyuchnikova NF, Klyuchnikov MT, Klyuchnikova EM and Naumova LI, 2021. IOP Conference Series: Earth and Environmental Sciences 723: 022047. https://doi.org/10.1088/1755-1315/723/2/022047
Leparmarai P, Sinz S, Kunz C, Liesegang A, Ortmann S, Kreuzer M and Marquardt S, 2019. Transfer of total phenols from a grapeseed-supplemented diet to dairy sheep an goat milk, and effects on performance and milk quality. Journal of Animal Science 97: 1840-1851. https://doi.org/10.1093/jas/skz046
Leroy F, Abraini F, Beal T, Dominguez-Salas P, Gregorini P, Manzano P and van Vliet S, 2022. Animal board invited review: Animal source foods in healthy, sustainable, and ethical diets – An argument against drastic limitation of livestock in the food system. Animal 16(3): 100457. https://doi.org/10.1016/j.animal.2022.100457
Man K, Chow K, Man Y, Mo W and Wong M, 2020. Use of biochar as feed supplements for animal farming. Critical Reviews in Environmental Science and Technology 51: 187-217. https://doi.org/10.1080/10643389.2020.1721980
Man KY, Chow KL, Bon Y, Wing M, Ming YM and Wong H, 2021. Use of biochar as feed supplements for animal farming. Critical Reviews in Environmental Science and Technology 51: 187-217. https://doi.org/10.1080/10643389.2020.1721980.
Mendel M, Chłopecka M, Dziekan N and Karlik W, 2017. Phytogenic feed additives as potential gut contractility modifiers - A review. Animal Feed Science and Technology 230: 30-46. https://doi.org/10.1016/j.anifeedsci.2017.05.008
Mendonça F, Carvalho J, Silva R, Ferreira LC, Cerqueira D, Rogge H, Andrade J, Ferreira LD, Araújo M, Moreira T, Carvalho A and Facury-Filho E, 2021. Use of a natural herbal-based feed additive containing isoquinoline alkaloids in newborn calves with cryptosporidiosis. Veterinary Parasitology 300: 109615. https://doi.org/10.1016/j.vetpar.2021.109615
Muhammed A, Arowolo and He J, 2018. Use of probiotics and botanical extracts to improve ruminant production in the tropics: A review. Animal Nutrition 4: 241-249. https://doi.org/10.1016/j.aninu.2018.04.010
Reissig P and Lebendiker A, 2021. Transitioning from food systems toward food ecosystems. In: Transdisciplinary Case Studies on Design for Food and Sustainability. Elsevier, pp: 75-94. https://doi.org/10.1016/B978-0-12-817821-8.00017-5
Schmidt H, Hagemann N, Draper K and Kammann C, 2019. The use of biochar in animal feeding. Peer J 7: e7373 https://doi.org/10.7717/peerj.7373
Shah A, Totakul P, Matra M, Cherdthong A, Hanboonsong Y and Wanapat M, 2022. Nutritional composition of various insects and potential uses as alternative protein sources in animal diets. Animal Biosciences 35(2): 317-331. DOI: https://doi.org/10.5713/ab.21.0447
Shahrajabian M, Sun W, Marmitt D and Cheng Q, 2021. The roles of medicinal plants in organic poultry and livestock production with considerations of drug residue and immunoassay. Nova Science Publishers, Inc.
Shmatkovska T, Dziamulych M, Vavdiiuk N, Petrukha S, Koretska N and Bilochenko A, 2022. Trends and Conditions for the formation of profitability of agricultural enterprises: A case study of Lviv Region, Ukraine. Universal Journal of Agricultural Research 10(1): 88–98. https://doi.org/10.13189/ujar.2022.100108
Sultanayeva L and Balji Y, 2021. Effektivnost ispolzovaniya fitobioticheskih dobavok v racione krupnogo i melkogo rogatogo skota. J. Jivotnovodstvo i kormoproizvodstvo 104: 96-110. https://doi.org/10.33284/2658-3135-104-2-96