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Potential benefits of early-life supplementation of feed additives on the growth and health of lambs

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Abstract

Neonatal mortality in small ruminant production is a significant economic challenge for farmers, requiring techniques to improve survival rates among newborn lambs. This study focused on mitigating neonatal lamb mortality and enhancing growth rates under semi-intensive farming conditions in the Eastern Mediterranean Region. The study used 320 sheep of two breed types, Awassi and Awassi × Chios (F1) cross-breeds, with each breed type divided into an experimental and a control group. Lambs received immediate umbilical cord care and were subjected to a birth protocol. The experimental groups received an oral feed additive daily from birth until five days of age and from weaning until three days after weaning. This additive aimed to improve the health of the intestinal microbiome and immune function, and included electrolytes and vitamins. The reproductive performances of the ewes and the growth and mortality rates of the lambs were monitored. The study found significant impacts of both genotype and the feed additive on newborn lamb viability. In addition, the weaning weights of lambs of both genotypes improved with the use of the feed additive. The study concludes that administering the recommended feed additive during critical periods from birth to weaning reduces mortality rates and positively influences the growth and development of newborn lambs.

Keywords: birth protocol, native breeds, neonatal treatment, supplementation

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Introduction

The mortality of newborn lambs is a source of economic loss, and greatly affects farm profitability. The survivability and growth performance of lambs until weaning are important factors impacting the income of sheep farms. The time between birth and when their immune systems develop is a period when lambs are most vulnerable to environmental conditions and diseases, and up to 50% of pre-weaning deaths occur during this period (Nowak *et al*., 2000). The sustainability of sheep farms depends more on the survival of newborns than on other yields of economic importance, with lamb mortality causing approximately 15%–30% of the loss of income of sheep farms. Therefore, newborn losses should be kept to a minimum on both dairy and meat-type farms. The economic success of sheep

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farms largely depends on increasing the number of lambs per ewe at weaning and reducing production costs (Ünal *et al*., 2018). Lamb losses vary depending on the care, feeding, and environmental conditions provided at many stages of production. For this reason, optimisation of the environmental conditions lambs are exposed to, especially after birth, is important for their health. This topic has been previously investigated (Haughey, 1957; Watson, 1957; Alexander & Peterson, 1961), with studies focusing on improving lamb rearing efficiency, and significant progress has thus been made to mitigate lamb mortality rates on sheep farms.

Lamb losses usually occur within the first two weeks after birth, depending on the twinning rate, management conditions, and environmental factors (Ipsen, 2013; Holmøy & Waage, 2015). Alexander & Peterson (1961) reported that deaths in newborn lambs occurred mostly in the first three days after birth (88%). Johnston *et al*. (1980) reported similar data, with perinatal death rates of 77.8%. Lamb losses in Turkey vary between 29.50% and 34.43% (Ünal *et al*., 2018), depending on the twinning rate and production system. The most important factors determining the rates of perinatal lamb mortalities are the varieties of preparations and practices employed before and after birth. As producers operate under increasingly competitive conditions, the number of offspring they obtain each year is becoming more important.

More than five million ruminant farm animals die during or immediately after birth in Turkey every year, and farmers therefore need to find ways to improve neonatal survival rates. It is difficult to find a definitive solution to this problem, as many factors, such as production system, feeding practices, and the management plan and programme in place, will affect the survival rate. One way to reduce neonatal losses is to improve the care and feeding plan. It is possible to reduce neonatal losses with prevention strategies aimed at improving management and feeding conditions. However, unnecessary overfeeding of mothers during pregnancy will cause negative results rather than benefits for lamb yield (Dwyer *et al*., 2016). Conversely, a lack of vitamin and mineral supplementation is a practical problem and is associated with increased lamb mortality. For this reason, the nutritional conditions of both the ewes and lambs during all physiological periods should be balanced, and additives should be given as per the animals' needs, as well as according to the feed raw materials that are being used. This is also important in terms of optimising the feed costs of sheep farms (Rooke *et al*., 2008).

Supplementing the diets of goats with a blend of oregano essential oils resulted in increased weight gain and improved feed efficiency. However, it also led to decreased blood total protein and albumin concentrations, with no significant effect on the blood concentrations of globulin, aspartate aminotransferase, and alanine aminotransferase (Lei *et al*., 2018). In a separate study, supplementing a blend of oregano essential oils and cobalt resulted in increased weight gain, enhanced feed efficiency, and broader head and rump widths (Wu *et al*., 2021). Additionally, it elevated blood concentrations of glucose, total protein, albumin, and immunoglobulins (IgA, IgM, and IgG), while reducing blood cholesterol, triglyceride, and globulin levels. These effects were observed without an impact on feed intake and nutrient digestibility, except for a higher crude protein digestibility in the supplemented lambs (Wu *et al*., 2021).

In this study, the effects of a feed additive on lamb mortality and growth in the period from birth to weaning were determined.

Materials and Methods

This research project received ethical approval from the Cukurova University Animal Experiments Local Ethics Committee on 25 July 2018, under decision number 11 in meeting 4. The results of this study were previously presented at the 10th International Conference on Information and Communication Technologies in Agriculture, Food & Environment (Koluman & Göncü, 2022).

The study was conducted on a commercial sheep farm situated at 35° 5' 42.6912" N and 33° 12' 12.3480" E in the eastern Mediterranean area. This locale is characterised by a subtropical climate, with gentle, rainy winters and arid, scorching summers from May through to September. The farm utilised semi-open barns in a semi-intensive framework, accommodating a total of 320 ewes in prime health and condition during the production season of 2020–2021.

In May, a flushing regimen was initiated, with each ewe receiving 500 g of feed containing 18%–19% protein and 2500 kcal metabolisable energy/kg per day, along with high-quality straw and four hours of daily grazing on medium-grade pasture. Subsequently, the ewes were bred using the ram effect

technique, maintaining a 20:1 sheep-to-ram ratio. Adequate fresh water was freely available to all animals in both treatment groups.

To verify pregnancy status, an ultrasonic examination was conducted on all experimental animals during the second month of gestation. The study had two dietary treatment categories, each including two different genotypes: pure (Awassi) and cross-bred (Awassi × Chios; F1). The 320 ewes were equitably distributed between the two treatment groups, with 60 lambs each allocated to the control and treatment groups.

Following the birth of the lambs, a standardised protocol for umbilical cord care was implemented across both experimental groups, adhering to the researchers' developed procedures for consistency. Subsequently, the lambs were housed in an intensive lamb rearing unit, where controlled conditions were maintained.

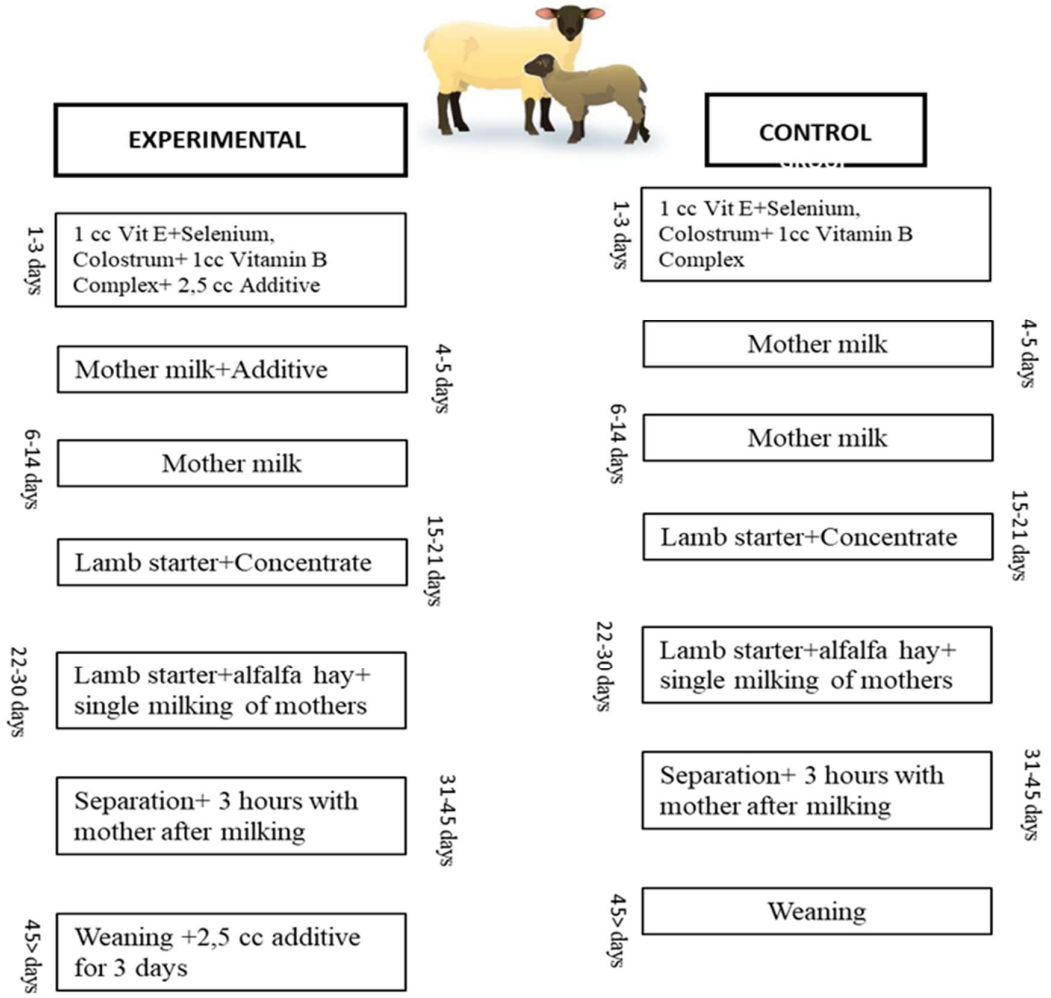

Figure 1 The lamb rearing protocol for the two dietary treatment groups (experimental and control)

The pens were naturally ventilated, utilising sand bedding that was refreshed every alternate day. Additionally, manure was removed daily to ensure that the pens remained visibly clean and dry. The feeding protocol for the experimental group, as outlined in Figure 1, involved the oral administration of 2.5 mL of the feed additive (Macrovit Portacure Diakes™ product) daily until the fifth day post-birth, and daily from weaning until the third day post-weaning. The additive was dissolved in boiled, cooled water at 37 °C and administered orally to the lambs using sterile syringes. These steps ensured the

standardised care and management of the lambs, facilitating accurate assessment of the feed additive's impact on lamb health and development throughout the study period.

The dietary supplement (Macrovit Portacure Diakes™ product) was employed to concurrently fortify the gut microbiota of the lambs, fulfil their electrolyte and vitamin requirements, and enhance their immune systems. The constituents of the utilised product are detailed in Table 1.

Table 1 Contents of the Makrovit Portacure Diakes™ feed additive (as per the package insert)

Active substance	Substance name	Level in premix	Unit
Immune boosters			
MOSS	MOSS/Beta-glucan + oligosaccharide	30.000	mg/kg
Egg Immunoglobulin IgY	Egg products	12.500	mg/kg
Mannan	Cell wall polysaccharides of *S. cerevisiae*	10.800	mg/kg
Glucan	Cell wall polysaccharides of *S. cerevisiae*	13.200	mg/kg
Probiotics			
Enterococcus faecium	*E. faecium* NCI104 15	$9x10^{10}$	CFU/kg
Yeast	*S. boulardii*	$9x10^{10}$	CFU/kg
Amino acids			
Glycine	Glycine monohydrate	5.000	mg/kg
Carbohydrates			
Lactose monohydrate	B-D-galactopyranosyl-D-glucose	298.720	mg/kg
Protectors			
Citric acid anhydrous	Citric acid anhydrous	48.730	mg/kg
Electrolytes			
Chloride	Sodium chloride	85.500	mg/kg
Potassium	Potassium chloride	20.300	mg/kg
Sodium	Sodium bicarbonate ($NaHCO_3$)	67.300	mg/kg
Vitamins			
Vitamin A	Retinol acetate	2.000.000	IU/kg
Vitamin C	Ascorbic acid	7.000	mg/kg
Vitamin K	Synthetic menadione	7.000	mg/kg
Vitamin D3	Cholecalciferol	400.000	IU/kg
Vitamin E	Alpha tocopherol acetate	2.000	mg/kg
Vitamin B1	Thiamine	1.000	mg/kg
Vitamin B2	Riboflavin	1.250	mg/kg
Vitamin B6	Pyridoxine	1.000	mg/kg
Vitamin B12	Cyanocobalamin	10	mg/kg
Carrier			
Yeast	Inactive yeast culture	quantum sufficit partum (qsp)	
Dextrose	Dextrose monohydrate	qsp	

The Makrovit Portacure Diakes™ feed additive is formulated to address various aspects of ruminant health, aiming to optimise digestion, nutrient utilisation, and immune function. The following components are included in the additive:

- Microbial enhancers: ingredients aimed at supporting the beneficial bacterial population in the gut, promoting digestive health and nutrient absorption.

- Electrolyte blend: a combination of essential minerals crucial for maintaining proper hydration and electrolyte balance.
- Vitamin mix: a blend of vitamins including vitamin A, vitamin D, and vitamin E, essential for overall health, growth, and immune function support.
- Immune boosting agents: components designed to enhance the immune response and bolster the animal's defences against diseases and pathogens.

From the age of 14 days, the lambs were separated from their mothers between 08:00 and 16:00, and the mothers were milked using an automated milking machine in the afternoon. Enterotoxaemia vaccines were administered on the 20th day of age, followed by the provision of concentrated lamb starter feed (containing 16% protein and 2300 kcal/kg metabolisable energy) on the same day. From when the lambs were 21 days old, high-quality hay (clover straw) was cut into 2 cm lengths and made freely available as straw feed.

When the lambs were 30 days old, they were fully separated from their mothers but were allowed to spend three hours with them after the evening milking session to consume residual milk. The second, booster dose of enterotoxaemia vaccine was given on the 40th day of age, and weaning was carried out when the lambs were 45 days old. After weaning, the trial lambs were orally administered 2.5 mL of the Diakes feed additive for three consecutive days.

During the experiment, records were kept of matings, pregnancies, births, numbers of lambs born, birthweights, and weights at 60 days post-weaning. These measurements were used to calculate standard weights using linear interpolation and extrapolation methods. Any deaths among the lambs within the first two months of life were also noted. The control group lambs received the same care and feeding protocols as the trial lambs, except for the provision of the feed additive.

The data obtained in this study were analysed using IBM SPSS (Statistical Package Program for Social Sciences) version 22.0. Continuous variables were evaluated using the means ± standard deviations. Since there were fewer than 50 samples, normality analyses were performed using the Shapiro-Wilk test. Data that did not show a normal distribution, according to the Shapiro-Wilk test (mortality rate) were analysed using a chi-square test. This test was used for the analysis of both non-normally distributed data and discrete data. Factorial analysis was used to determine the interaction between genotype and treatment and the effect of each factor on the dependent variables.

Results and Discussion

In regions where sheep breeding is important, one of the factors affecting the productivity rate is reproductive performance. Data on the reproductive performance of native pure Awassi and Awassi × Chios (F1) cross-bred sheep during the 2020–2021 mating and lambing periods are given in Figure 2. There were no significant differences between the treatment and control groups of each genotype. The same number of sheep were mated in all experimental groups, and the infertility rate was similar in both groups. When the experimental and control groups were compared within each genotype, it was determined that they had similar twinning, fertility, and prolificacy rates. No feed additive was used during this period, and the reproductive performances of the sheep therefore varied depending on the genotype alone.

Kridli & Al-Yacoub (2006) determined that the pregnancy rates, multiple birth rates, lambing rates, and fecundity of three- to six-year-old Awassi ewes were 60.7%, 91%, 90%, and 1.08, respectively. Abdullah *et al*. (2002) reported that the lambing rates of Awassi sheep from first mating ranged from 33% to 35%. Üstüner (2007) reported that Awassi sheep fertility and prolificacy were 85.71% and 96.43%, respectively. Chios sheep are known for their high twinning rate. Although twinning is a low heritability trait, it has been observed that it is transmitted to the F1 progeny when Awassi sheep are crossed with Chios sheep. As a result of the cross-breeding carried out to improve the reproductive characteristics of the Awassi sheep in this semi-intensive system, the fertility of the F1 cross-bred progeny was similar to that of Chios sheep, increasing almost 60%. The fact that the fertility of the Chios × Awassi sheep was higher than that of the pure Awassi sheep can be explained by the effect of the reproductive ability of the Chios sheep, as previously mentioned (Tekerli *et al*., 2002; Ceyhan *et al*., 2007). Significant differences between the genotypes and treatment groups in terms of twinning rates were also found. The fertility of the F1 cross-bred ewes was significantly higher than that of the pure-bred Awassi ewes, with an average increase of approximately 0.7 lambs per ewe (Figure 2).

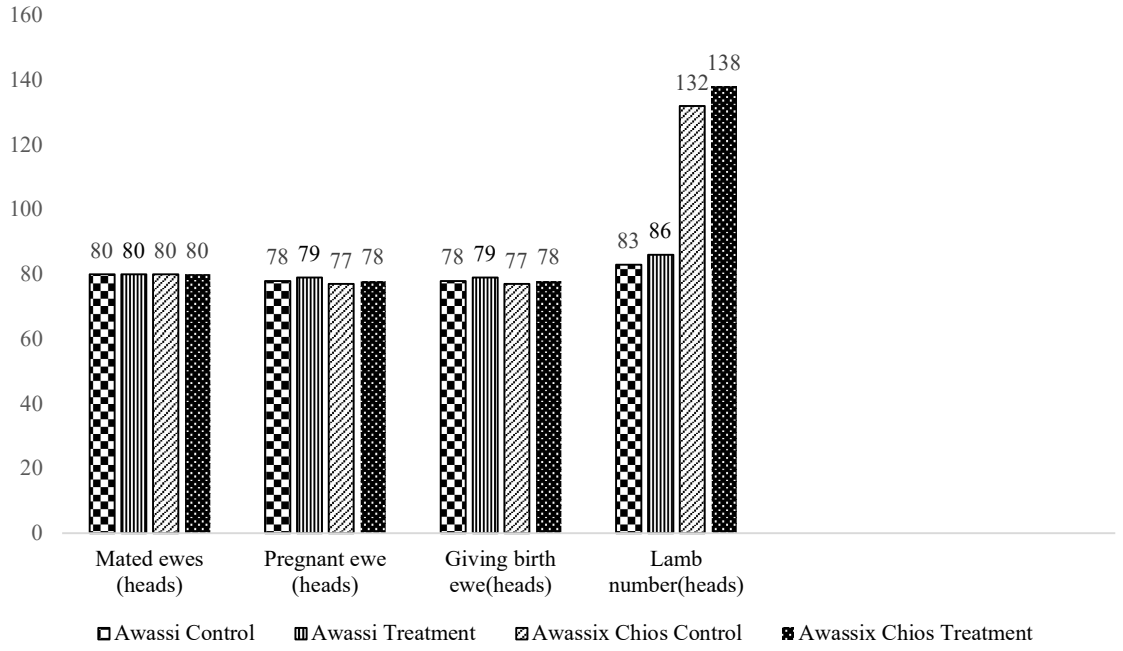

Figure 2 Reproductive performance of the control and treatment groups of each genotype (P <0.01)

Chios sheep are typically kept under moderately intensive farming conditions, predominantly in the relatively warm and humid coastal regions of the Aegean region of Turkey. They are usually kept in small flocks, particularly for milk production. They are an early-maturing (8–9 months of age) and prolific (1.8–2.0 lambs per lambing) breed. Ceyhan *et al*. (2007) reported that the fertility of Chios sheep, based on the birth rates and number of ewes mated, was 74.5% and 1.36%, respectively. Tekerli *et al*. (2002) reported that fertility ranged between 77.8% and 86.6% in the Chios breed, while litter size was between 1.46 and 2.50. When the current performances were compared, it was determined that although reproductive performance was similar, the birth rate was higher than found in previous studies.

Table 2 Growth performances of experimental lambs

Traits	Awassi		Chios × Awassi		Treatment effect	Breed effect
	Control	Treatment	Control	Treatment		
Birth live weight (kg)	4.82 ± 0.54	4.64 ± 0.23	2.11 ± 0.15	1.97 ± 0.34	NS	NS
Mortality rate (0–14 days) (%)	5.3	2.3	12.26	5.6	P <0.05	P <0.01
Mortality rate (0–30 days) (%)	1.3	0	8.4	3.2	P <0.01	P <0.01
Mortality rate (30–45 days) (%)	0	0	2.2	0	NS	P <0.01
Mortality rate (>45 days) (%)	0	0	1	0	NS	NS
Weaning weight (kg)	18.68 ± 1.05	19.65 ± 1.02	12.21 ± 2.06	14.86 ± 2.22	NS	P <0.05

As seen in Table 2, neither genotype nor treatment factors had any significant effects on the birth weights and mortality rates (after 45 days) of the lambs. However, the feed additive treatment reduced the 14-day and 30-day mortality rates by almost half in both breeds (P <0.01). The feed supplement also maintained its effect during the period from the 30th day until weaning in the Chios × Awassi cross-bred lambs. During this period, the mortality rate of the control group was 2.2%, while there were no deaths in the treatment group.

Both the control and treatment group Awassi lambs gained more body weight than the cross-bred lambs. This may be associated with the different twinning rates of the two genotypes, because as

the number of lambs increases, the birthweight decreases, depending on the ewe's carrying capacity (İnal *et al*., 2021). Although the difference was not statistically significant, the treatment group Awassi lambs weighed approximately 1 kg more at weaning than the control group Awassi lambs, and the treatment group cross-bred lambs weighed 2.5 kg more at weaning than the control group cross-bred lambs. The cost of 1 kg of live weight is € 6.5, and the economic importance of this difference in income for the farmer is therefore evident. Considering that the mortality rate was also lower, the value, in terms of profitability, of the use of the feed additive is clear.

The effect of the feed additive on the mortality rates and weaning weights of the cross-bred lambs concurred with the results reported by previous researchers that treatment with feed additives in the form of probiotics reduced the mortality rate and increased the growth rate of newborns (Abdelrahman & Hunaiti, 2008). Fayed (2001) carried out a study on sheep and goats to determine the effects of Yea-Sacc® addition on the digestibility, rumen and blood metabolites, average daily gain, feed efficiency, and carcass characteristics. Their results showed that the dry matter, crude protein, N-free extract, and organic material digestibility coefficients, the ruminal ammonia concentration, serum cholesterol, albumin, average daily gain, feed and economic efficiency, and carcass measurements increased non-significantly in sheep compared to goats. Andrighetto *et al*. (1993) reported that yeast supplements decreased the rumen pH (P <0.05) and increased the total volatile fatty acid concentration (P <0.05), but did not affect the distribution of volatile fatty acids, or the acetate to propionate ratio. Furthermore, they reported that there were no differences in the dry matter, crude protein, neutral detergent fibre, or acid detergent fibre digestibility. Ruminal turnover rate and retention time were also similar for the diets. Baijun *et al*. (2021) examined the effects of supplementing a yeast culture to fattening lambs fed a pelleted total mixed ration with two proportions of maize on animal performance, feed digestion, blood parameters, rumen fermentation, and the rumen microbiome. Their results indicated that yeast culture products can be supplemented with pelleted total mixed rations to improve lamb growth performance, despite the live yeast cells being inactive after pelleting.

Some studies have suggested that feed additives with a high probiotic content and a variety of vitamins help improve digestion by modulating the digestive processes and balancing the intestinal microbiota (Abdelrahman & Hunaiti, 2008; Dwyer *et al*., 2016). It is possible that the Diakes' feed additive used in this study provided a more favourable gut environment for an earlier recovery from diarrhoea syndrome through its antimicrobial activity, by modulating host immunity and improving the conditions of digestion.

Conclusions

This study investigated the reproductive performance of pure Awassi and Awassi × Chios cross-bred ewes, and the impact of a feed additive on the lamb growth performance of pure Awassi and Awassi × Chios cross-bred lambs.

The economic success of a farm hinges on the lamb birth and weaning numbers, as well as on their weight gain during this crucial period. Nutritional deficiencies and environmental factors can elevate mortality rates in lambs born with lower body weights. Our findings indicate that employing this feed additive, particularly in cross-bred lambs with higher twinning rates and lower body weights, can yield significant economic benefits. The viability and economic performances of lambs throughout their growth are pivotal for farmers. Our results demonstrate that the use of the Makrovit Portacure Diakes™ feed additive promotes live weight gain and lamb viability, while mitigating adverse genotypic and environmental effects. While the economic burden of this feed additive may deter its widespread use, our study suggests that it can enhance enterprise profitability, when viewed holistically.

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Author contributions

YP: investigation, conceptualisation, resources, data collection, methodology and writing the original draft; NK: investigation, formal analysis, writing, review and editing; SG: review and editing.

Data availability statement

None of the data were deposited in an official repository. Data that support those study findings are available upon request.

Conflicts of interest

The authors declare no conflict of interest.

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