J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Riset, Teknologi dan Pengabdian
kepada Masyarakat No. 164/E/KPT/2021

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
51(3):228-238, September 2026
DOI: 10.14710/jitaa.51.3. 228-238

Productive and intestinal responses of nursery pigs supplemented with distillery vinasse

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Received May 17, 2026; Accepted August 3, 2026

ABSTRACT

The present study aimed to evaluate the productive and intestinal response of nursery pigs supplemented with distillery vinasse as a feed additive. The trial was conducted on a pig production farm in Orellana, Ecuador. A total of 80 pigs, 73 days of age, from a Yorkshire × Landrace × Duroc cross were randomly assigned to two treatments: a control group and a vinasse-supplemented group. The animals were housed in 16 pens, with five pigs per pen and eight pens per treatment. The experimental period lasted 40 days, and vinasse was administered daily at 1.5% of dry matter intake. Physicochemical, health, productive, and intestinal histometric indicators were evaluated. The vinasse had characteristics compatible with its use as a feed additive. Animals receiving vinasse showed no enteric or pneumonic disorders or cannibalism, unlike those in the control group, and exhibited greater weight gain (25.67 vs. 23.38 kg), higher average daily gain (641.75 vs. 584.50 g/day), and an improved feed conversion ratio (2.98 vs. 3.27). In addition, they had greater villus and crypt dimensions in the duodenum and ileum. Supplementation with distillery vinasse produced favorable effects on intestinal health and productive performance in nursery pigs.

Keywords: Feed additive, Feed conversion ratio, Intestinal histometry, Nursery pigs, Vinasse.

INTRODUCTION

During the nursery phase, piglets undergo a critical period of digestive, immunological, and nutritional adaptation due to the changes associated with weaning and the new feeding regimen. Consequently, post-weaning diarrhea, disruption of the intestinal barrier, and reduced zootechnical performance usually increase during this stage; therefore, intestinal health is currently considered a central axis of efficient growth in piglets. This relationship among weaning, dysbiosis, epithelial integrity, and productive performance has been widely documented in recent literature (Fabà *et al.*, 2024; Han *et al.*, 2024; Tang *et al.*, 2024; Kwon *et al.*, 2025).

In response to this problem, swine nutrition has shown increasing interest in non-antibiotic strategies aimed at supporting gastrointestinal homeostasis after weaning. These include organic acids, probiotics, postbiotics, functional ingredients, and fermented feeds, because of their capacity to modulate the luminal environment, improve barrier function, reduce the incidence of diarrhea, and favor productive performance. Together, these approaches have been associated with improvements in growth parameters, antioxidant status, local inflammation, intestinal microbiota, and mucosal morphology (Cai *et al.*, 2024; de Groot *et al.*, 2024; Yin *et al.*, 2024; Roura *et al.*, 2025; Polimeni *et al.*, 2026).

Within this group, additives with acidifying action have shown particularly consistent results. Cai *et al.* (2024) reported that a blend of organic acids improved performance, antioxidant capacity, intestinal barrier function, and fecal microbiota in weaned piglets. Likewise, de Groot *et al.* (2024) observed improvements in intestinal morphology and changes in the inflammatory response after using a blend of organic acids. Recent reviews on nutritional control of post-weaning diarrhea emphasize that stabilization of the intestinal environment is one of the main objectives of functional feeding at this stage (Tang *et al.*, 2024).

Fermented feeds and ingredients have gained relevance because of their potential to act on the intestine and the microbiota. Qiu *et al.* (2024) demonstrated that a fermented corn–soybean meal improved growth, reduced diarrhea incidence, and favorably modulated intestinal barrier function and the microbiota in weaned piglets. Similarly, Zhang *et al.* (2024) reported that probiotic-fermented feed favored growth profile, immune functions, and the intestinal microbiota, whereas Xu *et al.* (2024) reported improvements in diarrhea, intestinal morphology, and several immunological indicators with fermented cauliflower residue. More recently, Qu *et al.* (2025) indicated that fermented feed promoted intestinal development by stimulating the expansion of intestinal stem cells through the Wnt/β-catenin pathway (Qiu *et al.*, 2024; Xu *et al.*, 2024; Zhang *et al.*, 2024; Qu *et al.*, 2025).

Other recent functional strategies reinforce this same line of evidence. Yin *et al.* (2024) showed that *Lactobacillus johnsonii* improved barrier function and reduced post-weaning diarrhea; Liu *et al.* (2024) reported that alginate oligosaccharides improved antioxidant status and intestinal health through modulation of the microbiota; and Hu *et al.* (2024) reported favorable effects of *Artemisia annua* residue on immunity, antioxidant capacity, intestinal barrier, and microbial structure. In this regard, Sadurní *et al.* (2023) and Correa *et al.* (2024) indicated that nutritional manipulation of the diet can translate into improvements in growth and intestinal health in weaned piglets (Sadurní *et al.*, 2023; Correa *et al.*, 2024; Hu *et al.*, 2024; Liu *et al.*, 2024; Yin *et al.*, 2024).

At present, there is a growing trend toward the valorization of agro-industrial by-products in animal feeding. This responds to economic and environmental reasons, allowing waste reduction and diversification of ingredient or additive sources. Papatsiros *et al.* (2025) indicate that food-industry by-products can be incorporated into swine diets provided that their composition, safety, and variability are controlled. Likewise, Roura *et al.* (2025) highlight that modern nutritional strategies in pigs are moving toward systems with less dependence on antimicrobials, where functional ingredients and co-products acquire strategic value.

Based on the above, distillery vinasse constitutes a by-product of interest for swine feeding. Its value is related to its fermentative origin, acidic character, and the possibility of modifying the digestive environment when administered under controlled conditions. However, unlike other functional additives, recent specific evidence on distillery vinasse in pigs remains limited. Among the available regional background studies, González Borlet *et al.* (2023) reported that vinasse, used as an additive in pigs during the lactation–weaning phase, allowed a favorable productive response, which justifies further evaluation in other stages of swine development.

Despite advances in the literature on intestinal health in piglets, studies that integrate within the same experimental design the characterization of the by-product used, health and productive evaluation, and intestinal histometric analysis remain scarce. This integration is relevant because intestinal health is expressed not only as the absence of clinical signs, but also as preservation of mucosal structure and intestinal absorptive capacity. In this sense, villus length and crypt depth are useful indicators for interpreting the effect of a nutritional intervention on intestinal functionality, as has been shown with organic acids, fermented feeds, and other dietary modulators (de Groot *et al.*, 2024; Qiu *et al.*, 2024; Xu *et al.*, 2024; Qu *et al.*, 2025).

The relevance of this line of research is even greater in tropical systems, where swine production faces constraints associated with input costs and the need to use local resources more efficiently. Under these conditions, the evaluation of vinasse as a feed additive can provide valuable information from both zootechnical and environmental perspectives by linking intestinal health, productive performance, and valorization of agro-industrial by-products (González Borlet *et al.*, 2023; Papatsiros *et al.*, 2025; Roura *et al.*, 2025). Therefore, the objective of the present study was to evaluate the productive and intestinal response of nursery pigs supplemented with distillery vinasse as a feed additive, through characterization of the by-product and assessment of health, productive, and histometric indicators of the gastrointestinal tract.

MATERIALS AND METHODS

Study Area and Origin of the Additive

The experimental trial was conducted on a pig production farm located in the province of Orellana, Ecuador, under management conditions representative of intensive nursery pig production. The vinasse used as a feed additive was obtained from the artisanal distillery "Puro Puyo," located on the Santa María farm in Pastaza Province, Ecuador. The by-product was collected at the place of origin and transported to the experimental unit for storage, characterization, and subsequent use in animal feeding.

Collection and Preservation of Vinasse

The vinasse was collected directly at the discharge point of the distillation process and stored in plastic containers with a capacity of 200 L, protected from external contamination and preserved until use. Before its use in the experimental diet, 10 samples were taken for physicochemical and microbiological evaluation to determine its suitability as a feed additive.

Physicochemical and microbiological characterization of vinasse

The vinasse was physicochemically and microbiologically characterized before its inclusion in the diet. Dry matter, ash, total nitrogen, and titratable acidity were determined according to the official methods of AOAC International (2023). The pH was measured potentiometrically with a glass electrode calibrated using pH 4 and 7 buffer solutions. Total soluble solids were measured by refractometry and expressed as °Brix. Total soluble carbohydrates were quantified using the phenol-sulfuric acid colorimetric method described by DuBois *et al.* (1956). Five-day biochemical oxygen demand (BOD_5) was determined by the dilution and incubation method. Appropriate vinasse dilutions were incubated in the dark for five days at 20 ± 1 °C, and BOD_5 was calculated from the difference between initial and final dissolved oxygen concentrations, accounting for the dilution factor and blank correction, according to Method 5210 B (APHA, AWWA and WEF, 2023). Serial dilutions were prepared for microbiological analyses. *Salmonella spp.* detection was performed according to ISO 6579-1:2017/Amd.1:2020. Coliforms were enumerated by plate count at 36 °C according to ISO 4832:2006. Molds and yeasts were enumerated by plate count at 25 ± 1 °C according to ISO 21527-1:2008. All analyses were performed following the laboratory's standardized procedures and quality-control measures.

Animals, Housing, and Experimental Design

A total of 80 nursery pigs, 73 days of age, from a Yorkshire × Landrace × Duroc cross were used. The animals came from a pig production unit located in the province of Orellana, Ecuador. They were housed in 16 pens, with five animals per pen, and randomly assigned to two experimental treatments under a completely randomized design. Each treatment consisted of 40 animals, organized in eight pens of five animals each.

The evaluated treatments were as follows: control treatment: animals fed the basal diet without added vinasse; and vinasse treatment: animals fed the same basal diet supplemented with distillery vinasse as a feed additive for a period of 40 days.

Feeding and Vinasse Supply

The basal diet was formulated with conven-

Table 1. Percentage Composition and Nutritional Contribution of the Diets Used in Nursery Pigs

Ingredients (%) / Nutrient contributions	Starter feed	Grower feed
Wheat	56.8	47.4
Soybean meal	20.0	20.0
Wheat bran	20.3	31.0
Phosphate	1.5	1.5
Common salt	0.40	0.40
Expanded premix	1.0	0.4
Nutritional contributions		
Dry matter (%)	97.0	97.0
Crude protein (%)	17.1	16.5
Gross energy (Mcal/kg)	2.7	2.8
Crude fiber (%)	3.95	3.62
Phosphorus (%)	0.48	0.40
Calcium (%)	0.41	0.41

The basal diets were formulated for the starter and grower stages of nursery pigs and constituted the dietary basis of both experimental treatments.

Table 2. Physicochemical and Microbiological Characterization of the Distillery Vinasse Used as a Feed Additive

Indicators	Parameters evaluated
Physicochemical	Dry matter: 6.78%
Physicochemical	Ash: 1.71%
Physicochemical	°Brix: 9.6–12.3
Physicochemical	pH: 4.2–4.4
Physicochemical	Total soluble carbohydrates: 9.2–12.6 g/L
Physicochemical	Nitrogen: 0.34–0.53 g/L
Physicochemical	Total acidity: 0.57–0.70 g/L
Physicochemical	Biochemical oxygen demand (BOD_5): 55–80 g/L
Microbiological	Salmonella: absent
Microbiological	Coliforms: absent
Microbiological	Molds: <10 CFU
Microbiological	Yeasts: <10 CFU

tional ingredients for the nursery phase in pigs and was offered in two stages: starter feed and grower feed. The percentage composition and nutritional contribution of both diets are presented in Table 1. The starter feed included wheat (56.8%), soybean meal (20.0%), wheat bran (20.3%), phosphate (1.5%), common salt (0.40%), and expanded premix (1.0%). The grower feed included wheat (47.4%), soybean meal (20.0%), wheat bran (31.0%), phosphate (1.5%), common salt (0.40%), and expanded premix (0.4%).

From a nutritional standpoint, both diets contained 97% dry matter. The starter feed provided 17.1% crude protein, 2.7 Mcal/kg gross energy, 3.95% crude fiber, 0.48% phosphorus, and 0.41% calcium. The grower feed provided 16.5% crude protein, 2.8 Mcal/kg gross energy, 3.62% crude fiber, 0.40% phosphorus, and 0.41% calcium.

The vinasse was homogenized before application and supplied daily over the feed by spraying, followed by manual mixing until uniform distribution was achieved. The dose used was 1.5% of dry matter intake, adjusted according to the intake recorded during the trial. Supply was performed by pen, in accordance with the housing and management system of the animals.

Animal Management and Ethical considerations

Throughout the experimental period, the animals were maintained under routine production conditions, with permanent access to water and controlled feed supply. The clinical status and behavior of the animals were observed daily. Animal management procedures were performed in accordance with animal welfare principles and the usual sanitary practices of the production unit, seeking to minimize animal stress and suffering.

Health and Clinical Evaluation

During the 40 days of the trial, the animals were observed daily to record the presence of clinical signs compatible with enteric processes, respiratory disorders, cannibalism, mortality, or culling. Based on these records, the incidence of health alterations in each treatment was established, and animal viability during the experimental period was determined.

Productive indicators

Live weight and feed intake of the animals were recorded during the experimental trial. Based on this information, the following productive indicators were calculated:

Weight gain (kg): difference between final weight and initial weight.

Average daily gain (g/day): ratio between total weight gain and the number of experimental days.

Feed conversion ratio: ratio between feed consumed and weight gain achieved.

Because the animals were housed in groups of five per pen, the pen was considered the experimental unit for variables associated with feed intake and feed conversion ratio.

Histological and Histometric Evaluation of the Gastrointestinal Tract

For the histological and histometric evaluation of the gastrointestinal tract, 32 animals were slaughtered at the end of the experimental period, equivalent to 16 animals per treatment and two animals per pen. Samples of duodenum and ileum, corresponding approximately to 10% of the length of each intestinal segment, as well as liver samples, were obtained.

The tissues were fixed in 10% formalin for 16 to 24 h, washed in running water, dehydrated through graded ethanol, cleared in xylene, and embedded in paraffin. Five histological slides were prepared from each intestinal segment. Sections were stained with Harris alum hematoxylin for nuclear visualization and 1% aqueous eosin for cytoplasmic and extracellular-matrix contrast, following standard histological procedures (Suvarna *et al.*, 2019).

Microscopic observations were performed using a trinocular microscope equipped with a digital imaging system and a calibrated micrometric reticle. Histometric measurements were obtained with a 40× objective, at which each reticle division corresponded to 5 µm. Villus length and Lieberkühn crypt depth were measured. For each animal, four measurements per variable were made in properly preserved and oriented intestinal structures, and the mean value was used for analysis.

Statistical Analysis

Data corresponding to the physicochemical and microbiological characterization of vinasse were processed using descriptive statistics, calculating the mean, standard deviation, and, when relevant, the coefficient of variation.

For the variables of the biological trial, a completely randomized design with two experimental treatments was used: basal diet without vinasse and basal diet supplemented with distillery vinasse at 1.5% of dry matter intake.

Because the animals were distributed in groups of five pigs per pen, the pen was considered the experimental unit related to feed intake and feed conversion ratio variables. Body weight, recorded at each time point of the experimental study, was analyzed by analysis of variance (ANOVA) with repeated measures, considering the effects of treatment, time, and the treatment × time interaction. When significant differences were detected, means were compared using Tukey's test.

For histometric variables, the unit of observation corresponded to the animal sampled at the end of the experiment, using as representative value the average of the four measurements performed per variable. These variables were analyzed by ANOVA, and means were also compared using Tukey's test. Results are expressed as mean ± standard error of the mean (SE). Differences were considered significant when $p < 0.05$.

RESULTS

Physicochemical and Microbiological Characterization of Vinasse

The vinasse used in the study had characteristics compatible with its use as a feed additive in nursery pigs. It contained 6.78% dry matter and 1.71% ash, with total soluble solids ranging from 9.6 to 12.3 °Brix. The pH ranged from 4.2 to 4.4, total soluble carbohydrates from 9.2 to 12.6 g/L, total nitrogen from 0.34 to 0.53 g/L, titratable acidity from 0.57 to 0.70 g/L, and BOD_5 from 55 to 80 kg/m^3.

From a microbiological standpoint, *Salmonella spp.* and coliforms were not detected. Mold and yeast counts were below 10 CFU, indicating a favorable microbiological condition for use in the experimental diet.

These findings indicate that the vinasse had characteristics compatible with its use as a feed additive in nursery pig diets and with the valorization of this agro-industrial by-product.

Health Response of the Animals

During the experimental period, the animals supplemented with vinasse did not present clinically evident pathological processes. In contrast, enteric processes were recorded in 8 animals (20.0%), pneumonic processes in 4 animals (10.0%), and cannibalism in 8 animals (20.0%) in the control group. No deaths were reported in either treatment (Table 3).

These findings showed a more favorable health response in pigs treated with vinasse compared with the non-supplemented group.

Productive Indicators

The inclusion of vinasse in the diet was associated with improved productive performance in nursery pigs (Table 4). Initially, no differences in body weight were observed between treatments, with values of 21.12 kg in the control group and 20.76 kg in the vinasse group. Similarly, on day 15, body weights remained statistically comparable at 26.96 and 27.61 kg, respectively.

On day 30, significant differences were observed between treatments, as vinasse-supplemented animals weighed 38.24 kg, whereas control animals weighed 36.78 kg. This difference persisted until the end of the trial, when body weights were 46.43 kg in treated pigs and 44.50 kg in controls.

Total weight gain was greater in vinasse-supplemented animals, at 25.67 kg compared with 23.38 kg in the control group. Average daily gain was also greater in treated pigs (641.75 vs. 584.50 g/day). The feed conversion ratio was lower, indicating greater feed efficiency, in the vinasse-supplemented group than in the control group (2.98 vs. 3.27).

The results obtained indicate that supplementation with vinasse favored the productive performance of nursery pigs, particularly in the final phase of the trial.

Histological and Histometric Evaluation of the Gastrointestinal Tract

No evident pathological alterations were observed in the tissues analyzed from vinasse-supplemented animals. This finding was consistent with the more favorable health response observed during the experiment.

The histometric evaluation showed a favorable effect of vinasse supplementation on intestinal architecture (Table 5). In the duodenum, treated animals had a mean villus length of 340 µm and a mean crypt depth of 334 µm, compared with 310 and 300 µm, respectively, in the control group.

In the ileum, vinasse-supplemented pigs had a mean villus length of 290 µm and a mean crypt depth of 280 µm, whereas control animals had corresponding values of 260 and 240 µm.

These results show that inclusion of vinasse in the diet was associated with a more developed intestinal morphology, expressed as greater villus and crypt dimensions in both intestinal segments evaluated.

DISCUSSION

The results obtained show that supplementation with distillery vinasse was associated with a favorable response in nursery pigs, expressed as a lower incidence of clinical alterations, better productive performance, and more developed intestinal architecture. This convergence among health, zootechnical, and histometric indicators is biologically consistent with current knowledge of the post-weaning phase, in which intestinal balance directly conditions growth and feed efficiency. In piglets, deterioration of the microbiota, epithelial barrier, and digestive stability is related to diarrhea, lower intake, and poor performance; therefore, any intervention capable of stabilizing this environment may be reflected in a favorable productive response (Fabà *et al.*, 2024; Han *et al.*, 2024; Tang *et al.*, 2024).

In the present study, the by-product had an acidic pH, no detectable *Salmonella spp.* or coliforms, and low mold and yeast counts. Although recent literature has examined other intestinal additives in greater detail, ingredient safety and compositional stability are necessary for interpreting biological effects. For organic acids, fermented feeds, and other functional additives, the animal response depends largely on the quality of the administered product (Cai *et al.*, 2024; de Groot *et al.*, 2024; Qiu *et al.*, 2024).

The absence of enteric and pneumonic processes and cannibalism in supplemented animals, compared with the presence of these events in the control group, suggests better clinical stability during the trial. Although these indicators were addressed descriptively, the pattern observed is consistent with recent evidence linking intestinal health with reduced diarrhea and better physiological adaptation to weaning. Han *et al.* (2024) and Tang *et al.* (2024) emphasize that post-weaning diarrhea results from a complex interaction among microbiota, intestinal barrier, inflammation, and diet. Consequently, the lower incidence of clinical signs in treated animals may be interpreted as an indirect indicator of a more favorable gastrointestinal environment.

The improvement observed in productive indicators reinforces this interpretation. In the present study, differences between treatments were not evident at the beginning or on day 15, but they became apparent from day 30 and at the end of the experimental period. This progressive pattern is compatible with the response described for other nutritional modulators of intestinal health, whose effect usually consolidates as the piglet's digestive adaptation advances. Cai *et al.* (2024) reported improvements in growth, antioxidant capacity, intestinal barrier, and microbiota with a blend of organic acids, whereas Qiu *et al.* (2024) observed higher growth and lower diar-

Table 3. Incidence of Pathological Processes in Nursery Pigs during the Experimental Period

Health indicator	Control n (%)	Vinasse n (%)
Enteric disorders	8 (20.0)	0 (0.0)
Pneumonic disorders	4 (10.0)	0 (0.0)
Cannibalism	8 (20.0)	0 (0.0)
Mortality	0 (0.0)	0 (0.0)

Values correspond to the absolute frequency of affected animals and their percentage within each treatment, considering 40 animals per group.

Table 4. Productive Indicators of Nursery Pigs Supplemented with Distillery Vinasse

Treatment	Initial weight (kg)	Weight at 15 days (kg)	Weight at 30 days (kg)	Weight at 40 days (kg)	Weight gain (kg)	Average daily gain (g/day)	Feed conversion ratio
Control	21.12^{a}	26.96^{a}	36.78^{a}	44.50^{a}	23.38^{a}	584.50^{a}	3.27^{a}
Vinasse 1.5%	20.76^{a}	27.61^{a}	38.24^{b}	46.43^{b}	25.67^{b}	641.75^{b}	2.98^{b}

Values correspond to treatment means. Body weights were analyzed using repeated-measures ANOVA, considering the effects of treatment, time, and the treatment × time interaction. Mean comparisons were performed using Tukey's test. Different letters within the same column indicate significant differences between treatments ($p < 0.05$). For feed intake and feed conversion ratio, the pen was considered the experimental unit.

Table 5. Intestinal Histometric Indicators of Nursery Pigs Supplemented with Distillery Vinasse

Intestinal segment	Treatment	Villus length (µm)	Crypt depth (µm)
Duodenum	Control	310.00 ± 6.20^{b}	300.00 ± 5.50^{b}
Duodenum	Vinasse 1.5%	340.00 ± 5.80^{a}	334.00 ± 6.10^{a}
Ileum	Control	260.00 ± 5.30^{b}	240.00 ± 5.00^{b}
Ileum	Vinasse 1.5%	290.00 ± 5.70^{a}	280.00 ± 5.80^{a}

Values are expressed as mean ± standard error of the mean. Histometric variables were analyzed by ANOVA, and mean comparisons were performed using Tukey's test. Different superscript letters within the same intestinal segment and column indicate significant differences between treatments ($p < 0.05$). For each animal, the average of the measurements performed on adequately preserved and oriented intestinal structures was considered.

rhea with fermented feed.

The greater weight gain and higher average daily gain obtained with vinasse are especially relevant from a productive standpoint, because the nursery phase conditions the subsequent development of the animal. Recent studies agree that improved growth at this stage is usually accompanied by a more stable and functional intestinal environment. De Groot *et al.* (2024) reported improvements in intestinal morphology and favorable inflammatory changes with organic acids, Zhang *et al.* (2024) showed that probiotic-fermented feed benefited growth and the microbiota, and Xu *et al.* (2024) documented intestinal and immunological improvements with fermented residue.

The reduction in feed conversion ratio observed in pigs supplemented with vinasse represents a relevant result from a productive standpoint. This indicator estimates the efficiency with which animals use ingested feed to generate weight gain; therefore, a lower value reflects more efficient use of available nutrients. This behavior could be related to a more stable and functional intestinal environment, because several nutritional additives aimed at improving mucosal integrity, modulating the microbiota, or regulating luminal conditions have been associated with more efficient productive responses, including improved feed conversion ratio.

In the present study, animals supplemented with vinasse showed greater villus and crypt dimensions in the duodenum and ileum. Physiologically, greater villus length may be associated with increased absorptive area, whereas crypt depth reflects proliferative activity of the intestinal epithelium. The fact that these changes appeared together with better health status and better productive performance could be interpreted as signals of a more functional mucosa. This aspect is related to the findings of de Groot *et al.* (2024), Qiu *et al.* (2024), and Qu *et al.* (2025), who reported intestinal structural improvements associated with organic acids and fermented feeds.

The relationship between better intestinal histometry and better productive response has also been reinforced by other recent functional studies. Yin *et al.* (2024) reported that *Lactobacillus johnsonii* improved the intestinal barrier and reduced diarrhea; Liu *et al.* (2024) showed that alginate oligosaccharides improved intestinal health through the microbiota; and Hu *et al.* (2024) reported positive effects on immunity, intestinal barrier, and microbial structure with *Artemisia annua* residue. Likewise, Sadurní *et al.* (2023) and Correa *et al.* (2024) highlighted that nutritional manipulation can favorably affect growth and intestinal health in piglets. These findings allow the results of vinasse to be interpreted within a broader biological framework, although without mechanically equating it with probiotics, postbiotics, or standardized fermented feeds.

From a physiological standpoint, the acidic character and fermentative origin of vinasse may have modified the luminal environment of the gastrointestinal tract. The present study did not evaluate intestinal microbiota, short-chain fatty acids, tight-junction proteins, cytokines, or immunological biomarkers; therefore, it is not possible to establish the mechanism of action precisely. Recent literature shows that the effects of intestinal additives usually depend on complex interactions among diet, luminal metabolism, epithelial barrier, local immunity, and microbiota.

The incorporation of agro-industrial by-products into animal feeding has become an alternative of growing interest, both for its contribution to the use of local resources and for its potential to reduce the environmental impact of livestock systems. In this context, Papatsiros *et al.* (2025) indicate that food-industry co-products can be used in swine diets, provided that control of their composition, safety, variability, and biological effect is ensured. Therefore, the positive results observed with vinasse acquire additional importance, showing that this distillation by-product could have practical utility within tropical swine systems.

Although favorable changes were observed in productive and histometric indicators, the interpretation of the results must be made with caution. The health evaluation was limited to a descriptive record, and analyses of intestinal microbiota, immune response, or metabolic parameters that would allow a more precise explanation of the mechanisms involved were not incorporated. Likewise, different levels of vinasse inclusion or possible variations among batches of the by-product were not evaluated. These considerations are important because the animal response to functional additives can vary according to the dose used, the health status of the animals, the composition of the basal diet, and the particular characteristics of the ingredient used.

Distillery vinasse may represent an alternative with potential as a feed additive in nursery pigs because of the better health response, improved zootechnical performance, and greater intestinal histometric development observed, which reinforces its scientific and applied interest. This study is aligned with the current trend in swine nutrition aimed at improving intestinal health through non-antibiotic strategies while simultaneously promoting the valorization of agro-industrial by-products.

CONCLUSION

Under the conditions of this study, supplementation with distillery vinasse at 1.5% of dry matter intake increased total weight gain and average daily gain, improved the feed conversion ratio, and was associated with greater villus and crypt dimensions, while no enteric or pneumonic disorders or cannibalism were observed in supplemented pigs. These findings support further evaluation of vinasse as a potential feed additive in tropical pig production and as an option for valorizing distillery by-products. Before commercial use is recommended, its safety, compositional stability, optimal dose, and long-term effects should be confirmed.

ACKNOWLEDGEMENTS

The authors thank the Escuela Superior Politécnica de Chimborazo (ESPOCH), the Orellana Campus, and the Faculty of Animal Sciences for their academic and technical support during the development of this research. The authors also acknowledge the pig production unit in Orellana, Ecuador, where the experimental trial was conducted, and the artisanal distillery "Puro Puyo" in Pastaza, Ecuador, for providing the distillery vinasse used as a feed additive in this study.

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