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IMPACT OF ADMINISTERING POLYPHENOL-RICH SUGARCANE EXTRACT THROUGH DRINKING WATER ON THE GROWTH PERFORMANCE AND MEAT QUALITY OF BROILER CHICKENS

N. D. Karunaratne [1] *, R. Senaarachchi [2], P. Weththasinghe [3], B. Jayawardana[3], E. De Seram[1], K. Nizanantha[1], P. G. A. Pushpakumara[1], M. Flavel [4]

[1]*Department of Farm Animal Production and Health, University of Peradeniya, Peradeniya 20400, Sri Lanka*

[2]*PJM Bioactives (Pvt) Ltd, 723/33, Lake Terrace, Athurugiriya, Sri Lanka*

[3]*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya 20400, Sri Lanka*

[4]*Bioactives Division, The Product Makers, Melbourne VIC, Australia*

SUMMARY: There is a growing interest in the broiler industry to explore innovative approaches that enhance productivity while maintaining optimum animal health and welfare. The current study focused on evaluating the effect of a polyphenol-rich sugarcane extract (PRSE) administered via drinking water on growth performance and meat quality of broiler chickens. Four experimental groups of Cobb 500 broilers (496) were housed in litter floor pens, viz., no PRSE (Control), 0.05% PRSE (Treatment-1), 0.25% PRSE (Treatment-2) from Day 0 to 35, and a transition dose of 0.25% (Day 0 to 17) reduced to 0.05% PRSE (Day 18 to 35) (Treatment-3). Treatments were prepared by adding the respective levels of PRSE to drinking water and supplying it for the specified periods. Each treatment was randomly assigned to two pens in each room. Each of the two rooms (blocks) was portioned into eight pens (31 birds/pen). Birds were fed commercial starter (Day 0 to 17) and finisher (Day 18 to 37) diets according to Cobb 500 broiler performance objectives, and water was given *ad libitum*. Feed intake, water intake, and mortality were recorded daily. Body weight gain and feed-to-gain ratio were evaluated on Days 11, 22, and 35 on a pen basis, and the birds selected for meat quality were euthanised on Day 38. Data were analysed using one-way ANOVA for a randomised complete block design. The supplementation of PRSE via drinking water did not affect broiler performance. Both 0.05 and 0.25% PRSE were found to reduce levels of Thiobarbituric Acid Reactive Substances (TBARS) in meat on Day 1 post-processing compared to the control by 99.8% and 96.0%, respectively. These concentrations increased the water holding capacity of meat on Day 7 when compared with the other groups. Birds receiving 0.25% and the transition dose of PRSE reduced meat colour luminosity on Day 7 as compared with other treatments. The consistent provision of 0.05 and 0.25% PRSE treatments resulted in enhanced broiler meat quality, although it did not impact broiler performance.

Keywords: antioxidant, poultry, malonaldehyde, meat quality, water holding capacity

INTRODUCTION

In response to the increasing global demand for poultry products, the poultry industry must innovate and adopt sustainable practices to enhance the growth performance and meat quality of broiler chickens (Statista, 2023). This challenge is further highlighted by the rising consumer expectations for high-quality poultry products while reducing the use of antibiotics and adhering to environmentally sustainable and ethical production standards (Pellattiero *et al*., 2020). As a result, there is a rising interest within the broiler industry to explore novel approaches that not only enhance productivity but also prioritise animal health and welfare (Korver, 2023). In this context, the integration of natural bioactive compounds into broiler diets has emerged as a focal point of research, with the potential to serve as a sustainable and health-promoting solution (El-Ashram and Abdelhafez 2020).

Polyphenols, a diverse class of plant-derived secondary metabolites, have gained considerable attention for their comprehensive bioactivities, including antioxidant, anti-inflammatory, and antimicrobial properties (Awais *et al*., 2011; Zhang *et al*., 2016). These compounds exhibit the potential to positively impact various physiological processes in poultry (Abdel-Moneim *et al*., 2020; Al-Mnaser *et al*., 2022). Sugarcane (*Saccharum officinarum*), a perennial grass commonly found in South Asia, Southeast Asia, and other tropical and subtropical

Corresponding author: Namalika D. Karunaratne, Email: nkarunaratne@vet.pdn.ac.lk

regions presents itself as a particularly promising source of polyphenols (Singh *et al*., 2015). The plant possesses bioactive compounds, ranging from flavonoids to phenolic acids, with documented health-promoting attributes in humans, including anti-inflammatory and immunomodulatory effects (Ji *et al*., 2020; Feehan *et al*., 2021). These plant-derived polyphenols are recognised for their ability to combat oxidative stress in living cells through the absorption of reactive oxygen species (ROS), thereby contributing to the overall well-being of animals (Ji *et al*., 2021).

In poultry, oxidative stress is a significant concern in the industry as various sources, including mycotoxicosis and heat stress (Akbarian *et al*., 2016), can induce lipid peroxidation and cell apoptosis that affect broiler performance and meat quality (Min and Ahn, 2005). Despite the knowledge regarding polyphenols in livestock nutrition, a notable research gap exists concerning the specific impact of polyphenol-rich sugarcane extract on the growth performance and meat quality of broiler chickens (Gessner *et al*., 2017). While previous studies have studied polyphenols derived from diverse sources, the unique composition of sugarcane-derived polyphenols and their potential implications for broiler production remain insufficiently studied and the results were not consistent (Senaarachchi *et al*., 2022). Further, limited research exists on the impact of polyphenols derived from sugarcane on broiler meat quality (Shakeri *et al*., 2020). The present study is essential for understanding sugarcane polyphenol interactions with broiler physiology and developing sustainable dietary strategies in the poultry industry. It addresses this knowledge gap by examining the effects of administering polyphenol-rich sugarcane extract through drinking water on growth performance and meat quality parameters in broiler chickens. Notably, this is the first time in research that polyphenol is administered through drinking water to evaluate broiler production and meat quality according to the best of our knowledge, as the polyphenol derivatives have been used in feed in the previous research in poultry.

The objective of this study was to assess how varying levels of PRSE supplementation in drinking water impact the growth performance and meat quality of broiler chickens in the absence of antibiotics. Our hypothesis suggested that the administration of PRSE in drinking water would enhance both the growth performance and meat quality of broilers.

MATERIALS AND METHODS

The experimental protocol received approval from the Ethics Committee of the Faculty of Veterinary Medicine and Animal Science at the University of Peradeniya, as indicated by the Ethical Clearance Certificate Number VERC-21-14. The study strictly followed the Guidelines for Ethics Review of Research Proposals Involving Animals in Sri Lanka, established by the Forum of Ethics Review Committees of Sri Lanka in 2009 (FERCSL, 2009).

Experimental treatments

Two sets of treatments were formulated by manually blending different concentrations (0.05% and 0.25%) of PRSE in drinking water individually. A third treatment involved the supplementation of PRSE at a concentration of 0.25% from Day 0 to 17 and 0.05% from Day 18 to 38. The birds in the control group were given water without adding PRSE (0%). Water was provided *ad libitum* throughout the entire study duration.

Birds and housing

A total of 496 newly hatched mixed-sex broiler chickens (Cobb 500) were procured from a commercial hatchery and placed randomly, with 31 birds per pen, across 16 floor pens measuring 2.54 m in length and 2.22 m in width. These pens were situated in two open-sided broiler rooms at the Veterinary Teaching Farm of the University of Peradeniya, Sri Lanka. Initial weights of broilers were recorded on a per-pen basis before placement. Each broiler room was divided into eight pens, and each of the four experimental groups was randomly assigned to two pens, resulting in four replications for each treatment and control group. Paddy husk, with an 8 cm thickness, was uniformly spread on the concrete floor of each room. A brooding period, from Day 0 to 17, was provided using gas brooders. Each broiler house, comprising 8 floor pens, was equipped with two common brooders, covering four pens each, consisting of circularly arranged metal brooder guards and heating lamps. The room temperature was initially set at 33°C on Day 0 and gradually reduced by expanding the brooder area and adjusting the brooder guards based on bird behaviour and distribution. During the brooding period, each pen was equipped with a plastic turbo feeder (4 L capacity; 27.94 cm pan diameter) and a plastic mini poultry drinker (1 L water capacity; 20 cm pan diameter). On Day 17, the mini poultry drinker was replaced with a manual plastic drinker (4 L water capacity; 40 cm pan diameter), and a manual plastic pan feeder (10 kg capacity; 40.5 cm pan diameter) was placed to substitute the turbo feeder used during the brooding period in each broiler pen. All birds received glucose supplementation through drinking water for the first

3 days after placement. During the initial 18 days, the birds were fed a commercial starter diet, followed by the introduction of a commercial grower diet. The transition from commercial starter to grower diet occurred gradually over a 3-day interval (from Day 18 to 21).

The commercial starter and grower diets were composed of corn-soybean meal-based formulations with anticoccidial drugs, presented in crumble and pellet forms, respectively. The feeding regimen followed the guidelines outlined in the Cobb 500 Broiler Performance and Nutrition Supplement (Cobb Vantress, 2022).

Study material

In this study, a recently identified sugarcane extract was used, and the sugarcane extract was initially developed by the hydrophobic resin procedure outlined by Ji *et al*. (2020). The utilised sugarcane extract, featured in a liquid-to-paste form, exhibits a brown colouration, produced by The Product Makers Pvt Ltd in Melbourne, Australia. According to the analysis using liquid chromatography-mass spectrometry, the sugarcane extract exhibited a total polyphenol content of 221 mg/g GAE (as gallic acid equivalency) and a flavonoid content of 53.8 mg/g CE (as catechin equivalency). The pH value of a 1% solution at 20ºC was measured at 3.74 (Ji *et al*., 2020). Moreover, the total antioxidant activity of the sugarcane extract was determined to be 18,837 µmole TE (as Trolox equivalency)/g. The elemental composition of the extract revealed levels of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and zinc (Zn) at concentrations of 170, 130, 6600, 3000, and 15 mg/kg, respectively. Additionally, selenium (Se) and chromium (Cr) were present at concentrations of 0.3 and 2.4 mg/kg (Ji *et al*., 2020).

Data collection and sample analyses

Performance metrics, encompassing feed intake, water consumption, and body weight, were assessed on a per-pen basis on Days 11, 22, and 35. Body weight gain and the feed-to-gain ratio were adjusted for mortality and computed for each weighing. Mortality rates and carcass weights of dead birds were documented daily, with a comprehensive postmortem examination conducted for every deceased bird. On Day 38, two birds were randomly chosen from each pen and humanely euthanised by jugular vein incision. Both breast muscles from each carcass were extracted and placed in re-sealable polythene bags, then stored at -20°C. Breast muscles were divided into three portions and stored in separate bags for meat quality analysis at three distinct time points. Following the removal of the breast muscles from the same carcass, the abdominal cavity was opened, and the digestive tract was extracted. The small intestine was separated into duodenum, jejunum, and ileum, and the prevalence of haemorrhages was recorded for all the sampled birds.

Determination of antioxidant activity

To homogenise and process each meat sample, 2 g was placed in a centrifuge tube, and 5 ml of a 10% (W/V) trichloroacetic acid solution was added, followed by vortexing (K-550-GE, USA) for 2 min. Subsequently, 5 ml of a 0.02 M aqueous solution of 2-thiobarbituric acid was introduced into each centrifuge tube and vortexed for an additional 30 s. After centrifugation at 3000 *g* (MF6 Hitachi, Japan) for 10 min, the supernatants were filtered through the Whatman No.3 filter paper. The filtrates underwent heating in a boiling water bath for 45 min, then cooled to room temperature in an ice bath, and the absorbance of the resulting pigment was measured at 532 nm using a UV spectrophotometer (D-17, Shimadzu, Japan). Thiobarbituric Acid Reactive Substances (TBARS) values were determined by multiplying the absorbance reading by a factor obtained from a standard line, which was prepared using 1,1,3,3-tetramethoxypropane as a precursor of malonaldehyde (Jayawardana *et al*., 2015).

Determination of water holding capacity

Two grams of the meat samples were accurately measured (W1) and wrapped in filter tissue paper. Subsequently, these wrapped samples were transferred into a centrifuge tube and subjected to centrifugation using a centrifuge (CF 1502, Himac, Hitachi, Japan) at 2600 rpm for 4 min. Following centrifugation, the samples were carefully extracted from the centrifuge tube and precisely weighed by placing them on crucibles (W2). The samples were then dried in a vacuum oven (T 5042 K, Tamson, P. O. Box 208, Zoe Termeer, Holland) at 70°C for an overnight period. Ultimately, the processed samples were transferred to a desiccator, allowed to cool for 15 min, and accurately weighed (W3), adhering to the methodology outlined by AOAC (AOAC, 1995). The water holding capacity was calculated according to the following formula.

Water holding capacity = [Sample weight after centrifugation (W2) – Sample weight after drying (W3)/ Initial weight of the sample (W1)] × 100.

Value of pH and instrumental colour evaluation

The pH value of meat samples was determined using a digital pH meter (HM-5S; TOA Electric Industrial Co. Ltd., Tokyo, Japan), after homogenising a 10 g meat sample with 50 ml of distilled water. The colour characteristics (L*, a*, and b*) of meat were

analysed using a chroma meter (5104, No: 453, WPA Linton Cambridge, UK).

Statistical analysis

The study employed a randomised complete block design, utilising a broiler room as a block to alleviate environmental impacts. Growth performance and meat quality data were analysed through a one-way analysis of variance using the Proc mixed model in Stata statistical software. The significance level was set at $P \leq 0.05$. The significant differences among means were separated using the Tukey-Kramer test. Before variance analysis, data normality was assessed through the Shapiro-Wilk test. Additionally, the occurrence of small intestine lesions was examined using a multivariable binary logistic regression model.

RESULTS

Growth performance

Supplementation of PRSE in drinking water exhibited no significant impact on the body weight gain, feed intake, water intake, and feed-to-gain ratio of broiler chickens across each evaluated interval or when considering the total duration of the trial, as detailed in Table 1. Nevertheless, all the treatment groups reached the Cobb 500 performance objectives at the end of the study period.

Meat quality

Table 2 illustrates the impact of PRSE on the meat quality parameters of broiler chickens. Notably, the TBARS value in chicken meat exhibited a significant reduction in birds consistently provided with 0.05% or 0.25% PRSE compared to both the control and the transition dose of PRSE on Day 1 post-slaughtering ($P < 0.01$). Furthermore, on Day 7 post-slaughtering, the water-holding capacity of meat was higher in broiler chickens supplemented with 0.05% or 0.25% PRSE consistently, in contrast to both the control and the transition dose of PRSE ($P = 0.02$). Interestingly, broiler chickens supplemented with 0.25% or the transition dose of PRSE in drinking water decreased L* value (luminosity) of chicken meat on Day 7 post-slaughtering compared to the other two treatments.

Intestinal gross lesions

The variable levels and extents of PRSE supplementation in drinking water demonstrated no discernible impact on the occurrence of mucosal haemorrhages in the duodenum, jejunum, or ileum of the broiler chickens, as indicated in Table 3.

Table 1. Effect of supplementing polyphenol-rich sugarcane extract (PRSE) in drinking water on the growth performance of broiler chickens

Item	PRSE [1] concentration (%) in drinking water				SEM[2]	*P* value
	0	0.05%	0.25%	0.25% and 0.05%		
Body weight gain (g)						
Day 0-11	215	211	215	210	0.004	0.93
Day 12-22	732	731	743	735	0.005	0.55
Day 23-35	1094	1207	1100	1171	0.044	0.38
Day 0-35	2041	2149	2058	2118	0.044	0.48
Feed intake (g)						
Day 0-11	314	314	313	320	0.004	0.22
Day 12-22	1024	1024	992	1018	0.018	0.63
Day 23-35	1980	1987	2058	1980	0.039	0.48
Day 0-35	3318	3325	3363	3326	0.042	0.87
Water intake (L)						
Day 0-11	0.73	0.73	0.75	0.76	0.010	0.20
Day 12-22	2.06	2.11	2.06	2.14	0.032	0.30
Day 23-35	4.66	4.57	4.88	4.72	0.108	0.44
Day 0-35	7.44	7.41	7.69	7.62	0.117	0.44
Feed to gain ratio						
Day 0-11	1.47	1.50	1.46	1.55	0.047	0.62
Day 12-22	1.40	1.40	1.33	1.39	0.028	0.44
Day 23-35	1.86	1.65	1.88	1.70	0.093	0.48
Day 0-35	1.64	1.55	1.64	1.57	0.051	0.62
Total Mortality (%)	4.83	3.17	12.09	7.99	2.664	0.26

[1]PRSE - Polyphenol rich sugarcane extract.
[2]SEM – Pooled standard error of mean (n=4).

Table 2. Effect of supplementing polyphenol-rich sugarcane extract (PRSE) in drinking water on the meat quality of broiler chickens

Item	PRSE[1] concentration (%) in drinking water				SEM[2]	*P* value
	0	0.05%	0.25%	0.25% and 0.05%		
TBARS (mmol/cm^3)						
Day 1	4.88^a	0.01^b	0.17^b	7.66^a	0.793	<0.01
Day 7	7.92	6.83	8.28	7.41	0.644	0.49
Day 14	7.14	7.72	7.67	7.89	0.408	0.63
Water holding capacity (%)						
Day 1	69.66	66.56	69.45	71.06	1.400	0.20
Day 7	68.16^b	74.50^a	74.29^a	68.93^b	1.375	0.02
Day 14	79.37	74.40	77.01	78.85	1.679	0.18
Meat pH						
Day 1	5.92	5.90	5.87	5.85	0.036	0.61
Day 7	5.94	5.82	5.76	5.82	0.042	0.09
Day 14	5.87	5.80	5.83	5.94	0.037	0.06
Meat colour L*, luminosity						
Day 1	5.72	3.41	3.84	2.67	1.971	0.74
Day 7	-6.52^a	-6.95^a	-10.56^b	-10.63^b	0.654	<0.01
Day 14	-10.11	-9.79	-10.23	-11.27	1.326	0.64
Meat colour a*, red intensity						
Day 1	-2.49	-2.01	-0.47	-0.71	0.600	0.06
Day 7	-0.17	1.11	0.26	-0.80	0.472	0.09
Day 14	3.35	1.84	2.20	2.51	0.629	0.49
Meat colour b*, yellow intensity						
Day 1	-0.53	-0.10	-0.79	-0.12	0.353	0.38
Day 7	-0.52	0.10	0.02	0.55	0.345	0.76
Day 14	1.52	1.56	1.28	1.45	0.286	0.83

[a-b]Means within a row without a common superscript differ significantly ($P < 0.05$).
[1]PRSE - Polyphenol-rich sugarcane extract.
[2]SEM – Pooled standard error of mean (n=8).

Table 3. Effect of supplementing polyphenol-rich sugarcane extract (PRSE) in drinking water on the small intestinal mucosal lesions of broiler chickens (n=8)

Outcome = Intestine lesions	Odds ratio (95% CI[1])	*P* value
Duodenum		overall model = 0.34
0% PRSE [2]	Reference	
0.05% PRSE	0.360 (0.047-2.725)	0.32
0.25% PRSE	0.085 (0.006-1.084)	0.06
0.25 and 0.05% PRSE	0.360 (0.047-2.725)	0.32
Jejunum		overall model = 0.97
0% PRSE	Reference	
0.05% PRSE	1.000 (0.131-7.601)	1.00
0.25% PRSE	0.599 (0.081-4.409)	0.62
0.25 and 0.05% PRSE	1.000 (0.131-7.601)	1.00
Ileum		overall model = 0.32
0% PRSE	Reference	
0.05% PRSE	3.134 (0.364-26.965)	0.30
0.25% PRSE	1.000 (0.118-8.450)	1.00
0.25 and 0.05% PRSE	1.770 (0.214-14.601)	0.60

[1]CI - Confidence interval.
[2] PRSE - Polyphenol-rich sugarcane extract.

DISCUSSION

In the current study, PRSE supplementation in drinking water did not result in any significant impact on broiler performance from Day 0 to 38. The influence of sugarcane extract-derived polyphenols on the growth performance of broiler chickens has been explored in limited studies, with varied and inconsistent results. Notably, Shakeri *et al*. (2020) reported positive outcomes in broiler growth performance, including an increase in average daily gain and a linear reduction in feed conversion ratio with a sugarcane extract rich in polyphenols in increasing doses (0, 0.2, 0.4, 0.6, 0.8, and 1%) in the diet. Conversely, enhanced body weight gain in broiler chickens with a 0.05% dietary sugarcane extract (Khambualai *et al*., 2020), while no significant effects on feed intake, body weight gain, and feed conversion with a 0.1% dietary addition of sugarcane extract (Khonyoung *et al*., 2019) were reported. Comparing performance outcomes across these studies is challenging due to the lack of information on the analysed total polyphenol content, a crucial factor that varies among different sugarcane varieties (Khonyoung *et al*., 2019). Total polyphenol content is crucial for meaningful comparisons, as it varies among varieties. Analysing the polyphenol profile of sugarcane extract is essential to understand its impact on broiler production, given the differing phenolic profiles among varieties. The absence of significant effects on broiler performance may be due to differences in total polyphenol content and phenolic profiles between this study and previous ones (Shakeri *et al*., 2020). Increasing the number of replications could enhance statistical power, potentially revealing improvements in broiler growth performance with PRSE supplementation.

In contrast to previous studies that incorporated sugarcane extract via feed, the present study uniquely employed drinking water as an approach for supplementing PRSE. This novel advance marks the first instance in poultry research where sugarcane polyphenol extract is delivered through drinking water in broiler chickens according to the best of our knowledge. The manner in which polyphenols are absorbed in poultry could potentially vary between drinking water and in-feed administration, consequently influencing polyphenol bioavailability that affects growth performance and meat quality outcomes (Manach *et al*., 2004). Moreover, the supplementation of PRSE in feed might influence the feed intake of the birds, thereby impacting water consumption (Aggrey *et al*., 2023) in chickens differently through the feed route compared to the drinking water route. This difference in drinking water and feed routes may contribute to variations in performance and meat quality parameters across the studies.

Polyphenols and their microbial metabolites affect the composition of the intestinal microbiota and associated metabolic pathways, as demonstrated by previous research (Iqbal *et al*., 2020). This impact demonstrates a reduction of pathogenic bacterial colonisation, while promoting commensal microbes and favourable alterations in intestinal morphology, as evidenced by some studies (Cueva *et al*., 2010). However, no significant treatment effects were observed in the current study concerning the presence of lesions in the small intestinal mucosae. This lack of significant effects should be interpreted cautiously, given that the appearance of lesions was attributed to an unforeseen subclinical coccidiosis outbreak during the later stages of the trial. The mucosal damage caused by *Eimeria* spp. may not demonstrate uniformity across treatments and replications in the current research, thereby complicating the observed effects specifically to the impact of PRSE.

The constant administration of water with 0.05% or 0.25% PRSE yielded consistent reductions in TBARS values, indicative of reduced lipid peroxidation in chicken meat, which is a critical factor in the degradation of meat quality and the shortening of its shelf life (Amaral *et al*., 2018). This aligns with previous research findings related to dietary supplementation of polyphenols derived from sugarcane. Nevertheless, the significant reduction in TBARS values was shown only on Day 1 post-processing, exhibiting no lasting impact on Days 7 and 14. The cascade of lipid peroxidation creates a sequence of secondary reactions following the primary auto-oxidation event (Amaral *et al*., 2018), ending in the accumulation of ROS over time. This sequential progression contributes to an augmentation in TBARS levels within the meat matrix (Shakeri *et al*., 2020). The decreased efficacy of PRSE in reducing TBARS values during later post-processing intervals may be attributed to the

increasing production of ROS as the post-slaughter period extends. The potential of PRSE to mitigate ROS generation or scavenge oxidants may prove inadequate with the prolonged duration post-slaughter, as explained by previous research (Gessner *et al*., 2017). Transitioning from a high to a low dose of PRSE did not affect TBARS values, suggesting that abrupt dose changes may stress living cells adapted to the former concentration. This highlights the relationship between dosage variations and cellular responses to PRSE supplementation, necessitating further exploration for optimal dosing strategies.

On Day 7 post-slaughtering, chicken meat exhibited increased water-holding capacity in the birds administered with 0.05% or 0.25% PRSE, consistently exceeding the outcomes of the remaining two treatments. A parallel observation was made by a previous study (Shakeri *et al*., 2020), where increasing doses (ranging from 0 to 10 g/kg) of sugarcane-derived polyphenol in broiler diets linearly increased water-holding capacity in meat. The interaction between antioxidant capacity and drip loss, affecting the migration and distribution of water within muscle tissues, has been explained (Cheng *et al*., 2020). A negative relationship between antioxidant capacity and drip loss features that reduced drip loss indicates an elevated water-holding capacity (Warner *et al*., 2014). Consequently, the observed increase in water-holding capacity in the present study is possibly linked to the mitigation of lipid oxidation in the breast meat of birds supplemented with consistent doses of PRSE, as suggested by previous research (Wang *et al*., 2023). Nevertheless, the transitional dose of PRSE failed to give an improvement in water-holding capacity compared to the control, reflecting a similar trend in TBARS values. This phenomenon could be attributed to cellular stress induced by abrupt alterations in antioxidant capacity.

The inclusion of PRSE in the drinking water exhibited no significant impact on meat pH value; nevertheless, trends were observed on Day 7 and 14, revealing reduced pH values with a consistent administration of 0.05% or 0.25% PRSE. The lower pH values observed can be attributed to anaerobic glycolysis in muscle tissues, leading to lactate accumulation, causing reduced water holding capacity (Scheffler *et al*., 2015; Jankowiak *et al*., 2021). Contrary to this concept, water holding capacity values demonstrated enhancement with consistent doses of PRSE supplementation throughout the study in the present research. This improvement may be linked to the mitigation of pH reduction trends, suggesting a potential mechanism through which PRSE positively influences water holding capacity despite the observed pH trends. Moreover, the trends in pH reduction were only manifested after Day 7 post-slaughtering, indicating a slowed pH decline with the addition of PRSE.

The indication of meat colour is linked to its lightness (L*), redness (a*), and yellowness (b*), corresponding to the presence of myoglobin, haemoglobin, and cytochrome-c (Yu *et al*., 2021). This colour profile serves as a vital indicator of meat freshness, which depends on factors such as light reflection and oxidation, thereby influencing market demand (Gao *et al*., 2022). In terms of poultry, L* emerges as the principal determinant of meat colour, where elevated values signify a lighter colour (Garcia *et al*., 2010). Notably, in the current study, the single parameter affected by the incorporation of PRSE was L*, exhibiting a reduction on Day 7 with 0.25% PRSE and the transition dose. This alteration in L* assumes significance in the context of meat quality. It is crucial to underline that lighter poultry is associated with characteristics such as pale, soft, and exudative meat, coupled with diminished water holding capacity traits generally undesired by a majority of consumers globally (Hong *et al*., 2006). Consequently, the favorable reduction in L*, as observed with 0.25% PRSE supplementation and the transition dose, warrants attention. However, interpreting the specific impact of the transition dose on L* proves to be a complex task, given the absence of concurrent improvements in other meat quality parameters under the same treatment. This complexity needs a comprehensive assessment of the broader effects of transition dose on overall meat quality, suggesting potential comprehensive effects.

The apparent impact of PRSE on L* occurred distinctly on Day 7, an important observation that establishes a temporal relationship. This association gains further support through the particular significance of water holding capacity on the same day, highlighting the interplay between L* and the crucial characteristic of water retention in meat. Notably, the absence of any treatment-induced effect on a* could be attributed to the primarily low myoglobin content in chicken meat, distinguished by its predominantly white muscle fibres. Given that myoglobin content is a key determinant of meat redness, the observed lack of influence on this parameter aligns with the intrinsic composition of chicken meat (Mancini *et al*., 2005). Moreover, the favourable finding of the lack of significant impacts on a* and b* values in the three treatments containing PRSE, in comparison to the control, suggests that PRSE does not cause any adverse effect on meat colour. The data were not consistent regarding the impact of sugarcane extract on L*, a* and b*, as reported in previous studies (Shakeri *et al*., 2020). It is imperative to acknowledge, however, that a direct comparative analysis among these investigations is challenging. This challenge arises

from the inherent variability in sugarcane extract compositions, involving differences in polyphenol profiles and concentrations. Additionally, methodological differences, such as variations in feeding protocols, feed types, and inherent physiological factors like bird strains and age, further complicate the establishment of comparisons across studies (Shakeri *et al*., 2020).

Meat quality represents a complex characteristic, reflective of diverse parameters such as antioxidant capacity, water holding capacity, drip loss, cooking loss, meat pH, and colour, as interpreted by Shakeri *et al*., (2020). In contrast to single assessments, a comprehensive evaluation of these parameters collectively informs the determination of overall meat quality. Notably, the consistent supplementation of PRSE in drinking water throughout the trial duration has granted promising outcomes concerning meat quality, exhibiting favourable effects on TBARS levels, water holding capacity, and meat colour.

It is important that the PRSE did not exert significant effects on growth performance, despite the significant impact observed in meat quality parameters. A complex association between growth rate and meat quality has been documented in previous studies, showing higher chicken growth rates with compromised meat quality, characterised by low pH and reduced water holding capacity (Barbosa *et al*., 2017; Poompramun *et al*., 2022). This interrelation may account for the absence of significant effects of PRSE on broiler growth performance. However, in the present study, the consistent administration of 0.05% or 0.25% PRSE has demonstrated positive effects on meat quality without detrimentally affecting growth performance. This observation emphasises the potential utility of PRSE supplementation in drinking water to enhance meat quality parameters in broilers without compromising their overall growth performance.

CONCLUSION

In conclusion, the present study revealed that supplementation of PRSE in drinking water did not significantly impact broiler growth performance, while significantly improving overall meat quality. Both 0.05% and 0.25% PRSE in constant supplementation throughout the study period notably improved lipid stability of meat, while increasing water-holding capacity at early post-slaughtering.

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