GUT ORGANS AND INTESTINAL HISTO-MORPHOLOGICAL CHARACTERISTICS OF THE IMPROVED INDIGENOUS CHICKEN ON DIETARY SUPPLEMENTATION WITH LIVE YEAST (*saccharomyces cerevisiae*) IN KENYA.

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Abstract: This study was carried out to evaluate the effects of dietary supplementation with live yeast (*Saccharomyces cerevisiae)* on the gut organs and intestinal histo-morphological characteristics of improved indigenous chicken in Kenya. A total of 240 uniformly sized day-old chicks (DoCs) were procured from the Kenya Agricultural Livestock Research Organization (KALRO) Naivasha hatchery. A complete randomized design (CRD) experiment was used. The DoCs were randomly placed in 6 experimental treatment groups replicated 4 times. The treatments consisted of starter and grower basal diets supplemented with *Saccharomyces cerevisiae* (SC) as follows: Control (T0) - 0 g SC/kg of basal feed; T1 – 2.5 g SC/kg, T2 - 5.0 g SC/kg, T3 - 7.5 g SC/kg, T4 - 10.0 g SC/kg and T5 - 12.5 g SC/kg. The *isonitrogenous* and *isocaloric* basal diets in crumble form were formulated to meet the nutritional specifications of the birds as per the National Research Council (NRC, 1994) recommendations and provided *ad libitum*. The research was carried out at the University of Nairobi (Kabete Campus-Nairobi), Department of Animal Production Poultry Unit. The results of this study show that there was a significant difference ($P<0.05$) in the live weight($P<0.001$) and hot dressed carcass weight($P<0.001$), weight of ventriculus ($P<0.001$) and proventriculus ($P<0.001$). Also, a significant difference ($P<0.05$) was observed in the length of villi ($P<0.001$) and depth of the crypts ($P<0.001$) at week 12. However, there was no significant difference ($P>0.05$) in the weight and length of the small intestines, and the weight of liver and spleen. Diets supplemented with live yeast at 7.5 g/kg and 10 g/kg had the highest quality results in gut organs characteristics and intestinal histomorphometry compared to the control diet. Dietary supplementation with live yeast can be employed as a viable in-feed growth promoter that can be incorporated into the diets of the improved indigenous chicken to improve their productivity. Therefore, addition of supplemental yeast to the diets of the improved indigenous chicken at 7.5 g SC/kg of feed -10 g SC/kg of feed birds to improve the performance of gut integrity and nutrient utilization.

Index Terms: gut health, Improved Indigenous chicken, intestinal histomorphology, live yeast,

I. INTRODUCTION

The poultry industry is the fastest-growing subsector among the livestock subsectors, and it accounts for a significant source of protein supplements in the form of meat and eggs (Rao & Krishna, 2020). Products derived from poultry are in high demand worldwide because they are a crucial source of high-quality proteins, which are required by humans for their growth and development (Fathima et al., 2023). In many regions of the world, the poultry industry is still expanding quickly as a result of urbanization and population growth, and the demand for their commodities has drastically risen by 86% in the past decade (Gbuewu et al., 2020).

Indigenous chickens constitute 80% of the 57.7 million poultry reared and constitute 71% of all poultry meat and eggs consumed in Kenya (Kariuki et al., 2022). Kenyan poultry farmers favor indigenous chicken (IC) production. This is because of their capacity to withstand difficult weather conditions, high feed conversion rates, tasty final products, scavenging capabilities, and potential to lower greenhouse gas (GHG) emissions, among other advantages (Kamau et al., 2023). Approximately 70% of the rural inhabitants in Kenya derive their livelihoods from indigenous poultry production. Further, this enterprise has been identified as an exit strategy for addressing food scarcity among rural households (Evans et al., 2021). However, IC production systems are characterized by low productivity despite their potential to contribute to Kenya's economy and nutrition. Some of the setbacks experienced in IC production include low genetic potential, high disease prevalence, and chick mortalities, which lead to low productivity (Okoba et al., 2023). In an attempt to bridge the production gap, in the last few years, agricultural stakeholders have been at the forefront of the promotion of improved IC breeds, such as KALRO's improved chicken. This is a dual-purpose breed (source of eggs and meat) with a higher potential for productivity and matures faster to reach market weight more quickly than the local IC (Kamau et al., 2023). IIC is a better crossbreed of various indigenous chicken ecotypes from various Kenyan communities (Okoba et al., 2023). Scientists and other poultry stakeholders disseminated the Improved Indigenous Chicken (IIC) to Kenyan farmers as a productivity-boosting strategy.

In order to maximize the productivity of the IIC, nutritional interventions such as the use of in-feed growth promoters have been employed. Probiotics have proven to be safe and viable alternatives to antibiotics (He et al., 2021). According to the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO), probiotics are living microorganisms that, when administered in adequate amounts, confer a health benefit on the host (Krysiak & Konkol, 2021). Among these probiotics, Baker's yeast (*S. cerevisiae)* has attracted much interest due to its capacity to foster growth (Sun et al., 2020). *Saccharomyces cerevisiae* is a unicellular eukaryote microorganism that is most generally utilized probiotic due to its high biological value; having a good amount of crude protein (40- 45%), β-glucans, vitamin B complex, biotin, niacin, pantothenic acid, and thiamin. (Nath et al., 2020).

It has been demonstrated that *Saccharomyces cerevisiae* improves growth and increases egg production, blood and intestinal histo-morphological characteristics, and carcass quality in poultry and other monogastric animals (He et al., 2021). Furthermore, *Saccharomyces cerevisiae* in different forms, either as whole yeast products or yeast cell wall (YCW) components, have been utilized to improve growth attainment and modulate the physiology, morphology, and microbiology of the intestinal tract of broilers and turkeys (Kiarie et al., 2021). It contains mannan oligosaccharides and β-glucans. Mannan oligosaccharides hinder the attachment and colonization of pathogenic microscopic organisms to the digestive system, while β-glucans enhance gut health, improving villi tallness, cryptal depth, and muscular weight (Shurson, 2018). Their effects lead to improved intestinal function, gut health, and overall performance in broiler birds. However, there is a dearth of information demonstrating the effects of *Saccharomyces cerevisiae* supplementation on the gut health of the IIC. Therefore, this study aimed to determine the effects of *Saccharomyces cerevisiae* supplementation on some of the gut organs and intestinal histo-morphological characteristics of the IIC at the end of the grower's phase (12 weeks).

2.0: NEED OF THE STUDY

With the increasing demand for products derived from animals, towns and cities in urban areas that are increasing in size and affluence, the Kenyan poultry sector is evolving. The improved indigenous chicken has enormous potential to boost the income and alleviate poverty among the rural population who rely on them for their livelihood. Hence, alternative advanced ways of improving the productivity of the IIC by improved feeding and better management of their health are necessary. Therefore, this study's primary goal was to investigate the response of the IIC to dietary supplementation with graded levels of live yeast in basal starter and grower diets on their growth performance and gut health.

3.0 RESEARCH METHODOLOGY

Study Area: The study was carried out at the University of Nairobi, College of Agriculture and Veterinary Studies poultry unit (Kabete) located in Nairobi County. The GPS coordinates are 1°15'10.4"S 36°43'47.4"E Latitude: -1.2508146 Longitude: 36.7378815.

Study design: The feeding trial used a complete randomized design (CRD). The DoCs were acclimatized for 7 days, whereby they were put on a commercial diet without directly fed microbial. The chicks were weighed and randomly distributed to 6 experimental treatments; each treatment was replicated 4 times in 24 cages, each holding 10 birds. The experiment was carried out in 2 phases: the starter phase (0-8 weeks) and the growers' phase (9-12 weeks).

Birds, Housing, Experimental Design and Procedures: A total of 250 mixed-sex uniformly sized day-old improved indigenous chicks were purchased from the KALRO- Naivasha hatcheries. Only 240 were used in the experiment. The remaining 10 were used to cater for those with deformities and any mortality just before the onset of the experiment.

Test Ingredient and Experimental Diets: The powder form of live yeast (*Saccharomyces cerevisiae*) was sourced from Animix Kenya Limited, while the other feed ingredients were sourced from a local feed manufacturing company (Treasure Feeds Limited). In the experiment, 12 *isocaloric* and *isonitrogenous* experimental diets in crumble form were formulated to meet the nutritional specifications of the chicks (6 diets) and growers (6 diets) as per the NRC (1994) recommendations at 2,800 Kcal/kg ME and 18% CP for the chick diets and 2,550 Kcal/Kg ME and 15% for growers. The diets were formulated without any direct-fed microbial (DFM) in order to avoid interference with the activity of the live yeast, and the outcome of the research. The inclusion levels of the live yeast were as follows: Control (T0) - 0 g SC/kg; T1 - 2.5 g SC/kg; T2 - 5.0 g SC/kg; T3 - 7.5 g SC/kg, T4 - 10.0 g SC/kg and T5-12.5 g SC/kg.

Laboratory Analysis. Feed samples were analyzed for proximate composition according to AOAC (2012). The feed samples of the 12 experimental diets were subjected to proximate analysis at the animal production laboratory of the University of Nairobi. Dry matter (DM) content was determined by drying the samples in an oven at 105ºC for 5 hours. Ash content was determined by burning the sample at 600ºC in a muffle furnace for 3 hours to ensure that all the carbon had been removed. The Kjeldahl method was used to determine the crude protein (CP) content. The ether extract was determined using the Velp solvent extractor (SER 148/6). Crude fiber was determined by sequential treatment of the samples with sulphuric acid and potassium hydroxide. Nitrogen-free extracts (NFE%) were obtained as the difference between the feed sample's percentage of dry matter (DM) and the CP, ash, ether extract and crude fiber in the sample.

Histo-morphological analysis and gut organ measurements

At the end of the experiment (week 12), 1 bird per replicate was randomly picked and sacrificed according to the existing regulations and ethics on animal research. For gut organ measurements, the small intestines, ventriculus (gizzard) and proventriculus (glandular stomach), liver, and spleen in their fresh form were collected and weighed using a digital weighing balance. Thereafter, the small intestine samples were divided into section: duodenum, jejunum and ileum. The length of each section was taken using a 30 cm ruler. For histo-morphological analysis, each segment was flushed with formal saline and a small section was cut in transverse section from the mid-region. Samples were immersed in a 10% neutral buffered formalin solution to preserve the tissue samples for morphology analysis.

Fixed tissues were cut into smaller sizes (0.5-1 cm) and loaded into labeled plastic cassettes to hold them in place during processing. The tissues were dehydrated using different concentrations of alcohol ranging from 70-100% for 1 hour. The clearing, which involves removing the dehydrating agents, was done by passing the tissues through 2 changes of toluene for 1 hour each to remove alcohol completely. Infiltration was done by putting the tissues in molten wax at 50-60^0 C overnight. This is to offer internal support to the tissue. Embedding was done by covering the tissue with paraffin wax in a plastic mound to offer external support to the tissue and to hold it in place during sectioning.(Isaac et al., 2023)

A rotary microtome (Leica RM 2125 RTS) was used to cut the embedded tissues into ribbons of 4µm thickness. The ribbons were placed in a water bath at 48-52^{0}C to straighten them to enhance mounting. Frosted microscope slides that had been smeared with an adhesive (10% egg albumin) were used for fishing the tissue ribbons from the water bath. Excess wax was removed by keeping the slides in an oven at 50-60^{0}C for 30 minutes. This also helps to enhance the proper adhesion of the tissues on the slides. Before staining, the tissues were rehydrated using xylene, and the concentration of alcohol decreased from 100% - 70%. Staining was done by dipping the slides in hematoxylin for 15 minutes and then in water for 15 minutes to enhance color development. They were then dipped in eosin for 3 minutes, dried overnight at 37^{0}C, and cleared using xylene to remove excess wax. Mounting was done using a DPX mount, and a cover slip was placed and allowed to dry.

The slides were scanned by an Aperio Scan Scope XT (Leica Microsystems, VIC, Melbourne, Australia) to measure the villus height, crypt depth, and mucosa width. Villus height was measured from the tip of the villus to the crypt between 2 individual villi. Crypt depth was measured from the valley between the bases of the villi to the submucosa. A morphometric technique was used to determine the width of the mucosa. Four readings per specimen were taken.

Statistical Analysis: Raw data was recorded on workbooks and later entered into Excel spreadsheets in specific folders indicating clearly when the data was collected, cleaned and sorted to eliminate errors. Data was subjected to a one-way analysis of variance (ANOVA) and the Turkeys Test at $P< 0.05$ (Turkey, 1991) was used to separate substantially distinct means. This analysis was done using the Gen Start statistics software.

Conceptual framework: The conceptual framework of this study shows interaction between the dependent, independent and intervening variables. The outcome of this study is the status of IIC production among smallholder farmers in Kenya. The independent variables were poor nutrition and productivity of the IIC disease. The dependent variables were higher productivity and profitability of the IIC, increase in income for the rural farmers, improvement of the rural economy and increase in the overall contribution to the GDP. The intervening variables are improved feed intake and feed conversion ratio, improved gut health and improved overall growth performance of the IIC.

4.0 RESULTS AND DISCUSSION

The nutrient composition of the starter phase (0-8 weeks) and growers' phase (9-12 weeks) experimental diets are shown in Tables 3 and Table 4.

Table 3: Nutrient composition of starter phase experimental diet fed to the improved indigenous chicken

Nutrient composition	T0	T1	T2	T3	T4	T5
Dry Matter (%)	90.30	90.34	90.67	92.03	92.12	93.09
Moisture (%)	9.7	9.66	9.33	7.97	7.88	6.91
Crude Protein (%)	18.04	18.24	18.53	18.68	18.88	18.90
Crude Fiber (%)	4.25	4.52	4.54	4.05	3.93	3.72
Ether Extract (%)	5.65	5.75	5.55	5.73	5.44	6.17
Ash (%)	10.43	10.73	11.02	15.18	14.58	10.02
NFE (%)	51.93	51.1	51.03	48.10	48.70	51.72
ESTME (Kcal/kg)	**2850**	**2850.09**	**2850.23**	**2850.32**	**2850.44**	**2850.78**

Where: NFE – Nitrogen free extracts, ME – Metabolizable energy, Control (T0) - 0 g SC/kg, T1-2.5 g SC/kg, T2 -5.0 g SC/kg, T3 -7.5 g SC/kg, T4-10 g SC/kg and T5 -12.5 g SC/kg.

Table 4: Nutrient composition of grower's phase experimental diet fed to the improved indigenous chicken

Nutrient Composition	T0	T1	T2	T3	T4	T5
Dry Matter (%)	89.75	89.87	89.98	89.34	90.87	91.15
Moisture (%)	10.25	10.13	10.02	10.66	9.03	8.85
Crude Protein (%)	16.19	16.21	16.35	16.40	16.60	16.69
Crude Fiber (%)	5.22	5.80	5.59	6.00	6.02	6.92
Ether Extract (%)	3.20	3.03	3.22	3.22	2.99	3.24
Ash (%)	10.91	10.31	10.42	11.14	12.58	12.69
NFE (%)	54.23	54.52	54.4	52.58	47.22	51.91
EST:ME Kcal/Kg	**2656.12**	**2676.24**	**2676.44**	**2688.58**	**2690.63**	**2686.80**

Where: NFE – Nitrogen free extracts, ME – Metabolizable energy, Control (T0) - 0 g SC/kg; T1 - 2.5 g SC/kg; T2 - 5.0 g SC/kg; T3 - 7.5 g SC/kg, T4 - 10.0 g SC/kg and T5-12.5 g SC/kg.

The experimental diets were *isonitrogenous* and *isocaloric*. The birds were fed according to their nutritional requirements. The CP of 18% for starter and 16% for growers respectively is per the National Research Council (NRC) (1994) requirements for layer chicken, and the KALRO nutritional requirements for the improved indigenous chicken, which is crucial to enhance the growth and development of the birds

The results of the length and weight of the sections of the intestines and the weight of various gut organs as affected by live yeast at the age of 12 weeks varied as shown in Table 5.

Table 5: Length and weight of some gut organs of improved indigenous chicken on dietary supplementation with graded levels of live yeast at week 12.

Parameters	T0	T1	T2	T3	T4	T5	SEM	P-Value
Length of duodenum (cm)	18.80[a]	20.75 [a]	22.27[a]	20.55 [a]	23.30[a]	19.65[a]	1.18	0.130
Length of jejunum (cm)	50.62[a]	50.30 [a]	55.12[a]	51.60[a]	53.38[a]	55.40[a]	4.41	0.746
Length of ileum (cm)	48.40[a]	43.48[a]	49.62[a]	51.90[a]	52.65[a]	45.67[a]	3.07	0.637
Weight of duodenum (g)	9.07 [a]	10.25[a]	10.65[a]	10.00[a]	11.43[a]	8.60[a]	0.77	0.166
Weight of jejunum (g)	13.95 [a]	13.05 [a]	14.18[a]	13.10[a]	13.65[a]	11.07[a]	1.54	0.753
Weight of ileum (g)	9.40[a]	9.67[a]	10.00[a]	11.80[a]	9.10[a]	9.02[a]	1.28	0.669
Weight of Ventriculus+Proventriculus (g)	77.45[c]	54.55[a]	68.25[ab]	72.35[bc]	72.10[bc]	63.02[ab]	2.27	<0.01
Weight of liver (g)	21.60[a]	22.95[a]	23.93[a]	23.60[a]	22.48[a]	20.23[a]	1.26	0.358
Weight of spleen (g)	1.22[a]	1.72[a]	1.55[a]	1.85[a]	1.72[a]	1.47[a]	0.17	0.170
Live weight (g)	1178[b]	1050[a]	1132[ab]	1320[c]	1130[ab]	1030[a]	25.4	<0.01
Weight of carcass (g)	824[ab]	735.1[a]	792.8[ab]	924.0[c]	791.0[b]	721[a]	17.77	<0.01

Where: Control (T0) - 0 g SC/kg; T1 - 2.5 g SC/kg; T2 - 5.0 g SC/kg; T3 - 7.5 g SC/kg, T4 - 10.0 g SC/kg and T5-12.5 g SC/kg. SEM - standard error of the mean, IICs - Improved indigenous Chickens, and Means in the same row having different superscripts are significantly different (P<0.05).

There were no significant differences (P>0.05) in the length of duodenum, jejunum and ileum (P=0.130, P=0.746 and P= 0.637). Also, there was no significant difference (P>0.05) in the weight of the duodenum, jejunum, and ileum between treatments (P=0.166, P=0.7537, P=0.669), respectively.

There were no significant differences (P>0.05) in the weight of the spleen and the liver between treatments (P=0.358 and P=0.170), respectively.

There was a significant difference (P<0.05) in the weight of the ventriculus and proventriculus between treatments. The highest weight was recorded in T0 (77.45 g), which was significantly different (P< 0.001) from other treatments except T3 and T4. T1 had the lowest at 45.70 g and was not significantly different from T2 and T5.

There were significant differences (P<0.05) in the live weight and carcass weight of the sacrificed birds. The highest live weight was recorded in T3 (1320 g), while the lowest weight was recorded in T5 (1030 g). The highest carcass weight was recorded in T3 at 924 g, while the lowest was recorded in T0 at 721 g.

Table 6: Villus height, crypt depth and mucosa width of the duodenum, jejunum and ileum of improved indigenous chicken at 12 weeks

The villus height, crypt depth, and mucosa width of the duodenum, jejunum and ileum of improved indigenous chicken on dietary supplementation with graded levels of live yeast at week 12 varied as shown in Table 6.

Table 6. Histomorphology characteristics of some gut organs of IICs as affected by live yeast at 12 weeks

Parameter	TO	T1	T2	T3	T4	T5	SEM	P -Value
Duodenum villus height (mm)	22.63^{a}	24.17^{ab}	26.40^{bc}	28.71^{cd}	30.76^{d}	31.44^{d}	0.883	<.001
Duodenum crypt depth (mm)	3.578^{c}	2.083^{a}	3.967^{c}	3.703^{c}	4.482^{d}	2.725^{b}	0.129	<.001
Duodenum mucosa width (mm)	2.844^{d}	1.878^{a}	2.660^{b}	2.585^{b}	2.663^{b}	2.844^{d}	0.026	<.001
Jejunum villus height (mm)	27.82^{a}	31.81^{b}	38.02^{c}	47.26^{e}	44.21^{d}	32.36^{b}	0.575	<.001
Jejunum crypt depth (mm)	13.04^{a}	14.17^{b}	14.80^{c}	16.53^{e}	16.06^{d}	12.93^{a}	0.0420	<.001
Jejunum mucosa width (mm)	3.020^{b}	3.218^{c}	3.973^{d}	5.862^{f}	5.075^{e}	2.056^{a}	0.001566	<.001
Ileum villus height (mm)	11.46^{a}	10.57^{b}	14.58^{e}	17.26^{f}	11.14^{c}	13.61^{d}	0.1788	<.001
Ileum crypt depth (mm)	1.160^{a}	1.1573^{c}	2.540^{d}	2.945^{e}	1.134^{b}	1.323^{b}	0.1788	<.001
Ileum mucosa (mm)	2.400^{b}	1.745^{a}	2.670^{b}	4.135^{c}	6.155^{d}	4.298^{c}	0.0917	<.001

Where: T0-(Control) - Control (T0) - 0 g SC/kg; T1 - 2.5 g SC/kg; T2 - 5.0 g SC/kg; T3 - 7.5 g SC/kg, T4 - 10.0 g SC/kg and T5-12.5 g SC/kg. SEM-standard error of the mean, IICs-improved indigenous chickens, and means in the same row having different superscripts are significantly different (P<0.05).

There was a significant difference (P<0.05) in the villus height of the duodenum, jejunum and ileum. The highest length of the duodenum (31.44mm) was recorded in T5, while the lowest (22.63mm) was in T0. The length of duodenum in T5 was significantly different (P <.001) from all other treatments except T3 and T4. In the jejunum, the highest villi height was recorded in T3, while the lowest height was recorded in T0. Similarly, T3 recorded the highest ileum villi height, while the lowest villi height was recorded in T1. The lengths of the jejunum and ileum in T3 were significantly different from the lengths in all other treatments (P <.001).

There was also a significant difference (P<0.05) in the crypt depth of the duodenum, jejunum and ileum. In the duodenum, the highest measurement of crypt depth (4.482mm) was recorded in T4, while the lowest (2.083mm) was recorded in T1. In the jejunum, the deepest crypts (16.53mm) were recorded in T3, which was significantly (P<.001) different from the other treatments, while the shallowest crypt depth (12.93mm) was recorded in T5. In the ileum, the deepest crypts (2.945mm) were recorded in T3, which was significantly different (P<0.001) from the other treatments, while the shallowest (1.160mm) was recorded in T0.

There was a significant difference in the mucosal width (P<0.05) in the duodenum, jejunum, and ileum. The highest measurement of duodenal mucosa width (2.884mm) was recorded in T5 and was significantly different (P <0.001) from all other treatments except T0, while the lowest (1.878 mm) was recorded in T1. In the jejunum, the highest widest mucosa measurement (5.862 mm) was recorded in T3 and was significantly different (P<.001) from the other treatments, while the lowest (2.056 mm) was in T0. In the ileum, the highest mucosa width measurement (6.155mm) was recorded in T4 and was significantly different (P<0.001) from the other treatment, while the lowest ileal mucosa (1.754 mm) was recorded in T1.

Discussion

At 12 weeks, dietary supplementation with live yeast has no effects on the weight of the duodenum, jejunum, and ileum (table 5). This is most likely because the amount of live yeast used in this study was below the levels required to influence the weight of small intestine of birds at this age was. This finding is in agreement with Maoba et al., (2021), who found no significant difference in the weight of small intestines (P=0.37) of indigenous chicken on dietary supplementation with graded levels of live yeast at 91 days of age. However, they found a significant difference in the length of the small intestine, with the highest length reported in birds fed on diets containing 10 g SC/kg live yeast, suggestive of better surface area for digestion and nutrient uptake.

An increase in the weight of the spleen with the increasing levels of live yeast inclusion in the diets ((table 5), can be attributed to the immunomodulating effects of beta-glucans in the yeast. According to El-Manawey et al. (2021), there is an increase in splenic weight (2.4 g) with dietary supplementation (2 g/kg) with beta-glucans especially at the late stages of growth.

There was a significant difference (P<0.001) in the live and hot dressed weight carcass weights of the sacrificed birds. The highest live and carcass weights were recorded in the birds fed on diets containing 7.5 SC g/kg. This can be attributed to the fact that the diet containing 7.5 g/kg live yeast had the most noticeable effects on the villi heights and crypts depths (table 6). This contributed to better nutrient digestibility and utilization. A study by Teng Fe et al. (2021) showed that live yeast supplementation at above 5 g/kg in monogastrics improved voluntary feed intake by improving feed palatability. Ugwuoke et al. (2021) reported that *Saccharomyces cerevisiae* improved the efficacy of the immune system, improved intestinal lumen health, and increased digestion and absorption of nutrients. This resulted in better performance and improved live and carcass weights. Similarly, Fathi et al. (2012), reported an improvement and increase in the carcass and live weights of broiler birds on dietary supplementation with yeast extracts. All these agree with the findings of the current study.

The proximate analysis of the diets showed an improvement in CP with increasing levels of live yeast (table 3 and 4). Crude protein is crucial for growth and cell proliferation, which facilitates productivity in terms of live weight gain and carcass weight. The best results for the various parameters were recorded in the diets containing 7.5 g /kg live yeast, which had a crude protein of 18.84% and 18.40% at the chick stage and growers' stage, respectively. At 12.5 g/kg, despite having a high CP, CF, and ME, there was a noticeable decline in the live and carcass weights and weights of some of the organs, suggesting that this inclusion level was beyond the threshold in the diets of IIC. These findings agree with a study by Maoba et al. (2021) in native Boschvled chicken, who found the highest noticeable significance difference in the diets containing 5.0, 7.5, and 10 g/kg of live yeast and a decline in various parameters for diets containing 12.5 g/kg live yeast.

Dietary supplementation with live yeast had a significant difference ($P<0.05$) in the villi height, crypt depth, and mucosa width of the duodenum, jejunum, and ileum. This study demonstrated an increase in the height of the villi, the depth of the crypt, and the width of the mucosa, at increasing inclusion levels of live yeast in the diets. Yeasts and their constituents have been shown to speed up villus development and goblet cell synthesis at the tips of the villus, which is probably related to live yeasts' protection of the gut mucosa (Kim et al., 2022). There was a noticeable increase in the villi height, crypt depth, and mucosa thickness in the jejunum, where most absorption takes place. The diet containing 10 g SC /kg live yeast recorded the highest quality results. This can be attributed to the action of the yeast that stimulated the growth of taller villi, which improved digestibility and absorption of nutrients as a result of an increase in the digestive enzymes released from the tip of the villus.

Furthermore, mucosa width increased with an increase in the inclusion level; this is because the cell wall component of the yeast that contains mannan-oligosaccharides provided a protective function on the mucosa by preventing the growth and binding of harmful pathogens(Nath et al., 2020). Moreover, taller and deeper crypts of liberkun are an indication of more mature epithelia, hence better absorption of nutrients, and this explains why birds fed 10 g SC/kg performed the best. This is because of the quality of this diet, which contained a CP of 18.40 %, which may have contributed to the improved performance. This is illustrated in plates 1- 3

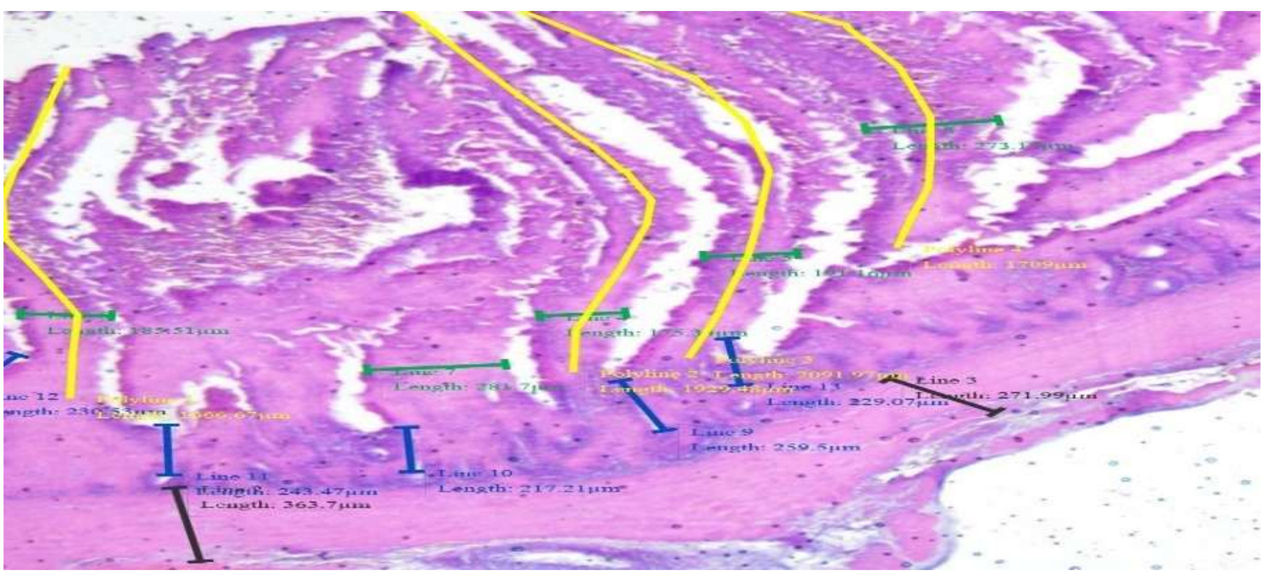

Plate 1: Microphotographic image of the duodenum of birds fed on T4-10g Sc/kg live yeast

Villus height Crypt depth Mucosa width

Source: Author

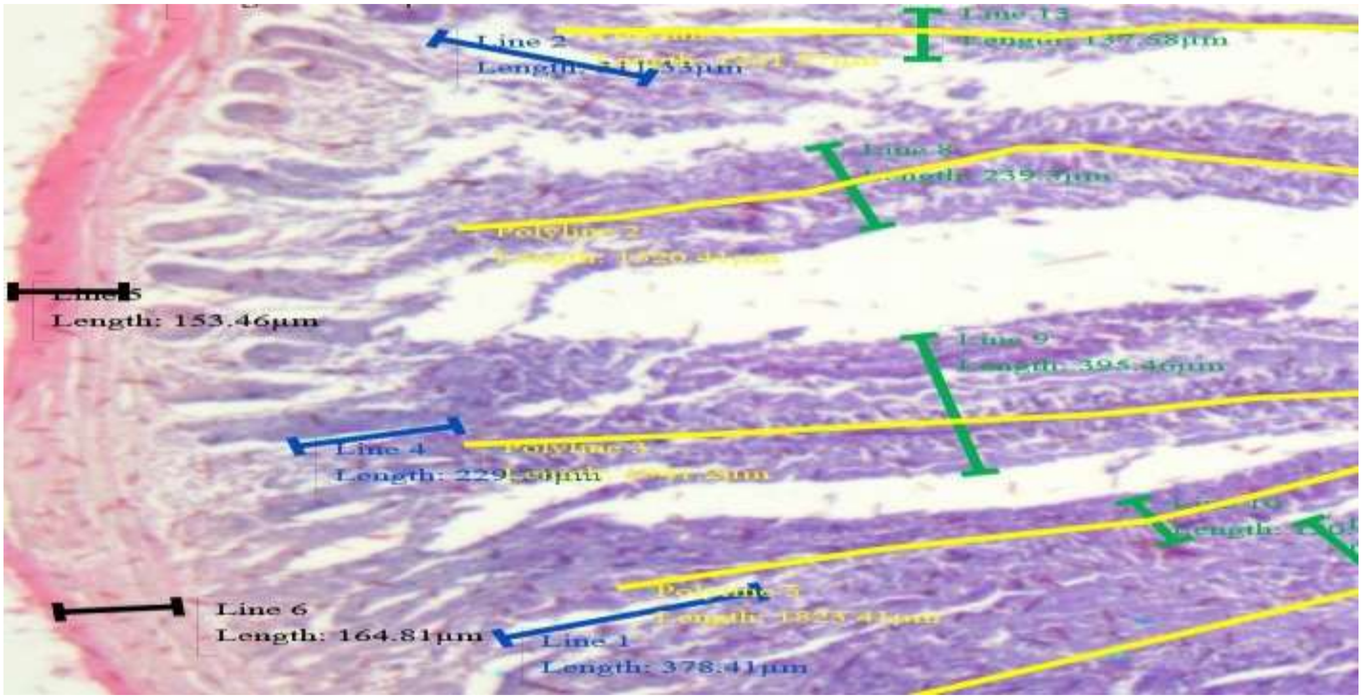

Plate 2: Microphotographic image of the jejunum of birds fed on T4-10g Sc/kg live yeast

Villus height Crypt depth Mucosa width

Source: Author

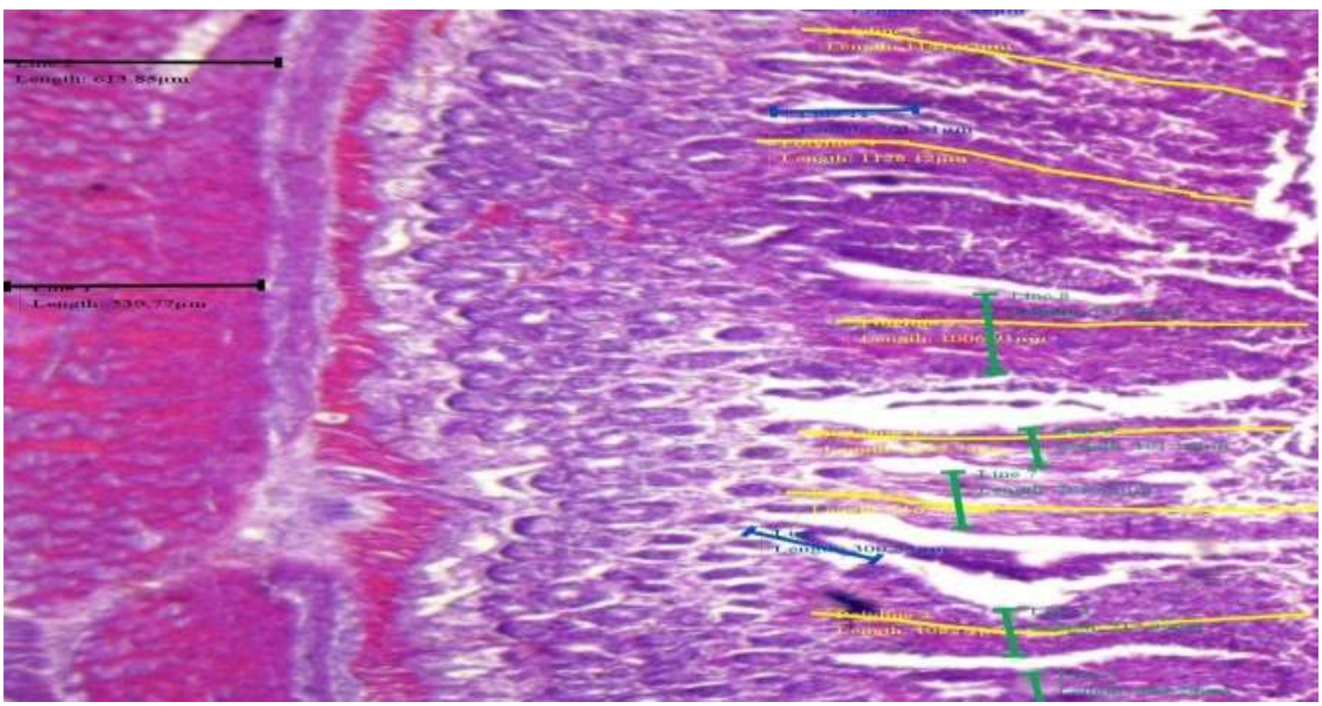

Plate 4.6: Microphotographic image of the ileum of birds fed on T4-10g SC/kg live yeast

Villus height Crypt depth Mucosa width

Source: Author

From this study, the jejunum section of the small intestines was the most developed in terms of the highest villi height and crypt depth and also had the thickest mucosa. The finding of this study, however, does not agree with those of Adebiyi et al. (2012). They reported the highest villi height (566.60um and 500.5 um), crypt depth (456.47um and 508.46 um) and mucosa muscularis (369.87 um and 166.03 um) of the ileum and jejunum respectively at 1.5g /kg live yeast supplementation at 8 weeks in broiler birds. Similarly, Kanti et al. (2021) observed that live yeast supplementation at 2 g/kg in broiler chicks at 5 weeks had significant effects (P<.001) in the ileum and jejunum. The highest villi height (3.77 um), crypt depth (282 um) and thickest mucosa (31.50 um) in the jejunum.

5 0. CONCLUSIONS AND RECOMMENDATIONS

Dietary supplementation with baker's yeast (*Saccharomyces cerevisiae*) had positive effects on the villi height, crypt depth, mucosa width of the improved indigenous chicken. These gut organs play a crucial role in nutrient digestibility and absorption. The oligosaccharides, i.e., the mannan oligosaccharides and fructooligosaccharides contained in the yeast, pose growth-promoting effects by maintaining the gut microbiota at optimum levels, which improves nutrient absorption, hence better growth performance. The live yeast acts by improving feed intake, digestibility, nutrient uptake, and utilization, hence the improved productivity of the bird. Therefore, live yeast can be recommended as a viable in-feed growth promoter that can be incorporated into commercial diets of IICs to improve their productivity. The most effective inclusion rates according to this study is 7.5 g SC/kg - 10 g SC/kg.

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