Evaluate the Efficiency of Fermented local Corn by *Saccharomyces cerevisiae* on the Productive Performance of Broiler

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Abstract

Current study was conducted in the poultry field of the Department of Animal Production, Faculty of Agriculture, University of Kufa from 22/10/2021 to 25/11/2021 (35 days) to evaluate the efficiency of fermented local corn on the productive performance of broiler. 300 chicks of one day old hybrid Ross 308 with primary weight of 39g were used. Chicks were obtained from private Anwar hatchery in Babylon province then raised in closed house divided into pens with $3m^2$ for each and distributed randomly on 5 treatments with three replicates for each treatment (60 chicks for each treatment and 20 for each replicate). Treatments were prepared as follows: T1: Imported corn, T2; Unfermented local corn, T3; Replacing fermented local corn instead of imported corn in a ratio of 50%, T4; Replacing fermented local corn instead of imported corn in a ratio of 75% and T5; Replacing fermented local corn instead of imported corn in a ratio of 100%. The outcome indicated that fermenting local corn by *Saccharomyces cerevisiae* ($1g.kg^{-1}$ corn for 24h) was improved the nutritional value of corn particularly crude protein and fat as well as decreasing aflatoxin B1 to very low level. Replacing fermented local corn in a ratio of 50 or 75% instead of imported corn was gave close results for final body weight, total weight gain, total feed intake and feed conversion ratio (FCR) compare to imported corn. While, the results of using fermented local corn (T2) was reduced values significantly ($P\leq0.05$) between treatments for most studied characteristics.

Keywords: Fermentation, Corn, Broiler, Productive performance, *Saccharomyces cerevisiae*.

Introduction

Poultry farming faces many challenges particularly the provision of feed in suitable quantities, quality and prices. Contamination with mycotoxins as a result of the growth of toxic fungi on feed is the very important problems it leads to the death, deterioration of the growth and weakness of immune system of birds which causes great financial losses to producers or the accumulation of toxins especially aflatoxins which may be transmitted to the consumer and accumulate in his internal organs including liver and kidneys causing real threat to human health. The farmer's lack of modern scientific methods in agriculture and feed storage is one of the most important causes of feed contamination with mycotoxins (23).

Yellow corn (*Zea mays* L.) ranks as the third largest cereal crop globally and in Iraq it considered very important crop as the local production of its both seasons (spring and autumn) in 2021 reached about 374400 ton (13). The grain of yellow corn represent an essential component in poultry diets as the percentage of its use in these diets about 75%. It is also the most polluted grain with mycotoxins (24) especially *Aspergillus* species as it can be found in crops and plants before harvest and in stores.

Studies confirmed that the fermentation process reduces mycotoxins in animal feeds (28) as well as improves the nutritional value of fermented feed materials (38) and increases the digestibility of various nutrients such as organic matter, nitrogen, amino acids and calcium (12). Many types of microorganisms including bacteria, fungi and yeasts were used in the fermentation process such as *Saccharomyces cerevisiae* which is an important food source that contains large amount of proteins and minerals including zinc, iron and chromium (2). *S. cerevisiae* is used in the fermentation of many food industries as it is distinguished by its rapid growth, low cost, ability to grow in low pH ,and the absence of undesirable intermediate products (20) in addition to its ability to inhibit many types of bacteria (7) and also used to produce some enzymes (5). This yeast was used as aprobiotic (9) and as a single additive in poultry feed (4). Therefore, the use of fermentation by *S. cerevisiae* gained more attention to inhibit mycotoxins on yellow local corn and improve its nutritional value as well as using it as a probiotic and making diets to increase the productive performance of broiler.

Materials and Methods

Current study was carried out in the poultry field of the Department of Animal Production, Faculty of Agriculture, University of Kufa from 22/10/2021 to 25/11/2021 (35 days). 300 chicks of one day old of hybrid Ross 308, unsex with initial weight of 39g were used. Chicks were raised in a closed house divided into pens with $3m^2$ for each and distributed randomly on 5 treatments with three replicates for each treatment (60 chicks for each treatment, 20 chicks for each replicate). Treatments were prepared as follows:

T1: Control treatment (imported corn).

T2: Unfermented local corn.

T3: Replacing fermented local corn instead of imported corn in a ratio of 50%.

T4: Replacing fermented local corn instead of imported corn in a ratio of 75%.

T5: Replacing fermented local corn instead of imported corn in a ratio of 100%.

Feed and management of chicks

Chicks (Ross 308) fed with diet (starter) from 1 to 21 days and fed with (finisher) from the 21 to 35 days. Nutritional requirements have been calculated for starter and finisher diets according to Ross Nutrition Specifications (30) then the ingredients of used diets were mixed after making the structure of these diets by computer. Diets ingredients and chemical formulations are listed in Tables 1 and 2. Broiler characteristics of body weight, weight gain, feed intake and feed conversion ratio (FCR) were studied.

Fermentation of corn

Grain of local and imported corn were grinded into suitable size then put in 2kg polyethylene bags and moistened with 50% of water after that *S. cerevisiae* (Turkish) was added in $1g.kg^{-1}$ corn ratio. Bags were sealed and stored at 25 to 30Cº for three periods (6, 12 and 24h), the fermentation process was done according to Semeniuk *et al.* (33). Bags were opened and dried on clean ground then lab analysis was conducted then based on this analysis, the 24h period was selected for fermentation of the required amounts of local corn to make the diets.

Table 1. Chemical composition and calculated analyses of the starter diets.

Ingredients	Starter diet %				
	T1	**T2**	**T3**	**T4**	**T5**
Imported corn	10	0	5	2.5	0
Local corn	0	10	0	0	0
Fermented local corn	0	0	5	7.5	10
Wheat	50.5	50.5	50.5	50.5	50.5
Soybean meal	34	34	34	34	34
Premix	2.5	2.5	2.5	2.5	2.5
Sun flower oil	1.5	1.5	1.5	1.5	1.5
Dicalcium phosphate (3)	1.2	1.2	1.2	1.2	1.2
Salt	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100
Calculated chemical analysis (2)					
Crude protein%	24.03	24.03	24.03	24.03	24.03
Metabolizable energy ($Kcal.kg^{-1}$)	2970	2970	2970	2970	2970
Energy : Protein	124	124	124	124	124
Cystine %	0.393	0.393	0.393	0.393	0.393
Lysine %	1.11	1.11	1.11	1.11	1.11
Methionine + cystine%	0.711	0.711	0.711	0.711	0.711
Calcium %	1.02	1.02	1.02	1.02	1.02
Available Phosphorus%	0.87	0.87	0.87	0.87	0.87

Table 2. Chemical composition and calculated analyses of the finisher diets.

Ingredients	finisher diet %				
	T1	T2	T3	T4	T5
Imported corn	10	0	5	2.5	0
Local corn	0	10	0	0	0
Fermented local corn	0	0	5	7.5	10
Wheat	51	51	51	51	51
Soybean meal	30	30	30	30	30
Premix	2.5	2.5	2.5	2.5	2.5
Sun flower oil	5	5	5	5	5
Dicalcium phosphate (3)	1.2	1.2	1.2	1.2	1.2
Salt	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100
Calculated chemical analysis (2)					
Crude protein%	22.18	22.18	22.18	22.18	22.18
Metabolizable energy (Kcal.kg^{-1})	3203	3203	3203	3203	3203
Energy : Protein	144	144	144	144	144
Cystine %	0.369	0.369	0.369	0.369	0.369
Lysine %	0.98	0.98	0.98	0.98	0.98
Methionine + cystine%	0.69	0.69	0.69	0.69	0.69
Calcium %	1.005	1.005	1.005	1.005	1.005
Available Phosphorus%	0.845	0.845	0.845	0.845	0.845

(1) Use of Premix Jordanian Origin Type Provimi 3110 Contains: 2750 kcal.kg^{-1} Representative energy, 10% raw protein, 1.1% fat, 21% calcium, 11.0% phosphorus, 6.5% methionine, 6.5% methionine + Lysine, 4.8% Sodium, 5.4% Chloride, 575000 IU Vitamin A, 201250 IU Vitamin D3, 1380 mg Vitamin E, 138 mg Vitamin K3, 138 mg Vitamin B1, 345 mg Vitamin B, 1840 mg Vitamin B3, 552 mg Vitamin 5 B, 184 mg B vitamins, 46 mg vitamin B9, 1000 micrograms B12, 6900 micrograms peyutin, 14,000 mg choline chloride, 460 mg copper, 2760 mg iron, 3680 mg manganese, 3680 mg zinc, 50 mg iodine, 9.2 mg selenium, 30000 m Vitez mine, 250 mg antioxidants, 250 mg lincomycin, 2400 mg selenomycin).

(2) Based on nutritional ingredients for each substance using tables NRC (27).

(3) Dicalcium phosphate contains 22% of non-organic calcium and 18% of non-organic phosphorous.

The chemical analysis of yellow corn grains

Samples of local and imported corn grain were collected before and after the fermentation to do the chemical analysis in the Central Laboratory/ Ministry of Science and Technology as the nutritional analysis included (crude protein, crude fat, ash, crude fibers and moisture) and the estimation of aflatoxins B1.

Statistical analysis:

Data of studied traits were analysed using completely randomized design (CRD) to determine the effect of different treatments. The significant differences between treatments were tested using Duncan (17) new multiple test at 0.05 level of significance and the statistical program SAS (32).

Results and Discussion

The chemical analysis of yellow corn before and after the fermentation

Table 3 results showed the chemical structure of unfermented and fermented imported and local corn for three periods (6, 12 and 24h). It can be noted that imported corn contained 9.69% of crude protein, while, the unfermented local corn contained 9.32% of crude protein and the percentage of crude protein was increased gradually with increasing of fermentation time. The fermented local corn by *S. cerevisiae* for 24h was gave the highest crude protein percentage 9.87%. Results also indicated that the percentage of ash, crude fat and crude fibers were increased gradually with increasing of fermentation time, while, carbohydrates was decreased slightly with increasing of fermentation time. This may be result of the proliferation of *S. cerevisiae* and consumption of available energy in local corn or converted it to crude protein (3). Detection of aflatoxin B1 showed that the imported corn contained very low percentage of aflatoxin B1 as it not detected during the analysis. While, the percentage of aflatoxin B1 in the unfermented local corn was 16.25ppm and this percentage was significantly decreased to 3.58ppm when it fermented for 6h then decreased to 2.05ppm in 16h of fermentation and became undetectable in 24h of fermentation. Teng *et al.* (35) noted that the fermentation of wheat bran by *S. cerevisiae* was increased crude protein and fibers with decreasing in the extract percentage of ether and ash. Hajimohammadi *et al.* (19) reported that the fermentation of sesame meal by *L. acidophilus* and *S. cerevisiae* was increased crude protein and ether extract with decreasing in the percentage of ash and crude fibers compared to unfermented sesame meal.

Table 3. The chemical analysis of imported and local corn before and after the fermentation for three periods of time based on dry weight.

Corn type and fermentation Period Chemical Analysis	Imported corn	Non-fermented local corn	Fermented local corn for 6h	Fermented local corn for 12h	Fermented local corn for 24h
Dry matter %	89.33	89.75	89.67	89.48	89.19
Crude protein %	9.69	9.32	9.55	9.63	9.87
Ash %	2.77	2.59	2.64	2.72	2.86
Crude fat %	4.96	4.62	4.74	4.88	5.08
Crude fibers %	2.01	1.78	1.84	1.95	2.15
Carbohydrates	69.90	71.44	70.90	70.30	69.23

%					
B1 Aflatoxin (ppm)	Undetectable level	16.25	3.58	2.05	Undetectable level

Results of chemical analysis of fermented coconut with *S. cerevisiae* for 5 and 7 days showed significant increasing in crude protein and decreasing in crude fat and fibers. Choua *et al.* (14) obtained same results as they noted improving in the percentage of crude protein, ether extract and ash as well as increasing crude fibers, while decreasing the extract of empty nitrogen when they fermented Shea nut cake by *S. cerevisiae*. Azrinnahar *et al.* (10) found that the fermentation of free oil rice bran by *S. cerevisiae* was increased crude protein, ash and ether extract compared to unfermented free oil rice bran. Moreover, Zhang *et al.* (38) noted an increasing in crude protein and decreasing in ether extract and ash and crude fibers in fermented wheat bran by some microorganisms including *S. cerevisiae* in comparison with unfermented wheat bran. Many studies have been conducted to decrease the level of aflatoxin in animal feeds, Mukandungutse *et al.* (25) noted that the fermentation of yellow corn powder naturally by *S. cerevisiae* was decreased the level of aflatoxins over the time of fermentation as it decreased from 20.4ppm to 10.9ppm after 72h of fermentation. While, Wang *et al.* (36) mentioned that the fermentation of wheat bran by *Plantarum lactobacillus*, *Bacillus subtilis*, *S. cerevisiae* and *Aspergillus fragrans* for three days was decreased the level of aflatoxin B1, Zearalenone and Deoxynivalenol from 0.22, 6.36, 924 $\mu g.kg^{-1}$ before the fermentation to 0.13, 1.26 and 889.18 $\mu g.kg^{-1}$ respectively after the fermentation.

Productive characteristics

The average of body weight

Table 4 showed the effect of using fermented local yellow corn by *S. cerevisiae* on the weekly average of body weight as it can be noted that non-significant differences ($P \leq 0.05$) between treatments in body weight of one day birds, first, second, third and fourth week, while, results of fifth week indicated non-significant differences for T3, T4 and T5 which recorded 2051.6, 2094.4 and 1904g respectively compare to 2081g in first control. There was significant decreasing in the second control as it recorded 1874.2g in comparison with T4, also there was non-significant differences between T2, T3 and T5.

Table 4. The effect of using fermented local yellow corn by *S. cerevisiae* on the average of body weight (g) during the experiment weeks

	The average of bird weight (g/bird)during the experiment weeks					
Treatments	Initial weight (one day old)	First week	Second week	Third week	Fourth week	Fifth week
T1	41.1 ± 2.35	144.5 ±3.32	400.5 ±9.01	836.0 ±18.00	1398.6 ±9.28	2081.6ab ±24.45
T2	38.9 ±1.21	147.3 ±6.12	410.0 ±2.88	816.8 ±5.83	1447.0 ±13.53	1874.2c ±15.88
T3	37.8 ±0.29	140.6 ±0.33	401.6 ±1.48	837.1 ±15.93	1436.5 ±38.41	2051.6abc ±55.26
T4	38.2 ±0.30	138.0 ±3.68	398.6 ±11.55	864.1 ±35.73	1421.8 ±47.07	2094.4a ±63.27
T5	39.8 ±2.53	135.0 2.51±	388.6 ±10.97	815.8 ±19.02	1405.7 23.09±	1904.6bc 81.67±
Significant level	N.S	N.S	N.S	N.S	N.S	*

*Different letters within same column means there were significant differences at P≤0.05.

N.S means non-significant differences between means.

Weight gain

Results of Table 5 showed the effect of using local yellow corn fermented by *S. cerevisiae* on the average of weekly weight gain. It can be noted that non-significant differences (P≤0.05) between treatments for first, second and fourth week, while, results of third week indicated non-significant differences for T3, T4 and T5 compare to first control. There was significant increasing in T4 compare to second control. Results of fifth week showed non-significant differences in T3 and T4 which recorded 615.3 and 673g respectively in comparison with 683 in the first control. There was significant decreasing in T2 and T5 compare to first control, T3 and T4. Results of total weight gain showed non-significant differences in T3 and T4 which recorded 2013 and 2056g respectively compare to first control with non-significant differences between second control and T5 and T3 and T5. It can be concluded from final body weight and total weight gain of broiler that replacing local corn in 50 and 75% ratio (T3 and T4) gave equal results with imported corn (T1), this may be attributed to the fact that the fermentation was improved local corn characteristics and reduced aflatoxins significantly, in addition, mixing between local and imported corn gave better results than fermented local corn alone (T5) due to the differences of its content of nutrients which improve final body weight and total weight gain. While, the significant decreasing of using unfermented local corn may be attributed to its low content of nutrients and the present of mycotoxins in high percentage rather than fermented corn. Al-Warshan *et al.* (6) mentioned that the Iraqi probiotic treatment which contained 10^9cell of *S. cerevisiae* to broiler diets that contained 2mg.kg^{-1} of aflatoxin B1 was exceeded and reduced the stress causing by adding aflatoxin B1, as these mycotoxins were stressful to birds (37). While, Santin et al. (31) attributed the improving in body weight to the adding of *S. cerevisiae* by 0.1 and 0.2% to broiler diet. Moreover, Devegowda *et al.* (16) indicated that *S. cerevisiae* can reduce the percentage of aflatoxins in culture medium to 56 and 92% when it incubated for 48 and 72h respectively and they noted decreasing of these mycotoxins when increasing yeast percentage. Bradley *et al.* (11) mentioned that *S. cerevisiae* was added to broiler diets to reduce mycotoxins in gastrointestinal tract as well as its enzymatic secretion of amylase and protease. Also this yeast works to rid of harmful salmonella (21), and used as activator during feeds fermentation by consuming oxygen which make anaerobic conditions that help the growth of useful bacteria *Lactobacillus* which reflected positively on body weight and weight gain of chicks in experimental treatments when using fermented local corn by *S. cerevisiae*. Makki and Abed (22) reported that adding yeast alone or with aflatoxins to the diets of broiler was improve body weight and weight gain significantly when *S. cerevisiae* was added in 2% percent with 100 mg.kg^{-1} of aflatoxins compare to the treatment of adding aflatoxins alone to diets.

Table 5. The effect of using fermented local corn by *S. cerevisiae* on the average of weight gain (g) during the experiment weeks

	The average of weight gain (g/bird) during the experiment weeks					
Treatments	First week	Second week	Third week	Fourth week	Fifth week	Cumulative weight gain
T1	103.6 ±5.60	256.3 ±6.48	435.6ab ±14.62	563.0 ±8.73	683.0a ±26.76	2040.3a ±22.76
T2	108.6 ±6.48	263.0 ±4.04	407.0b ±3.05	630.3 ±8.87	427.3b ±20.36	1835.6c ±16.97
T3	103.0 ±0.57	261.3 ±1.85	435.6ab ±14.16	599.6 ±23.45	615.3a ±30.05	2013.6ab ±54.96
T4	100.0 ±3.21	261.0 ±7.81	465.3a ±24.12	557.6 ±23.77	673.0a ±16.37	2056.0a ±62.91
T5	95.0 2.51±	254.0 ±10.11	427.3ab ±11.34	590.0 ±36.35	499.0b ±61.17	1864.6bc ±79.20
Significant level	N.S	N.S	*	N.S	*	*

*Different letters within same column means there were significant differences at P≤0.05.

N.S means non-significant differences between means.

The average of feed intake

Table 6 showed the effect of using fermented local corn by *S. cerevisiae* on the average of feed intake as it can be noted that there were non-significant differences (P≤0.05) in week one and week two, while, week three results showed non-significant differences between T3, T4 and T5 compare to first control. It can be also noted that there was significant increasing in T3, T4 and T5 compare to second control with non-significant differences between both control treatments. Fourth week results indicated non-significant differences in T3 and T4 compare to first control with significant increasing in T5 compare to first control which non-significantly differ from the second control. Also week fifth results showed that there was non-significant difference in T3 and T4 compare to first control (T1) with significant increasing in T3 and T4 compare to second control (T2). Results of total feed intake showed non-significant differences between T3 and T4 which recorded 2946 and 2912g respectively compare to 2931 in T1, there was significant decreasing in T2 compare to T1. It can be concluded that the total feed intake of broiler was not affected by replacing fermented local corn in 50 and 75% ratio compare to imported corn (T1), this may be attributed to the fact that the fermentation was improved local corn characteristics in term of nutritional value and reduced aflatoxins significantly. There was significant increasing in total feed intake of using unfermented local corn (T2) compare to imported corn (T1). Chicks were increased feed intake when it feed on unfermented local corn due its low content of nutrients particularly fat percentage which reflected on the amount of energy and led to increasing feed intake to compensate energy amounts. The decreasing in feed intake in T5 occurred due to the decreasing of body weight of the same treatment. Zhao *et al.* (39) reported that the decreasing in feed intake is a protective mechanism by bird to reduce the consumption of feeds that contain aflatoxins, while, Al-Daraji at al. (1) showed that adding *S. cerevisiae* with aflatoxins was increased feed intake significantly compare to using aflatoxins alone in the diet. Naji *et al.* (26) mentioned that using diets contained contaminated yellow corn with aflatoxins was reduced feed intake, while adding *S. cerevisiae* to these diets was increased feed intake despite the present of mycotoxins. Pizzolitto *et al.* (29) found a decreasing the amount of feed intake when adding 1010 cell.kg^{-1} of Baker's yeast to the feed alone or with 1.2mg.kg^{-1} of aflatoxin B1 compare to control (without addition). Yousif and Al-Jugifi (37) found that there were non-significant differences of using diets containing 1.5ppm of mycotoxins with the probiotic that contained *S. cerevisiae* or without yeast and using fermentation by *S. cerevisiae* with aflatoxins. Sli´zewska *et al.* (34) mentioned a decreasing in the total feed intake significantly when adding the probiotic that contained *S. cerevisiae* with aflatoxins compare to control treatment. In addition, Arif *et al.* (8) noted that adding *S. cerevisiae*to the diets of broiler in 0.0, 1.25, 2.5 and 3.75 g.kg^{-1} with 100ppm of aflatoxin B1 was led to increase feed intake gradually with the increasing the use of yeast.

Table 6. The effect of using fermented local yellow corn by *S. cerevisiae* on the average of feed intake (g/bird) during the experiment weeks

Treatments	The average of feed intake (g/bird) during the experiment weeks					
	First week	Second week	Third week	Fourth week	Fifth week	Overall period 0−5 weeks
T1	109.3 ±5.78	309.0 ±4.16	575.6ab ±33.11	878.0b ±12.00	1059a ±33.51	2931a ±13.69
T2	111.0 ±5.03	306.0 ±3.46	522.6b ±16.82	990.0a ±23.15	807b ±29.05	2736b ±63.61
T3	114.3 ±2.90	309.3 ±4.17	606.3a ±4.66	897.0ab ±23.18	990a ±30.53	2916a ±42.45
T4	110.0 ±3.51	315.3 ±3.75	615.3a ±14.16	879.0b ±6.65	993.3a ±13.19	2912ab ±53.18
T5	108.3 ±1.85	310.0 ±1.00	593.3a ±14.33	960.0a ±29.90	801.6b ±45.29	2773b ±29.16
Significant level	N.S	N.S	*	*	*	*

*Different letters within same column means there were significant differences at P≤0.05.

N.S: means non-significant differences between means.

Feed conversion ratio

Results of Table 7 showed the effect of using fermented local corn by *S. cerevisiae* on feed conversion ratio as it can be noted that there were non-significant differences (P≤0.05) in week two and week three, while, week one results showed non-significant differences between T3 and T4 compare to first control (T1). It can be also noted that there was non-significant differences between first and second control with non-significant differences between T3, T4 and T5. Fourth week results indicated non-significant differences in T4 and T5 compare to first (T1) and second control (T2). Fifth week results showed non-significant differences between T3, T4 and T5 compare to first control (T1) also non-significant different in the second control (T2) compare to other treatments. Results of feed conversion ratio showed that there was non-significant difference in T3 and T4 which reached 1.46 and 1.42 respectively compare to 1.44 in first control (T1), with non-significant increasing the second control (T2) compare to first control, T3 and T4. Treatments of partial replacing (T3, T4) were achieved positive results as it not differ significantly from first control (T1 imported corn) which may be attributed to the improving of fermented local corn by *S. cerevisiae* that considered as a probiotic, in addition to yeast absorbs toxins from corn grain and the mixing between fermented local and imported corn gave better results than fermented local corn alone (T5) due to the differences of its content of nutrients which improve feed conversion ratio. Denli *et al.* (15) reported that the deterioration in the feed conversion ratio was occurred due to decreasing of utilization of protein and energy as a result of deterioration in the digestive system and metabolic efficiency of birds fed on diets containing aflatoxins. Makki and Abed (22) mentioned an improving in feed conversion ratio when using *S. cerevisiae*which binding mycotoxins as well as stimulating immune system by preventing pathogens to stuck on intestines wall. Pizzolitto *et al.* (29) found significant deterioration in feed conversion ratio when adding 1.2 mg.kg^{-1} of aflatoxin B1 to broiler diets and also led to deterioration in the digestive system and metabolic efficiency of birds. While, El_Nezami *et al.* (18) mentioned that the significant improving in feed conversion ratio in broiler chicks attributed to the role of microorganisms which absorb toxins molecules and pathogens and making it non-absorbable from the intestines, thus reducing its negative effects on the bird.

Table 7. The effect of using fermented local yellow corn by *S. cerevisiae* on feed conversion ratio (g feed/ g weight gain) during the experiment weeks

Treatments	Feed conversion ratio (g feed/ g weight gain) during the experiment weeks					
	First week	Second week	Third week	Fourth week	Fifth week	Overall period 0−5 weeks
T1	1.06bc ±0.00	1.20 ±0.01	1.32 ±0.04	1.56a ±0.03	1.55b ±0.10	1.44b ±0.01
T2	1.02c ±0.03	1.16 ±0.03	1.28 ±0.04	1.57a ±0.05	1.89a ±0.08	1.49a ±0.04
T3	1.11ab ±0.02	1.18 ±0.01	1.39 ±0.03	1.50b ±0.03	1.61b ±0.09	1.46b ±0.03
T4	1.10ab ±0.01	1.21 ±0.02	1.32 ±0.04	1.58a ±0.05	1.48b ±0.10	1.42b ±0.02
T5	1.14a ±0.01	1.22 ±0.05	1.39 ±0.03	1.63a ±0.04	1.61b ±0.12	1.49a ±0.04
Significant level	*	N.S	N.S	*	*	*

*Different letters within same column means there were significant differences at P≤0.05.

N.S means non-significant differences between means.

Conflict of interest

The authors have no conflict of interest.

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