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Associated efficiency of *Saccharomyces cerevisiae* and vitamin E in ameliorating adverse effects of ochratoxin A on production performance in broiler chickens

SATYENDRA SINGH[1], RAM SINGH[2], A B MANDAL[3] and MOHIT SINGH[4]

ICAR-Central Avian Research Institute, Izatnagar, Uttar Pradesh 243 122 India

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ABSTRACT

In the present study, efficiency of *Saccharomyces cerevisiae* and vitamin E together in ameliorating ochratoxicosis in broiler chickens was investigated. Day-old broiler chicks (320) were divided into 8 treatment groups (T_1- control (basal diet); T_2- T_1+ 150 ppb OTA; T_3-T_2 + 0.05% SC + 100 mg vitamin E-VE; T_4- T_2 + 0.075% SC + 100 mg VE; T_5- T_2 + 0.1% SC + 100 mg VE; T_6- T_2 + 0.05% SC + 200 mg VE; T_7- T_2 + 0.075% SC + 200 mg VE; T_8- T_2 + 0.1% SC + 200 mg VE per kg diet). Each diet was fed to 5 replicated groups of 8 birds from 0 to 42 days of age. During overall growth period (0–6 weeks), the body weight gain (BWG) of birds fed ochratoxin contaminated diet (T_2) was lower than that of control group (T_1). The BWG of group T_5, T_7 and T_8 was higher than T_2 but statistically similar to that of control. During overall growth period, the FI in control group was statistically similar to other treatment groups. The FI in groups T_7 and T_8 was higher than that of group received basal diet with toxin (T_2). The overall FCR in control group (T_1) was lower than that of T_2. The FCR in groups T_3, T_4 and T_6 was higher than the control, but lower than that of T_2. The FCR in groups T_5, T_7 and T_8 was lower than T_2 and statistically similar to that of control (T_1).The overall liveability percentage in control group (T_1) was higher than that of ochratoxin fed group (T_2). The liveability percentage in group T_3 was lower than control and similar to that of T_2. The liveability percentage in groups T_4 to T_8 was statistically similar to that of control. Ochratoxin contamination in diet caused significant reduction in body weight gain, feed consumption, feed efficiency and livability percentage. It was concluded that inclusion of *S. cerevisiae* at 0.1% level along with 100 mg vitamin E per kg diet or *S. cerevisiae* at 0.075% level along with 200 mg vitamin E/kg diet to the ochratoxin (150 ppb) contaminated feed ameliorated the adverse effects of ochratoxicosis on production performance of broiler chickens.

Key words: Broiler chicken, Ochratoxin, *Saccharomyces cerevisiae*, Vitamin E

The presence of ochratoxin A in poultry feed causes significantly to health disorders and decreases production. In a survey conducted to investigate global occurrence of mycotoxins, the incidence of OTA in South Asia was found to be 55% on analyzing the feed samples (Nahrer and Kovalsky 2014). Ochratoxin A causes significant losses and reduction in the profitability of poultry industry due to its effects on performance and health (Agawane and Lonkar 2004). It causes a reduction in productive performance (growth rate, feed consumption, poorer feed conversion) and increased mortality (Singh *et al.* 2015, Singh *et al.* 2016). The risk associated with ochratoxin residues in poultry meat represents a public health concern.For preventive management of mycotoxins in the field and during storage, new approaches have been employed including physical, chemical and nutritive treatments that can be advised to detoxify mycotoxins in contaminated feeds and feedstuffs (Varga and Toth 2005) along with amelioration of its toxicity in animal body system. A live yeast, *Saccharomyces cerevisiae*, was found to alleviate the adverse effects of mycotoxicosis in poultry (Stanley *et al.* 1993). *S. cerevisiae* has shown considerable binding ability with several commonly occurring mycotoxins (Devegowda *et al.* 1998), and is also found more effective as a low-inclusion binder to bind mycotoxins present in contaminated poultry feed when compared with other physical or chemical materials (Mahesh and Devegowda 1996). Incorporation of 0.1% *S. cerevisiae* to the ochratoxin contaminated diet ameliorated the ill effects of ochratoxicosis as evidenced through production performance and relative weight of organs during 0–6 weeks of age in broiler chickens (Singh *et al.* 2016).Various antioxidants are beneficial in reducing the toxicity of ochratoxins, involved in increasing oxidative stress (Sorrenti *et al*. 2013). Vitamin C and E, being anti-oxidants, play an important role in the stimulation and enhancement of the chicken immune response.The objective of this investigation was to study the associated efficiency of *S. cerevisiae* and vitamin E to ameliorate ochratoxicosis in broiler chickens.

Present address: [1]Mycotoxin laboratory (satyendras782@gmail.com), [2]Principal Scientist (carirsingh@yahoo.co.in), [3]Head and Principal Scientist (abmcari@rediffmail.com), [4]Ph.D. Scholar (singh.mohit204@gmail.com), Avian Nutrition and Feed Technology Division.

MATERIALS AND METHODS

Ochratoxin production: The lyophilised preparation of *Aspergillus westerdijkiae* NRRL 3147 was revived on potato dextrose agar medium and used for experimentation. Ochratoxin was produced as per Singh *et al.* (2013). Cracked maize (50 g) was taken in 250 ml conical flasks. The moisture content of substrate was adjusted to have a moisture level of 35%. Thus flasks were plugged with non-absorbent cotton and sealed with aluminium foil. The flasks were autoclaved for 20 min at 121°C and inoculated with 1-week old mycelium of *Aspergillus westerdijkiae* NRRL 3174. The inoculated flasks were incubated in a BOD incubator for 14 days. After removal from the incubator, the flasks were dried at 70°C and the ochratoxin assays were performed as per AOAC (1995).

Experimental design: Experimental design was completely randomized design (CRD). There were 8 dietary treatments. Each dietary treatment had 5 replicates and each replicate had 8 chicks. The experiment was conducted in broiler chickens from day-old to 6 weeks of age. The various dietary treatments were prepared by mixing the required quantity of mouldy maize to get the desired concentration of 150 ppb OTA in basal diet (Table 1).

Biological experiment and analysis: Day-old broiler chicks (320) were obtained from experimental hatchery, CARI, Izatnagar. The chicks were wing banded, weighed individually and distributed randomly into 8 groups. All birds were reared under standard management conditions from 0–6 weeks. All birds were fed with broiler starter ration from 1–21 days and broiler finisher ration from 22 to 42 days. The ingredient and chemical composition of broiler starter and finisher ration are presented in Table 2.

The protein as per AOAC (1995) and calcium contents as per Talapatra *et al*. (1940) were estimated, while the concentrations of lysine, methionine, available P and metabolizable energy values were calculated. Weekly individual body weight and feed consumption of each group were recorded and the FCR was calculated. Mortality was recorded as and when occurred. The statistical analysis was done using SPSS 16.0 version.

Table 1. Experimental groups and treatments

Group	Dietary treatment
T_1	Control (Basal diet)
T_2	T_1 + 150 ppb OTA
T_3	T_2 + 0.05% *Saccharomyces cerevisiae* + 100 mg vit. E/kg
T_4	T_2 + 0.075% *Saccharomyces cerevisiae* + 100 mg vit. E/kg
T_5	T_2 + 0.1% *Saccharomyces cerevisiae* + 100 mg vit. E/kg
T_6	T_2 + 0.05% *Saccharomyces cerevisiae* + 200 mg vit. E/kg
T_7	T_2 + 0.075% *Saccharomyces cerevisiae* + 200 mg vit. E/kg
T_8	T_2 + 0.1% *Saccharomyces cerevisiae* + 200 mg vit. E/kg

Table 2. Ingredients and chemical composition of basal feed

Ingredients	Starter (%)	Finisher (%)
Maize	52	61.6
Deoiled rice bran	1.235	1.005
Soybean	31	22.5
Guar korma	4	4
Rape seed meal	4	4
Fish meal	4.5	4
Limestone	1.5	1.4
Di-calcium phosphate	1.1	0.8
Common salt	0.2	0.25
DL- methionine	0.1	0.06
Lysine	0	0.02
TM premix*	0.1	0.10
Vitamin premix**	0.15	0.15
B complex***	0.015	0.015
Choline chloride	0.05	0.05
Coccidiostat	0.05	0.05
Chemical composition of basal diet		
Crude protein (%)	22.01	19.06
ME (Kcal/kg)	2802	2902
Calcium (%)	0.99	0.91
Available phosphorus (%)	0.46	0.41
Lysine (%)	1.22	1.03
Methionine (%)	0.50	0.42

*TM premix supplied Mg, 300; Mn, 55; I, 0.4; Fe, 56, Zn, 30; Cu, 4 mg/kg diet. **Vitamin premix supplied Vit A, 8250 IU; Vit. D_3, 1200 ICU; Vit.K, 1 mg/kg diet. ***B complex supplied Vit. B_1, 2 mg; Vit.B_2, 4 mg; Vit. B_{12}, 10 mcg; niacin, 60 mg; pantothenic acid, 10 mg; choline, 500 mg/kg diet.

RESULTS AND DISCUSSION

The data pertaining to body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) at different growth phases is presented in Table 3.

Body weight gain (BWG): Significant (P≤0.05) difference in BWG among various dietary treatments were recorded from second week of age onwards. During starting growth phase (0–3 weeks), the BWG of birds in control group (T_1) was higher (P≤0.05) than that of ochratoxin fed group (T_2). The BWG in T_3 and T_4 was lower (P≤0.05) than control but higher (P≤0.05) than that of toxin fed group (T_2). However, the BWG in T_5 was statistically similar to that of control, indicating that addition of 0.1% *S. cerevisiae* along with 100 mg vitamin E to the ochratoxin contaminated diet ameliorated the adverse effects of ochratoxicosis. The BWG of T_6 was lower (P≤0.05) than control, but higher (P≤0.05) than that of toxin (T_2) fed group. The BWG in groups T_7 and T_8 was higher (P≤0.05) than T_2 and statistically similar to that of control, depicting that addition of 0.075% *S. cerevisiae* along with 200 mg vitamin E (T_7) was efficient to ameliorate the adverse effects of ochratoxicosis during starting growth phase. During finisher phase (4–6 weeks), the BWG in control group was higher (P≤0.05) than that of toxin fed group (T_2). The BWG in T_3 to T_8 was statistically similar to that of control. During overall growth period (0–6 weeks), the BWG of control

Table 3. Body weight gain, feed intake and FCR in different growth phases as influenced by various dietary treatments

Treatment	0–3 wk	3–6 wk	0–6 wk
Body weight gain (g/bird)			
T_1	489.10±6.02^{d}	978.42±59.37^{b}	1467.52±65.36^{b}
T_2	411.12±4.07^{a}	739.45±47.87^{a}	1150.57±51.78^{a}
T_3	436.31±5.38^{b}	850.15±54.30^{ab}	1286.46±59.68^{a}
T_4	456.54±3.96^{c}	914.69±58.18^{b}	1371.73±62.54^{ab}
T_5	481.82±6.50^{d}	962.34±55.92^{b}	1444.17±62.42^{b}
T_6	448.31±4.19^{bc}	900.62±58.61^{ab}	1348.93±62.80^{ab}
T_7	483.80±5.87^{d}	955.56±45.69^{b}	1439.61±51.76^{b}
T_8	488.97±7.47^{d}	962.69±49.24^{b}	1451.66±56.72^{b}
Feed intake (g/bird)			
T_1	801.24±6.48^{c}	2028.99±128.01^{a}	2830.24±134.48^{ab}
T_2	762.71±0.10^{a}	1767.12±95.73^{a}	2529.83±95.75^{a}
T_3	761.95±2.63^{a}	1881.33±37.18^{a}	2643.28±39.81^{ab}
T_4	787.90±1.10^{bc}	2052.78±106.66^{a}	2840.68±107.72^{ab}
T_5	822.01±1.97^{d}	2038.84±104.00^{a}	2860.85±102.31^{ab}
T_6	773.51±0.87^{ab}	2024.43±106.76^{a}	2797.92±107.53^{ab}
T_7	831.11±7.45^{d}	2069.47±91.05^{a}	2900.59±98.19^{b}
T_8	818.39±12.41^{d}	2068.33±98.73^{a}	2886.72±111.06^{b}
Feed conversion ratio (FCR)			
T_1	1.637±0.00^{a}	2.072±0.00^{a}	1.927±0.00^{a}
T_2	1.855±0.01^{d}	2.394±0.03^{c}	2.200±0.02^{c}
T_3	1.746±0.01^{c}	2.231±0.10^{b}	2.063±0.06^{b}
T_4	1.725±0.01^{c}	2.250±0.04^{b}	2.073±0.02^{b}
T_5	1.706±0.02^{bc}	2.120±0.01^{ab}	1.982±0.01^{ab}
T_6	1.725±0.01^{c}	2.254±0.04^{b}	2.076±0.02^{b}
T_7	1.717±0.00^{bc}	2.166±0.01^{ab}	2.014±0.00^{ab}
T_8	1.673±0.01^{ab}	2.149±0.01^{ab}	1.988±0.01^{ab}

Values bearing different superscripts in a column differ significantly (P≤0.05).

group (T_1) was higher (P≤0.05) than that of toxin fed group (T_2). The BWG of groups T_3, T_4 and T_6 did not vary (P≤0.05) from that of toxin fed group (T_2). The BWG of group T_5, T_7 and T_8 was higher (P≤0.05) than T_2 but statistically similar to that of control, indicating that addition of *S. cerevisiae* along with vitamin E to the ochratoxin contaminated diet ameliorated the adverse effects of ochratoxicosis in groups T_5, T_7 and T_8.

The present investigation indicated that addition of 150 ppb ochratoxin to the basal diet of broiler chickens resulted in significant decrease in body weight gain of broilers. Significant reduction in BWG of birds was in agreement with previous investigation with dietary ochratoxin level of 50–100 ppb (Stove *et al*. 2004, El-Barkouky 2008, El-Barkouky and Abu- Taleb 2008), 200 ppb (Sakhare*et al*. 2007, El-Barkouky *et al*. 2010, Singh *et al*. 2015, Singh *et al*. 2016) and 567 ppb (Garcia *et al*. 2003). In the present study, inclusion of 0.1% *S. cerevisiae* + 100 mg vitamin E or 0.075% *S. cerevisiae* + 200 mg vitamin E per kg to the ochratoxin contaminated feed ameliorated the adverse effects of ochratoxin on weight gain of broiler chickens. El-Barkouky (2008) and El-Barkouky *et al*. (2010) also reported that addition of *S. cerevisiae* to broiler diet provided partial protection against ill effects of ochratoxin on growth. Stanley *et al*. (1993), Mahesh and Devegowda (1996), Volkl and Karlovsky (1998) found that *S. cerevisiae* has beneficial effects on weight gain of broiler chickens exposed to mycotoxins. Singh *et al*. (2016) reported that incorporation of 0.1% *S. cerevisiae* to the ochratoxin contaminated diet ameliorated the ill effects of ochratoxicosis on production performance and relative weight of organs in broiler chickens. *S. cerevisiae* has considerable binding ability against ochratoxin (Devegowda *et al.* 1998) and protect the birds against its harmhul effects. Also, Singh (2015) reported that addition of 200 mg/kg vitamin E to the 200 ppb ochratoxin contaminated feed ameliorated the adverse effects of ochratoxicosis.

Decreased body weight gain might be attributed to the decrease in protein absorption and/or utilization or to the inhibition of protein synthesis caused by ochratoxin (Kubena *et al*. 1983, 1988 and 1989). The amelioration of ochratoxicosis on addition of *S. cerevisiae* might be attributed to its adsorption ability as reported by several workers. Several studies indicated involvement of oxidative stress to the toxicity of ochratoxin (Baudrimont *et al*. 1994, Omar *et al*. 1998, Rahimtula *et al*. 1988). Rahimtula *et al*. (1988) reported that ochratoxin induced lipid peroxidation (LPO) in subcellular fractions. There is also evidence showing that ochratoxin is a potent pro-oxidant as it induced LPO in primary cultures of brain cells (Belmadani *et al*. 1999). In addition, the formation of reactive oxygen species (ROS) was significantly increased after exposure of foetal rat telencephalon cells to high ochratoxin concentrations (Monnet-Tschudi *et al*. 1997). The kidney is a prominent site for intense oxidative processes in the body and ROS plays an important role in the pathogenesis of a variety of renal diseases (Shiraishi *et al*. 2000). Therefore, supplementation of vitamin E might have reduced the oxidative stress caused by ochratoxin and thus cell damage.

Feed intake (*FI*)*:* During starter phase (0–3 weeks), the FI in control group (T_1) was higher than that of toxin fed group (T_2). The FI in groups T_3 and T_6 was statistically similar to that of T_2, however, the FI in groups T_4, T_5, T_6 and T_7 was higher than that of T_2. During finisher phase (4–6 weeks), FI did not differ (P≤0.05) among various dietary treatments. During overall growth period (0–6 weeks), the FI in control group was statistically similar to other treatment groups. The FI in groups T_7 and T_8 was higher (P≤0.05) than that of group received basal diet with toxin (T_2). In the present study, dietary contamination of ochratoxin resulted in reduced feed consumption in broilers. Similar observations of reduced feed consumption were also reported by earlier workers (Verma *et al*. 2004, Elaroussi *et al*. 2006, Denli *et al*. 2008 and Sawale *et al*. 2009). Other workers (El-Barkouky 2008, El-Barkouky and Abu- Taleb 2008, El-Barkouky *et al*. 2010, Singh *et al*. 2015, Singh *et al*. 2016), also reported significantly reduced feed intake in broilers fed ochratoxin contaminated feed at a concentration ranging from 50–200 ppb. In the present study, addition of 0.1% *S. cerevisiae* along with 100 mg vitamin E or 0.075% *S. cerevisiae* along with 200 mg vitamin E/kg diet to the 150 ppb ochratoxin contaminated

Table 4. Liveability percentage as influenced by various dietary treatments

Treatment	First wk	Second wk	Third wk	Fourth wk	Fifth wk	Sixth wk
T_1	100.00±0.00	100.00±0.00	100.00±0.00	97.50±2.50	95.00±5.00^{b}	95.00±5.00^{b}
T_2	100.00±0.00	95.00±2.88	92.50±4.78	87.50±4.78	82.50±2.50^{a}	82.50±2.50^{a}
T_3	100.00±0.00	97.50±2.50	92.50±2.50	90.00±4.08	85.00±2.88^{ab}	82.50±4.78^{a}
T_4	100.00±0.00	97.50±2.50	95.00±2.88	92.50±2.50	87.50±2.50^{ab}	87.50±2.50^{ab}
T_5	100.00±0.00	100.00±0.00	100.00±0.00	95.00±2.88	92.50±2.50^{ab}	92.50±2.50^{ab}
T_6	100.00±0.00	97.50±2.50	95.00±2.88	92.50±2.50	87.50±4.78^{ab}	87.50±4.78^{ab}
T_7	100.00±0.00	100.00±0.00	97.50±2.50	95.00±2.88	90.00±0.00^{ab}	90.00±0.00^{ab}
T_8	100.00±0.00	100.00±0.00	97.50±2.50	95.00±2.88	95.00±2.88^{b}	95.55±2.88^{b}

Values bearing different superscripts in a column differ significantly (P≤0.05).

feed ameliorated the ill effects of ochratoxin on feed consumption of broilers. El-Barkouky (2008), El-Barkouky *et al*. (2010) and Singh *et al*. (2016) also reported that addition of *S. cerevisiae* to the 50–200 ppb ochratoxin contaminated diet improved the feed consumption in broiler chickens. Also, Singh (2015) reported that addition of vitamin E (200 mg/kg) to 200 ppb ochratoxin contaminated feed ameliorated the adverse effects of ochratoxicosis on feed intake of broiler chickens.

Feed conversion ratio (*FCR*)*:* With regard to FCR in various growth phases, the FCR during starter phase (0–3 weeks) in control group (T_1) was lower (P≤0.05) than that of ochratoxin fed group (T_2). The FCR in groups T_3 to T_7 was higher (P≤0.05) than T_1 but lower than that of T_2. The FCR of group T_8 was statistically similar to that of control. During finisher phase (4–6 weeks) and overall growth phase (0–6 weeks), the FCR in control group (T_1) was lower (P≤0.05) than that of T_2. The FCR in groups T_3, T_4 and T_6 was higher (P≤0.05) than the control, but lower than that of T_2. The FCR in groups T_5, T_7 and T_8 was lower than T_2 and statistically similar to that of control (T_1), indicating that inclusion of *S. cerevisiae* along with vitamin E in T_5, T_7 and T_8 ameliorated the adverse effects of ochratoxicosis on FCR. In the present study, ochratoxin (150 ppb) contamination in feed significantly (P≤0.05) increased the FCR, thus resulted in poor feed efficiency in broiler chickens. Poor feed efficiency due to ochratoxin contamination in feed was earlier reported by Elaroussi *et al*. (2006), Santin *et al*. (2006), Koynarski *et al*. (2007), Hanif *et al*. (2008), Denli *et al*. (2008) and Sawale *et al*. (2009). Singh *et al*. (2016), Sakhare *et al*. (2007), El-Barkouky (2008), El-Barkouky and Abu-Taleb (2008), El-Barkouky *et al*. (2010) and Singh *et al*. (2015) also reported poor feed conversion in broiler chickens fed ochratoxin (50–200 ppb) contaminated feed. The present study revealed that inclusion of *S. cerevisiae* (0.1%) along with vitamin E (100 mg/kg feed) or *S. cerevisiae* (0.075%) along with vitamin E (200 mg/kg feed) to the 150 ppb ochratoxin contaminated feed ameliorated the adverse effects of ochratoxicosis on feed efficiency in broiler chickens. El-Barkouky (2008), El-Barkouky *et al*. (2010) and Singh *et al*. (2016) also reported that addition of *S. cerevisiae* in the diet of broiler chickens ameliorated the ill effects of 50–200 ppb ochratoxin on feed efficiency. Singh (2015) also reported that addition of vitamin E at 200 mg/kg level to 200 ppb ochratoxin contaminated feed ameliorated the adverse effects of ochratoxicosis on feed efficiency in broiler chickens.

Liveability percentage: During first week of age, no mortality was recorded. During second, third and fourth weeks of growth period, the liveability percentage did not vary (P≤0.05) among various dietary treatments. During fifth week of age, the liveability percentage in control group (T_1) was higher (P≤0.05) than that of ochratoxin fed group (T_2). The liveability percentage in groups T_3 to T_8 was statistically similar to that of control. During sixth week of growth trial, the liveability percentage in control group (T_1) was 95.00 which significantly (P≤0.05) reduced to 82.50 in ochratoxin fed group (T_2). The liveability percentage in group T_3 was significantly (P≤0.05) lower than control and similar to that of T_2. The liveability percentage in groups T_4 to T_8 was statistically similar to that of control, indicating that inclusion of *S. cerevisiae* along with vitamin E at any level in these groups ameliorated the adverse effects of ochratoxicosis on mortality in birds. The present study revealed that ochratoxin (150 ppb) contamination of broiler feed resulted in higher mortality compared to that of control. These findings were in agreement with earlier reports in literature (Singh *et al*. 2016, El-Barkouky and Abu-Taleb 2008, El-Barkouky *et al*. 2010, Singh *et al*. 2015). Our results revealed that addition of *S. cerevisiae* along with vitamin E at any level, barring T_3, to the ochratoxin contaminated broiler diet alleviated the adverse effects on mortality caused by ochratoxicosis in broiler chickens. Stanley *et al*. (1993), El-Barkouky (2008), El-Barkouky *et al*. (2010) and Singh *et al*. (2016) also reported that addition of *S. cerevisiae* in the diet of broiler chickens ameliorated the ill effects of 50–200 ppb ochratoxin on mortality. Singh (2015) also reported that addition of vitamin E at 100 mg/kg level to 200 ppb ochratoxin contaminated feed ameliorated the adverse effects of ochratoxicosis on mortality in broiler chickens.

Cost of feeding: During starter phase (0–3 wk), the feed cost (Table 5) in control group (T_1) was lower (P£0.05) that that of T_2. The feed cost in groups T_3 to T_8 was higher (P£0.05) than control (T_1) but lower (P£0.05) than that of toxin fed group (T_2). During finisher phase (4–6 wk), the feed cost in control group (T_1) was lower (P£0.05) that that

Table 5. Cost of feeding (₹) as influenced by various dietary treatments

Treatment	0–3 wk	4–6 wk	0–6 wk
T_1	39.73±0.18^{a}	45.70±0.11^{a}	43.71±0.95^{a}
T_2	45.00±0.44^{d}	52.81±0.78^{c}	50.00±0.53^{d}
T_3	42.91±0.38^{c}	49.93±2.25^{bc}	47.47±1.52^{bc}
T_4	42.50±0.31^{bc}	50.47±1.02^{bc}	47.77±0.66^{bc}
T_5	42.13±0.66^{bc}	47.69±0.37^{ab}	45.84±0.41^{b}
T_6	42.75±0.35^{bc}	50.89±1.03^{bc}	48.15±0.68^{cd}
T_7	42.65±0.15^{bc}	49.04±0.37^{b}	46.88±0.22^{bc}
T_8	41.65±0.40^{b}	48.77±0.45^{ab}	46.36±0.27^{bc}

Values bearing different superscripts in a column differ significantly (P≤0.05).

of T_2. The feed cost in groups T_5 and T_8 was statistically similar to that of control, however, the feed cost in groups T_3, T_4, T_6 and T_7 was higher (P£0.05) than that of control. Between T_5 and T_7, the cost of feed in group T_5 was statistically similar to that of control, however, the feed cost in group T_7 was higher (P£0.05) than that of control. Therefore, the cost of feeding in group T_5 was lower than that of T_7. During overall growth period (0–6 wk), the feed cost in control group (T_1) was lower (P£0.05) that that of T_2 due to depressed growth and feed conversion caused by ochratoxin contamination in T_2. The feed cost in groups T_3 to T_8 was higher (P£0.05) than that of control. Between T_5 and T_7, the cost of feed in group T_5 was lower than that of T_7. The results indicated that the feed-cost of production was reduced when additives were added in ochratoxin contaminated diet, attributed to ameliorating effect of those additives on performance. However, the production cost, incurred due to addition of additives, could not be compensated.

It was concluded that ochratoxin contamination of feed at the rate of 150 ppb impaired the production performance assessed through body weight gain, feed intake, feed utilization efficiency and survivability. Inclusion of *Saccharomyces cerevisiae* at 0.1% level along with 100 mg vitamin E/kg diet or *Saccharomyces cerevisiae* at 0.075% level along with 200 mg vitamin E/kg diet to the ochratoxin (150 ppb) contaminated feed ameliorated the adverse effects of ochratoxicosis in broiler chickens. However, the production cost, incurred due to addition of additives to ameliorate the adverse effects of ochratoxin could not be compensated.

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