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Performance and some blood constituents of broilers fed sesame meal sup-plemented with microbial phytase

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ABSTRACT

Objective: To investigate the effect of the interaction between dietary sesame meal (SSM) level and levels of microbial phytase supplementation on growth performance, carcass traits and some blood plasma constituents of broilers. **Methods:** A total of 288 one-day-old unsexed Cobb chicks were randomly allocated in 12 experimental treatments for 42 days. Each treatment had 24 broilers arranged in 3 replicates of 8 broilers each. A 4×3 factorial arrangement of 12 dietary treatments was used including four levels of SSM (*i.e.*, 0, 250, 500, 1 000 g/kg) and three levels of microbial phytase (*i.e.*, 0, 300, 600 FTU/kg). At 42 days of age, nine birds per treatment (three birds per replicate) were randomly selected and fasted for 12 h and killed. Abdominal fat, giblets, and dressing proportion were recorded. Blood samples were collected from five birds of each replicate and used for determination of total protein (TP), albumin, total cholesterol (COL), triglycerides (TG), liver aspartate amino transferase enzyme (AST) and alanine amino transferase (ALT), calcium (Ca), inorganic P, globulin and albumin to globulin ratio. **Results:** the experiment showed that SSM level had a significant effect on average body weights of broilers for the studied experimental periods, where negative effects were observed on body weights with increasing SSM level (*i.e.*, 500 and 1 000 g/kg). The same was true for the interaction between SSM and phytase. SSM level, significantly, affected feed CR during the studied growth periods ($P<0.01$). The dressing proportion, giblets and abdomen fat were significantly ($P<0.01$) affected by the SSM, however, none of these variables were affected by phytase. Diets with 1 000 g/kg SSM and 600 FTU/kg showed the highest ($P<0.05$) giblets percentage. Phytase supplementation significantly ($P<0.01$) affected the plasma TP, albumen, globulin, albumin: globulin ratio, COL and ALT activity. SSM by phytase interaction significantly affected plasma content of total TP, globulin, albumin: globulin ratio, COL, TG, ALT activity and Ca. However, it had no effect on plasma albumin ($P=0.07$), AST activity ($P=0.06$) and inorganic P ($P=0.19$) levels. **Conclusions:** SSM had positive effects on broilers performance especially at low inclusion level. However, SSM and phytase had variable effects on plasma con-stituents. More research is needed to conclude the appropriate supplementation levels of SSM and phytase.

1. Introduction

The demand on SBM as a source of crude protein in livestock diets is increasing[1,2]. The increasing price of SBM is one of the major obstacles facing livestock operations. Therefore, attempts to find alternative protein sources are always appreciated. Sesame meal (SSM) (Sesamum indicum) contains 41 % conversion ratio and has most of the essential amino acids in adequate amounts (with the exception of lysine) for the substitution of SBM in practical diets for both growing chicks and laying hens[3]. It is high in sulfur-containing amino acids, methionine (12.2 g/kg) and cystine (7.2 g/kg), but is low in lysine 9.1 g/kg[4]. It was demonstrated that SSM has a high phytic acid content being, that in

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turn results in poorer utilization in poultry feeds and low utilization of calcium[5]. Also, the reduction in feed intake when SSM was fed at a higher level might be one of the signs of calcium deficiency. That reduction in feed consumption with a higher dietary level of SSM might be also due to that its content of bitter substances[3].

A combination of SSM and SBM resulted in better performance (*i.e.*, weight gain and feed CR) in broiler[6], however, reports on the replacement level are in disagreement[7]. Yamauchi *et al*[7] reported that 200 g/kg replacement of dieta-ry SBM with SSM, had no negative impact on performance of broiler chicks.

The low nutritional value of SSM containing-diet might be improved by supple-mentation with phytase enzyme to improve phytate utilization. Ayssiwede *et al*[8] reported positive broilers responses when 250 and 500 g/kg of dietary SBM were replaced with similar amounts of SSM along with phytase supplementation at level of 750 FTU/kg diet during starter, grower and finisher periods.

This study was carried out to investigate the effect of the interaction between dietary SSM level and levels of microbial phytase supplementation on growth performance, carcass traits and some blood plasma constituents of broilers.

2. Materials and methods

2.1. Experimental site, design and diets

The experiment was conducted at a private farm at Beit Lahia, Gaza Strip of Palestine, while the laboratory work was done at the Faculty of Agriculture, Al Azhar University. The experiment was approved by the Animal Care and Use Committee. A total of 288 one-day-old unsexed chick of a commercial strain (Cobb) obtained from a local hatchery. Broilers were vaccinated on day 1 for Marek, infectious bronchitis, and Newcastle disease and were randomly allocated in 12 experimental treatments for 42 days. Each treatment had 24 broilers arranged in 3 replicates of 8 broilers each. Each replicate was assigned to a clean floor pen (1 m^2) and birds were raised on a wood shavings litter. Heat was provided with a heating lamp per pen. The temperature was regulated at (27±1) ℃ during the starter phase and at (25±1) ℃ for the rest of the experiment (15 to 42 days). Except from day 1, a 23 light: 1 dark lighting program was applied during the ex-periment. A 4×3 factorial arrangement of 12 dietary treatments was used to eva-luate the effects of level of SSM (*i.e.*, 0, 250, 500, 1 000 g/kg) and the

Table 1

Formulation and nutrient composition of the starter and finisher diets,

	Starter (g/kg)				Finisher (g/kg)			
Sesame meal levels[1]	0	250	500	1 000	0	250	500	1 000
Yellow corn	36	36	36	36	41	41	41	41
Wheat	20.5	20.5	20.5	20.5	21	21	21	21
Soy bean meal (44%)	36	27	18	0.0	30.5	22.87	15.25	0.0
Dry fat	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Sesame meal (43%)	0.0	9	18	3.6	0.0	7.63	15.25	30.5
Dicalcium phosphate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Premix[2]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
DL-Methionine	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
L-Lysine HCl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100	100	100	100
Calculated analysis ME (MJ / kg diet)	704.5	709.4	710.6	713.0	718.0	709.0	711.0	713.0
Crud protein	216.3	216.1	216.9	215.6	195.0	196.8	196.7	196.4
Lysine	11.0	10.8	10.6	10.0	11.0	1.07	1.07	10.7
Methionine	5.5	5.7	5.7	5.8	5.6	5.8	5.8	5.9
Calcium	10.0	10.5	11.0	11..0	10.0	11.0	11.0	11.0
AP[3]	4.6	4.4	4.3	4.3	4.7	4.3	4.3	4.3

[1]*n*=24.

[2]Premix supplied per 1 kg of diet: vit. A=12000 IU; vit. D3=220 IU; vit. E=10 mg; vit. K3=2 mg; vit. B1=1 mg; vit. B2=4 mg; Vit. B6=1.5 mg; vit. B12=10 μ g; vit. B3=20 mg; vit. B5=10 mg; vit. B9=1 mg; vit. B8=50 μ g; Choline chloride=500 mg; Cu=10 mg; I=10 mg; Fe=30 mg; Mn=55 mg; Zn=850 mg; Se=0.1 mg; Co=0.25 mg.

AP=available phosphorus.

level of microbial phytase, fungal phytase-3 Natuphos®, a product of BASF, Germany, (*i.e.*, 0, 300, 600 FTU/kg) on nutrient utilization and growth performance of broiler chickens. The birds were given access to water and were given a starter diet from 1 to 21 days and a grower–finisher diet from 22 to 42 days. Composition and calculated analyses of the experimental diets according to NRC (1994)[4] was shown in Table 1.

2.2. Performance, carcass and blood constituents

Chicks were weighed weekly by replicated pen, and feed consumption was measured for 6–week period. Cumulative weight gain and feed/gain ratio were calculated. Mortality per pen was recorded daily and calculated for the 6–week period by treatment. At 42 days of age, nine birds per treatment (three birds per replicate) were randomly selected and fasted for 12 h, weighed, and euthanized by cervical dislocation. After bleeding for 2 min, birds were scalded in water at 60 ℃ for 2 min before feather plucking by a machine, evisceration, and tissue sample collection. Abdominal fat and giblets were weighed and recorded as percentages of body weight. Serum was separated by centrifugation at 2000×*g* for 15 min, and frozen at −24 ℃ until used.

2.3. Biochemical constituents of blood plasma

Blood samples were collected from five birds of each replicate in heparinzed tubes at 42 days of age. Plasma was separated by centrifugation at 3000 rpm for 15 min and stored at −20 ℃ for later analysis.

Plasma total protein, albumin, total cholesterol, triglycerides, liver enzymes AST (aspartate amino transferase) and ALT (alanine amino transferase), Ca, inorganic P serum were measured by commercial kit based on Pharma Diagnostics kits (Jerusalem, Palestine). Globulin was calculated by the difference between total protein and albumin. Also, albumin to globulin ratio was calculated.

2.4. Statistical procedures

Data from all response variables were subjected to a factorial analysis using SAS[9]. Variables having significant differences were compared using Duncan's Multiple Range Test[10].

The following model was applied;

$Y_{ij}= \mu+S_i+P_j+(SP)_{ij}+E_{ij}$; where;

Y_{ij}=Individual observation.

μ=Overall mean.

S_i=Effect of sesame meal level (i=1, 2, 3 and 4).

P_j=Effect of phytase supplementation level (j=1, 2, and 3).

$(SP)_{ij}$=Effect of the interaction between sesame meal level and phytase supplementation level.

E_{ij}=Experimental error.

3. Results

3.1. Feed intake, body weight and feed conversion ratio

Neither dietary SSM level nor phytase supplementation significantly affected feed intake of broilers during any of the studied intervals (Table 2). The same trend was observed for the SSM and phytase interaction.

Table 2
Effect of dietary sesame meal (SSM) level and/or phytase level on feed intake of broilers (g).

Sesame level	Phytase Level (FTU)	1–14 d	15–28 d	29–42 d	1–42 d
SSM 0[1]		461±7.0	1114±19.0	1883±25.5	3458±33.0
SSM 250		454±14.0	1122±17.0	1891±31.9	3467±27.0
SSM 500		457±7.0	1126±16.0	1885±24.75	3468±29.0
SSM 1000		453±8.0	1119±15.0	1894±24.17	3466±3.0
Significance		ns	ns	ns	ns
	0	459±9.0	1122±18.0	1880±25.0	3461±31.0
	300	454±8.0	1118±16.0.	1895±28.0	3467±32.0
	600	455±11.0	1121±17.0	1890±24.0	3446±28.0
Significance		ns	ns	ns	ns
SSM 0	0	463±4.0	1113±23.0	1896±15.0	3472±40.
	300	455±8.0	1126±20.0	1880±36.0	3461±36
	600	463±7.0	1103±5.0	1873±25.0	3439±25.0
SSM 250	0	452±14.0	1131±16.0	1870±26.0	3453±17.0
	300	464±3.0	1113±15.0	1910±30.0	3487±25.0
	600	444±7.0	1120±20.0	1893±35.0	3457±32.0
SSM 500	0	461±9.0	1126±11.0	1876±25.0	3463±6.0
	300	451±2.0	1116±21.0	1893±37.0	3460±53.0
	600	458±7.0	1135±15.0	1885±13.0	3478±18.0
SSM 1000	0	460±5.0	1116±21.0	1878±37.0	3454±55.0
	300	445±5.0	1115±13.0	1898±12.0	3458±12.0
	600	455±5.0	1127±11.0	1906±11.0	3488±18.0
Significance		ns	ns	ns	ns

ns: not significant
1SSM0, zero SSM, n=24; SSM250, 250 SSM g/kg, n=24; SSM500, 500 SSM g/kg, n=24; SSM1000, 1000 g/kg, n=24.

Body weight as a response to the main effects (SSM level) and interac–tions between SSM level and phytase level were presented in Table 3.

It was quite clear that SSM level had a significant effect on body weights of broilers for the studied experimental periods, where negative effects were observed on body weights associated with high SSM levels (*i.e.*, 500 and 1000 g/kg). Also, differences in body weights between 0 and 250 g/kg SSM levels were not statistically significant. The phytase level in most studied periods had no significant effect on body weight except that of 600 FTU/kg diet at 15–28 days compared to 0 and 300 FTU/kg diets.

The interaction between SSM level and phytase supplementation revealed a significant impact on body weights of broilers. Body weights at 1–14 dayS of age were heavier (P<0.01) in birds fed the 0, 250 or 500 g/kg SSM with

Table 3

Effect of dietary sesame meal (SSM) level and/or Phytase level on body weight of broilers (g).

Sesame level	Phytase Level (FTU)	Initial	1-14 d	15-28 d	29-42 d	1-42 d
SSM 01		40.4±0.5	192^{a}±23.0	799^{a}±100.0	587^{b}±97.0	1618^{a}±99.0
SSM 250		40.6±0.7	190^{a}±21.0	805^{a}±108.0	581b±93.0	1616^{a}±107.0
SSM 500		40.4±0.6	175^{b}±34.0	537^{b}±82.0	626^{a}±110.0	1378^{b}±82.0
SSM 1000		40.4±0.5	73^{c}±7.0	210^{c}±39.0	369^{c}±29.0	692^{c}±38.0
Significance		ns	0.01	0.01	0.01	0.01
	0	40.5±0.7	160±54.0	574^{b}±402.0	545^{a}±126.0	1319±403.0
	300	40.4±0.6	153±55.0	567^{b}±393.0	560^{a}±154.0	1320±393.0
	600	40.5±0.6	159±53.0	622^{a}±373.0	518^{b}±116.0	1339±373.0
Significance		ns	ns	0.01	0.01	ns
SSM 0	0	40.5±0.6	192^{a}±21.0	796^{a}±68.0	610^{b}±64.0	1639^{a}±99.0
	300	40.3±0.4	193a±20.0	818^{a}±83.0	522^{bc}±122.0	1573^{a}±92.0
	600	40.4±0.5	190^{a}±26.0	784^{a}±67.0	628^{b}±57.0	1642^{a}±95.0
SSM 250	0	40.7±0.8	190^{a}±23.0	819^{a}±75.0	596^{b}±78.0	1646^{a}±106.0
	300	40.5±0.8	195^{a}±19.0	805^{a}±61.0	587^{b}±110.0	1628^{a}±122.0
	600	40.5±0.6	190^{a}±18.0	790^{a}±68.0	561^{b}±87.0	1572^{a}±84.0
SSM 500	0	40.4±0.5	187^{a}±22.0	476c±56.0	605^{b}±102.0	1308^{c}±105.0
	300	40.3±0.6	151^{a}±39.0	476^{c}±46.0	745^{a}±31.0	1412^{b}±32.0
	600	40.6±0.8	188^{a}±23.0	659^{b}±28.0	528^{bc}±24.0	1417^{b}±32.0
SSM 1000	0	40.5±0.5	72^{b}±7.0	204^{d}±25.0	368^{d}±35.0	685^{d}±45.0
	300	40.3±0.4	73.^{b}±6.0	172^{f}±16.0	385^{d}±19.0	670^{d}±20.0
	600	40.4±0.6	74^{b}±6.0	254^{d}±27.0	353^{d}±19.0	721^{d}±27.0
Significance		ns	0.01	0.01	0.01	0.01

ns: not significant

a-d means within the same column at each item having different superscripts are sig-nificantly different ($P<0.01$).

1SSM0, zero SSM, n=24; SSM250, 250 SSM g/kg, n=24; SSM500, 500 SSM g/kg, n=24; SSM1000, 1000 g/kg, n=24.

Table 4

Effect of dietary sesame meal (SSM) level and/or phytase level on feed conversion ratio (CR) of broilers

Sesame level	Phytase level (FTU)	1-14 d	15-28 d	29-42 d	1-42 d
SSM 01		1.99^{c}±0.09	1.46^{c}±0.03	3.25^{b}±0.07	2.14^{c}±0.07
SSM 250		1.97^{c}±0.05	1.39^{c}±0.05	3.27^{b}±0.06	2.14^{c}±0.06
SSM 500		2.14^{b}±0.21	2.15^{b}±0.32	3.07^{b}±0.10	2.52^{b}±0.10
SSM 1000		3.97^{a}±0.10	5.49^{a}±0.91	5.15^{a}±0.15	5.15^{a}±0.16
Significance		0.01	0.01	0.01	0.01
	0	2.50±0 .92	2.67^{b}±1.77	3.62±0.91	2.98±1.27
	300	2.55±0.85	2.90^{a}±2.21	3.60±0.95	2.99±1.31
	600	2.49±0.88	2.25^{c}±1.33	3.83±0.98	2.89±1.18
Significance		ns	0.05	ns	ns
SSM 0	0	1.99^{d}±0.08	1.40^{g}±.03	3.11^{f}±0.12	2.12^{h}±0.04
	300	1.95^{d}±0.06	1.38^{g}±0.04	3.65^{c}±0.55	2.20^{g}±0.07
	600	2.02^{d}±0.13	1.41^{g}±0.01	2.99^{f}±0.16	2.10^{h}±0.06
SSM 250	0	1.96^{d}±0.07	1.38^{g}±0.06	3.13d^{f}±0.02	2.10^{h}±0.03
	300	1.97^{d}±0.04	1.38^{g}±0.04	3.29d^{f}±0.44	2.14^{gh}±0.09
	600	1.98^{d}±0.06	1.42^{g}±0.06	3.38d±0.07	2.19^{gh}±0.02
SSM 500	0	2.03^{d}±0.03	2.37^{d}±0.10	3.11^{f}±0.13	2.65^{d}±0.07
	300	2.38^{c}±0.20	2.35^{d}±0.06	2.54^{g}±0.10	2.46^{f}±0.03
	600	2.00^{d}±0.03	1.72^{f}±0.01	3.57^{cd}±0.04	2.46^{f}±0.01
SSM 1000	0	4.03^{a}±0.17	5.51^{b}±0.27	5.11^{b}±0.21	5.05^{b}±0.14
	300	3.92^{b}±0.04	6.50^{a}±0.23	4.93^{b}±0.04	5.16^{a}±0.02
	600	3.95^{ab}±.05	4.45^{c}±0.18	5.41^{a}±0.17	4.83^{c}±0.01
Significance		0.01	0.01	0.01	0.01

ns: not significant

a-c means within the same column at each item having different superscripts are sig-nificantly different ($P<0.05$).

a-h means within the same column at each item having different superscripts are sig-nificantly different ($P<0.01$).

1SSM0, zero SSM, n=24; SSM250, 250 SSM g/kg, n=24; SSM500, 500 SSM g/kg, n=24; SSM1000, 1000 g/kg, n=24.

Table 5

Effect of dietary sesame meal (SSM) level and/or phytase level on carcass characteris-tics of broilers at 42 days of age

Sesame level	Phytase level (FTU)	Slaughter weight (g)	Dressing (%)	Giblets (%)	Abdominal fat (%)
SSM 01		1871^{a}±212	70.5^{a}±1.6	6.03^{b}±0.41	0.98^{a}±0.37
SSM 250		1891^{a}±221	69.6^{a}±2.2	6.42^{b}±0.94	1.15^{a}±0.57
SSM 500		1795^{a}±224	67.8^{b}±2.8	6.13^{b}±0.43	0.69^{b}±0.29
SSM 1000		962^{b}±238	64.4^{c}±2.3	7.38^{a}±0.97	1.22^{a}±0.45
Significance	0.01	0.01	0.01	0.01	
	0	1596.3±484	68.19±2.61	6.45±0.68	0.89±0.27
	300	1663.6±383	68.23±3.60	6.30±1.02	1.04±0.58
	600	1628±489	67.83±3.55	6.72±0.95	1.10±0.49
Significance		ns	ns	ns	ns
SSM 0	0	2058^{a}±189	68.91±1.35	6.21^{cd}±0.31	0.74^{bc}±0.168
	300	1746^{bc}±99	71.36±1.24	5.60^{d}±0.37	0.72^{bc}±0.105
	600	1808^{b}±210	71.26±1.10	6.27^{cd}±0.19	1.47a±0.075
SSM 250	0	1842b±274	70.80±.15	5.98^{cd}±0.77	1.11^{ab}±0.247
	300	2001^{ab}±236	69.58±5.27	6.64^{bc}±1.41	1.21^{ab}±0.997
	600	1829^{b}±132	68.46±0.95	6.64^{bc}±0.45	1.14^{ab}±0.273
SSM 500	0	1589^{c}±141	68.02±0.91	6.42^{c}±0.43	0.77^{bc}±0.115
	300	1776^{bc}±127	68.02±3.17	6.15^{cd}±0.24	0.92^{b}±0.250
	600	2021^{ab}±150	67.30±4.12	5.83^{cd}±0.44	0.38^{c}±0.122
SSM 1000	0	897^{f}±165	65.04±2.60	7.20^{b}±0.58	0.924^{b}±0.385
	300	1133^{d}±309	63.96±1.31	6.81^{bc}±1.28	1.32^{ab}±0.516
	600	857^{f}±146	64.18±3.08	8.12^{a}±0.46	1.43^{a}±0.344
Significance		0.01	ns	0.05	0.01

ns: not significant

a-d means within the same column at each item having different superscripts are sig-nificantly different ($P<0.05$).

a-f means within the same column at each item having different superscripts are sig-nificantly different ($P<0.01$).

1SSM0, zero SSM, n=24; SSM250, 250 SSM g/kg, n=24; SSM500, 500 SSM g/kg, n=24; SSM1000, 1000 g/kg, n=24.

Table 6

Effect of dietary sesame meal (SSM) level and/or phytase level on some plasma constituents of broilers at 42 days of age.

Sesame level	Phytase Level (FTU)	TP1 (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Albumen/Globulin ratio	COL (mg/dl)
SSM 02		3.31^{a}±0.16	2.11^{a}±0.19	1.28±0.21	1.73 ±0.51	138±13.0
SSM 250		3.34^{a}±0.23	2.05^{a}±0.10	1.27±0.19	1.73±0.24	140±14.0
SSM 500		3.24^{ab}±0.16	2.03^{a}±0.13	1.22±0.18	1.73±0.28	132±14.0
SSM 1000		3.13^{b}±0.32	1.92^{b}±0.16	1.20±0.32	1.77±0.52	130±11.0
Significance		0.01	0.01	ns	ns	ns
	0	3.31^{a}±0.18	2.07^{a}±0.20	1.30^{a}±0.25	1.71^{ab}±0.50	135^{ab}±11.0
	300	3.08^{b}±0.21	1.95^{b}±0.12	1.11^{b}±0.21	1.89^{a}±0.40	130^{b}±10.0
	600	3.39^{a}±0.21	2.07^{a}±0.13	1.32^{a}±0.18	1.57^{b}±0.21	141^{a}±15
Significance	0.01	0.01	0.01	0.01	0.05	
SSM 0	0	3.22^{cd}±0.16	2.26^{a}±0.20	1.14^{bc}±0.24	2.23^{ab}±0.61	127.6^{bc}±7.54
	300	3.30^{cd}±0.07	1.94^{c}±0.11	1.30^{b}±0.16	1.45^{c}±0.20	139.0^{ab}±9.67
	600	3.42^{bc}±0.16	2.12^{ab}±0.11	1.40^{ab}±0.16	1.51^{c}±0.18	147.8^{a}±11.76
SSM 250	0	3.34^{c}±0.11	2.10^{b}±0.07	1.22^{bc}±0.15	1.68^{bc}±0.19	146^{a}±7.0
	300	3.14^{d}±0.11	1.98^{bc}±0.11	1.17^{bc}±0.16	1.84^{bc}±0.20	126^{bc}±10.0
	600	3.56a±0.23	2.07^{bc}±0.08	1.42^{ab}±0.18	1.49^{c}±0.23	147^{a}±14.0
SSM 500	0	3.28^{cd}±0.13	2.06^{bc}±0.11	1.30^{b}±0.16	1.64^{bc}±0.30	134^{b}±14.0
	300	3.08^{d}±0.08	1.98^{bc}±0.13	1.06^{c}±0.15	1.96^{b}±0.16	132^{bc}±10.0
	600	3.36^{c}±0.11	2.06^{bc}±0.15	1.30^{b}±0.16	1.58^{c}±0.23	130^{bc}±18.0
SSM 1000	0	3.40^{bc}±0.27	1.84^{c}±0.11	1.52^{a}±0.31	1.29^{c}±0.33	131^{bc}±4.0
	300	2.80^{e}±0.15	1.90^{c}±0.14	0.92^{c}±0.20	2.31^{a}±0.42	121^{c}±7.0
	600	3.20^{cd}±0.15	2.02±0.19	1.16^{bc}±0.11	1.71^{bc}±0.16	137^{ab}±13.0
Significance	0.01		0.07	0.01	0.01	0.05

ns: not significant

a-c means within the same column at each item having different superscripts are sig-nificantly different ($P<0.05$).

a-e means within the same column at each item having different superscripts are sig-nificantly different ($P<0.01$).

1TP, total protein; COL, cholesterol.

2SSM0, zero SSM, n=24; SSM250, 250 SSM g/kg, n=24; SSM500, 500 SSM g/kg, n=24; SSM1000, 1000 g/kg, n=24.

or without phytase supplementation compared to those fed 1 000 g/kg SSM, even if it was supplemented with phytase. At 15-28 days of age, 600 FTU/kg added to 500 and 1 000 g/kg SSM diets was able to improve (P<0.01). Body weights of broilers compared to that of broilers fed the non phytase diets. At 29-42 days of age, only the 300 FTU/ kg diet in 500 g/kg SSM diet significantly (P<0.01) surpassed the body weights in other treatments. For the total experimental period, 300 and 600 FTU/ kg diets managed to enhance body weights in the 250 and 500 g/kg SSM diets, but failed to impact the negative effect of high inclusion level of SSM, however, within each SSM category, the included level of phytase was not sufficient to induce a promising response.

The SSM level had significant (P<0.01) effect on feed CR during the studied periods (Table 4). Phytase level had a significant (P<0.05) effect on feed CR only for the 15-28 day period.

The interaction resulted a significant (P<0.01) effect on feed CR for all expe-rimental periods. However, an inverse relationship was observed between SSM level and feed CR of groups. Phytase supplementation at 600 FTU/kg level to 500 and 1 000 g/kg SSM diets improved (P<0.01) FCR for the whole experimental periods.

3.2. Carcass characteristics

Table 7
Effect of dietary sesame meal (SSM) level and/or phytase level on some plasma constituents (mg/dl) of broilers at 42 days of age

Sesame level	Phytase level	TG1	AST	ALT	Ca	P
SSM02		110^{b}±7.0	346±57.0	16.1^{a}±4.3	10.8^{b}±0.7	5.35±0.30
SSM250		118^{a}±15.0	331±49.0	13.8^{ab}±6.9	11.6^{a}±1.1	5.17±0.55
SSM500		115^{ab}±9.0	308±26.0	12.2^{b}±2.4	10.7^{b}±1.2	5.07±0.52
SSM1000		113^{ab}±9.0	319±41.0	16.7^{a}±7.8	10.3^{b}±0.9	5.14±0.75
Significance		0.01	ns	0.01	0.01	ns
	Zero	112±6.0	307±56.0	14.3^{b}± 6.8	11.0± 0.9	5.32 ±0.46
	300 FTU	118±14.0	336±17.0	12.6^{b}±3.2	10.8±1.2	5.02±0.75
	600 FTU	112±9.0	335±50.0	17.2^{a}±6.4	10.7±1.1	5.14±0.75
Significance		0.12	0.10	0.01	.09	0.20
SSM0	Zero	116^{bc}±8.0	359±90.0	14.6^{bc}±1.6	10.8^{b}±0.8	5.16±0.49
	300 FTU	105^{c}±3.0	324±15.0	13.6^{bc}±1.5	10.6^{bc}±0.7	5.46±0.11
	600 FTU	108^{c}±5.0	354±49.0	19.9^{a}±5.6	10.8^{b}±0.9	5.12±0.13
SSM250	Zero	108^{c}±6.0	306±29.0	6.2^{d}±1.9	11.7^{ab}±1.3	5.22±0.73
	300 FTU	134^{a}±15.0	338±23.0	15.3^{b}±3.4	10.8^{bc}±0 9	5.16±0.61
	600 FTU	112^{bc}±4.0	351±75.0	19.7^{a}±6.0	12.2^{a}±0.8	5.12±0.35
SSM500	Zero	113^{bc}±4.0	294±10.0	13.6^{bc}±2.1	10.4^{bc}±0.7	5.62±0.31
	300 FTU	112^{bc}±7.0	333±12.0	12.5^{bc}±2.5	12.0^{ab}±1.2	4.60±0.25
	600 FTU	119^{b}±16.0	296±29.0	10.5^{c}±1.6	9.8^{c}±0.5	4.98±0.31
SSM1000	Zero	112^{bc}±5.0	274±27.0	22.7^{a}±6.3	11.1^{b}±0.9	5.26±0.16
	300 FTU	120^{b}±12.0	347±14.0	9.0^{cd}±1.0	9.9^{c}±0.9	4.84±1.29
	600 FTU	107^{c}±2.0	339±19.0	18.5^{ab}±7.1	9.9^{c}±0.2	5.32±0.28
Significance		0.01	ns	0.01	0.01	ns

ns: not significant
Means within the same column at each item having different superscripts are signifi-cantly different (P<0.01).
1TG, triglyceride; ALT, alanine amino transferase; AST, aspartate amino transferase
2SSM0, zero SSM, n=24; SSM250, 250 SSM g/kg, n=24; SSM500, 500 SSM g/kg, n=24; SSM1000, 1000 g/kg, n=24.

Dressing proportion, giblets and abdominal as percent of live weight were significantly (P<0.01) affected by SSM level (Table 5). However, none of these parameters was affected by level of phytase. The largest dressing proportion was observed in 0 and 250 g/kg SSM birds. The 1 000 g/kg SSM fed birds groups had the inferior dressing proportion value of the study. On the other hand, 500 g/kg SSM fed birds averaged lighter (P<0.01) abdominal fat compared to that of birds in other treatments. The SSM and phytase interaction resulted in heavier (P<0.05) giblets in birds fed the 1 000 g/kg SSM supplemented with 600 FTU/kg phytase.

3.3. Plasma measurements

Although dietary SSM level significantly affected plasma TP, albumen, TG, ALT activity and Ca, it had no significant effect on plasma globulin, albumin: globulin ratio, COL, AST activity and P concentration (Table 6). Birds fed diets without SSM had the highest (P<0.01). TP and albumen values, while those fed 1 000 g/kg SSM had the lowest counterparts. However, control birds attained the lowest TG value compared to SSM fortified groups. Meanwhile, the 250 g/kg SSM fed birds had the lowest ALT activity, the same birds had the highest plasma Ca level.

Phytase supplementation had a significant (P<0.01) effect on the plasma TP, albumen, globulin, albumin: globulin ratio, COL, and ALT activity. While, it had no effect on plasma TG, AST activity, Ca, and P levels (Table 7). Broilers fed the FTU/ kg diet had the lowest values for the parameters that significantly affected by phytase supplementation, except in for the albumin: globulin ratio. The plasma measurements were comparable in birds fed the 0 and 600 FTU/kg diets except for ALT activity, where 600 FTU/kg diet had the lowest ALT activity.

The SSM and phytase level interaction significantly had significant effect on plasma TP, globulin, albumin: globulin ratio, COL, TG, ALT activity, and Ca. However, it had no effect on levels of plasma albumin (P=0.07), AST activity (P=0.06) and P (P=0.19).

4. Discussion

Results of this study are in agreement with previous findings reported by Kaneko *et al*[11] and Yamauchi *et al*[7] where low to moderate levels of SSM could partially replace dietary SBM.

Response of body weights to phytase, as indicated by this study, had been variable. Significant improvement in body weights associated with phytase supplementation was reported by previous research[12-16]. Lack of phytase effect on broilers body weights was reported by other researchers[17-19] or negatively affected growth performance[20]. Selim[21] reported that phytase supplementation had a positive effect on body weight of Sasso broilers only at ages higher than 8 weeks. Following the same manner, phytase supplementation has been shown to either improve feed CR[22,13-16] or to have no effect[18,19]. However, it had no significant effect on feed intake.

The improvement in feed conversion due to phytase supplementation as observed by this study might be interpreted that phytase limited the availability of several nutrients in diets such as minerals, protein and digestive enzymes and energy[23].

In agreement with our results showed that the absence of significant effect of phytase on growth of Sasso chicks during the most of the experimental periods may be due to high Ca and available P contents of the experimental diet since diets were not adjusted for phytase equivalent value[21,24,25].

The absence of response to supplemental phytase could be further attributed to the adequacy in nutrients provided in the diets, especially with the dietary P level. In this connection, Yan *et al*[26] indicated that the level of dietary P influences the effect of phytase supplementation on growth performance of broilers. Also, Powell[27] came to such reduced growth performance with the addition of phytase to diets high in P and indicated that the effect of phytase supplementation is dependent on the level of dietary P fed, with the lower levels of dietary P receiving the positive benefits. The no more increase in weight gain of broilers fed phytase in the finisher period seem to be a carry-over effect from the grower period because there was no difference in live weight gain and feed CR upon these periods.

Respecting the effect on carcass traits, in line with the present contentions, Kaneko *et al*[11] reported that as the dietary SSM level increased, the dressing proportion de-creased. Mahmoudnia and Madani[28] reported different results where body fat and fat deposition was decreased.

Respecting the response to phytase supplementation, in agreement with the present findings, Abdo[29] and El-Nagmy *et al*[30] found that phytase did not significantly affect carcass yield. While, Abdel-Hakim and Abd El-Samee[31] found that phytase supple-mentation significantly increased broilers dressing proportion and abdominal fat compared to that of birds fed the control diet.

Phytase had no effect on plasma TP, total lipids, and COL[32]. However, Ja-lali *et al*[15], Jalali and Babaei[16] found that serum TP and albumin concentrations were increased by phytase addition. Selim[21] found that phytase decreased plasma cholesterol of broilers.

Phytase supplementation increased plasma P when added to low dietary available P level, while, phytase reduced the Ca concentration[15,33]. Also, Lan *et al*[34] reported similar results for plasma P, but not for plasma Ca. Viveros *et al*[33] reported that phytase supplementation increased serum AST but decreased ALT activity. Meanwhile, Abdo[29] found that phytase supplementation in broiler diet had no significant effect on AST activity.

It can be concluded that SSM had positive effects on broilers performance especially at low inclusion level. However, SSM and phytase had variable effects on plasma constituents. More research is needed to conclude the appropriate sup-plementation levels of SSM and phytase.

Conflict of interest statement

We declare that we have no conflict of interest.

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