Table 1. Specification of phytogenic feed additives (PFA) used in this study

Items, %	PFA1	PFA2	PFA3	PFA4	PFA5	PFA6
Bitter citrus extract	20	-	10	20	-	10
Microencapsulated blend of thymol and carvacrol	10	10	10	20	20	20
Premixture of grape seed & grape marc extract, green tea, and hops	-	20	10	-	20	10
Excipient	70	70	70	60	60	60
Total	100	100	100	100	100	100

Table 2. Effect of different ratios of phytogenic feed additives on growth performance of weaned pigs challenged with *Escherichia coli*[1]

Items	NC	PC	T1	T2	T3	T4	T5	T6	SE	P-value
BW, kg										
d - 5	8.01	8.00	8.03	8.01	8.00	8.02	7.99	7.98	0.176	1.000
d 0	8.36	8.38	8.45	8.23	8.29	8.36	8.24	8.28	0.167	0.984
d 7 PI	9.97^{ab}	9.28^{c}	9.38^{bc}	9.77^{abc}	9.46^{bc}	10.15^{a}	9.39^{bc}	10.01^{ab}	0.145	<0.001
d 11 PI	11.02^{ab}	10.21^{c}	10.58^{abc}	11.06^{ab}	10.49^{bc}	11.09^{ab}	10.63^{abc}	11.24^{a}	0.151	<0.001
d - 5 to 0										
ADG, g	69.33	74.67	83.33	42.67	59.33	67.33	51.33	60.00	12.911	0.439
ADFI, g	126.67^{bc}	135.33^{bc}	193.33^{a}	112.00^{c}	124.67^{bc}	156.00^{abc}	164.00^{ab}	144.67^{abc}	11.424	<0.001
G:F, g/g	0.55	0.52	0.41	0.40	0.47	0.43	0.31	0.38	0.077	0.451
d0 to 7 PI										
ADG, g	229.52^{a}	128.57^{b}	133.81^{b}	220.95^{ab}	166.67^{ab}	255.71^{a}	163.33^{ab}	246.67^{a}	20.884	<0.001
ADFI, g	344.76^{a}	325.95^{abc}	318.57^{c}	333.81^{abc}	323.10^{bc}	340.00^{ab}	343.33^{ab}	343.33^{ab}	4.635	<0.001
G:F, g/g	0.67^{abc}	0.40^{c}	0.41^{c}	0.66^{abc}	0.51^{abc}	0.75^{a}	0.48^{bc}	0.72^{ab}	0.060	<0.001
d7 to 11 PI										
ADG, g	262.50^{abc}	233.33^{c}	299.17^{abc}	320.83^{a}	256.67^{abc}	236.67^{bc}	311.67^{ab}	308.33^{abc}	16.762	0.001
ADFI, g	397.50^{a}	380.83^{b}	397.50^{a}	392.08^{ab}	398.33^{a}	400.00^{a}	395.00^{ab}	400.00^{a}	3.662	0.012
G:F, g/g	0.66^{abc}	0.61^{bc}	0.75^{abc}	0.82^{a}	0.64^{abc}	0.59^{c}	0.79^{ab}	0.77^{abc}	0.042	0.001
d0 to 11 PI										
ADG, g	241.51^{ab}	166.67^{c}	193.94^{bc}	257.27^{ab}	199.39^{abc}	248.79^{ab}	217.27^{abc}	269.09^{a}	15.811	<0.001
ADFI, g	363.94^{a}	345.91^{b}	347.28^{b}	355.00^{ab}	350.46^{ab}	361.82^{ab}	362.12^{ab}	363.94^{a}	3.683	0.001
G:F, g/g	0.66^{ab}	0.48^{b}	0.55^{ab}	0.72^{a}	0.57^{ab}	0.69^{a}	0.60^{ab}	0.74^{a}	0.041	0.001

[1]Abbreviation : NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%; BW, body weight; PI, post-inoculation; ADG, average daily gain; ADFI, average daily feed intake; G:F, feed efficiency; SE, standard error.

$^{a-c}$Means with different letters are significantly differ ($p < 0.05$).

Table 3. Effect of different ratios of phytogenic feed additives on diarrhea score of weaned pigs challenged with *Escherichia coli*[1]

Items	NC	PC	T1	T2	T3	T4	T5	T6	SE	P-value
Diarrhea score										
d -5 to 0	1.42	1.50	1.17	1.25	1.38	1.71	1.67	1.17	0.203	0.399
d 0 to 7 PI	1.03^{b}	2.05^{a}	1.76^{a}	1.43^{ab}	1.55^{ab}	1.62^{ab}	1.57^{ab}	1.38^{ab}	0.157	0.005
d 7 to 11 PI	0.57^{ab}	1.03^{a}	0.73^{ab}	0.60^{ab}	0.67^{ab}	0.63^{ab}	0.50^{b}	0.47^{b}	0.108	0.022
d 0 to 11 PI	0.83^{b}	1.63^{a}	1.33^{ab}	1.08^{b}	1.18^{ab}	1.21^{ab}	1.13^{ab}	1.00^{b}	0.117	0.002

[1]Abbreviation : NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%; PI, post-inoculation; SE, standard error.

[a,b]Means with different letters are significantly differ ($p < 0.05$).

Table 4. Effect of different ratios of phytogenic feed additives on nutrient digestibility of weaned pigs challenged with *Escherichia coli*[1]

Items	NC	PC	T1	T2	T3	T4	T5	T6	SE	P-value
d 7 PI										
DM, %	80.12[a]	76.89[b]	77.10[b]	78.01[ab]	77.43[ab]	78.37[ab]	77.83[ab]	77.95[ab]	0.656	0.043
CP, %	72.22	69.61	69.81	71.64	71.22	70.44	71.18	71.46	1.292	0.829
GE, %	73.06	71.36	71.13	72.21	73.23	72.11	74.55	73.84	1.158	0.406
d 11 PI										
DM, %	81.16	77.65	78.09	79.63	78.22	78.83	78.38	80.35	0.919	0.119
CP, %	75.17	73.86	74.25	74.83	74.95	74.17	74.73	75.02	0.755	0.905
GE, %	74.21[ab]	71.91[ab]	70.22[b]	72.61[ab]	73.29[ab]	70.79[ab]	71.76[ab]	76.01[a]	1.195	0.033

[1]Abbreviation : NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%; DM, dry matter; CP, crude protein; GE, gross energy; PI, post-inoculation; SE, standard error.

[a,b]Means with different letters are significantly differ ($p < 0.05$).

Table 5. Effect of different ratios of phytogenic feed additives on serum concentrations of immunoglobulins and cytokines of weaned pigs challenged with *Escherichia coli*[1]

Items	NC	PC	T1	T2	T3	T4	T5	T6	SE	P-value
d 0										
IgG, mg/dL	237.00	216.67	216.00	210.67	232.00	221.67	218.33	213.67	25.033	0.995
IgA, mg/dL	1.00	1.00	1.00	1.00	1.33	1.33	1.00	1.00	0.105	0.061
TNF-α, pg/mL	112.65	100.24	120.54	134.68	127.75	105.09	104.83	130.24	15.966	0.691
IL-6, pg/mL	1478.78	1344.58	1543.14	1491.56	1525.30	1480.38	1430.27	1444.38	86.441	0.817
d 2 PI										
IgG, mg/dL	200.33	143.00	150.67	160.33	165.67	153.00	158.67	171.00	17.098	0.415
IgA, mg/dL	1.67	1.00	1.00	1.33	1.00	1.33	1.00	1.33	0.197	0.169
TNF-α, pg/mL	82.15^{b}	112.05^{a}	86.52^{b}	81.34^{b}	78.81^{b}	97.57^{ab}	82.67^{b}	78.86^{b}	4.983	<0.001
IL-6, pg/mL	1303.09^{ab}	1569.85^{a}	1385.74^{ab}	1295.04^{ab}	1234.92^{b}	1430.53^{ab}	1328.20^{ab}	1180.45^{b}	71.997	0.017
d 4 PI										
IgG, mg/dL	218.33	174.67	213.67	216.00	214.33	207.67	216.67	208.00	13.047	0.327
IgA, mg/dL	1.67	1.00	1.00	1.00	1.00	1.00	1.33	1.00	0.167	0.053
TNF-α, pg/mL	75.15^{bc}	103.80^{a}	84.49^{abc}	72.39^{bc}	73.95^{bc}	89.74^{ab}	70.95^{bc}	68.20^{c}	4.669	<0.001
IL-6, pg/mL	1233.65^{bc}	1474.67^{a}	1348.99^{abc}	1283.82^{abc}	1240.84^{bc}	1389.58^{ab}	1274.28^{abc}	1144.74^{c}	51.438	0.002
d 7 PI										
IgG, mg/dL	200.00	197.00	224.00	205.00	231.33	196.00	219.00	224.33	15.229	0.547
IgA, mg/dL	1.33	1.00	1.00	1.00	1.00	1.33	1.00	1.00	0.105	0.061
TNF-α, pg/mL	67.54^{ab}	86.32^{a}	78.84^{ab}	72.17^{ab}	76.59^{ab}	80.78^{a}	76.44^{ab}	60.35^{b}	4.384	0.006
IL-6, pg/mL	1018.76^{c}	1367.53^{a}	1235.32^{abc}	1163.15^{abc}	1274.19^{ab}	1334.01^{a}	1209.01^{abc}	1094.18^{bc}	50.286	<0.001
d 11 PI										
IgG, mg/dL	219.33	200.67	219.67	218.33	220.33	220.67	237.67	254.33	12.665	0.177
IgA, mg/dL	1.00^{b}	1.00^{b}	1.00^{b}	1.00^{b}	1.33^{a}	1.00^{b}	1.00^{b}	1.00^{b}	0.075	0.031
TNF-α, pg/mL	62.37^{bc}	80.90^{a}	74.67^{ab}	69.84^{abc}	73.87^{abc}	61.16^{bc}	63.43^{bc}	60.77^{c}	2.997	<0.001
IL-6, pg/mL	1001.10^{c}	1259.43^{a}	1160.77^{abc}	1068.15^{bc}	1209.32^{ab}	1156.59^{abc}	1107.66^{abc}	1021.85^{c}	39.282	<0.001

[1]Abbreviation : NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%; IgG, immunoglobulin G; IgA, immunoglobulin A; TNF- α, tumor necrosis factor α; IL-6, interleukin-6; PI, post-inoculation; SE, standard error.

[a-c]Means with different letters are significantly differ ($p < 0.05$).

Table 6. Effect of different ratios of phytogenic feed additives on intestinal morphology of weaned pigs challenged with *Escherichia coli*[1]

Items	NC	PC	T1	T2	T3	T4	T5	T6	SE	P-value
VH, μm	374.72[ab]	331.01[b]	335.08[b]	389.12[ab]	388.33[ab]	372.06[ab]	360.78[ab]	406.55[a]	15.303	0.013
CD, μm	153.01	170.79	188.25	170.61	208.80	159.70	160.06	162.43	12.446	0.057
VH:CD	2.53[a]	2.01[ab]	1.88[b]	2.29[ab]	1.93[b]	2.33[ab]	2.28[ab]	2.52[a]	0.163	0.039

[1]Abbreviation : NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%; VH, villus height; CD, crypt depth; VH:CD, villus height to crypt depth ratio; SE, standard error.

[a,b]Means with different letters are significantly differ ($p < 0.05$).

Table 7. Effect of different ratios of phytogenic feed additives on relative protein expression of tight junction proteins of weaned pigs challenged with *Escherichia coli*[1]

Items	NC	PC	T1	T2	T3	T4	T5	T6	SE	P-value
Calprotectin, ng/mg protein	2.53^{c}	5.36^{a}	4.26^{abc}	3.08^{bc}	3.19^{abc}	4.75^{ab}	4.72^{abc}	4.16^{abc}	0.488	0.002
CLDN1, ng/mg protein	2.61^{a}	1.27^{b}	1.88^{ab}	2.03^{ab}	2.05^{ab}	2.27^{ab}	1.47^{b}	1.75^{ab}	0.228	0.005

[1]Abbreviation : NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%; CLDN1, claudin 1; SE, standard error.

[a-c]Means with different letters are significantly differ ($p < 0.05$).

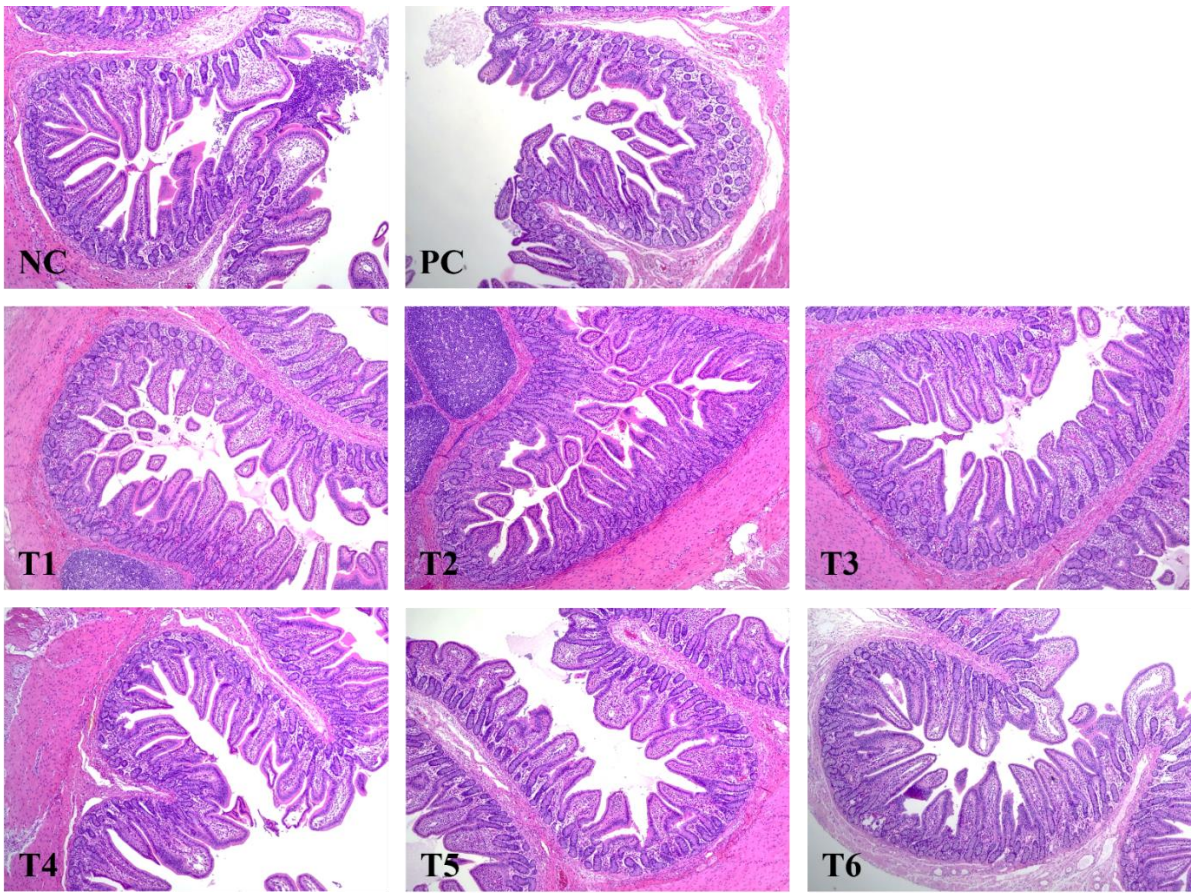

Figure 1: Effect of different ratios of phytogenic feed additives on intestinal microscopic morphology (H&E staining) of weaned pigs challenged with *Escherichia coli*. NC, basal diet without *E. coli* challenge (negative control); PC, basal diet with *E. coli* challenge (positive control); T1, PC + PFA1 0.1%; T2, PC + PFA2 0.1%; T3, PC + PFA3 0.1%; T4, PC + PFA4 0.1%; T5, PC + PFA5 0.1%; T6, PC + PFA6 0.1%.