ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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International Journal of Poultry Science 8 (7): 677-683, 2009
ISSN 1682-8356

Egg Quality Traits of Layers Fed Sugarcane Press Residue with Biotechnological Agents

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Abstract: An experiment was conducted to investigate the influence of inclusion of Sugarcane Press Residue (SPR) as a feed ingredient in layer diets on the qualities of the egg. Three experimental diets were formulated by incorporating SPR at 0, 5 and 10%. Another set of nine diets were prepared by supplementing each diet with either lipid utilizing agents (lipase and lecithin) or NSP degrading enzymes or together. Each of the twelve diets was offered to triplicate groups of 4 laying birds each. The trial lasted for 84 days divided in to three periods of 28-days each. The egg quality characteristics such as egg shape index, albumen index, Haugh unit scores, yolk index and yolk colour was statistically similar ($p>0.05$) among different treatments at different stages of experiment. However, the influence of different treatment diets on egg shell thickness was significant ($p<0.01$) on 28th and 56th day of trial. No significant differences could surface at different levels of SPR and between combinations of biotechnological tools excepting for shell thickness and yolk colour. Thus the SPR can be effectively utilized as a source of Ca and P in layers.

Key words: Layers, sugarcane press residue, egg characteristics

INTRODUCTION

The unprecedented demand for cereal and protein sources has resulted in escalation of feed costs which might marginalize the survival and growth of poultry industry (Chadha, 2005). This calls for the use of unconventional feed resource. Sugarcane Press Residue (SPR), a byproduct of sugarcane industry is one such potential feed ingredient. It is a good source major minerals as well as trace elements (Suresh *et al*., 2006 and Suma *et al*., 2007). Recent attempt revealed that the SPR can be included up to 10% in layer rations without any adverse effect on bird performance and egg characteristics (Suma *et al*., 2007). However, there is a paucity of information in the literature on the effect of SPR along with biotechnological agents such as exogenous enzymes and nutrient utilization enhancers on the performance and egg characteristics of layers. Hence, an experiment in layers to study the influence of SPR with some potential biotechnological interventions on egg quality traits was attempted.

MATERIALS AND METHODS

A control diet containing shell grit, calcite powder, di-Ca phosphate and salts of pertinent trace elements was prepared as per the specification of BIS (1992). In the test diets, the sun dried SPR was included at 5 and 10% levels at the expense of relevant mineral contributing salts. Further, the diets were supplemented with either lipid utilizing agents (lipase @ 0.2 g and lecithin 2 g/kg diet) or NSP degrading enzyme preparation @ 0.5 g/kg diet or together to result in another set of nine diets. The ingredient and calculated nutrient composition of the experimental diets are given in Table 1.

One hundred forty four BV-300 commercial layers of 40 weeks age were distributed randomly into 36 replicate of 4 birds each. Each diet was offered to four replications of 4 birds each in colony cage units. The birds were maintained under standard managemental conditions. The trial lasted for 84 days which was conveniently divided into three 28-day interval periods.

On the terminal day of every 28-day interval, all the eggs produced from different replicate groups were collected and were weighed individually during the experimental period of 84 days. Further, on the immediate next day, each egg was broken and the entire contents were carefully placed on a glass slab for egg quality study. Albumen index score was calculated as the ratio height and diameter of thick albumen (in mm) which were measured by Ames® spherometer and by Vernier Caliper respectively. Yolk index score, the ratio of height to diameter of yolk calculated in similar way. Egg shape index expressed as a relationship of length and breadth of the egg (in cm) obtained by using Vernier Calipers. The height of albumin was recorded at two consistent places by using Ames Haugh unit meter to obtain the Haugh unit score. The shell pieces devoid of shell membranes at broad end, narrow end and middle band were selected and their thickness were measured using a digital calipers as described by Ounmodde and Oguntela (1971). The average of all the three pieces was represented as shell thickness. The colour of yolk of every broken open egg was scored by matching

Table 1: Ingredient and nutrient composition of experimental diets[1]

Ingredient composition				Calculated nutrient composition			
Ingredients, kg	0% SPR	5% SPR	10% SPR	Nutrient	0% SPR	5% SPR	10% SPR
Maize	43.55	45.30	46.91	ME, kcal/kg	2433	2410	2386
De-oiled rice bran	17.00	11.00	5.40	CP, %	17.57	17.41	17.22
Soybean meal	12.90	12.90	12.90	EE, %	1.97	2.48	3.00
Groundnut extractions	5.00	5.00	5.00	LA, %	1.08	1.29	1.50
Sunflower extractions	10.00	9.98	9.70	CF, %	7.18	7.06	6.93
Di-Ca phosphate	1.25	1.18	1.10	Ca, %	3.93	3.93	3.93
Calcite powder	3.00	2.35	1.69	TP, %	0.80	0.76	0.73
Shell grit	7.00	7.00	7.00	Pav, %	0.35	0.35	0.35
Salt	0.30	0.30	0.30	Na, %	0.15	0.15	0.14
Sugarcane Press Residue	0.00	5.00	10.00	Cl, %	0.23	0.22	0.21
$FeSO_4$	0	0	0	Mg, mg	0.28	0.31	0.33
ZnO	10	9.64	9.27	Fe, ppm	205.95	416.15	626.59
$CuSO_4$	8	6.94	5.81	I, ppm	2.01	2.01	2.01
$CoSO_4$	0	0	0	Cu, ppm	25.47	25.60	25.56
KI	0.34	0.34	0.34	Co, ppm	0.00	0.32	0.64
Na_2SeO_3	0.44	0.44	0.44	Mn, ppm	89.68	89.63	89.57
$MnSO_4$	25	21.15	17.28	Zn, ppm	93.94	93.76	93.60
DL-methionine	49.8	50	50	Se, ppm	2.02	2.02	2.02
L-Lysine	20	21.3	22.4	Met, %	0.27	0.27	0.27
Additives[2]	+	+	+	Met+Cyst, %	0.50	0.50	0.50
				Lys, %	0.73	0.71	0.70
Total	100.11	100.11	100.11	Arg, %	1.24	1.21	1.18
				C/P	138.46	138.45	138.55
				Ca/Pav	11.22	11.23	11.22
				Arg/Lys	1.71	1.70	1.69

[1]Parallely, another set of 9 diets with SPR at 0, 5 and 10% were also prepared using either lipase and lecithin or NSP degrading enzymes or their combination. [2]Additives contained AB_2D_3K - 100 g (each 500 g contained vit A-12.5 MIU, vit D_3-2.8 MIU, vit E-30 g, vit K-2 g), B-complex-200 g (vit B_1-2 g, vit B_2-5 g, vit B_6-3 g, vit B_{12}-0.015 g, niacin-40 g, Cal-d-panthothenate-15 g, folic acid-1 g, biotin-0.08 g, Organic Nutritive Carrier.Q.S), Oxymycin-500 g, toxin binder-750 g, choline chloride-500 g and hepatocaare-100 g

(contrast) technique using Roche yolk colour fan (Roche Company, 1969).

The data was subjected for statistical analysis as per Snedecor and Cochran (1989) and the comparison among means were made by Duncan's multiple range test (Duncan, 1955). The values so obtained were then arranged according to treatments and main factors wise under each 28-day period as well as cumulatively.

RESULTS AND DISCUSSION

Composition of SPR and biotechnological agents: The sun-dried SPR employed in the present study contained 92.83, 23.95, 11.80, 13.73, 11.95, 38.57 and 4.93% of DM, TA, CP, CF, EE, NFE and AIA, respectively, besides 4.90, 1.25 and 1.35% of Ca, total P and Mg. The ME content was 1105 kcal/kg (Suresh, 2007). Each g of NSP degrading enzyme preparation used contained 2500, 1000, 500 and 250 units of xylanase, beta-glucanase, cellulase and pectinase, respectively and the experimental lipase contained lipase-500 units/g.

The influence of different treatments and main factors on the qualities of the eggs of experimental birds fed different diets during different periods is presented in Table 2 and 3.

Egg shape index: The result did not reveal any significant ($p>0.05$) differences during different periods of the experiment nor for that matter cumulatively. As regards the main factors, both SPR and biotechnological agents also showed non-significant ($p>0.05$) variation among different groups. The values with reference to the SPR level ranged from 77.22 (10% SPR group) to 78.05 (0% SPR group) on cumulative basis. As far as the biotechnological tools were concerned, NSP degrading enzymes supplemented diets produced better shape index (78.32) than with lipid utilizing agents (76.71). The results suggested that the SPR at any given level in the diets did not affect the shape index of the eggs and such results were also observed by (Suma *et al*., 2007).

Albumen index: The mean albumen index values pooled over the periods ranged from 4.36 (T_3 and T_9) to 4.71 (T_7), which were non-significantly ($p>0.05$) different from each other among different treatments. As regards the main factors, the albumen index scores were found to be not significantly ($p>0.05$) influenced by the SPR level or biotechnological tools and showed inconsistent trends throughout the experimental period.

Haugh Unit Score (HUS): It is an important egg quality measure for shelf life of eggs. The average values at any particular interval were statistically non-significant ($p>0.05$). The pooled over (periods) average values ranged non-significantly ($p>0.05$) from 57.01 (T_8) to

Table 2: The retention of dietary minerals and blood mineral status of birds as influenced by various treatments and main factors

	Treatment description		Yolk index				
SPR %	Biotechnological Tool	Tr. No	1st day	28th day	56th day	84th day	Cumulative
0	No supplement	T_1	29.97	36.43	32.33	33.47	33.18
	Lipase+Lecithin	T_2	30.13	36.41	33.55	34.24	33.80
	NSPases	T_3	31.34	35.42	33.39	34.99	33.73
	Lipase+Lecithin+NSPases	T_4	31.50	34.95	32.70	33.61	33.05
5	No supplement	T_5	29.92	36.55	33.77	34.52	33.61
	Lipase+Lecithin	T_6	30.15	36.28	34.01	34.34	33.72
	NSPases	T_7	30.31	36.07	32.68	32.42	32.82
	Lipase+Lecithin+NSPases	T_8	31.41	35.06	32.708	32.79	32.95
10	No supplement	T_9	30.10	36.34	32.99	35.42	33.76
	Lipase+Lecithin	T_{10}	30.01	34.80	33.73	33.62	32.97
	NSPases	T_{11}	31.53	35.62	32.97	33.82	33.44
	Lipase+Lecithin+NSPases	T_{12}	31.57	35.73	33.69	33.20	33.50
	SEM		0.768	0.697	0.608	0.873	0.569
	Significance		NS	NS	NS	NS	NS
Effect of SPR							
	0%		30.74	35.80	32.99	34.08	33.44
	5%		30.45	35.99	33.29	33.52	33.27
	10%		30.80	35.62	33.35	34.01	33.42
	SEM		0.384	0.348	0.304	0.437	0.285
	Significance		NS	NS	NS	NS	NS
Effect of Biotechnological Tools							
	No supplement		30.00	36.44	33.03	34.47	33.51
	Lipase+Lecithin		30.10	35.83	33.76	34.07	33.50
	NSPases		31.06	35.70	33.02	33.74	33.33
	Lipase+Lecithin+NSPases		31.49	35.25	33.03	33.20	33.17
	SEM		0.443	0.402	0.351	0.504	0.329
	Significance		NS	NS	NS	NS	NS
	Treatment description		Yolk colour				
SPR %	Biotechnological Tool	Tr. No.	1st day	28th day	56th day	84th day	Cumulative
0	No supplement	T_1	7.17	6.61	6.364	6.55	6.68
	Lipase+Lecithin	T_2	7.27	7.19	6.091	6.30	6.73
	NSPases	T_3	7.36	7.00	6.272	6.45	6.78
	Lipase+Lecithin+NSPases	T_4	7.50	6.82	6.091	6.37	6.71
5	No supplement	T_5	7.08	7.10	7.182	6.25	6.91
	Lipase+Lecithin	T_6	7.29	7.10	7.000	6.55	6.99
	NSPases	T_7	7.5	7.10	6.364	6.45	6.87
	Lipase+Lecithin+NSPases	T_8	7.50	7.29	6.575	6.36	6.94
10	No supplement	T_9	7.60	7.44	6.482	6.34	6.98
	Lipase+Lecithin	T_{10}	7.20	7.45	6.259	6.33	6.82
	NSPases	T_{11}	7.17	7.20	6.182	6.64	6.80
	Lipase+Lecithin+NSPases	T_{12}	7.63	6.63	6.636	6.09	6.77
	SEM		0.245	0.263	0.290	0.247	0.160
	Significance		NS	NS	NS	NS	NS
Effect of SPR							
	0%		7.32	6.90	6.204	6.42	6.73
	5%		7.34	7.15	6.780	6.40	6.93
	10%		7.40	7.18	6.390	6.35	6.84
	SEM		0.123	0.132	0.145	0.123	0.080
	Significance		NS	NS	NS	NS	NS
Effect of Biotechnological Tools							
	No supplement		7.28	7.05	6.676	6.38	6.86
	Lipase+Lecithin		7.25	7.25	6.450	6.39	6.85
	NSPases		7.34	7.10	6.272	6.51	6.82
	Lipase+Lecithin+NSPases		7.54	6.91	6.434	6.27	6.81
	SEM		0.142	0.152	0.167	0.143	0.093
	Significance		NS	NS	NS	NS	NS

Continued

	Treatment description		Shell thickness				
SPR %	Biotechnological Tool	Tr. No.	1st day	28th day	56th day	84th day	Cumulative
0	No supplement	T_1	0.352	0.310	0.321	0.333	0.329
	Lipase+Lecithin	T_2	0.371	0.321	0.303	0.335	0.333
	NSPases	T_3	0.356	0.347	0.322	0.328	0.339
	Lipase+Lecithin+NSPases	T_4	0.364	0.342	0.347	0.329	0.346
5	No supplement	T_5	0.352	0.325	0.327	0.331	0.334
	Lipase+Lecithin	T_6	0.352	0.347	0.302	0.335	0.335
	NSPases	T_7	0.350	0.364	0.320	0.327	0.341
	Lipase+Lecithin+NSPases	T_8	0.356	0.356	0.332	0.325	0.342
10	No supplement	T_9	0.348	0.314	0.331	0.338	0.333
	Lipase+Lecithin	T_{10}	0.344	0.366	0.304	0.347	0.341
	NSPases	T_{11}	0.362	0.360	0.338	0.339	0.350
	Lipase+Lecithin+NSPases	T_{12}	0.347	0.356	0.341	0.335	0.345
	SEM		0.012	0.013	0.012	0.016	0.007
	Significance		NS	**	**	NS	NS
Effect of SPR							
	0%		0.361	0.330	0.323	0.331	0.337
	5%		0.353	0.348	0.320	0.330	0.338
	10%		0.350	0.349	0.328	0.340	0.342
	SEM		0.006	0.006	0.006	0.008	0.004
	Significance		NS	**	NS	NS	NS
Effect of Biotechnological Tools							
	No supplement		0.351	0.316	0.326	0.334	0.332
	Lipase+Lecithin		0.356	0.345	0.303	0.339	0.336
	NSPases		0.356	0.357	0.326	0.332	0.343
	Lipase+Lecithin+NSPases		0.356	0.351	0.340	0.329	0.344
	SEM		0.007	0.007	0.007	0.009	0.004
	Significance		NS	**	**	NS	NS

NS = Non-significant (p>0.05), **= Significant at p<0.01, [a,b]Mean with no common superscript differ significantly (p<0.01)

60.20 (T_7). As regards the main factors, the HUS values were non-significantly (p>0.05) influenced by the main factors, SPR level and biotechnological tool. Similar to albumen index, there was no definitive trend in either SPR or biotechnological tool. This revealed that HUS was not affected by the inclusion of SPR and none of the biotechnological additives improved the HUS.

Yolk colour: Egg yolk colour is an important quality characteristic from the consumer point of view. The influence of different treatment diets in imparting colour to the yolks was found to be non-significant (p>0.05) at different periods of experiment. As regards main factors, the yolk colour scores were significantly (p<0.01) affected by the SPR factor on the 56th day with a highest Roche yolk colour fan value being 6.78 (5% SPR) as against lowest value of 6.20 (control) and significantly (p<0.05) on cumulative basis (6.73-0% SPR to 6.93-5% SPR). Infact such trend might be due to the chance factor as evident by the fact that during preceding and successive 28-day intervals as well as between control and 10% SPR based diets, no significant (p>0.05) differences were surfaced. For the biotechnological tool factor, no significant (p>0.05) differences were observed during all the periods as well as cumulatively. The results were in conformation with the findings of Suma *et al*. (2007) who reported non-significant (p>0.05) differences in yolk colour between control and SPR included diets. Also observed was the fact that the SPR based diets did not enhance the yolk colour intensity which otherwise would have been possible in view of the fact that the SPR *per se* appears to be rich in colouring pigments as that with forages (Reddy, 1979).

Yolk index: The values at different intervals differed non-significantly (p>0.05) among different treatments. The effect observed when the data was analyzed on the basis of main factors was found to be non significant (p>0.05) as regards the SPR factor was concerned, while the biotechnological tool revealed significant (p<0.05) differences only on 1st day of experiment which was obviously not due to lipid utilizing agents, NSP degrading agents or their combinations. Stability of yolk as reflected by higher yolk index scores is important from the point of shelf life of eggs as well as the hatchability. Since SPR contains large amount of lipid portion (11.95 %), it might cause mottling of yolks and affect yolk index, which however did not occur in the A. study even at 10% inclusion of SPR. The results obtained were in agreement with the findings of Suma *et al*. (2007) who observed no significant (p>0.05) difference in yolk indices between diets containing SPR

Table 3: The retention of dietary minerals and blood mineral status of birds as influenced by various treatments and main factors

	Treatment description		Haugh unit score				
SPR %	Biotechnological Tool	Tr. No.	1st day	28th day	56th day	84th day	Cumulative
0	No supplement	T_1	55.27	70.92	57.884	53.07	59.82
	Lipase+Lecithin	T_2	54.12	70.63	58.087	49.84	58.73
	NSPases	T_3	58.15	69.31	54.279	51.08	58.85
	Lipase+Lecithin+NSPases	T_4	57.53	70.22	56.465	50.54	59.30
5	No supplement	T_5	51.06	69.96	60.203	48.82	58.03
	Lipase+Lecithin	T_6	54.18	71.81	55.970	51.85	59.00
	NSPases	T_7	54.92	70.72	56.994	56.14	60.20
	Lipase+Lecithin+NSPases	T_8	51.42	69.81	58.783	45.72	57.01
10	No supplement	T_9	52.42	69.81	58.783	45.72	57.01
	Lipase+Lecithin	T_{10}	52.64	69.52	58.880	50.41	58.40
	NSPases	T_{11}	56.29	67.70	56.906	52.22	58.88
	Lipase+Lecithin+NSPases	T_{12}	54.24	69.12	57.569	50.63	58.46
	SEM		2.498	2.144	2.303	3.155	2.127
	Significance		NS	NS	NS	NS	NS
Effect of SPR							
	0%		56.27	70.27	56.200	51.13	59.31
	5%		52.89	70.57	57.988	50.63	58.92
	10%		54.37	68.15	57.777	51.35	58.68
	SEM		1.249	1.072	1.152	1.577	1.075
	Significance		NS	NS	NS	NS	NS
Effect of Biotechnological Tools							
	No supplement		52.99	70.13	58.736	50.77	58.91
	Lipase+Lecithin		54.86	70.05	56.349	51.30	59.00
	NSPases		55.77	69.72	56.281	52.62	59.31
	Lipase+Lecithin+NSPases		54.43	68.76	57.919	49.46	58.66
	SEM		1.422	1.238	1.330	1.822	1.242
	Significance		NS	NS	NS	NS	NS
	Treatment description		Albumen index				
SPR %	Biotechnological Tool	Tr. No.	1st day	28th day	56th day	84th day	Cumulative
0	No supplement	T_1	3.11	6.31	4.504	4.08	4.56
	Lipase+Lecithin	T_2	3.02	6.51	4.296	3.77	4.45
	NSPases	T_3	3.12	6.36	4.159	3.92	4.36
	Lipase+Lecithin+NSPases	T_4	3.38	6.64	4.448	3.96	4.58
5	No supplement	T_5	2.76	6.40	4.696	3.84	4.39
	Lipase+Lecithin	T_6	3.10	7.11	4.260	4.13	4.61
	NSPases	T_7	3.14	6.83	4.613	4.42	4.71
	Lipase+Lecithin+NSPases	T_8	3.14	6.35	4.598	3.69	4.42
10	No supplement	T_9	2.82	6.32	4.586	3.87	4.36
	Lipase+Lecithin	T_{10}	3.16	6.23	4.298	4.11	4.42
	NSPases	T_{11}	2.95	6.55	4.602	3.93	4.47
	Lipase+Lecithin+NSPases	T_{12}	3.10	6.07	4.357	4.19	4.40
	SEM		0.203	0.356	0.251	0.324	0.307
	Significance		NS	NS	NS	NS	NS
Effect of SPR							
	0%		3.16	6.46	4.352	3.93	4.49
	5%		3.04	6.67	4.541	4.02	4.53
	10%		3.01	6.29	4.461	4.03	4.42
	SEM		0.101	0.178	0.125	0.162	0.153
	Significance		NS	NS	NS	NS	NS
Effect of Biotechnological Tools							
	No supplement		2.90	6.34	4.595	3.93	4.44
	Lipase+Lecithin		3.09	6.62	4.285	4.00	4.50
	NSPases		3.07	6.58	4.458	4.09	4.52
	Lipase+Lecithin+NSPases		3.21	6.35	4.468	3.95	4.47
	SEM		0.117	0.206	0.145	0.187	0.177
	Significance		NS	NS	NS	NS	NS

Continued

	Treatment description		Egg shape index				
SPR %	Biotechnological Tool	Tr. No.	1st day	28th day	56th day	84th day	Cumulative
0	No supplement	T_1	77.71	78.33	75.813	77.30	77.30
	Lipase+Lecithin	T_2	77.37	80.29	77.476	76.88	77.99
	NSPases	T_3	84.52	76.81	79.202	76.57	79.39
	Lipase+Lecithin+NSPases	T_4	76.92	76.78	78.243	78.26	77.54
5	No supplement	T_5	76.31	79.74	77.493	76.71	77.54
	Lipase+Lecithin	T_6	76.77	76.56	77.255	76.93	76.88
	NSPases	T_7	76.43	78.36	76.344	77.77	77.21
	Lipase+Lecithin+NSPases	T_8	76.51	74.07	75.418	78.76	76.20
10	No supplement	T_9	77.02	77.44	77.681	79.87	77.98
	Lipase+Lecithin	T_{10}	74.35	76.51	74.667	75.64	75.27
	NSPases	T_{11}	76.65	75.44	82.98	78.58	78.37
	Lipase+Lecithin+NSPases	T_{12}	76.19	78.28	76.866	77.78	77.26
	SEM		3.446	1.825	2.423	1.360	1.232
	Significance		NS	NS	NS	NS	NS
Effect of SPR							
	0%		79.13	78.05	77.251	77.25	78.05
	5%		76.51	77.18	77.542	77.54	76.95
	10%		76.05	76.92	77.969	77.97	77.22
	SEM		1.723	0.913	1.212	0.680	0.616
	Significance		NS	NS	NS	NS	NS
Effect of Biotechnological Tools							
	No supplement		77.02	78.5	77.960	77.96	77.61
	Lipase+Lecithin		76.17	77.79	76.482	76.48	76.71
	NSPases		79.2	76.87	77.640	77.64	78.32
	Lipase+Lecithin+NSPases		76.54	76.38	78.267	78.27	77.00
	SEM		1.989	1.054	1.399	0.785	0.711
	Significance		NS	NS	NS	NS	NS

NS = Non-significant ($p>0.05$)

at 0, 5, 10 and 15% level. Thus, it was inferred that egg quality is sustainable with SPR even up to 10% in layer diets.

Egg shell thickness: Shell thickness is also an important egg quality factor, which is dependent on dietary regimen amongst many factors. Analysis of variance revealed that the differences among different treatments were statistically ($p>0.05$) similar except for the values on 28th day of the experiment. No definitive trend was observed among dietary treatments. Amongst the main factor effects, cumulative average egg shell thickness values were 0.337, 0.338 and 0.342 mm at 0, 5 and 10% SPR inclusion levels. The average values were statistically similar ($p>0.01$) during all the periods except on 28th day. A close observation indicated that the mean cumulative egg shell thickness values were slightly higher in 10% SPR group when compared to control. For the main factor biotechnological tool, the egg shell thickness values differed significantly ($p<0.01$) on 28th and 56th days of experiment. The cumulative values varied significantly ($p<0.05$) from 0.332 (no supplement) to 0.344 mm (lipid utilizing agents with NSP degrading agents) However, no definitive trend could be traced at all the time intervals.

Egg shell thickness is largely affected by calcium assimilation, under the influence of vit. D_3 as well as by minerals namely zinc and manganese (Leeson and Summers, 2001). Inclusion of SPR appeared to have effectively contributed the said nutrients to support optimal shell thickness since they were quantitatively replaced to the extent that could be contributable from SPR even at 10% level of inclusion. Similar observations were also made Suma *et al.* (2007).

Thus, it was opined that the SPR can be incorporated up to 10% in layer rations effectively as a source of minerals substituting the expensive conventional feed ingredients without affecting egg quality, however.

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