Growth, Nutrient Utilization and Carcass Characteristics in Broiler Chickens Fed Raw and Alkali Processed Solvent Extracted Karanj (*Pongamia glabra*) Cake as Partial Protein Supplement

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An experiment was conducted to evaluate the effect of dietary incorporation of raw and alkali [1.5% NaOH and 3% Ca (OH)₂, w/w] treated solvent extracted karanj (*Pongamia glabra*) cake (SKC) on growth performance and carcass characteristics in broiler chickens during 0 to 6 weeks of age. A basal reference diet was formulated containing soybean meal (SBM) as the major protein source. Another six isonitrogenous and isocaloric test diets were formulated incorporating SKC, 1.5% NaOH treated SKC (NaOH-SKC) and 3% Ca (OH)₂ treated SKC (Ca (OH)₂-SKC) at 6.43 or 5.5% during starter phase and 12.86 or 11.0% during finisher phase replacing SBM nitrogen of reference diet at 12.5 and 25%, respectively. Each diet was offered *ad libitum* to 4 replicates of 10 chicks each. The body weight gain and feed efficiency of broilers fed 6.43% NaOH-SKC incorporated diet was comparable with reference diet during 0 to 28 d. However, weight gain and feed efficiency reduced in all karanj cakes incorporated diet during 29 to 42 d. The overall weight gain during 0 to 42 d was significantly higher in the reference diet. Significantly higher nutrient intake was observed in the reference group except 6.43% NaOH-SKC diet during both the balance trials and 6.43% Ca (OH)₂-SKC during 2nd trial. The percent retention of DM, N, Ca, P and GE did not differ significantly. Higher liver weight was observed due to dietary incorporation of SKC and NaOH-SKC at 25%, and Ca (OH)₂-SKC. The gizzard weight was significantly higher in SKC incorporated diet, at both the levels of replacement compared to reference diet. The breast yield lowered significantly when soybean meal nitrogen was replaced with processed or unprocessed karanj cake at 25% level. The findings suggested that 1.5% NaOH (w/w) treated SKC could be incorporated upto 6.43% level, replacing 12.5% of soybean nitrogen of reference diet in broiler chicken upto 4 weeks of age.

Key words: Growth performance, carcass characteristics, solvent extracted karanj cake, alkali treatment, broiler chickens

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Introduction

Escalating cost of feed ingredients and chronic shortage of protein and energy rich animal feeds due to enhanced needs of ever increasing human population are the major threats to reorient poultry industry into an economic enterprise in India. The animal nutritionists are thus compelled to explore the possibilities of feeding non-edible and non-competitive unconventional agro-forest based industrial byproducts, to meet the nutritional requirement of the animals. Since protein sources are costlier, measures are often adapted to partially or completely replace the conventional dietary protein with unconventional protein supplements in order to reduce the cost of production. One such unconventional feed is karanj (*Pongamia glabra*)

cake, the residue left after oil extraction from karanj seed, is a rich source of protein (28–34%). In India the availability of karanj seed has been estimated to be 1,300,000 metric tonne per year (Ministry of Agriculture, 1992).

Though, karanj cake was recommended for its inclusion in different type of poultry ration (Mandal, 1977), it is not commonly used as a feed ingredient for livestock and poultry due to the presence of toxic principle “Karanjin” a furanoflavonoid (Limaye, 1925; Roy *et al.*, 1977). Karanj is fat-soluble and are removed during the process of oil extraction. However, feeding of de-oiled karanj cake after extraction at higher levels (>5.0%) adversely affected the performance (Natnam *et al.*, 1989a, Dhara *et al.*, 1997), which was attributed to the residual toxin (karanjin) still left in the solvent extracted cake. Karanj can be converted to less toxic intermediates by treatments with alkali (Seshadri and Venkateswarlu, 1943). However, no studies have made for its proper utilization in poultry feeding after detoxification, except physical treatments with water washing and soaking (Mandal and Banerjee, 1974) and

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Table 1. Analyzed chemical composition (%) of feed ingredients

Ingredients	ME (kcal/kg)	Crude protein	Ether extract	Crude fibre	Total ash	Calcium	Phosphorus
Maize	3368	9.10	3.3	2.4	1.2	0.12	0.36
Soybean meal	2340	48.4	2.2	6.9	8.6	0.44	0.96
De-oiled rice bran	1800	15.1	3.2	11.8	9.4	0.36	0.71
Solvent extracted karanj cake	1910	33.9	4.3	5.5	4.9	0.87	0.55
Di-calcium phosphate	—	—	—	—	—	24.0	18.0
Lime stone	—	—	—	—	—	35.0	—

autoclaving (Natanam *et al.*, 1989b). Recent study by us revealed that chemical treatment of karanj cake with alkali treatments [NaOH and Ca (OH)₂] reduced the karanjin content substantially (Panda *et al.*, 2006). The present study was, therefore, conducted to see the effect of dietary incorporation of raw and alkali treated solvent extracted karanj cake on growth performance and carcass characteristics of broiler chickens during 0 to 6 weeks of age.

Materials and Methods

Processing of Karanj Cake

Solvent extracted karanj cake (SKC) was procured from local market and was detoxified adopting various physico-chemical methods such as dry heat, water washing, pressure cooking, alkali [NaOH, Ca (OH)₂] and acid (HCl) treatments as well as microbiologically with *Saccharomyces cerevisiae* (strain-49). The residual karanjin left back in the processed cake was quantified through high performance liquid chromatography (HPLC) (Panda *et al.*, 2006). Based on the residual karanjin left back in the processed cake two best methods for detoxification of SKC [1.5% NaOH and 3% Ca (OH)₂, w/w] were selected. The sodium and calcium hydroxide treated SKC was, thus, prepared by soaking the cake for 24 h in water (w/v, 1 : 1) having sodium hydroxide at 1.5% (w/w) and calcium hydroxide at 3% (w/w) of cake. The processed cakes were sun dried, ground and packed in gunny bags, in addition to SKC as such, for incorporation into the diet to substitute soybean meal nitrogen partially for broiler feeding.

Stocks and Husbandry

Two hundred and eighty, day-old commercial broiler (CARIBRO) chicks were wing banded, vaccinated against Marek's disease and distributed in a completely randomized design (CRD) into 7 groups of 40 chicks each, which was further replicated to 4 of 10 chicks each. The chicks of each replicate were housed in the pens of wire floored battery brooders having provision of feeders, waterers and faecal trays from 1 to 42 days of age. The brooder temperature was maintained at 34±1°C up to 7 days of age and gradually reduced to 26±1°C by 21 days of age after which chicks were maintained at room temperature (25–27°C). Light was provided continuously throughout the experimental period. Birds were protected against Newcastle disease, infectious bursal disease and fowl pox as routine vaccination schedule. All the chicks were kept

under uniform managerial conditions throughout the experimental period.

Experimental Diets

Feed ingredients were analysed for moisture, crude protein, crude fibre, calcium, phosphorus and ether extract (AOAC, 1990) (Table 1). The apparent metabolizable energy (AME) content of major ingredients were measured by European Reference Method (Bourdillan *et al.*, 1990) except solvent extracted karanj cake, whose AME was measured by practical diet replacement assay (Sibbald *et al.*, 1960) using 6 white leghorn cockerels (24 weeks old) for 3 d, after 7 d adaptation period. A basal reference diet was prepared containing soybean meal as the principal protein source (D1). Subsequently another 6 test diets were prepared by incorporating SKC (12.5-D2; 25.0-D3), NaOH treated SKC (12.5-D4; 25.0-D5) and, Ca (OH)₂ treated SKC (12.5-D6; 25.0-D7) to replace SBM nitrogen of reference diet at either 12.5 or 25%, respectively. All the diets were kept nearly isonitrogenous and isocaloric through the adjustment of other ingredients and each diet was fed *ad lib* to 4 replicates of 10 chicks each. The ingredient composition of starter (0–4 wk) and finisher (5–6 wk), reference and test diets are presented in Table 2 and 3, respectively.

Experimental Procedures

Individual body weight of chicks and replicate-wise feed intakes were recorded at weekly intervals through out the experimental period. Feed consumption from 1 to 28, 29–42 and 1–42 d of age was recorded for each replicate and feed efficiency (weight gain/feed intake) for the respective period was calculated. Mortality was monitored on daily basis.

After 24 and 38 days of experimental feeding, a balance study of 4 days (25–28 d; 39–42 d) duration each was conducted on all birds to determine the retention of various nutrients by considering a replicate as a single unit. Daily feed offered and faeces voided during this period were recorded. The DM, N, Ca, P and GE in feed and faeces were analyzed as per the AOAC (1990). Based on feed intake and excreta voided, the net retention of DM, N, Ca, P and GE was calculated as retention of nutrients on percent basis.

On 43rd day of experimental feeding, six birds from each dietary group were sacrificed, after removal of feed for two hours with free access to water, through cervical dislocation to observe the weight of dressed carcass, breast,

Table 2. **Ingredient and nutrient composition of starter diets (%)**

Ingredient	Ref	SKC		NaOH treated SKC		Ca (OH) ₂ treated SKC	
	D1	D2 12.5%	D3 25%	D4 12.5%	D5 25%	D6 12.5%	D7 25%
Yellow maize	60.50	59.02	55.77	59.02	55.77	59.12	56.47
Soybean meal	35.0	30.4	26.5	30.4	26.5	30.5	26.6
Solvent extracted karanj cake	—	6.43	12.86	6.43	12.86	6.43	12.86
De-oiled rice bran	0.72	—	—	—	—	—	—
Vegetable oil	—	0.5	1.20	0.5	1.20	0.5	1.20
Limestone	1.6	1.5	1.35	1.5	1.35	1.2	0.75
Di-calcium Phosphate	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Lysine	—	0.07	0.13	0.07	0.13	0.07	0.13
Methionine	0.16	0.16	0.17	0.16	0.17	0.16	0.17
Common salt	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Trace mineral ¹	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin premix ²	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Nutrient composition (%)							
Metabolizable energy (kcal/kg)	2870	2857	2850	2857	2850	2865	2866
Crude protein	22.04	21.72	21.70	21.77	21.78	21.79	21.81
Lysine	1.20	1.19	1.19	1.18	1.19	1.19	1.19
Methionine	0.51	0.54	0.55	0.53	0.55	0.53	0.55
Calcium	1.01	1.01	1.01	1.01	1.01	1.01	1.00
Non phytate Phosphorus	0.4	0.4	0.4	0.4	0.4	0.4	0.4

¹ Trace mineral premix contained: Cu-.25 mg, Fe-80 mg, I-1.2 mg, Mn-65 mg and Zn-68 mg per kg diet.

² Vitamins premix contained: Calcium pantothenate-8 mg, choline chloride-1000 mg, niacin-12 mg, pyridoxine hydrochloride-1.6 mg, vitamin A-8250 IU, vitamin D₃-1200 ICU, vitamin-E 8 mg, vitamin K-10 mg vitamin B₁-0.8 mg, vitamin B₂-5 mg, vitamin B₁₂-8 mcg per kg diet.

Table 3. **Ingredient and nutrient composition of finisher diets (%)**

Ingredient	Ref	SKC		NaOH treated SKC		Ca (OH) ₂ treated SKC	
	D1	D2 12.5%	D3 25%	D4 12.5%	D5 25%	D6 12.5%	D7 25%
Yellow maize	62.0	63.0	60.0	63.0	60.0	63.0	60.5
Soybean meal	30.0	26.5	23.5	26.5	23.5	26.5	23.5
Solvent extracted karanj cake	—	5.5	11.0	5.5	11.0	5.5	11.0
De-oiled rice bran	2.8	0.0	0.0	0.00	0.16	0.45	0.26
Vegetable oil	1.3	1.35	2.0	1.35	2.0	1.20	1.8
Limestone	1.75	1.50	1.35	1.50	1.35	1.20	0.75
Di-calcium phosphate	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Lysine	—	—	0.03	—	0.03	0.07	0.03
Methionine	0.13	0.13	0.14	0.14	0.14	0.13	0.14
Common salt	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Trace mineral ¹	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin premix ²	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Nutrient composition (%)							
Metabolizable energy (kcal/kg)	2948	2954	2942	2954	2942	2951	2946
Crude protein	20.18	20.01	20.11	20.01	20.11	20.01	20.11
Lysine	1.04	1.01	1.00	1.01	1.00	1.01	1.00
Methionine	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Calcium	1.02	1.00	0.98	1.00	0.98	0.99	0.98
Non phytate Phosphorus	0.4	0.39	0.39	0.39	0.39	0.39	0.39

¹ Trace mineral premix contained: Cu-.25 mg, Fe-80 mg, I-1.2 mg, Mn-65 mg and Zn-68 mg per kg diet.

² Vitamins premix contained: Calcium pantothenate-8 mg, choline chloride-1000 mg, niacin-12 mg, pyridoxine hydrochloride-1.6 mg, vitamin A-8250 IU, vitamin D₃-1200 ICU, vitamin-E 8 mg, vitamin K-10 mg vitamin B₁-0.8 mg, vitamin B₂-5 mg, vitamin B₁₂-8 mcg per kg diet.

Table 4. Growth performance of broiler chickens fed karanj cake incorporated diets from 0 to 4 weeks of age

		0-4 wk			5-6 wk			0-6 wk		
Treatment		BWG (g)	FI (g)	FE	BWG (g)	FI (g)	FE	BWG (g)	FI (g)	FE
Ref	D1	603 ^a	973 ^a	0.621 ^a	560 ^a	1099 ^a	0.510 ^a	1162 ^a	2072 ^a	0.563 ^a
SKC	D2-(12.5)	533 ^b	990 ^a	0.539 ^c	429 ^{bc}	974 ^b	0.439 ^b	962 ^c	1964 ^{ab}	0.490 ^c
	D3-(25.0)	442 ^c	811 ^c	0.545 ^c	323 ^c	740 ^c	0.437 ^b	764 ^e	1551 ^d	0.494 ^c
1.5%	D4-(12.5)	597 ^a	988 ^a	0.604 ^{ab}	466 ^b	991 ^{ab}	0.471 ^{ab}	1063 ^b	1979 ^{ab}	0.538 ^a
NaOH	D5-(25.0)	468 ^c	832 ^c	0.565 ^{bc}	370 ^d	823 ^c	0.478 ^b	839 ^d	1655 ^{cd}	0.507 ^b
3.0%	D6-(12.5)	571 ^b	932 ^b	0.615 ^{ab}	384 ^{cd}	838 ^c	0.455 ^{ab}	958 ^c	1770 ^{bc}	0.549 ^a
Ca(OH) ₂	D7-(25.0)	442 ^c	824 ^c	0.525 ^c	326 ^c	721 ^c	0.416 ^b	768 ^e	1545 ^d	0.489 ^c
SEM		5.8	19.2	0.006	7.8	28.3	0.008	11.87	44.98	0.007

a, b, c, d, e Means with different superscripts in a column differ significantly ($P < 0.05$).

BWG-body weight gain; FI-feed intake; FE-feed efficiency.

giblet (liver, heart and gizzard), abdominal fat, small intestine (SI) and large intestine (LI). All the carcass traits were expressed on percent live weight basis.

Statistical Analysis

The data pertaining to various parameters were subjected to one-way analysis of variance as per the methods of Snedecor and Cochran (1989). The means in different treatments were tested for statistical significance using Duncan's multiple range test (Duncan, 1955) with significance of $P \leq 0.05$. The body weight data was analysed on individual basis. As the number of observation for the live weight parameter was unequal due to mortality of birds, the live weight change in different dietary treatments were statistically analysed employing the least square analysis of variance technique as per Harvey (1975).

Results

Body Weight Gain, Feed Intake and Feed Efficiency

The data on body weight gain, feed intake and feed efficiency of broiler chickens fed reference and test diets during 0 to 4, 5 to 6 and 0 to 6 weeks of age are shown in Table 4. Dietary incorporation of SKC or Ca(OH)₂ treated SKC at either 6.43 or 12.86% replacing 12.5 or 25% replacement of SBM protein of reference diet significantly reduced the body weight gain of broiler chicks during 0 to 4 weeks of age. However, the body weight gain of broiler chicks fed diet incorporated with 6.43% NaOH treated SKC replacing SBM protein at 12.5% level was comparable with that of reference diet during the same period. Enhancing the inclusion of NaOH treated SKC to 12.86% to replace 25% protein of SBM significantly depressed the body weight gain. The feed intake of birds fed either SKC or NaOH treated SKC incorporated diet at 6.43% level was comparable with that of reference diet during 0 to 4 weeks of age. However, dietary incorporation of Ca(OH)₂ treated SKC at 6.43% resulted in decrease in feed intake. Dietary incorporation of SKC or NaOH and Ca(OH)₂ treated SKC at 12.86% level resulted further decrease in feed intake. The feed efficiency of birds fed either NaOH and Ca(OH)₂ treated SKC at 6.43% level was comparable with that of reference

diet during 0 to 4 weeks of age. But dietary incorporation of SKC at 6.43% resulted in significantly poor feed efficiency. Dietary incorporation of SKC or NaOH and Ca(OH)₂ treated SKC at 12.86% resulted in poor feed efficiency.

During 29 to 42 days, the body weight gain was significantly lower in the karanj cake diet (with or without processing) at both the level of incorporation (5.5 or 11.0%) as compared to that of reference diet. Similar trend in feed intake was observed during the same period except that the feed intake of birds fed 6.43% NaOH treated SKC diet was found comparable with that of reference diet. Significantly better-feed efficiency was observed in the birds fed the reference diet. The feed efficiency decreased in all the treated or untreated SKC diet except the NaOH and Ca(OH)₂ treated SKC at 6.43% level of incorporation.

The over all body weight gain during 0 to 6 weeks period was significantly higher in the birds fed the reference diet. Though significantly ($P < 0.05$) lowered body weight gain was observed on NaOH treated SKC containing diet at 6.43% inclusion, it was significantly higher than on other raw or processed SKC incorporated diets. The feed intake and efficiency during this period followed the same trend as that observed during 0 to 4 weeks of age.

Nutrient Retention

The data on daily intake and percent retention of DM, N, Ca, P and GE in birds of different dietary groups during 4th (25-28 d) and 6th (39-42 d) week of experimental feeding have been presented in Table 5 and 6, respectively. The DM intake (DMI) of the birds fed reference diet was comparable with those of either SKC or NaOH treated SKC incorporated diet at 6.43% replacing 12.5% of SBM protein during 25 to 28 d. However, the DMI decreased in the Ca(OH)₂ treated SKC incorporated diet at the same level of incorporation. Significantly lowered DMI were observed when processed or unprocessed SKC was incorporated at 12.86% replacing 25% protein of SBM protein. Similar trends were also observed in the percent intake of N, Ca, P and GE. However, the percent retention of DM, N, Ca, P and GE did not differ

Table 5. Nutrient intake and retention (g or kcal/day/bird) in broiler chickens fed karanj cake incorporated diets during 25 to 28 days of age

Treatment		DMI	DMR	NI	NR	GEI	GER	CaI	CaR	PI	PR
Ref	D1	60.77 ^a	66.35	13.39 ^a	41.21	249 ^a	71.19	0.638 ^a	29.86	0.419 ^a	63.88
SKC	D2-(12.5)	56.08 ^{ab}	64.96	12.23 ^b	42.88	232 ^{ab}	70.50	0.589 ^{ab}	37.50	0.376 ^b	60.84
	D3-(25.0)	46.00 ^c	59.63	10.02 ^d	38.69	191 ^c	64.53	0.483 ^c	37.53	0.308 ^c	53.22
1.5%	D4-(12.5)	59.35 ^a	63.19	12.94 ^a	39.41	244 ^a	66.95	0.623 ^a	32.08	0.406 ^a	50.34
NaOH	D5-(25.0)	51.82 ^b	62.24	11.31 ^c	36.83	213 ^b	66.09	0.544 ^b	28.21	0.347 ^b	53.22
3.0%	D6-(12.5)	52.50 ^b	65.47	11.37 ^c	34.06	218 ^b	71.75	0.551 ^b	31.05	0.362 ^b	57.87
Ca (OH) ₂	D7-(25.0)	44.81 ^c	63.78	9.76 ^d	44.88	186 ^c	70.08	0.471 ^c	33.49	0.305 ^c	53.69
SEM		1.37	1.06	1.40	1.71	8.02	1.02	0.02	1.29	0.009	1.45

^{a, b, c, d} Means with different superscripts in a column differ significantly ($P < 0.05$).

DMI-dry matter intake; DMR-dry matter retention; NI-nitrogen intake; NR-nitrogen retention; GEI-gross energy intake; GER-gross energy retention; CaI-calcium intake, CaR-Calcium retention, PI-phosphorous intake, PR -phosphorus retention.

Table 6. Nutrient intake and retention (g or kcal/day/bird) in broiler chickens fed karanj cake incorporated diets during 43 to 47 days of age

Treatment		DMI	DMR	NI	NR	GEI	GER	CaI	CaR	PI	PR
Ref	D1	94.82 ^a	74.00	19.25 ^a	65.38	387 ^a	77.63	0.956 ^a	48.29 ^a	0.654 ^a	63.44
SKC	D2-(12.5)	81.71 ^b	71.85	16.45 ^b	57.61	335 ^b	74.61	0.826 ^b	40.15 ^{abc}	0.563 ^b	69.38
	D3-(25.0)	64.12 ^c	70.09	12.98 ^c	58.71	263 ^c	73.59	0.646 ^c	32.25 ^c	0.429 ^d	60.35
1.5%	D4-(12.5)	89.15 ^{ab}	71.88	17.96 ^{ab}	61.71	366 ^{ab}	76.21	0.896 ^{ab}	44.06 ^{ab}	0.597 ^{ab}	64.39
NaOH	D5-(25.0)	78.80 ^b	68.38	16.01 ^b	58.01	323 ^b	71.54	0.796 ^b	37.08 ^{bc}	0.528 ^{bc}	60.31
3.0%	D6-(12.5)	86.33 ^{ab}	68.81	17.48 ^{ab}	59.09	354 ^{ab}	72.61	0.873 ^{ab}	43.96 ^{ab}	0.595 ^{ab}	50.38
Ca (OH) ₂	D7-(25.0)	66.77 ^c	68.44	13.56 ^c	58.15	275 ^c	73.81	0.676 ^c	37.14 ^{bc}	0.454 ^c	57.73
SEM		2.62	1.21	0.53	2.22	14.8	0.97	0.03	1.52	0.02	2.44

^{a, b, c} Means with different superscripts in a column differ significantly ($P < 0.05$).

DMI-dry matter intake; DMR-dry matter retention; NI-nitrogen intake; NR-nitrogen retention; GEI-gross energy intake; GER-gross energy retention; CaI-calcium intake, CaR-Calcium retention, PI-phosphorous intake, PR-phosphorus retention.

Table 7. Carcass characteristics (% live weight) of broiler chickens fed karanj cake incorporated diets

Treatment		Dressed weight	Liver	Heart	Gizzard	Abdominal fat	Small intestine	Large intestine	Breast weight
Ref	D1	70.11	2.47 ^c	0.53	2.10 ^c	0.72	4.77	0.46	15.60 ^{ab}
SKC	D2-(12.5)	72.77	3.11 ^{bc}	0.50	2.55 ^{ab}	1.02	4.22	0.70	15.44 ^{ab}
	D3-(25.0)	70.25	3.64 ^{ab}	0.44	2.91 ^a	0.72	4.43	0.57	13.91 ^{bc}
1.5%	D4-(12.5)	70.69	2.59 ^c	0.52	2.29 ^{bc}	0.87	4.47	0.74	16.10 ^a
NaOH	D5-(25.0)	71.38	3.75 ^a	0.50	2.32 ^{bc}	1.11	4.88	0.43	14.03 ^{bc}
3.0%	D6-(12.5)	70.68	3.19 ^{ab}	0.48	2.33 ^{bc}	1.07	4.65	0.64	14.30 ^{abc}
Ca (OH) ₂	D7-(25.0)	70.07	3.61 ^{ab}	0.50	2.43 ^{bc}	0.68	4.78	0.39	12.47 ^c
SEM		0.37	0.11	0.02	0.06	0.06	0.14	0.04	0.30

^{a, b, c} Means with different superscripts in a column differ significantly ($P < 0.05$).

significantly due to the incorporation of processed or unprocessed SKC at both the levels.

During 39 to 42 d, the DMI of the birds fed reference diet was significantly higher in all the SKC incorporated diets with or without processing except the NaOH and Ca (OH)₂ treated SKC diet at 5.5% level replacing 12.5% protein of SBM. The same trend was noticed for the intake of N, GE, Ca and P. The percent retention of all the above nutrients did not differ significantly due to the incorporation of either treated or untreated SKC except that of Ca retention. Highest and lowest retention of Ca

was observed in the reference and 11.0% SKC incorporated diet.

Carcass Traits

Dietary incorporation of raw or processed karanj cake did not affect relative weights (percentage of live body weight) of dressed weight, heart, abdominal fat, SI and LI (Table 7). However, the liver weight increased significantly due to incorporation of SKC and NaOH treated at 25% and Ca (OH)₂ treated SKC at both the levels of replacement. The gizzard weight was significantly higher in the SKC incorporated diet at both the levels of replacement

(12.5 or 25%) as compared to that of reference diet. The breast yield lowered significantly when soybean meal nitrogen was replaced with that of processed or unprocessed karanj cake at 25% level (12.86% during starter and 11.0% during finisher phase).

Discussion

The observed poor weight gain and lowered feed intake in the present study on solvent extracted karanj cake (SKC) incorporated diet was in agreement with the findings of Mandal and Banerjee (1974). Mandal and Banerjee (1979) recommended that deoiled karanj cake ($EE < 0.05\%$) could safely be included at 5% in the diet of broiler chicken. Similarly, Dhara *et al.* (1997) reported that deoiled karanj cake could be included in the diet to a maximum level of 4.45 kg in 100 kg of feed replacing 20% red til cake protein of the reference diet. Higher level resulted in adverse effect on growth, which was attributed to the presence of toxic factors left back in the cake after oil extraction. In the present study, even a lower level of replacement (12.5%) of soybean nitrogen with SKC or $Ca(OH)_2$ treated SKC i.e. 6.43% in the diet resulted in growth depression during 0 to 4 weeks of age. Only dietary replacement of 12.5% of soybean meal nitrogen with 1.5% NaOH (w/w) treated SKC (6.43%) supported the body weight gain up to 4 weeks of age. Higher level of incorporation of the same treated cake (12.86%) resulted in growth depression during the same period. However, after 28 d, growth depression was observed in the NaOH (w/w) treated SKC (5.5%) incorporated diet as compared to control.

Dietary incorporation of SKC at 6.43% level depressed the feed efficiency in the present study. However, dietary incorporation of 1.5% NaOH or 3% $Ca(OH)_2$ treated SKC at 6.43% level alleviated the depression on feed efficiency. Enhancing the inclusion from 6.43 to 12.86% resulted in lowered feed efficiency. Contrary to the findings of the present study, Natnam *et al.* (1989 b) reported comparable feed efficiency with reference diet in broiler chicks by incorporating SKC at 10% level in the diet. Processing of SKC by autoclaving or water soaking did not have any advantage on feed efficiency (Natnam *et al.* 1989b). Dhara *et al.* (1997) also observed poor FCR by dietary incorporation of 11.20% to 22.40% deoiled karanj cake in the diet of Japanese quail. Efficiency of feed utilization for various productive purposes depends on the level of protein and energy (Mellen *et al.*, 1984) and their ratio (Davidson, 1964) in addition to the presence of incriminated factors (Chand, 1987) and the balance of nutrients in the diet (Comb, 1964). Probably the presence of higher levels of residual incriminating factors in diets containing raw and processed SKC at all levels of incorporation except on diet containing 1.5% NaOH treated SKC replacing 12.5% soybean meal protein, resulted in poor FCR in broiler chicks despite feeding of uniformly balanced diets.

Mandal and Banerjee (1982) did not observe any differ-

ence on organ weights (liver, heart, kidney and spleen) of cockerels due to dietary replacement of black til cake with deoiled karanj cake at 30% level. Similarly, Dhara *et al.* (1997) found no significant variation in weight of different organs (giblet, liver, heart and gizzard) and commercial cuts (neck, wing, thigh, shank, breast and trunk) due to incorporation of deoiled karanj cake upto 22.40% in the diet of Japanese quail. However, in the present study, dietary inclusion of either SKC or NaOH treated SKC at 25% level and $Ca(OH)_2$ treated SKC at both the levels significantly increased the weight of liver leading to liver hypertrophy. Gizzard weight also increased significantly due to incorporation of SKC at both the levels. The adverse effect of the diet on organ weights relative to the body weight was attributed to the karanjin.

The HPLC analysis revealed that the SKC, NaOH and $Ca(OH)_2$ treated SKC contained 0.132, 0.062 and 0.082% karanjin. In the present study the birds during 1 to 28 d consumed 3.0, 1.4 and 1.8 mg karanjin daily on SKC (84.9 mg/kg), NaOH (39.9 mg/kg) and $Ca(OH)_2$ (52.7 mg/kg) treated SKC diet at 6.43% incorporation level replacing 12.5% protein of soybean meal. Adverse effect on growth and feed intake was noticed when daily karanjin intake was 1.8 mg and above. However, during 29 to 42 d, birds on average consumed 5.1, 2.4 and 2.7 mg karanjin on the same above diet, respectively. Probably the higher daily karanjin intake (> 1.8 mg) could be the probable reason for showing adverse effect. Similarly Natnam (1989b) reported the adverse effect of karanj cake feeding is due to the leftover karanjin left over in the processed cake. During 1 to 42 d, the birds on SKC, NaOH and $Ca(OH)_2$ treated SKC diet at 6.43% incorporation consumed on an average 3.7, 1.7 and 2.1 mg karanjin daily. In all the diets growth depression was observed during the same period. Assuming 1.8 mg daily intake of karanjin as said, it can be concluded that karanj cake incorporating diet containing more than 39.9 mg/kg diet is not suitable for broiler chicken feeding.

Thus, the present findings suggested that 1.5% NaOH (w/w) treated SKC could be incorporated up to 6.43% level, replacing 12.5% of soybean nitrogen of reference diet of broiler chicken up to 4 weeks of age.

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