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DIGESTION CUM METABOLISM TRIAL IN BROILER RABBIT FED ON SWEET POTATO BASED RATION

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ABSTRACT

Two breeds of broiler rabbits raised on rations containing various levels of sweet potato (*Ipomoea batatas*) as an energy source at ICAR Research Complex for NEH, Barapani, Meghalaya. Five groups of each weaned Neazealand White (NZ) and Soviet Chinchilla (SC) rabbits, six in each group were fed five is onitrogenous concentrate mixtures containing 0,10,20,30 and 40 percent boiled sweet potato replacing equivalent amount of maize grain for a period of 45 days. Chemical analysis and GE estimation revealed that concentrate mixtures during metabolism trial were isonitrogenous and isocaloric. The percent CP, TDN, DE and ME were almost similar in the composite rations, however, DCP decreased significantly along with the increased level of incorporation of sweet potato in the rations during metabolism trial. DM intake per kg, per 100 kg and per kgW$^{0.75}$ body weight were significantly ($P<0.05$) higher in Ration 1, 2 and 3 groups than Ration 3, 4 and 5 groups. The values were comparable within Ration 1, 2 and 3 groups and again in Ration 3, 4 and 5 groups. The digestibility coefficient of DM and all organic nutrients were significantly affected by incorporation of sweet potato during metabolism trial. The values of DM, OM, CP and CF were higher in control group (Ration 1) than the experimental groups (Ration 2, 3, 4 and 5), whereas EE was higher in experimental groups. Digestibility as well as metabolisability of GE intake did not differ significantly due to the various rations. The experimental groups show positive balance of N, energy, Ca and P during metabolism trial. All the groups utilized the various nutrients with similar efficiency except DCP utilization. It may be concluded that incorporation of sweet potato as a replacement of maize as energy source in broiler rabbit ration has a positive effect.

KEYWORDS: Digestibility, Feeding, Metabolism, Rabbit, Sweet Potato

INTRODUCTION

The rabbit can play a crucial role in meeting the critical meat shortage in regard to its potential in producing quality meat. Chakrabarti *et al*, 2014 opined that broiler rabbit production is a profitable venture and practiced in many countries in the world including India. According to FAO (1981) in the near future, world nourishing needs will be satisfied for one third of the human population by pork, poultry and rabbit meat. Rabbit farming although a new venture in India, but it is gaining popularity because of its tremendous scope; which grow rapidly and their growth rate is comparable to that of broiler chicken (Rao *et al*., 1977). This small animal can turn 20 per cent of protein they eat into edible meat under uniform manage mental condition, while for chicken, pig and beef cattle these values are 22 to 23, 16 to 18, 8 to 10, respectively. Rabbits can be raised on high roughage diets or diets without grain which have also comparative advantage over poultry and swine (Kalita, 1998). The food accounts 70 to 80 per cent of the total production cost in rabbit farming. Therefore, studies have been conducted in India and abroad confirmed that rabbits can be successfully raised on agricultural by-products and unconventional feeds reducing cost of production. Chakrabarti *et al.*, 2017_a and Chakrabarti *et al.*, 2017_b also observed broiler rabbit production was a profitable venture when maize was replaced with sweet potato as an energy source.

The sweet potato (*Ipomoea batatas*) is high yielding short cycle tuber crop and rich in vitamin A, ascorbic acid, thiamin, riboflavin and niacin (Dominguez, 1991). It is also rich in phosphorus, iron and potassium (Scott, 1991, Anon, 2002), which have been found as suitable substitute for maize in livestock feeding (Job *et al*., 1979; Teguia *et al*., 1993; Yadav *et al.*, 1995; Abu, 1997; Bora, 1999; Abu *et al*., 1999 and Nguyen *et al*., 2000). Sweet potatoes are a good source of energy (70% starch content) and could be used as energy feed for rabbits (Lebas *et al*., 1986).

MATERIALS AND METHODS

A 45 days feeding trial was conducted at Rabbit Research Farm, ICAR Research Complex for NEH Region, Umium, Meghalaya located at an altitude of 980 m above mean sea level and lying between 25°30′ N and 91°51′ E. Thirty weaned New Zealand White (NZ) and thirty weaned Soviet Chinchilla (SC) rabbits of 42 days old were divided randomly into five groups of six animals each as per uniformity in their body weight. The experimental rabbits were reared under uniform managemental conditions by housing them individually in clean metallic cages, fitted with feeders and waterers and kept inside well ventilated shed with cemented floor. Five isonitrogenous concentrate mixtures (Ration 1, 2, 3, 4 and 5) with 16% crude protein and 70% total digestible nutrients were prepared with conventional feed ingredients like maize, wheat bran, deoiled rice bran, soya bean meal, ground nut cake, rice husk, fish meal, mineral mixture and common salt. In experimental Ration 2, 3, 4 and 5 maize was replaced by sweet potato at the rate of 25, 50, 75 and 100 per cent level (w/w), respectively.

The digestion cum metabolism trials of 4 days duration were conducted with 3 representative rabbits from each group. The metabolism trial was conducted at 38^{th} day after feeding started. Body weights of the rabbits were recorded before and after metabolism trial in the two consecutive days and the average was considered as final weight.

During the metabolism trial weighed quantity of concentrate were offered at about 8.00 a.m. and 3.00 p.m. in a separate feeder to each rabbit. A well-mixed representative sample from each concentrate mixture was saved in previously labeled polyethylene bags. The residue of each concentrate mixture was collected next day morning before offering fresh feed, in labeled polyethylene bags. Hundred gram (100g) sample of each concentrate mixture offered and residues left were taken in preweighed petridishes and dried in hot air oven at 100 ± 1°C overnight to estimate dry matter (DM) content. The pooled dried samples were ground and stored in airtight containers for further analysis. Similarly, representative samples of feed and residue were dried at 60 ± 2°C overnight and pooled for gross energy estimation.

Weekly dry matter intake in W_1, W_2, W_3, W_4, W_5 and $W_{6,}$ average daily dry matter intake (ADDI) in different weeks, DM intake per kilogram of body weight and per kilogram of metabolic body weight in different weeks were calculated. Measured quantity of concentrate feed was offered to each of the animal daily. Dry matter percent of supplied and residual feed was determined at the end of the week, taking representative sample of each day. DM intake was calculated by subtracting dry matter of residual feed from dry matter of supplied food.

The faeces voided in 24 hours was collected in previously marked plastic container and weighed daily before collecting the fresh faeces. The faeces were mixed thoroughly and representative samples of faeces (1/15th of total amount) from each animal were separated in a previously marked wide mouthed Bakelite bottle. From each representative sample a suitable amount was mixed with few ml of 1: 4 sulphuric acid and kept it for nitrogen estimation. The remaining amount of faeces was kept for drying at 100 ± 1°C in hot air oven for DM and other proximate principal estimation. Dried samples were found and stored in previously labeled petridishes.

After measuring the total quantity of urine excreted by each rabbit during 24 hours, an aliquot of $^{1}/_{10}{}^{th}$ total urine output was transferred individually in duplicate to kjeldhal flasks containing 25 ml of commercial grade sulphuric acid for nitrogen estimation. Another aliquot of $^{1}/_{10}{}^{th}$ of urine were stored at –20°C for gross energy estimation. The ground representative samples of sweet potato and concentrate offered, residues left, dried and wet faeces were subjected to analysis of proximate principles (AOAC, 1980), gross energy (as per the Gallenkamp manual) and calcium and phosphorus (Talapatra *et al*., 1940). The urine samples were subjected to analysis of nitrogen (AOAC, 1980).

The experiment was conducted in 2 way interaction design (Snedecor and Cochran, 1980) and data were analysed by using MSTATC package of Computer.

RESULTS AND DISCUSSIONS

The range of crude protein (CP), digestible crude protein (DCP), total digestible nutrients (TDN), digestible energy (DE) and metabolisable energy (ME) in the rations were 18.29 to 18.39, 11.06 to 11.73, 68.40 to 68.50 per cent, 3.14 to 3.20 and 3.03 to 3.06 Mcal/kg of DM for Ration 1, 2, 3, 4 and 5, respectively (Table 1). There was significant difference (P<0.01) in DCP values, but no significant differences were found in CP, TDN, DE and ME. However, TDN, DE and ME contents slightly increased along with the increased level of incorporation of sweet potato in rations.

Table 1: Estimated Nutritive Value of Composite Rations (Mean ± SE) During Metabolism Trial

Constituents	Ration				
	1	2	3	4	5
CP (%)	18.392 ±0.013	18.395 ±0.084	18.295 ±0.015	18.330 ±0.025	18.327 ±0.019
DCP (%)	13.294^{a} ±0.053	13.052^{b} ±0.032	12.604^{c} ±0.015	12.913^{d} ±0.011	12.642^{d} ±0.019
TDN (%)	69.962 ±0.131	69.932 ±0.172	69.792 ±0.139	70.226 ±0.116	70.085 ±0.110
DE (Mcal/kg DM)	3.145 ±0.016	3.165 ±0.025	3.177 ±0.011	3.200 ±0.013	3.202 ±0.015
ME (Mcal/kg DM)	3.030 ±0.011	3.055 ±0.018	3.055 ±0.027	3.057 ±0.022	3.062 ±0.029

Means with different superscripts in a row differ significantly. ** Significant (P<0.01)

The CP values of composite rations were similar to those reported by Tortuero *et al*. (1989), Biobaku and Ekpenyong (1991), Balogun and Etukude (1991) and Saikia (1998). The CP values were slightly higher than NRC (1977) recommendation for growing rabbits (16%) and were within the range (16-20%) suggested by Deshmukh and Pathak (1991) for growing rabbits. The DCP content of composite rations during the trial was close to the values reported by Srinivas *et al*. (1994), Kumar (1995) and Saikia (1998). The TDN values were slightly higher than NRC (1977) recommendation for growing rabbits (65%). Yadav *et al*. (1995) observed a decreased DCP and increased TDN percent in the sweet potato incorporated diets of pigs. The DE content of all the rations during the trial was higher than the values (2500 Kcal/kg) recommended by NRC (1977). Similarly ME values of the control ration (Ration 1) were lowest as to the

ME concentrations of all sweet potato incorporated rations during the trial, but there was no significant differences among DE and ME values. The higher energy content of Ration 2, 3, 4 and 5 than the control (Ration 1) ration might be due to incorporation of sweet potato in place of maize grain in the concentrate mixture.

Average Daily Feed (DM) Intake

The average feed (DM) consumption (g/day) during the entire feeding trial ranged from 35.02 ± 0.37 to 103.39 ± 0.69, 36.40 ± 0.44 to 103.33 ± 0.69, 38.76 ± 0.89 to 103.61 ± 0.79, 38.31 ± 0.58 to 101.17 ± 0.51 and 37.95 ± 0.75 to 101.33 ± 0.52 g in NW_1, NW_2, NW_3, NW_4 and NW_5, respectively and 36.02± 0.80 to 100.94 ± 0.64, 37.50 ± 0.52 to 103.39 ± 0.69, 37.67 ± 0.27 to 102.28 ± 0.92, 36.52 ± 0.34 to 100.50 ± 0.31 and 35.79 ± 0.38 to 100.22 g in SC_1, SC_2, SC_3, SC_4 and SC_5 with the respective average values of 67.84 ± 0.35, 69.06 ± 0.34, 69.60 ± 0.50, 68.42 ± 0.35, 69.12 ± 0.22 and 67.73 ± 0.24, 69.59 ± 0.25 70.66 ± 0.21, 68.39 ± 0.37 and 67.09 ± 0.19 g, respectively (Table 2).

Table 2: Feed (DM) Consumption (G/Animal) Per Day during the Feeding Trial (Mean ± SE)

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
I	II	III	IV	V	VI	VII
1st week						
NZ	35.025^{a} ±0.375	36.405^{ab} ±0.445	38.762^{c} ±0.892	38.310^{c} ±0.582	37.952^{bc} ±0.752	37.291 ±0.369
SC	36.025^{ad} ±0.801	37.502^{ab} ±0.525	37.667^{b} ±0.275	36.525^{abd} ±0.344	35.787^{cd} ±0.377	36.701 ±0.251
Overall (Ration)	35.525^{a} ±0.448	36.953^{b} ±0.367	38.214^{c} ±0.475	37.417^{bc} ±0.420	36.869^{b} ±0.517	36.996 ±0.225
2nd week						
NZ	45.310^{a} ±0.379	46.808^{ac} ±0.737	47.498^{bcd} ±0.487	46.952^{c} ±0.627	48.617^{d} ±0.564	47.037^{A} ±0.310
SC	46.713^{a} ±0.487	49.667^{b} ±0.432	50.570^{bc} ±0.221	47.312^{a} ±0.846	45.882^{ad} ±0.345	48.029^{B} ±0.394
Overall (Ration)	46.012^{a} ±0.362	48.237^{bd} ±0.593	49.034^{b} ±0.529	47.132^{c} ±0.505	47.249^{cd} ±0.519	47.533 ±0.257
3rd week						
NZ	54.572^{a} ±0.493	57.023^{bc} ±0.673	56.262^{abc} ±0.677	55.690^{ab} ±0.832	57.643^{c} ±0.651	56.238^{A} ±0.343
SC	56.765^{ac} ±0.689	58.335^{a} ±0.450	61.238^{b} ±0.692	57.975^{a} ±0.891	55.833^{c} ±0.501	58.029^{B} ±0.438
Overall (Ration)	55.668^{a} ±0.522	57.679^{bd} ±0.434	58.750^{cd} ±0.881	56.832^{ab} ±0.676	56.738^{ab} ±0.477	57.134 ±0.299
4th week						
NZ	65.857^{a} ±0.373	67.953^{b} ±0.437	67.358^{b} ±0.743	67.643^{b} ±0.540	68.455^{b} ±0.532	67.453 ±0.277
SC	66.262^{a} ±0.258	67.737^{b} ±0.402	70.880^{c} ±0.313	67.713^{b} ±0.482	66.262^{a} ±0.566	67.771 ±0.358
Overall (Ration)	66.059^{a} ±0.225	67.845^{b} ±0.285	69.119^{c} ±0.655	67.678^{b} ±0.345	67.358^{b} ±0.497	67.612 ±0.226
5th week						
NZ	78.977^{ad} ±0.625	78.928^{ac} ±0.347	80.215^{a} ±0.530	78.430^{bcd} ±0.603	79.142^{ad} ±0.657	79.138^{A} ±0.258
SC	76.810^{a} ±0.280	79.215^{bd} ±0.518	79.882^{b} ±0.423	78.213^{cd} ±0.378	76.240^{a} ±0.287	78.072^{B} ±0.303
Overall (Ration)	77.893^{a} ±0.462	79.072^{bd} ±0.301	80.048^{c} ±0.327	78.322^{ad} ±0.341	77.691^{a} ±0.555	78.605 ±0.209
6th week						
NZ	91.762	93.002	93.523	90.737	90.715	91.948^{A}

	±0.592	±0.575	±1.013	±0.518	±0.613	±0.356
SC	90.620 ±0.593	91.300 ±0.515	92.120 ±0.751	90.548 ±0.314	89.407 ±0.776	90.799^{B} ±0.304
Overall (Ration)	91.191^{ab} ±0.435	92.151^{bc} ±0.448	92.822^{c} ±0.637	90.642^{a} ±0.290	90.061^{a} ±0.511	91.373 ±0.244
7th week						
NZ	103.388 ±0.690	103.333 ±0.688	103.612 ±0.786	101.167 ±0.515	101.333 ±0.524	102.567^{A} ±0.336
SC	100.945 ±0.642	103.390 ±0.691	102.277 ±0.925	100.500 ±0.308	100.223 ±0.582	101.467^{B} ±0.352
Overall (Ration)	102.167^{a} ±0.581	103.362^{a} ±0.465	102.944^{a} ±0.613	100.833^{b} ±0.304	100.778^{bc} ±0.409	102.017 ±0.252
During the entire feeding trial (g/animal/day)						
NZ	67.840^{a} ±0.347	69.065^{bd} ±0.339	69.602^{b} ±0.496	68.417^{ad} ±0.348	69.120^{bcd} ±0.217	68.809 ±0.188
SC	67.732^{ad} ±0.237	69.593^{b} ±0.255	70.660^{c} ±0.211	68.395^{d} ±0.368	69.092^{a} ±0.186	68.694 ±0.262
Overall (Ration)	67.786^{a} ±0.201	69.329^{b} ±0.217	70.131^{c} ±0.302	68.406^{a} ±0.242	68.106^{a} ±0.335	68.751 ±0.160

N.B. Sub-class averages with at least one superscript in common (lower case along the row and upper case along the column) do not differ significantly. ($P<0.01$)

From the perusal of the Table 2, it was observed that throughout the whole experimental period, the intake of feed (DM) per day was found to be lowest in NW_1 and SC_1 group and highest DM consumption was found in NW_3 and SC_3 groups with 50 per cent supplementation of maize with sweet potato. There was no significant difference among the breeds, but there was significant ($P<0.01$) difference between the ration and ration × breed.

The observed values of average feed consumption per day was comparable to the values reported by Prawirodigdo *et al*. (1985), Ayer *et al*. (1992), Srinivas *et al*. (1994), Bora (1995), Ridzwan *et al*. (1995), Gupta *et al*. (1995) and Saikia (1998). The values were lower to the value of 110 to 130 g/day suggested by Lebas (1988) for optimum performance of young growing rabbits which might be due to feeding of all the rations in mash form as rabbits prefer pelleted diet rather than mash form with similar composition (Harris *et al*., 1983). The tropical environmental conditions, under which the present investigations were undertaken, were other probable reasons for lowered feed intake and supported by Stephan (1980). According to Brody (1964), the zone of thermal neutrality or the comfort zone for rabbits is 21 – 25°C, however, the atmospheric temperature under which the present study was undertaken ranged from 20.50 to 28.67°C. Kasa *et al*. (1989) also opined that feed intake decrease by 12% at 30°C than that reared at 22°C. The feed consumption of rabbits increased with decreasing energy concentration of diet to meet calorie requirements (Spreadbury and Davidson, 1978; Pote *et al*., 1980). With high-fibre, low-energy diets, the rate of passage of digesta is very rapid, allowing a high level of feed intake (Cheeke, 1987). Ridzwan *et al*. (1993) reported that feed intake increased significantly along with the increase level of incorporation of cocoa-pod husks in the diet of rabbits. Abu *et al*. (1999) reported a decreased trend of average daily feed intake (g) in sweet potato root based rations than the control group in rabbits. Yadav *et al*. (1995) also observed a significant decrease in feed (DM) intake (kg/day) due to incorporation of sweet potato tuber in the diets of pig. Marrero (1975) observed that as raw sweet potato progressively replaces cereals in the diet tend to decrease daily feed intake in pigs. Feed intake in the present experiment is similar to the observed value of Gerpacio *et al*. (1978). They observed that as the level of sweet potato increased there was decreased feed intake.

Total Feed (DM) Consumption during the Entire Feeding Trial

During the entire feeding trial, the total feed (DM) intake was lowest in NZ_1 (2872.00 ± 13.96 g) and SC_1 (2925.50 ± 11.72 g and highest in NZ_3 (2777.83 ± 25.21) and SC_2 (3004.83 ± 13.91) groups of rabbits (Table 3). Statistical analysis revealed no significant difference between the breed and breed × ration. However, the significant (P<0.01) differences were found due to rations. On perusal of data it revealed that the control groups (Ration 1) consumed significantly (P<0.01) less feed (DM) than the groups consumed rations incorporated with sweet potatoes.

The present findings are comparable with the findings of Tortuero *et al*. (1989) and Saikia (1998) but, the values were lower than the findings of Rohilla *et al*. (2002). Oyenuga and Fetuga (1975) and Canope *et al*. (1977) opined that cooking of sweet potato increase the digestibility of the nutrients. In the present study the higher feed (DM) intake in sweet potato based ration might be due to increase in palatability and digestibility of the nutrients.

Table 3: Total Feed (DM) Consumption (Mean ± SE) (G/Animal) During the Entire Feeding Trial (P<0.01)

Breed	Ration					Overall (Breed)
	1	2	3	4	5	
NZ	2872.000 ±13.957	2970.833 ±14.528	2977.833 ±25.208	2950.000 ±16.717	2961.667 ±13.226	2946.467 ±10.117
SC	2925.500 ±11.719	3004.833 ±13.914	2984.167 ±19.287	2940.000 ±15.380	2973.000 ±13.952	2965.500 ±8.253
Overall (Ration)	2898.450[a] ±11.850	2987.833[b] ±10.871	2981.000[b] ±15.162	2945.000[c] ±10.935	2967.333[bc] ±9.322	2955.984 ±6.591

Means with different superscripts in a row differ significantly. (P<0.01)

Dry Matter (DM) Intake during Metabolism Trial

The DM intake (g/animal/day) was comparable in respect of Ration 1(Control), 2 and 3 groups and again Ration 1, 4 and 5 groups; however there was no significant difference due to breed and breed × ration. Almost same trend was observed in DM intake per kg, per 100 kg and in per $W_{kg}^{0.75}$ also. There was no significant difference between Ration 1, 2 and 3 and again Ration 3, 4 and 5. The average DM intake (g/animal/day) during metabolism trial were 89.20 ± 0.91, 91.47 ± 0.64, 89.20 ± 1.30, 87.03 ± 0.13 and 87.70 ± 0.84 g for NZ_1, NZ_2, NZ_3, NZ_4 and NZ_5 and 88.77 ± 0.59, 90.57 ± 0.53, 89.78 ± 0.72, 87.70 ± 0.51 and 87.23 ± 0.79 g, respectively (Table 4).

The corresponding values for DM intake per kg body weight were 59.27 ± 0.30, 60.04 ± 0.25, 58.42 ± 0.69, 57.51 ± 0.04 and 58.53 ± 0.46 g for NZ_1, NZ_2, NZ_3, NZ_4 and NZ_5 and 58.89 ± 0.67, 59.18 ± 0.16, 59.07 ± 0.60, 58.20 ± 0.58 and 58.04 ± 1.03 g for SC_1, SC_2, SC_3, SC_4 and SC_5, respectively. The same trend was also recorded for DM intake per 100 kg body weight. Ration 2 groups consumed significantly (P<0.05) higher DM per kg metabolic body weight (66.10 ± 0.28 g) and there were no significant different among Ration 1, 3, 4 and 5 groups and again in 1, 2 and 3 groups.

Table 4: Dry Matter (DM) Consumption (Mean ± SE) by the Experimental Rabbits during Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
I	II	III	IV	V	VI	VII
Average Body Weight (kg)						
NZ	1.505 ±0.008	1.523 ±0.004	1.527 ±0.004	1.513 ±0.003	1.497 ±0.003	1.513 ±0.003
SC	1.500 ±0.003	1.515 ±0.003	1.530 ±0.003	1.518 ±0.002	1.495 ±0.003	1.512 ±0.003
Overall (Ration)	1.502[a]	1.519[b]	1.528[c]	1.516[b]	1.496[a]	1.512

	±0.004	±0.003	±0.002	±0.002	±0.002	±0.002
Average Metabolic Body Weight (kg)						
NZ	1.360 ±0.006	1.373 ±0.003	1.373 ±0.003	1.363 ±0.003	1.357 ±0.003	1.365 ±0.002
SC	1.357 ±0.002	1.367 ±0.003	1.380 ±0.006	1.370 ±0.000	1.353 ±0.003	1.365 ±0.003
Overall (Ration)	1.358^{a} ±0.003	1.370^{bc} ±0.003	1.377^{b} ±0.003	1.367^{c} ±0.002	1.355^{a} ±0.002	1.365 ±0.002
DM Intake (g/animal/kg)						
NZ	89.200 ±0.907	91.467 ±0.638	89.200 ±1.301	87.033 ±0.134	87.700 ±0.839	88.920 ±0.520
SC	88.333 ±0.845	89.667 ±0.410	90.367 ±0.745	88.367 ±0.921	86.767 ±1.489	88.700 ±0.488
Overall (Ration)	88.767^{ab} ±0.588	90.567^{a} ±0.526	89.783^{a} ±0.719	87.700^{b} ±0.512	87.233^{b} ±0.792	88.810 ±0.351
DM Intake Per kg Body Weight (g)						
NZ	59.267 ±0.304	60.043 ±0.248	58.420 ±0.690	57.510 ±0.038	58.527 ±0.458	58.753 ±0.276
SC	58.890 ±0.674	59.183 ±0.162	59.067 ±0.596	58.197 ±0.583	58.037 ±1.032	58.675 ±0.282
Overall (Ration)	59.078^{ab} ±0.391	59.613^{a} ±0.234	58.743^{abc} ±0.433	57.853^{c} ±0.303	58.282^{bc} ±0.517	58.714 ±0.194
DM Intake Per 100 kg Body Weight (kg)						
NZ	5.927 ±0.028	6.007 ±0.026	5.843 ±0.068	5.753 ±0.007	5.860 ±0.044	5.878 ±0.027
SC	5.887 ±0.067	5.920 ±0.015	5.907 ±0.059	5.817 ±0.058	5.803 ±0.105	5.867 ±0.028
Overall (Ration)	5.907^{ac} ±0.034	5.963^{a} ±0.024	5.875^{ab} ±0.043	5.785^{b} ±0.030	5.832^{bc} ±0.052	5.872 ±0.019
DM Intake Per kg Metabolic Body Weight (kg)						
NZ	65.583 ±0.425	66.600 ±0.349	64.947 ±0.788	63.840 ±0.061	64.640 ±0.481	65.122 ±0.307
SC	65.113 ±0.774	65.610 ±0.158	65.490 ±0.811	64.500 ±0.673	64.113 ±1.074	64.965 ±0.326
Overall (Ration)	65.348^{ab} ±0.409	66.105^{a} ±0.280	65.218^{ab} ±0.520	64.170^{b} ±0.336	64.377^{b} ±0.539	65.044 ±0.221

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.05)

The observed values of average DM intake per animal per day during metabolism trial were comparable with the reported values (Ridzwan *et al*., 1993; Sreemannarayana *et al*, 1993; Srinivas *et al*., 1994; Kumar, 1995; Bora, 1995; Sundaram *et al*., 1997; Saikia, 1998; Abu *et al*., 1999 and Rohilla *et al*., 2002). The dry matter intake (g/animal/day) was significantly higher in Ration 1, 2 and 3 groups but lower in Ration 4 and 5 groups. Similar observations were reported by Abu *et al*. (1999). Gerpacio *et al*. (1978) observed lower feed intake in control ration than the 50 per cent replacement of corn with sweet potato and also the feed consumption reduced with the increased level of sweet potato in the poultry diet. Marrero (1975) in pigs also observed the similar trend of DM intake due to incorporation of sweet potato in the diet. In the present study similar trend of DM intake was observed in per 100 kg and per $kg_{W}^{0.75}$ body weight. Gerpacio *et al*. (1978) opined that sweet potato at the higher levels in the diet less satisfactory compared with corn, suggesting that for the tuber, only 50 per cent or at the most, 75 per cent replacement of the corn is advisable. Yadav *et al*. (1995) reported a significantly (P<0.01) higher DM intake (kg/100 kg body weight and g/kg $w^{0.75}$) in 50 per cent sweet potato based rations, whereas significantly (P<0.01) low DM intake in 100 per cent sweet potato based rations than the control group in both the experiments (Expt. 1 and Expt. 2). Lower DM intake in Ration 4 and 5 (75 and 100 percent sweet potato based diet) could be attributed to lower digestibility and high energy content of the ration. Thus, incorporation of 75 percent sweet potato in rabbit rations had adverse effect on the palatability and voluntary feed intake.

Mean Intake and Digestibility of Various Nutrients

The results pertaining to the intake, voided in faeces, digested and digestibility co-efficient of various nutrients in rabbits during metabolism trial are discussed under this heading.

Intake and Digestibility Co-Efficient of Dry Matter (DM)

Though the total intake of DM did not differ significantly among the breeds and breed × Ration, but differed significantly (P<0.01) between Rations. Significant (P<0.01) differences were observed between breeds, Rations and Ration × breed in respect of DM voided in faeces, DM digested and digestibility co-efficient of DM. DM voided in faeces were significantly higher in SC breed (29.99 ± 0.52 g) than NZ breed (27.51 ± 0.35 g) and due to Rations. The groups that consumed sweet potato based rations i.e. Ration 2, 3, 4 and 5 voided significantly (P<0.01) more DM in faeces. NZ breed digested (61.41 ± 0.34g) significantly (P<0.01) more DM than SC breed (58.71 ± 0.74 g). There was no significant different among the Ration 1, 2, 3 and again 3, 4 and 5 groups in respect of DM digested. The digestibility co-efficient was significantly (P<0.01) higher in NZ (69.07 ± 0.28) than the SC breed (66.18 ± 0.63). The digestibility of DM decreased along with increased level (75 and 100 per cent) of sweet potato in the diet (Table 5).

Table 5: Mean Intake (Mean ± SE) and Digestibility Coefficient of Dry Matter (DM) in Rabbits during Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
DM Intake (g/animal/day)						
NZ	89.200 ±0.907	91.467 ±0.638	89.200 ±1.301	87.033 ±0.134	87.700 ±0.839	88.920 ±0.521
SC	88.333 ±0.845	89.667 ±0.410	90.367 ±0.745	88.367 ±0.921	86.767 ±1.489	88.700 ±0.488
Overall (Ration)	88.767^{ab} ±0.588	90.567^{a} ±0.526	89.783^{a} ±0.719	87.700^{b} ±0.512	87.233^{b} ±0.792	88.810 ±0.351
DM Voided in Faeces (g/animal/day)						
NZ	28.100^{ac} ±0.305	29.500^{a} ±0.208	26.467^{b} ±0.491	26.100^{b} ±0.305	27.400^{bc} ±0.208	27.513^{A} ±0.347
SC	26.967^{a} ±0.186	29.033^{b} ±0.176	30.967^{c} ±0.851	31.367^{c} ±0.546	31.600^{c} ±0.889	29.987^{B} ±0.524
Overall (Ration)	27.533^{a} ±0.300	29.267^{b} ±0.160	28.717^{b} ±1.098	28.733^{b} ±1.210	29.500^{b} ±1.024	28.750 ±0.385
DM Digested (g/animal/day)						
NZ	61.100 ±0.603	61.967 ±0.498	62.733 ±0.939	60.933 ±0.291	60.300 ±0.907	61.407^{A} ±0.345
SC	61.367^{a} ±0.731	60.633^{a} ±0.233	59.400^{ab} ±1.595	57.000^{bd} ±0.866	55.167^{cd} ±1.317	58.713^{B} ±0.736
Overall (Ration)	61.233^{a} ±0.428	61.300^{a} ±0.386	61.067^{a} ±1.114	58.967^{b} ±0.970	57.733^{bc} ±1.352	60.060 ±0.472
Digestibility Co-Efficient of DM (%)						
NZ	68.500^{ab} ±0.031	67.747^{b} ±0.154	70.330^{c} ±0.316	70.013^{ac} ±0.340	68.750^{abc} ±0.415	69.068^{A} ±0.280
SC	69.473^{a} ±0.213	67.620^{b} ±0.049	65.710^{c} ±1.216	64.503^{cd} ±0.585	63.573^{d} ±0.902	66.176^{B} ±0.634
Overall (Ration)	68.987^{a}	67.683^{b}	68.020^{ab}	67.258^{bc}	66.162^{c}	67.622

	±0.238	±0.079	±1.176	±1.269	±1.240	±0.433

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The dietary variations significantly influenced the digestibility co-efficient of DM (DCDM) which were well nearer and within the reported range of 56 to 72 (Grobner *et al*., 1985), 48.21 to 74.15 (De Blas *et al*., 1986), 57.55 to 74.62 (Bora *et al*., 1996) and 54.40 to 73.01 (Saikia, 1998) in rabbits. Gerpacio *et al*. (1978) observed that digestibility of DM decreased as the level of replacement of corn is increased with sweet potato roots in broiler birds. Oyenuga and Fetuga (1975) and Canope *et al*. (1977) found that cooking sweet potato improved digestibility of all nutrients (Raw 90.4% DMDC and cooked 93.5% DMDC). Dominguez *et al*. (1991) also reported a lower level of DM digestibility along the increase level of sweet potato root in the pigs diet. Whereas, Yadav *et al*. (1995) reported significantly (P<0.01) higher digestibility percent (64.93 to 85.08 in Expt. 1 and 67.14 to 76.24 in Expt. 2) in pigs due to the incorporation of sweet potato in diets. Abu *et al*. (1999) observed a decreasing trend of digestibility co-efficient of DM in rabbits at increased level of sweet potato incorporation in the diets. The DC was higher in T_3 (80: 20 – sweet potato top: dehydrated sweet potato root meal) and the values ranged from 50.88 to 60.51 per cent. The present findings are in agreement with the findings of above workers.

Intake and Digestibility Coefficient of Organic Matter (OM)

There were no significant differences between breed, ration and breed × ration in respect of OM intake. However, significant differences were observed in breed, ration and breed × ration in respect of OM voided in faeces. The NZ breed (31.92 ± 0.86 g) voided more OM in faeces than SC breed (30.27 ± 0.77g). It was found that no significant differences in OM digested and digestibility co-efficient in breed and ration × breed, but significant (P<0.01) differences were among the rations. The OM digested and digestibility co-efficient of OM was significantly (P<0.01) lower along with the incorporation of sweet potato level in the rations. The digestibility co-efficient percent were 66.47 ± 0.38, 62.37 ± 0.69, 58.35 ± 1.09, 57.62 ± 0.50 and 56.66 ± 0.07 for Ration 1, 2, 3, 4 and 5, respectively (Table 6).

Table 6: Mean Intake (Mean ± SE) and Digestibility Coefficient of Organic Matter (OM) in Rabbits During Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
OM Intake (g/animal/day)						
NZ	80.173 ±0.813	82.210 ±0.574	80.170 ±0.171	78.230 ±0.120	78.823 ±0.752	79.921 ±0.468
SC	79.393 ±0.758	77.853 ±2.463	81.220 ±0.670	79.423 ±0.827	77.987 ±1.338	79.175 ±0.616
Overall (Ration)	79.783 ±0.527	80.032 ±1.493	80.695 ±0.647	78.827 ±0.459	78.405 ±0.711	79.548 ±0.386
OM Voided in Faeces (g/animal/day)						
NZ	26.563[a] ±0.713	30.857[b] ±0.722	34.673[c] ±0.907	32.450[b] ±0.369	35.073[c] ±0.462	31.923[A] ±0.862
SC	26.967[a] ±0.107	29.307[b] ±0.526	32.490[c] ±0.670	34.380[d] ±0.669	28.203[ab] ±0.613	30.269[B] ±0.766
Overall (Ration)	26.765[a] ±0.335	30.082[b] ±0.529	33.582[c] ±0.702	33.415[c] ±0.550	31.638[d] ±1.574	31.096 ±0.587
OM Digested (g/animal/day)						
NZ	53.610 ±0.499	51.353 ±0.417	45.497 ±1.996	45.780 ±0.463	43.750 ±0.821	47.998 ±1.086

SC	52.457 ±0.767	48.547 ±2.495	48.730 ±0.510	45.043 ±0.258	45.117 ±1.575	47.979 ±0.902
Overall (Ration)	53.033^{a} ±0.484	49.950^{b} ±1.294	47.113^{c} ±1.171	45.412^{cd} ±0.289	44.433^{d} ±0.850	47.988 ±0.694
Digestibility Co-Efficient of OM (%)						
NZ	66.873 ±0.657	62.473 ±0.677	56.703 ±0.683	58.520 ±0.518	55.497 ±0.676	60.013 ±1.169
SC	66.067 ±0.344	62.277 ±1.377	60.000 ±0.641	56.720 ±0.426	57.817 ±1.058	60.576 ±0.951
Overall (Ration)	66.470^{a} ±0.378	62.375^{b} ±0.688	58.352^{c} ±1.092	57.620_{c} ±0.502	56.657^{c} ±0.764	60.295 ±0.742

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The organic matter (OM) intake during the metabolism trial followed the trend similar with that was observed in DM intake by the rabbits. The OM intake did not differ significantly among the breed, ration and ration × breed. The digestibility co-efficient of organic matter (DCOM) was significantly (P<0.01) influenced by the dietary variation. Similar comparable values of DCDM were observed in NZW rabbits (De Blas *et al*., 1986; Saikia, 1998) and in Grey Giant rabbit (Srinivas *et al*., 1994). The observed values of digestibility of sweet potato tuber in respect of organic matter per cent were 92.1 in raw, 94.5 in cooked (Canope *et al*., 1977), 96.1 in raw (Rose and White, 1980), 91.0 in silage (Tomita *et al*., 1985) and 91.8 in chips (Noblet *et al*., 1990). McDonald *et al*. (1973) reported that an increase in the crude fibre content of feeds by one percentage unit causes a reduction in the digestibility of total organic nutrients of 0.7 to 1.0 units for ruminants and of twice this value in pigs. Oyenuga and Fetuga (1975) and Canope *et al*. (1977) opined that cooking of sweet potato improved digestibility of all nutrients. Gercapio *et al*. (1978) observed a decreasing trend of digestibility co-efficient in poultry birds after gradual increase in sweet potato level in the diet and suggested that only 50 per cent or at the most 75 per cent replacement of the corn is advisable with sweet potato roots. Dominguez *et al.* (1991) observed that inclusion of sweet potato foliage lowered the digestibility of all nutrients due to increases in the fibre content of the diet. Yadav *et al*. (1995) reported significantly (P<0.01) increased digestibility co-efficient of organic matter after feeding sweet potato tuber in the pigs. The value increased from 71.02 ± 0.48 to 78.77 ± 0.01 per cent. Abu *et al.* (1999) observed a decreased trend of digestibility co-efficient of DM in rabbits at increased level of sweet potato incorporation in the diets. The DC was higher in T_3 (80:20 - sweet potato top: dehydrated sweet potato root meal) and the values ranged from 50.88 to 60.51 per cent). The results obtained in the present study, was in agreement with the reported results of above workers. Significantly lowered DCOM during metabolism trial in the sweet potato based rations (Ration 2, 3, 4 and 5) than the control group (Ration 1) might be due to increased level of sweet potato in the composite ration.

Intake and Digestibility Co-Efficient of Crude Protein (CP)

There was no significant difference between the breed, breed × ration in respect of CP intake, CP digested and digestibility co-efficient of CP, but there was significant (P<0.01) difference among the breeds in respect of CP voided. NZ breed (4.88 ± 0.06 g) voided more CP in faeces than SC breed (4.80 ± 0.05 g). No significant differences were recorded among the Ration 1, 2, 3 and again in 1, 4, and 5 in respect of CP intake. During the metabolism trial increasing trend of CP voided in faeces, and a declining trend in CP digested and digestibility co-efficient was observed along with the increasing level of sweet potato in the diets (Table 7). The digestibility of co-efficient of CP were 72.28 ± 0.32, 70.96 ± 0.07, 68.89 ± 0.27, 70.45 ± 0.39 and 68.98 ± 0.31 in Ration 1, 2, 3 and 4 and 5, respectively (Table 7).

Table 7: Mean Intake (Mean ± SE) and Digestibility Coefficient of Crude Protein (CP) in Rabbits During Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
CP Intake (g/animal/day)						
NZ	16.393 ±0.168	16.813 ±0.116	16.393 ±0.238	15.997 ±0.026	16.120 ±0.156	16.343 ±0.096
SC	16.233 ±0.154	16.448 ±0.076	16.607 0.137	16.243 ±0.169	15.947 ±0.274	16.303 ±0.090
Overall (Ration)	16.313[abc] ±0.108	16.648[ab] ±0.096	16.500[a] ±0.132	16.120[c] ±0.094	16.033[c] ±0.146	16.323 ±0.065
CP voided in Faeces (g/animal/day)						
NZ	4.527 ±0.050	4.873 ±0.050	5.163 ±0.032	4.833 ±0.064	5.030 ±0.035	4.885[A] ±0.060
SC	4.513 ±0.054	4.797 ±0.009	5.100 ±0.061	4.690 ±0.038	4.910 ±0.031	4.802[B] ±0.055
Overall (Ration)	4.520[a] ±0.033	4.835[b] ±0.029	5.132[c] ±0.034	4.762[b] ±0.046	4.970[d] ±0.034	4.844 ±0.041
CP Digested (g/animal/day)						
NZ	11.867 ±0.174	11.940 ±0.071	11.230 ±0.228	11.163 ±0.087	11.090 ±0.155	11.458 ±0.114
SC	11.720 ±0.202	11.687 ±0.067	11.507 ±0.082	11.553 ±0.171	11.037 ±0.277	11.501 ±0.094
Overall (Ration)	11.793[a] ±0.124	11.813[a] ±0.072	11.368[b] ±0.125	11.358[b] ±0.122	11.063[b] ±0.142	11.479 ±0.073
Digestibility Co-Efficient of CP (%)						
NZ	72.380 ±0.406	71..013 ±0.132	68.493 ±0.422	69.783 ±0.442	68.790 ±0.341	70.092 ±0.410
SC	72.187 ±0.572	70.900 ±0.079	69.293 ±0.149	71.117 ±0.372	69.180 ±0.576	70.535 ±0.343
Overall (Ration)	72.283[a] ±0.317	70.957[b] ±0.074	68.893[c] ±0.269	70.450[b] ±0.394	68.985[c] ±0.312	70.314 ±0.266

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The observed values of crude protein (CP) intake during metabolism trial were comparable to the reported values (10.39 to 16.60 g/day) by Kumar (1995), (13.12 to 15.23 g/day) by Saikia (1998) and (10.87 to 17.15 g/day) by Rohilla *et al*. (2002). The CP intake (Table 4.18) followed the similar trend observed in DM intake. The variation in CP intake might be for the variation observed in DM intake by the rabbits and the reason for this variation might be the same as discussed at DM intake. The values of digestibility co-efficient of crude protein (DCCP) in rabbits were significantly (P<0.01) lowered in the sweet potato based rations (Ration 2, 3, 4 and 5) than the control group (Ration 1). The observed values of the present experiment were comparable and within the reported range of 63.56 to 78.34 (De Blas *et al*., 1986), 62.6 to 78.0 (Aderibigbe *et al*., 1990), 61.0 to68.8 (El-Sayaad, 1992), 48.80 to 70.29 (Kumar, 1995) and 60.93 to 72.28 (Saikia, 1998) and 61.88 to 74.77 (Abu *et al*., 1999) in rabbits. Protein digestibility is closely related to the quantity of protein (De Blas *et al*., 1984) and the type of raw material incorporated in the diet (Fraga *et al*., 1984). Amino acid analysis of sweet potato roots shows them to be of good nutritional quality but deficient in total sulphur amino acids and lysine in terms of the ideal protein (Fuller and Chamberlain, 1982). The presence of trypsin inhibitors in the raw sweet potato roots could decrease the protein digestibility in mixed feed. In raw sweet potato the percentage of trypsin inhibitor is 78.8 whereas in cooked sweet potato is only 16.7 per cent (Martinez and Dominguez, 1991). Gerpacio *et al*. (1978) conducted an experiment with poultry chicks by replacement of corn with various levels of sweet potato and observed that the digestibility of protein decreased along with the increased level of sweet potato. The digestibility of sweet potato per cent in respect of nitrogen were reported by Canope *et al*., 1977 (27.6 in raw and 52.8 in cooked), Rose and White, 1980 (49.8 in raw), Tomita *et al*., 1985 (32 in silage) and Noblet *et al*., 1990 (52.3 in chips). French (1955) observed the digestibility per cent of crude protein in fresh sweet potato in sheep was 37.5, whereas, Nenmark (1970) reported only 14.0 per cent. Tomita *et al*. (1985) evaluated ensiled sweet potato and observed the poor nitrogen digestibility and was probably due to antitryptic factors, which though low, are not totally eliminated by means of this method of conservation (Lin *et al*., 1988). Aderibigbe *et al*. (1990) reported that DCCP decreased along with the increased level of almond hulls in the diet of NZW rabbits. Dominguez *et al*. (1991) observed that the digestibility of nitrogen decreased from 89.6 to 73.3 percent along with the increased level of sweet potato roots in the pigs diet and opined that the nitrogen digestibility is somewhat low because of the poor digestibility of sweet potato protein, even when cooked. Yadav *et al*. (1995) reported the digestibility per cent of crude protein in pigs to be 40.99 to 63.29 in Expt. 1 and 52.42 to 60.00 in Expt. 2 and the values were decreased along with the increased level of sweet potato tuber in diets in both the experiments and opined that this might be due to low crude fibre content in the rations. Abu *et al*. (1999) found a decreased trend of CP digestibility in the ration of rabbit along with the increased level of sweet potato incorporation in the diet. The maximum CP digestibility was observed in T_3 (80% dehydrated sweet potato tops and 20% root meal) ration. In the present study, the digestibility co-efficient of CP showed a decreasing trend along with increase level of sweet potato in the ration. This might be due to increased level of sweet potato tuber in the concentrate mixture.

Intake and Digestibility Co-Efficient of Ether Extract (EE)

There were no significant differences among the breed (except ether extract intake), breed × ration in respect of intake, voided in faeces, digested and digestibility co-efficient. However, there were significant differences among the rations in respect of intake, voided in faeces, digested and digestibility co-efficient, respectively. Ether extract intake was significantly higher ($P<0.05$) in NZ (2.37 ± 0.09 g) than SC (2.35 ± 0.01 g) and the groups those consumed sweet potato based rations i.e. Ration 2 (2.37 ± 0.01), Ration 3 (2.36 ± 0.01), Ration 4 (2.36 ± 0.00) and Ration 5 (2.37 ± 0.02) g, respectively than the Ration 1 (control) group (Table 8). An increasing trend of ether extract digestibility was observed in sweet potato based rations i.e. Ration 2, 3, 4 and 5 than control group (Ration 1). Digestibility co-efficient was found to be higher in all the experimental groups than the control group.

Table 8: Mean Intake (Mean ± SE) and Digestibility Coefficient of Ether Extract (EE) in Rabbits During Metabolism Trail

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
EE Intake (g/animal/day)						
NZ	2.2330 ±0.025	2.390 ±0.017	2.360 ±0.006	2.367 ±0.009	2.397 ±0.012	2.369^{A} ±0.009
SC	2.320 ±0.015	2.353 ±0.012	2.353 ±0.009	2.363 ±0.003	2.350 ±0.025	2.348^{B} ±0.007
Overall (Ration)	2.325^{a} ±0.013	2.372^{b} ±0.012	2.357^{b} ±0.005	2.365^{b} ±0.004	2.373^{b} ±0.016	2.358 ±0.006
EE Voided in Faeces (g/animal/day)						
NZ	0.503 ±0.009	0.480 ±0.006	0.517 ±0.007	0.490 ±0.006	0.503 ±0.003	0.499 ±0.004
SC	0.513 ±0.003	0.480 ±0.006	0.510 ±0.006	0.500 ±0.006	0.503 ±0.009	0.501 ±0.004
Overall (Ration)	0.508^{a}	0.480^{b}	0.513^{a}	0.495^{c}	0.503^{ac}	0.500

	±0.005	±0.004	±0.004	±0.004	±0.004	±0.003
EE Digested (g/animal/day)						
NZ	1.827 ±0.034	1.910 ±0.015	1.843 ±0.012	1.877 ±0.014	1.893 ±0.013	1.870 ±0.011
SC	1.807 ±0.012	1.873 ±0.017	1.843 ±0.003	1.863 ±0.007	1.877 ±0.014	1.853 ±0.008
Overall (Ration)	1.817[a] ±0.017	1.892[b] ±0.013	1.843[ac] ±0.006	1.870[bc] ±0.008	1.885[b] ±0.010	1.861 ±0.007
Digestibility Co-Efficient of EE (%)						
NZ	78.383 ±0.615	79.913 ±0.210	78.107 ±0.329	79.290 ±0.321	78.997 ±0.198	78.938 ±0.221
SC	77.873 ±0.031	79.600 ±0.329	78.330 ±0.165	78.843 ±0.247	78.850 ±0.422	78.699 ±0.186
Overall (Ration)	78.128[a] ±0.298	79.757[b] ±0.188	78.218[a] ±0.172	79.067[c] ±0.207	78.923[c] ±0.211	78.819 ±0.144

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

Significant difference (P<0.05) was observed among the breeds and between the control group (Ration 1) and sweet potato based rations (Ration 2, 3, 4 and 5). The intake of EE in present study was higher than the reported values (1.41 to 1.67 g/day) of Saikia (1998). The digestibility co-efficient values of ether extract observed in metabolism trial were comparable to the values reported by El-Baki *et al*. (1992) and Saikia (1998) in NZW rabbits, Ridzwan *et al*. (1993) in French White rabbits. However, values were lower than the reported value 81.17 to 83.20 (Kumar, 1995) in WG and SC rabbits. French (1955) observed the digestibility percent of ether extract in fresh sweet potato tuber in sheep as 51.6, whereas Nenmark (1970) reported 74.0 per cent. Yadav *et al*. (1995) found the digestibility co-efficient of ether extract in pig in Expt.1 63.89 (control), 67.77 (50% sweet potato tuber with vines) and 52.27 (100% sweet potato with vines) and in Expt.2 55.26 (without sweet potato tubers) and 57.21% (with sweet potato tubers). Swarooparani *et al*. (1997) showed that enhanced dietary energy levels improved the digestibility of ether extract. Abu *et al*. (1999) reported apparent digestibility of ether extractives to be 80.12 to 87.26 per cent in rabbit when sweet potato root was incorporated in the diets and DC was maximum in T_4 (70:30, dehydrated sweet potato top: root meal) ration. The higher digestibility of EE in Ration 4 and 5 might be due to higher intake of EE from these rations.

Intake and Digestibility Co-Efficient of Crude Fibre (CF)

There were no significant differences among the breed in respect of CF intake, voided in faeces, CF digested and digestibility co-efficient of CF. However, there were significant differences among the ration, ration × breed in all the above mentioned traits. In respect of CF intake and CF voided there was an increasing trend along with the increased percentage of sweet potato level in the diet. CF digested was maximum in Ration 1 (4.20 ± 0.10 g) and Ration 5 (3.96 ± 0.06 g) followed by Ration 2 (3.53 ± 0.03), Ration 4 (3.42 ± 0.03 g) and Ration 3 (3.36 ± 0.06 g) groups, respectively (Table 9). The digestibility co-efficient was highest in control group (45.40 ± 0.63) followed by Ration 5 (41.19 ± 0.49), Ration 2 (38.85 ± 0.38), Ration 4 (37.25 ± 0.33) and Ration 3 (37.05 ± 0.53) groups, respectively (Table 9).

Table 9: Mean Intake (Mean ± SE) and Digestibility Coefficient of Crude Fibre (CF) in Rabbits During Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
CF intake (g/animal/day)						
NZ	9.453^{a} ±0.118	9.107^{b} ±0.048	9.033^{b} ±0.049	9.167^{b} ±0.009	9.583^{a} ±0.035	9.269 ±0.061
SC	9.173^{a} ±0.014	9.073^{a} ±0.022	9.090^{a} ±0.035	9.177^{a} ±0.019	9.627^{b} ±0.072	9.228 ±0.056
Overall (Ration)	9.313^{a} ±0.082	9.090^{bc} ±0.025	9.062^{b} ±0.030	9.172^{c} ±0.009	9.605^{d} ±0.037	9.248 ±0.041
CF Voided in Faeces (g/animal/day)						
NZ	5.097+ ±0.050	5.630^{b} ±0.046	5.750^{b} ±0.058	5.707^{b} ±0.050	5.713^{b} ±0.052	5.579 ±0.068
SC	5.130^{a} ±0.011	5.487^{be} ±0.047	5.657^{c} ±0.027	5.803^{d} ±0.012	5.567^{ce} ±0.034	5.529 ±0.061
Overall (Ration)	5.113^{a} ±0.024	5.558^{b} ±0.043	5.703^{cd} ±0.035	5.755^{c} ±0.031	5.640^{bd} ±0.043	5.554 ±0.045
CF Digested (g/animal/day)						
NZ	4.357^{a} ±0.151	3.477^{b} ±0.022	3.328^{b} ±0.082	3.460^{b} ±0.046	3.870^{c} ±0.075	3.689 ±0.108
SC	4.043^{a} ±0.003	3.587^{b} ±0.035	3.433^{bc} ±0.059	3.373^{c} ±0.023	4.060^{a} ±0.042	3.699 ±0.080
Overall (Ration)	4.200^{a} ±0.097	3.532^{bd} ±0.031	3.358^{c} ±0.056	3.417^{cd} ±0.030	3.965^{e} ±0.057	3.694 ±0.066
Digestibility Co-Efficient of CF (%)						
NZ	46.063^{a} ±1.503	38.177^{bd} ±0.259	36.340^{c} ±0.782	37.747^{cd} ±0.515	40.377^{e} ±0.677	39.741 ±0.952
SC	44.743^{a} ±0.659	39.530^{b} ±0.428	37.767^{c} ±0.512	36.760^{c} ±0.197	42.003^{d} ±0.296	40.161 ±0.794
Overall (Ration)	45.403^{a} ±0.629	38.853^{b} ±0.376	37.053^{c} ±0.526	37.253^{c} ±0.331	41.190^{d} ±0.491	39.951 ±0.610

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The observed range of total crude fibre intake (g/animal/day) during metabolism trial was comparable to the reported range of 6.88 to 10.88 g/day by Kumar (1995) and 7.62 to 9.52 g/day by Saikia (1998). The significant (P<0.01) variation in CF intake during the metabolism trial might be due to the variation in the DM intake by rabbits and the CF content of concentrate mixtures. Diets significantly (P<0.01) influenced the digestibility co-efficient of crude fibre (DCCF) during metabolism trial. The observed range of DCCF were comparable to the reported range of 16.7 to 40.0 by Martinez Pascual and Fernandez Carmona (1980), 18.32 to 38.33 by Bora *et al*. (1996), 18.96 to 38.35 by Dutta *et al*. (1997), 15.83 to 41.56 by Saikia (1998), but higher than the values (17.35 to 32.26) reported by De Blas *et al*. (1986). Digestibility of the crude fibre is related to the cellulose and hemicellulose fraction of the feed since feed high in cellulose and lignin generally have a CF digestibility of less than 15 per cent in rabbits (Voris *et al*., 1940; Maertens and De Groote, 1984). De Blas *et al*. (1986) reported that DCCF was higher (32.26%) in the diet with lowest fibre content than in all the other diets (17.5%). Ridzwan *et al*. (1993) observed slightly lower crude fibre digestibility in rabbits receiving diets containing cocoa-pod husks due to higher level of cellulose than the control diet. Gerpacio *et al*. (1978) observed in poultry birds that the increased level of incorporation of sweet potato from 0 to 100 per cent decreased the CF digestibility from 59.5 to 34.0 per cent. Dominguez *et al*. (1991) reported that digestibility of CF decreased from 76.6 to 67.7 per cent along with the increased level of incorporation of sweet potato in the pig ration. However, Yadav *et al*. (1995) observed a significant

(P<0.05) increase in CF digestibility per cent (51.06 to 57.61 in Experiment. 1 and 47.01 to 64.50 in Experiment. 2) in pigs with increased level of sweet potato tubers in the diet. Whereas, Abu *et al*. (1999) reported no significant difference in apparent digestibility of crude fibre (range 30.68 to 34.88) due to increased level of sweet potato in the rabbit rations

The significantly lower digestibility co-efficient of CF was observed in the sweet potato incorporated diets (Ration 2, 3, 4 and 5) as the level of fibre in these rations were higher than the control diet (Ration 1).

Intake and Digestibility Co-Efficient of Nitrogen Free Extract (NFE)

There were no significant differences among the breed, breed × Ration in respect of NFE intake, voided in faeces, digested and digestibility co-efficient. However, significant differences were found among the rations in all the above mentioned traits. There was an increasing trend of NFE intake, NFE digested and digestibility co-efficient along with the increasing level of sweet potato in the rations. The same trend was also followed in NFE voided in faeces except Ration 5 groups (Table 10).

Table 10: Mean Intake (Mean ± SE) and Digestibility Coefficient of Nitrogen Free Extract (NFE) in Rabbits During Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
NFE Intake (g/animal/day)						
NZ	51.897 ±0.528	52.693 ±0.369	52.627 ±0.767	54.153 ±0.554	52.663 ±0.279	52.807 ±0.280
SC	51.393 ±0.490	51.657 ±0.234	53.317 ±0.438	53.030 ±0.126	52.603 ±0.687	52.400 ±0.262
Overall (Ration)	51.645[a] ±0.341	52.175[ac] ±0.303	52.972[bc] ±0.424	53.592[b] ±0.357	52.633[ab] ±0.332	52.603 ±0.192
NFE Voided in Faeces (g/animal/day)						
NZ	15.737 ±0.292	16.870 ±0.178	16.847 ±0.179	17.930 ±0.346	15.403 ±0.162	16.557 ±0.258
SC	15.827 ±0.358	17.083 ±0.180	16.200 ±0.555	16.527 ±0.362	15.777 ±0.289	16.283 ±0.190
Overall (Ration)	15.782[a] ±0.208	16.977[bc] ±0.123	16.523[b] ±0.298	17.228[c] ±0.386	15.590[a] ±0.170	16.420 ±0.160
NFE Digested (g/animal/day)						
NZ	36.160 ±0.292	35.823 ±0.262	35.780 ±0.774	36.223 ±0.473	37.260 ±0.383	36.249 ±0.229
SC	35.567 ±0.847	34.573 ±0.401	37 .117 ±0.620	36.503 ±0.324	36.827 ±0.437	36.117 ±0.326
Overall (Ration)	35.863[ac] ±0.422	35.198[a] ±0.352	36.448[bc] ±0.535	36.363[bc] ±0.264	37.043[b] ±0.277	36.183 ±0.196
Digestibility Co-Efficient of NFE (%)						
NZ	69.677 ±0.313	67.983 ±0.222	67.977 ±0.552	66.893 ±0.542	70.747 ±0.403	68.655 ±0.401
SC	69.187 ±0.989	66.927 ±0.488	69.617 ±0.016	68.833 ±0.652	70.110 ±0.185	68.935 ±0.403
Overall (Ration)	69.432[ac] ±0.477	67.455[b] ±0.337	68.797[ad] ±0.634	67.863[bd] ±0.576	70.428[c] ±0.245	68.795 ±0.280

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The mean intake of NFE (g/animal/day) during metabolism trial was comparable to the values reported by Kumar (1995) in White Giant breed (WG) and SC rabbits and Saikia (1998) in NZW rabbits. The digestibility co-efficient of NFE

(DCNFE) during metabolism trial were comparable with the observed values (61.20 to 80.70) by Lall *et al*. (1985), (56.80 to 70.61) by Kumar (1995) and (62.61 to 80.26) by Saikia (1998). However, Alicata *et al*. (1992) observed no significant difference in NFE digestibility in NZW rabbits fed diets containing 0, 10 and 20 per cent chickpeas. Rabbits on diets containing alkali treated, water washed neem seed meal and GNC were similar in all the experimental groups (Bhosale, 1994). Yadav *et al*. (1995) reported a higher digestibility percent of NFE in pigs along with the incorporation of increased level of sweet potato tubers (75.31 to 92.46% in Expt. 1 and 77.46 to 86.86% in Expt. 2) in the rations. In the present study the significantly (P<0.01) higher digestibility of NFE of Ration 5 could be due to lower fibre content since the percentage of wheat bran and rice bran was less as compared to other rations.

Intake and Digestibility Co-Efficient of Total Carbohydrate (TCHO)

There were no significant differences among the breed and breed × ration in respect of intake, voided in faeces, digested and digestibility co-efficient of total carbohydrate, respectively but, highly significant (P<0.01) differences was observed among the rations in respect of all the above mentioned traits. There was an increasing trend of total carbohydrate intake, digested and digestibility co-efficient along with the increasing level of sweet potato percentage in the rations (Table 11).

Table 11: Mean Intake (Mean ± SE) and Digestibility Co-Efficient of Total Carbohydrate (TCHO) in Rabbits During Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
TCHO Intake (g/animal/day)						
NZ	61.647 ±0.628	62.537 ±0.436	63.820 ±0.174	62.880 ±0.070	61.877 ±0.113	62.552 ±0.247
SC	61.050 ±0.583	61.307 ±0.281	64.287 ±0.247	62.890 ±0.073	61.853 ±0.110	62.277 ±0.339
Overall (Ration)	61.348[a] ±0.406	61.922[a] ±0.360	64.053[b] ±0.171	62.885[c] ±0.046	61.865[a] ±0.071	62.415 ±0.207
TCHO Voided in Faeces (g/animal/day)						
NZ	16.103 ±0.098	18.640 ±0.268	17.443 ±0.168	15.713 ±0.303	18.657 ±0.283	17.311 ±0.342
SC	16.213 ±0.103	18.013 ±0.021	17.733 ±0.206	16.610 ±0.485	18.490 ±0.274	17.412 ±0.252
Overall (Ration)	16.158[a] ±0.068	18.327[b] ±0.185	17.588[c] ±0.135	16.162[a] ±0.325	18.573[b] ±0.180	17.362 ±0.209
TCHO Digested (g/animal/day)						
NZ	45.543 ±0.707	43.897 ±0.347	46.377 ±0.197	47.167 ±0.282	43.220 ±0.185	45.240 ±0.423
SC	44.837 ±0.685	43.293 ±0.301	46.553 ±0.143	46.280 ±0.552	43.363 ±0.384	44.865 ±0.408
Overall (Ration)	45.190[a] ±0.468	43.595[b] ±0.246	46.465[c] ±0.116	46.723[c] ±0.341	43.292[b] ±0.193	45.053 ±0.291
Digestibility Co-Efficient of TCHO (%)						
NZ	73.870 ±0.408	70.193 ±0.347	72.670 ±0.248	75.010 ±0.472	69.850 ±0.408	72.319 ±0.559
SC	73.437 ±0.420	70.617 ±0.170	72.413 ±0.245	73.587 ±0.800	70.103 ±0.496	72.031 ±0.424
Overall (Ration)	73.653[a] ±0.279	70.405[b] ±0.197	72.542[c] ±0.166	74.298[a] ±0.523	69.977[b] ±0.293	72.175 ±0.345

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The intake of total carbohydrate was significantly (P<0.01) higher in Ration 3 and Ration 4 groups than the control (Ration 1) group and there was no significant difference among Ration 1, 2 and 5. The digestibility co-efficient of total carbohydrate differed significantly (P<0.01) due to dietary variation. Carbohydrates generally make up between 80 to 90 per cent of the dry weight of sweet potato roots; however, the uncooked starch of the sweet potatoes is very resistant to the hydrolysis by amylase. When cooked, their susceptibility to the enzymes increases. Thus, after cooking the easily hydrolysable starch fraction of sweet potato increases from 4 to 55 per cent (Cerning-Beroard and Le Dividich, 1976). The structure of sweet potato starch does not differ from that of cereals and mandioca (Szylit *et al.*, 1978). Cooking sweet potato is therefore necessary for starch digestibility (Dominguez, 1991). Yoshida and Morimoto (1958) reported that the carbohydrate fraction in sweet potato to be about 90 per cent digestible in chicks. The significantly (P<0.01) higher digestibility of total carbohydrate in the Ration 3 and 4 might be due to higher level of NFE intake from these rations and thus higher amount of soluble carbohydrate (boiled sweet potato) ingested than the other groups.

Intake, Digestibility and Metabolisability of Gross Energy (GE) Of Feed

There were no significant differences among the breed in respect of GE intake, faecal energy loss, digestible energy (DE), digestibility percent, metabolisable energy (ME) and metabolisability per cent except urinary energy (UE) loss. The UE loss was significantly (P<0.05) higher in SC breed than NZ breed. GE intake, DE, UE loss and ME were significantly differed among the rations. However, there were no significant differences among the FE loss, digestibility per cent and metabolisability percent (Table 12). Ration × breed significantly differed in respect of FE loss, digestibility per cent and metabolisability percent.

Table 12: Mean Intake, Digestibility and Metabolisability of Gross Energy (GE) of Feed in Rabbits During Metabolism Trial

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
I	II	III	IV	V	VI	VII
GE Intake (Kcal/animal/day)						
NZ	371.963 ±3.782	381.417 ±2.665	377.313 ±5.505	366.410 ±0.559	368.340 ±3.521	373.089 ±2.016
SC	368.350 ±3.522	373.910 ±1.709	382.250 ±3.149	372.023 ±3.876	364.420 ±6.254	372.191 ±2.198
Overall (Ration)	370.157[ab] ±2.449	377.663[ac] ±2.196	379.782[c] ±3.043	369.217[b] 2.154	366.380[b] ±3.328	372.640 ±1.468
Faecal Energy Loss (Kcal/animal/day)						
NZ	84.657[ab] ±0.751	85.153[a] ±1.178	84.800[ab] ±0.230	82.413[b] ±0.554	86.893[a] ±0.176	84.783 ±0.461
SC	84.977[a] ±0.967	84.440[a] ±1.484	87.810[b] ±1.229	85.667[ab] ±0.757	80.203[c] ±0.927	84.619 ±0.784
Overall (Ration)	84.817 ±0.552	84.797 ±0.862	86.305 ±0.875	84.040 ±0.840	83.548 ±1.554	84.701 ±0.448
Digestible Energy ((Kcal/animal/day)						
NZ	287.440 ±4.400	296.263 ±1.496	292.513 ±5.463	283.997 ±0.651	281.447 ±3.568	288.332 ±1.988
SC	283.373 ±3.208	289.470 ±2.990	294.440 ±4.250	286.690 ±4.170	284.217 ±5.372	287.638 ±1.880
Overall (Ration)	285.407[ac] ±2.600	292.867[ab] ±2.132	293.477[b] ±3.125	285.343[ac] ±1.981	282.832[c] ±2.950	287.985 ±1.346
Digestibility (%)						
NZ	77.270[ab] ±0.400	77.680[a] ±0.153	77.513[a] ±0.316	77.507[a] ±0.145	76.407[b] ±0.242	77.275 ±0.158

SC	76.930[a] ±0.254	77.413[ab] 0.482	77.020[a] ±0.494	77.057[ab] 0.322	77.990[b] ±0.152	77.282 ±0.173
Overall (Ration)	77.100 ±0.225	77.547 ±0.234	77.267 ±0.284	77.282 ±0.188	77.198 ±0.376	77.279 ±0.115
Urinary Energy Loss ((Kcal/animal/day)						
NZ	15.217 ±0.222	14.923 ±0.072	16.120 ±0.074	16.913 ±0.103	16.973 ±0.073	16.029[A] ±2.230
SC	15.780 ±0.040	14.787 ±0.094	16.287 ±0.227	17.260 ±0.206	17.123 ±0.090	16.247[B] ±0.250
Overall (Ration)	15.498[a] ±0.161	14.855[b] ±0.061	16.203[c] ±0.113	17.087[d] ±0.129	17.048[d] ±0.061	16.138 ±0.168
Metabolisable Energy ((Kcal/animal/day)						
NZ	272.223 ±4.341	281.340 ±1.502	276.393 ±5.533	267.083 ±0.649	264.473 ±3.620	272.303 ±2.130
SC	267.593 ±3.168	274.683 ±2.965	278.153 ±4.460	269.430 ±3.975	267.093 ±5.422	271.391 ±1.932
Overall (Ration)	269.908[ac] ±2.617	278.012[b] ±2.105	277.273[ab] ±3.202	268.257[c] 1.877	265.783[c] ±2.974	271.847 ±1.415
Metabolisability (%)						
NZ	73.177[a] 0.428	73.763[a] ±0.136	73.240[a] ±0.397	72.890[a] ±0.124	71.797[b] ±0.303	72.973 ±0.209
SC	72.643 ±0.266	73.457 ±0.484	72.760 ±0.586	72.417 ±0.320	73.283 ±0.247	72.912 ±0.185
Overall (Ration)	72.910 ±0.255	73.610 ±0.235	73.000 ±0.334	72.653 ±0.186	72.540 ±0.376	72.943 ±0.137

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.05)

Dietary variation significantly (P<0.01) influenced the mean intake of gross energy (Kcal/animal/day) during metabolism trial. The reason of the variation observed in GE intake during metabolism trial might be the variation observed in DM intake by rabbits of different groups since voluntary feed intake is regulated according to energy need (Cheeke, 1987).Kumar (1995) observed significant differences in GE intake (Kcal/day) among the groups of rabbits receiving diets containing 0, 5, 10 and 20 per cent neem seed kernel cake. The observed values of GE intake during the metabolism trial were comparable to the values reported by Kumar (1995) and Saikia (1998). Fetuga and Oluyemi (1976) obtained a co-efficient of metabolisable energy of 90.9 or 87.2 in diets where the sweet potato tuber replaced 25 or 40 per cent of the glucose in a basal diet in chicks. Gerpacio *et al*. (1978) also observed the digestibility or availability of energy by replacing 0, 50, 75 and 100 per cent of corn in the ration of chicks up to 6 weeks of age and observed the metabolisable energy per cent 82.6, 64.3, 70.0 and 73.7, respectively and also opined that the presence of non-identified factors which inhibit the digestive and metabolic processes in sweet potato based rations. These factors caused the low energy values even when the rations contained adequate and high quality proteins. Oyenuga and Fetuga (1975) reported that cooking did not significantly affect the utilization of energy, but increased the digestibility of the nutrients. Rose and White (1980) observed a very high value (15.8 MJ/kg DM) digestible energy in pigs when they received low quantities of raw sweet potatoes and opined that a depression in apparent digestibility might be expected as the level of intake increased. Tomita *et al*. (1985) evaluated ensiled sweet potato and found high digestible energy value and might be due to the high gross energy value of the sweet potato silage. DE of sweet potato tuber was reported by various workers viz. Canope *et al*., 1977 (14.2 MJ in Raw and 14.5 MJ in cooked /kg DM), Rose and White, 1980 (15.8 MJ/kg DM), Tomita *et al*., 1985 (16.3 MJ/kg DM) and Noblet *et al*., 1990 (15.3 MJ/kg DM). Dominguez (1991) opined that the DE of cooked sweet potato diets was high (14.0 to 15.8 MJ/ kg DM). Takahashi *et al*. (1968) reported that the DE of sweet potato foliage is 4.1 MJ/kg DM and

Ravi *et al*. (2001) observed the GE of sweet potato vines 3644 Kcal/kg. French (1955) observed the metabolisability percent of fresh sweet potato tuber 3.24, whereas, Nenmark (1970) reported 2.71 per cent in sheep.There was no significant difference due to ration in digestibility and metabolisability percent of gross energy. The present findings are in corroboration with the findings of previous workers.

Nitrogen Balance in Rabbits

Although no significant (P<0.05) difference was observed among the breed and breed × ration in respect of nitrogen intake, nitrogen loss and nitrogen retention, however, significant (P<0.01) differences were observed in respect of all the above mentioned traits due to rations. Nitrogen intake was significantly (P<0.01) reduced along with the increased level of sweet potato in the diet in comparison to the control ration (Ration 1). The similar trend was followed in nitrogen loss and nitrogen retention also (Table 13).

Table 13: Nitrogen Balance in Rabbits during Metabolism Trial (Mean ± SE)

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
I	II	III	IV	V	VI	VII
Nitrogen Intake (g/animal/day)						
NZ	2.437 ±0.014	2.347 ±0.009	2.240 ±0.015	2.160 ±0.006	2.133 ±0.009	2.263 ±0.031
SC	2.447 ±0.009	2.340 ±0.015	2.233 ±0.012	2.167 ±0.009	2.130 ±0.011	2.263 ±0.031
Overall (Ration)	2.442^{a} ±0.008	2.343^{b} ±0.008	2.237^{c} ±0.009	2.163^{d} ±0.005	2.132^{e} ±0.006	2.263 ±0.022
Faecal Nitrogen Loss (g/animal/day)						
NZ	0.827 ±0.014	0.827 ±0.014	0.757 ±0.018	0.727 ±0.019	0.713 ±0.009	0.770 ±0.014
SC	0.850 ±0.011	0.837 ±0.009	0.767 ±0.012	0.743 ±0.018	0.697 ±0.009	0.779 ±0.016
Overall (Ration)	0.838^{a} ±0.010	0.832^{a} ±0.008	0.762^{b} ±0.010	0.735^{b} ±0.012	0.705^{c} ±0.007	0.774 ±0.010
Urinary Nitrogen Loss (g/animal/day)						
NZ	0.337 ±0.007	0.380 ±0.006	0.367 ±0.003	0.463 ±0.009	0.467 ±0.009	0.403 ±0.014
SC	0.323 ±0.018	0.367 ±0.007	0.357 ±0.009	0.433 ±0.009	0.480 ±0.011	0.392 ±0.016
Overall (Ration)	0.330^{a} ±0.009	0.373^{b} ±0.005	0.362^{b} ±0.005	0.448^{c} ±0.009	0.473^{d} ±0.007	0.397 ±0.010
Total Nitrogen Loss (g/animal/day)						
NZ	1.163 ±0.009	1.207 ±0.019	1.123 ±0.019	1.190 ±0.011	1.180 ±0.000	1.173 ±0.009
SC	1.173 ±0.029	1.203 ±0.012	1.123 ±0.007	1.177 ±0.009	1.177 ±0.012	1.171 ±0.009
Overall (Ration)	1.168^{a} ±0.014	1.205^{b} ±0.010	1.123^{c} ±0.009	1.183^{ab} ±0.007	1.178^{ab} ±0.005	1.172 ±0.006
Net Nitrogen Retention (g/animal/day)						
NZ	1.273 ±0.013	1.140 ±0.023	1.117 ±0.007	0.970 ±0.010	0.953 ±0.009	1.091 ±0.032
SC	1.273 ±0.023	1.137 ±0.014	1.110 ±0.015	0.990 ±0.006	0.953 ±0.022	1.093 ±0.031
Overall (Ration)	1.273^{a} ±0.012	1.138^{b} ±0.012	1.113^{b} ±0.008	0.980^{c} ±0.007	0.953^{c} ±0.010	1.092 ±0.022
Nitrogen Retention as Percent of Intake						

NZ	52.253 ±0.347	48.573 ±0.877	49.857 ±0.516	44.907 ±0.479	44.687 ±0.229	48.055 ±0.804
SC	52.047 ±1.071	48.573 ±0.470	49.700 ±0.458	45.693 ±0.272	44.750 ±0.810	48.153 ±0.756
Overall (Ration)	52.150[a] ±0.506	48.573[b] ±0.445	49.778[b] ±0.310	45.300[c] ±0.302	44.718[c] ±0.377	48.104 ±0.542
Nitrogen Retention as Percent of Digested						
NZ	79.083 ±0.437	74.987 ±0.575	75.280 ±0.149	67.677 ±0.433	67.140 ±0.240	72.833 ±1.255
SC	79.740 ±1.167	75.603 ±0.559	75.690 ±0.267	69.560 ±0.406	66.467 ±1.033	73.418 ±1.302
Overall (Ration)	79.412[a] ±0.576	75.295[b] ±0.384	75.485[b] ±0.165	68.618[c] ±0.498	66.818[d] ±0.496	73.126 ±0.890

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

The mean intake of nitrogen (g/animal/day) during metabolism trial was comparable among the groups and was within the range of reported values 1.89 to 2.62 g/day (Kumar, 1995) and 2.10 to 2.44 g/day (Saikia, 1998), but lower than the values reported by Prasad *et al*. 1999 (3.30 to 4.46 g/day).The net retention of nitrogen during metabolism trial was comparable to the values reported by Kumar (1995), Dutta *et al*. (1997) and Saikia (1998). The nitrogen retention as percentage of intake as well as digested were comparable to the values reported by Martinez Pascual and Fernandez Carmona (1980) and Saikia (1998) in NZW rabbits. However, Gupta *et al*. (2001) observed negative balance of nitrogen in adult rabbits when Job's tears (*Coix lachryma*) and broom grass (*Thysanolaena agrostis*) were given as sole feeding. The digestibility of sweet potato tuber (%) in various forms in respect of nitrogen in pigs was recorded by various workers. Canope *et al*. (1977) and Rose and White (1980) found that digestibility of nitrogen in raw sweet potato tuber in pigs to be 27.6 and 49.8 per cent, respectively. However, Canope *et al*. (1977) observed in cooked sweet potato tuber 52.8 percent in pigs. Tomita *et al*. (1985) reported 32 per cent digestibility of sweet potato tuber in silage in pigs and Noblet *et al*. (1990) observed 52.3 per cent in chips. Dominguez *et al*. (1991) opined that nitrogen digestibility is somewhat low because of the poor digestibility of sweet potato protein even when cooked and reported the value 76.0 per cent in cooked sweet potato

Yadav *et al*. (1995) in an experiment in pigs observed a decreased trend of nitrogen balance when the incorporation of sweet potato tuber was increased in the diets and the values were 45.08 ± 3.54 per cent in control, 38.64 ± 0.69 per cent in 50% and 12.85 ± 1.00 per cent in 100% sweet potato based diets, respectively in pigs. The present findings in respect of nitrogen intake, retention and nitrogen balance as percent of intake and digested were in good agreement with the above workers and the declined trend of nitrogen balance in the present experiment might be due to incorporation of sweet potato tuber in the diet of rabbits.

Energy Balance in Rabbits

There were no significant differences among the breed and rations in respect of total GE loss but, there was highly significant (P<0.01) difference in breed x Ration. In respect of energy retention, the net retention and as percent of digested were significantly differed among the Rations, whereas percent of intake did not differed significantly. The net retention of GE was significantly higher (P<0.05) in Ration 2 and Ration 3 groups than the other three groups (Table 14).

Table 14: Energy Balance in Rabbits during Metabolism Trial (Mean ±SE)

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
Total Gross Energy Loss (Faecal + Urinary) (Kcal/day)						
NZ	99.873[a] ±0.708	100.077[a] ±1.188	100.920[a] ±0.206	99.327[a] ±0.466	103.867[b] ±0.241	100.813 ±0.499
SC	100.757[ab] ±0.977	99.227[ac] ±1.428	104.097[b] ±1.456	102.927[b] ±0.711	97.327[c] ±0.909	100.867 ±0.782
Overall (Ration)	100.315 ±0.574	99.652 ±0.852	102.508 ±0.968	101.127 ±0.890	100.597 ±1.521	100.840 ±0.456
Net Energy Retention (Kcal/day)						
NZ	272.090 ±4.473	281.340 ±1.502	276.393 ±5.533	267.083 ±0.649	264.473 ±3.620	272.276 ±2.137
SC	267.593 ±3.168	274.683 ±2.965	278.153 ±4.460	269.107 ±4.147	267.093 ±5.422	271.326 ±1.947
Overall (Ration)	269.842[ac] ±2.650	278.012[b] ±2.105	277.273[bc] ±3.202	268.095[a] ±1.931	265.783[a] ±2.974	271.801 ±1.423
Net Energy Retention as Per Cent of Intake						
NZ	73.140 ±0.465	73.763 ±0.136	73.240 ±0.397	72.890 ±0.124	71.797 ±0.303	72.966 ±0.211
SC	72.643 ±0.266	73.457 ±0.484	72.760 ±0.586	72.327 ±0.387	73.283 ±0.247	72.894 ±0.192
Overall (Ration)	72.892 ±0.264	73.610 ±0.235	73.000 ±0.334	72.608 ±0.221	72.540 ±0.376	72.930 ±0.140
Net Energy Retention as Per Cent of Digested						
NZ	94.653 ±0.130	94.963 ±0.036	94.483 ±0.124	94.043 ±0.036	93.970 ±0.095	94.423 ±0.106
SC	94.430 ±0.048	94.890 ±0.057	94.463 ±0.155	93.867 ±0.150	93.957 ±0.136	94.321 ±0.109
Overall (Ration)	94.542[a] ±0.080	94.927[b] ±0.034	94.473[a] ±0.088	93.955[c] ±0.079	93.963[c] ±0.074	94.372 ±0.076

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly.

The net retention of GE intake (Kcal/day) and retentions as percentage of intake as well as digested during metabolism trial were comparable to the values reported by Kumar (1995) and Saikia (1998) in rabbits fed diets containing different level of neem seed kernel cake and ajar seed cake, respectively. The net retention of energy was significantly (P<0.05) higher in the Ration 2 and 3 groups and there were no significant differences among Ration 1 (Control), 4 and 5. Wu (1980) observed that the net energy of sweet potato (8.5 MJ/kg DM) was only 79 per cent of that of corn, whereas, Noblet *et al*. (1990) found that net energy of sweet potato and corn were equivalent (12.3 MJ/kg DM) in chicks. Kumar (1995) and Saikia (1998) observed the similar trend of energy retention as percentage of intake as well as digested in rabbits. The present findings are in good agreement with the finding of the above workers.

Intake and Balance of Calcium in Rabbits

In respect of intake, total calcium loss and calcium retention (net retention and as percent of intake) the rations differed significantly, but there were no significant difference among the breed in respect of all the traits. Only urinary calcium loss differed significantly among the breed × ration. Intake of calcium was significantly (P<0.01) higher in sweet potato based rations than the control group (Ration 1). The total calcium loss was maximum in Ration 2 group and there were no significant differences among the other four groups (Table 15). Net calcium retention was significantly (P<0.01) higher in all the four groups that consumed sweet potato based rations than the control group. As per cent of intake in

Ration 2 group the retention was maximum (69.72 ± 0.42) and there were no significant differences among the other groups.

Table 15: Intake and Balance of Calcium in Rabbits during Metabolism Trial (Mean ± SE)

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
I	II	III	IV	V	VI	VII
Intake of Calcium (g/animal/day)						
NZ	1.357 ±0.013	1.447 ±0.009	1.400 ±0.020	1.383 ±0.003	1.410 ±0.011	1.399 ±0.009
SC	1.343 ±0.014	1.417 ±0.009	1.417 ±0.012	1.403 ±0.013	1.397 ±0.024	1.395 ±0.009
Overall (Ration)	1.350[a] ±0.009	1.432[b] ±0.009	1.408[bc] ±0.011	1.393[c] ±0.008	1.403[bc] ±0.012	1.397 ±0.006
Faecal Calcium Loss (g/animal/day)						
NZ	0.153 ±0.003	0.153 ±0.003	0.160 ±0.006	0.153 ±0.003	0.157 ±0.003	0.155 ±0.002
SC	0.157 ±0.003	0.153 ±0.003	0.167 ±0.003	0.157 ±0.003	0.160 ±0.006	0.159 ±0.002
Overall (Ration)	0.155 ±0.002	0.153 ±0.002	0.163 ±0.003	0.155 ±0.002	0.158 ±0.003	0.157 ±0.001
Urinary Calcium Loss (g/animal/day)						
NZ	0.290[ab] ±0.006	0.277[a] ±0.003	0.300[b] ±0.006	0.293[ab] ±0.009	0.280[a] ±0.006	0.288 ±0.003
SC	0.290[ab] ±0.009	0.283[ac] ±0.009	0.280[a] ±0.006	0.303[b] ±0.003	0.300[bc] ±0.006	0.291 ±0.003
Overall (Ration)	0.290 ±0.004	0.280 ±0.004	0.290 ±0.006	0.298 ±0.005	0.290 ±0.006	0.290 ±0.002
Total Calcium Loss (g/animal/day)						
NZ	0.443 ±0.003	0.430 ±0.000	0.460 ±0.006	0.447 ±0.007	0.437 ±0.009	0.443 ±0.003
SC	0.447 ±0.003	0.437 ±0.009	0.447 ±0.003	0.460 ±0.006	0.460 ±0.006	0.450 ±0.003
Overall (Ration)	0.445[ab] ±0.002	0.433[a] ±0.004	0.453[b] ±0.004	0.453[b] ±0.005	0.448[b] ±0.007	0.447 ±0.002
Net Calcium Retention (g/animal/day)						
NZ	0.913 ±0.012	1.017 ±0.009	0.940 ±0.025	0.937 ±0.009	0.973 ±0.020	0.956 ±0.011
SC	0.897 ±0.018	0.980 ±0.015	0.970 ±0.011	0.943 ±0.009	0.937 ±0.019	0.945 ±0.010
Overall (Ration)	0.905[a] ±0.010	0.998[b] ±0.011	0.955[c] ±0.014	0.940[c] ±0.006	0.955[c] ±0.015	0.951 ±0.007
Calcium Retention as Percent of Intake						
NZ	67.317 ±0.288	70.273 ±0.182	67.120 ±0.842	67.707 ±0.523	69.017 ±0.874	68.287 ±0.393
SC	66.737 ±0.591	69.170 ±0.734	68.467 ±0.303	67.220 ±0.210	67.060 ±0.208	67.731 ±0.303
Overall (Ration)	67.027[a] ±0.321	69.722[b] ±0.419	67.793[a] ±0.501	67.463[a] ±0.274	68.038[a] ±0.594	68.009 ±0.249

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.01)

Dietary variation influenced significantly (P<0.01) the intake of calcium during metabolism trial, which might be due to the variation in the DM intake by rabbits. Diet did not significantly influence the faecal and urinary calcium loss during the trial; however, total loss was significantly (P<0.05) influenced. The net retention of calcium (g/animal/day) observed during the trial were comparable to the range 0.47 to 1.50 g per day (Singh *et al*., 1994) in WG and 1.00 to 1.33 g per day (Saikia, 1998) in NZW rabbits. The net retention of calcium were significantly (P<0.01) higher in sweet potato incorporated rations. Numerous negative effects of dietary fibre on calcium balance have been reported (Kelsay *et al*., 1979; Morris and Ellis, 1980; Oku *et al*., 1982) indicating that the capacity of dietary polysaccharides to chelates cataions plays a role in mineral utilization. Besides, high dietary fibre reduces the gastrointestinal transit time, which may not permit optimal calcium absorption. Tortuero *et al*. (1989) and Saikia (1998) observed that calcium absorption was significantly lower in the groups given higher level of olive pulp and ajar seed kernel, respectively than in the control group of NZW rabbits. The significantly higher retention of calcium in Ration 2 could be due to higher intake of minerals. However, in other experimental groups no significant difference was observed.

Intake and Balance of Phosphorus in Rabbits

Phosphorus intake, urinary loss, total loss and net retention were significantly differed among the rations; however, there were no significant differences in faecal phosphorus loss and phosphorus retention as percent of intake (Table 16). There were no significant differences among the breeds in all the above mentioned traits except urinary phosphorus loss. The NZ breed significantly (P<0.05) lost more phosphorus than the SC breed. The net retention as percent of intake was significantly (P<0.05) differed among ration × breed. The intake of phosphorus, urinary phosphorus loss, total phosphorus loss and phosphorus retention was significantly higher in sweet potato based ration groups than the control group (Ration 1).

Table 16: Intake and Balance of Phosphorus in Rabbits during Metabolism Trial (Mean ± SE)

Attribute	Ration					Overall (Breed)
	1	2	3	4	5	
I	II	III	IV	V	VI	VII
Intake of Phosphorus (g/animal/day)						
NZ	0.543 ±0.007	0.620 ±0.006	0.613 ±0.009	0.580 ±0.000	0.570 ±0.006	0.585 ±0.008
SC	0.540 ±0.006	0.600 ±0.006	0.623 ±0.003	0.590 ±0.006	0.567 ±0.009	0.584 ±0.008
Overall (Ration)	0.542[a] ±0.004	0.610[bc] ±0.006	0.618[c] ±0.005	0.585[d] ±0.003	0.568[e] ±0.005	0.585 ±0.005
Faecal Phosphorus Loss (g/animal/day)						
NZ	0.090 ±0.006	0.100 ±0.006	0.087 ±0.003	0.093 ±0.003	0.087 ±0.003	0.001 ±0.002
SC	0.083 ±0.003	0.093 ±0.003	0.093 ±0.003	0.097 ±0.003	0.087 ±0.003	0.091 ±0.002
Overall (Ration)	0.087 ±0.003	0.097 ±0.003	0.090 ±0.003	0.095 ±0.002	0.087 ±0.002	0.091 ±0.001
Urinary Phosphorus Loss (g/animal/day)						
NZ	0.072 ±0.003	0.078 ±0.002	0.072 ±0.003	0.073 ±0.004	0.073 ±0.004	0.073[A] ±0.001
SC	0.067 ±0.004	0.082 ±0.004	0.086 ±0.002	0.082 ±0.003	0.075 ±0.003	0.078[B] ±0.002
Overall (Ration)	0.069[a] ±0.003	0.080[b] ±0.002	0.079[b] ±0.004	0.077[b] ±0.003	0.074[ab] ±0.002	0.076 ±0.001
Total Phosphorus Loss (g/animal/day)						
NZ	0.167 ±0.009	0.180 ±0.006	0.163 ±0.007	0.170 ±0.006	0.163 ±0.003	0.169 ±0.003
SC	0.153 ±0.007	0.177 ±0.003	0.183 ±0.003	0.183 ±0.003	0.163 ±0.007	0.172 ±0.004

Overall (Ration)	0.160[a] ±0.006	0.178[b] ±0.003	0.173[bc] ±0.006	0.177[b] ±0.004	0.163[ac] ±0.003	0.170 ±0.002
Net Phosphorus Retention (g/animal/day)						
NZ	0.380 ±0.006	0.440 ±0.001	0.460 ±0.006	0.417 ±0.007	0.410 ±0.010	0.421 ±0.008
SC	0.393 ±0.007	0.427 ±0.009	0.440 ±0.000	0.407 ±0.007	0.403 ±0.003	0.414 ±0.005
Overall (Ration)	0.387[a] ±0.005	0.433[b] ±0.005	0.450[c] ±0.005	0.412[d] ±0.005	0.407[d] ±0.005	0.418 ±0.005
Net Phosphorus Retention as Percent of Intake						
NZ	69.667[a] ±1.577	70.980[a] ±0.661	74.197[bc] ±0.853	71.263[a] ±1.033	72.083[ac] ±1.012	71.638 ±0.569
SC	72.213[a] ±0.978	70.803[ab] ±0.662	70.593[ab] ±0.377	69.480[b] ±0.682	71.430[ab] ±0.766	70.904 ±0.365
Overall (Ration)	70.940 ±1.006	70.892 ±0.420	72.395 ±0.907	70.372 ±0.682	71.757 ±0.586	71.271 ±0.339

N.B. Sub-class averages with at least one superscripts in common (lower case along the row and upper case along the column) do not differ significantly. (P<0.05)

Incorporation of sweet potato in the diet of rabbits significantly (P<0.01) influenced the intake of phosphorus during metabolism trial, which could be due to the variation observed in DM intake by the rabbits. Statistically no significant difference was observed among the groups during metabolism trial in respect of faecal phosphorus loss, however, there were significant (P<0.05) differences in urinary phosphorus and total phosphorus loss and net phosphorus retention. Thus, it is clear that there was no influence of sweet potato based diet on phosphorus utilization.

CONCLUSIONS

Use of sweet potato as replacement of maize in broiler rabbit ration and successful digestion cum metabolism trial indicates that sweet potato is a very good source of tuber crop which could be suitably incorporated in rabbit ration without adverse effect. It gives a positive balance of N, energy, Ca and P during metabolism trial. Hence the growth of animal could be achieved up to the desired level. The cost of maize grain is very high thus increases feed cost. Inclusion of sweet potato in animal diet will reduce the feed cost and could be supplemented as energy source.

REFERENCES

1. A.O.A.C. (1980). Official methods of analysis, 13th edn., Association of Official Analytical Chemists. Washington, D.C. USA.
2. Abu, O.A. (1997). Biochemical characterization and utilization of processed sweet potato (Ipomoea batatas) for rabbit feeding. Ph.D. Thesis submitted to the Department of Animal Science, University of Ibadan, Ibadan, Nigeria, pp. 248.
3. Abu, O.A.; Tewe, O.O. and Bakare, J. (1999). Performance, nutrient digestibility and carcass characteristics of rabbit fed sweet potato based diets. Inter. J. Anim. Sci. **14**(2) : 197-201.
4. Aderibigbe, A.O.; Tor-Agbidye, Y.; Cheeke, P.R. and Patton, N.M. (1990). Evaluation of almond hulls as a feedstuff for rabbits. J. Applied Rabbit Res. **13** (3-4): 110-113.
5. Alicata, M.L.; Bonanno, A.; Alabiso, M.; Portolano, B. and Stimolo, M.C. (1992). Further trials on the use of chickpeas in growing rabbit feeding. J. Applied Rabbit Res. **15**(6): 1025-1032.

6. Anonymous (2002). Dainik Sambad. April 2, 2002, Tuesday, pp.3.

7. Ayer, A.C.; Cheeke, P.R. and Patton, N.M. (1992). Effect of weaning rabbits of black locust bark, oat sawdust, red alder bark and red alder sawdust in the diet. J. Applied Rabbit Res. **15**(6): 1166-1174.

8. Balogun, T.F. and Etukude, U.W. (1991). Undecorticated, full fat sunflower seeds in diet of rabbits. J. Applied Rabbit Res. **14(**2): 101-104.

9. Bhosale, D.T. (1994). Effect of dietary fibre levels on performance of fryer rabbits fed processed neem seed kernel meal. M.V.Sc. thesis, I.V.R.I., Izatnagar, India.

10. Biobaku, W.O. and Ekpenyong, T.F. (1991). Effect of feeding graded levels of water lettuce and water hyacinth on the growth rabbits. J. Applied Rabbit Res. **14** (2): 98-100.

11. Bora, A. (1995). Effect of dietary fibre levels on weight gain, feed conversion efficiency and blood biochemical profiles in rabbits. Ph.D. Thesis, Assam Agril. Univ., Khanapara, Guwahati, Assam.

12. Bora, A.; Baruah, R.N.; Baruah, K.K. and Bora, R.K. (1996). Effect of concentrate to roughage ratio on growth, feed conversion efficiency and nutrient utilization in rabbit. Indian Vet. J. **73**(12): 1239-1242.

13. Bora, J.R. (1999). Growth and carcass characteristics of crossbred pigs under unconventional feeding regimes. Ph.D. thesis, Assam Argil. Univ., Khanapara, pp. 194.

14. Brody, S. (1964). Bioenergetic and growth. Hafner, New York, USA.

15. Canope, J.; Le Dividich, J.; Hed Reville, F. and Deposis, F. (1977). Influence d’un traitement technologique sur l’efficacite alimentaire des principaux produits amylaces tropicaux (patata douce et banane) dans l’alimentation du prac. Nouvelles agronomiques des Antilles et de la Guyane. **3** (3/4) 310-322.

16. Cerning-Beroard and Le Dividich, J. (1976). Valeur alimentaire de quelques produits amylaces d’origine tropicale. Annales Zootechnique **25** (2) : 155-168.

17. Chakrabarti A, Buragohain S. C. and Baruah K. K. 2017. Carcass characteristics of broiler rabbit fed on sweet potato based ration. International J Agril Sci. and Res. 7(1): 347-358.

18. Chakrabarti A, Buragohain S. C.,Baruah K. K.and Sarmah B.C. 2017. Effect of sweet potato based ration on physiological and blood profile of broiler rabbit. International J Botany Res. 7(1): 1-18.

19. Chakrabarti A, Gupta J. J. and Dey A. 2014. Economics of Rearing Broiler Rabbit in an Organized Farm. Indian Journal of Applied Agriculture Research. 2(1): 9-12.

20. Cheeke, P.R. (1987). Rabbit feeding and Nutrition. Academic Press, Harcourt Brace, Jovanovieh, New York.

21. DeBlas, J.C.; Fraga, M.J.; Rodriguez, J.M. and Mendez, J. (1984). The nutritive value of feeds for growing fattening rabbits. 2. Protein evaluation. J. Appl. Rabbit. Res**. 7**: 97.

22. DeBlas, J.C.; Santoma, G.; Carabano, R. and Fraga, M.J. (1986). Fibre and starch levels in fattening rabbits diets. J. Anim. Sci. **63**(6): 1897-1904.

23. Deshmukh, S.N. and Pathak, N.N. (1991). Effect of different dietary protein and energy levels on growth

performance and nutrient utilization in New Zealand White rabbits. J. Appl. Rabbit Res. **14**: 18-24.

24. Dominguez et al., (1991) cited by Machin, D. and Nyvold, S. (1992). Roots, tubers, plantains and bananas in animal feeding. F.A.O., Rome.
25. Dutta, M.; Talukdar, R.P.; Das, P.C. and Chakravarty, B.N. (1997). Growth response and nutrient utilization of rabbits on different levels of doob grass. Indian J. Anim. Nutr. **14**(3) : 176-179.
26. El-Baki, S.M.A.; Sonobol, S.M.; El-Gendy, K.M. and Zaky, A.A. (1992). Leaf protein concentrate (LPC) from cassava and fodder beet as a protein source for rabbits. Egyptian J. Rabbit Sci. **2**(2) : 123-133.
27. El-Sayaad, G.A.E.; Luick, B.R. and Cheeke, P.R. (1992). Preliminary evaluation of seed screening of Orchard grass as a feedstuff for rabbits. Egyptian J. Rabbit Sci. **2** (1): 73-80.
28. FAO (Food and Agriculture Organization of the United Nations)(1981). FAO expert consultation on rural poultry and Rabbit Production, Rome.
29. Fetuga, B.L. and Oluyemi, J.A. (1976). The metabolizable energy of some tropical tuber meals for chicks. Poult. Sci. **55**: 868-873.
30. Fraga, M.J.; Barreno, C.; Carasono, R.; Mendez, J. and De Blas, J.C. (1984). Anabs de Institute Nacional de Investigaciones Agrarias, **21**: 91.
31. French, M.H. (1955). East African Agril. J**. 21**: 18.
32. Gerpacio, A.L.; Pascual, F.Sd.; Querubin, L.J.; Vergel de Dios, A.F. and Mercado, C.I. (1978). Evaluation of tuber meals as energy sources. Sweet potato and cassava based rations for broilers. Philippine Agriculturalist, **61** (9-10): 395-
33. Grobner, M.A.; Robinson, K.L.; Patton, N.M. and Cheeke, P.R. (1985). Comparison of Palmino and NZW breeds for commercial rabbit production. J. Appl. Rabbit Res**. 8**(2): 62.
34. Gupta, B.R.; Rao, V.P.; Reddy, C.E.; Satyanarayana, A. and Reddy, P.P. (2001). Diallel analysis of carcass characteristics in broiler rabbits. Indian J. Anim. Res. **35**(1): 40-43.
35. Gupta, J.J.; Das, A. and Yadav, B.P.S. (1995). Utilization of Job’s tears grain in rabbit ration. Indian J. Anim. Nutr. **12** (4): 201-204.
36. Job, T.A.; Oluyemi, J.A. and Entonu, S. (1979). Replacing maize with sweet potato in diets of chicks. Brit. Poult**. 20**: 515-519.
37. Kalita, P. (1998). Effect of various dietary levels of protein and energy on the performance of broiler rabbits. M.V.Sc. thesis, Assam Agril. Univ., Khanapara, pp. 79.
38. Kanua, M.N. and Rangat, S.S. (1989). Indigenous Technologies and Recent Advances in Sweet Potato Production, Utilization and Marketing in Papua New Guinea. In: Mackay et al. (1989).
39. Kasa, W.; Thwaites, C.J.; Jlanke, X. and Farrell, D.J. (1989). Rice-bran in the diet of rabbits grown at 22^{o}C and 30^{o}C. J. Appl. Rabbit Res. **12** : 75-77.

40. Kelsay, J.L.; Behall, K.M. and Prather, E.S. (1979). Effect of fibre from fruit and vegetables on metabolic responses of human subjects. II. Calcium, Magnesium, Iron and Silicon balances. Am. J. Clin. Nutr. **32**: 1876-1880.

41. Kumar, P.V. (1995). Effect of graded dietary levels of neem (Azadirachta indica) seed kernel cake on the performance of broiler rabbits. M.V.Sc. Thesis, IVRI, Izatnagar, India.

42. Lall, D.; Kishan, J.; Negi, S.S.; Goel, G.C. and Callear, J.F.F. (1985). Effect of partial replacement of concentrate by roughages in the diet of Angora rabbits on wool production. Indian J. Anim. Sci**. 55**(2): 152-154.

43. Lebas, F. (1988). Rabbits. Livestock Prod. Sci., **19**: 289.

44. Lebas, F.; Condert, P.; Rouvier, R. and De Rochambeau, H. (1986). The Rabbit Husbandry, Health and Production. FAO, Rome, Italy.

45. Lin, Y.H.; Huang, T.C. and Huang, C. (1988). Quality improvement of sweet potato (Ipomoea batatas L. Lam) roots as feed by ensilage. British J. Nutr. **60** (1): 173-184.

46. Maertens, L. and De Groote, G. (1984). Digestibility and digestible energy content of a number of feed stuff for rabbits. Proc. III World Rabbit Cong., Rome. **1**: 244-251.

47. Marrero, L.J. (1975). Utilizacion del boinato como principal fuente energetica en la alimentacion del cerdo. 1. Estudio sobre la sustitucion del maiz por boniato en las dietas de cerdos en ceba. Centro. Serie Ciencia Animal**. II**. (1-2): 33-41.

48. Martinez and Dominguez (1991). cited by Machin, D. and Nyvold, S. (1992). Roots, tubers, plantains and bananas in animal feeding. F.A.O., Rome.

49. Martinez Pascual, J. and Fernandez Carmona, J. (1980). Citrus pulp in diets for fattening rabbits. Anim. Food Sci. Technol**. 5**: 23-31.

50. McDonald, P.; Edwards, R.A. and Greenhalgh, J.F.D. (1973). Animal nutrition. 2nd Edn. Oliver and Boyd, Edinburgh.

51. Morris, E.R. and Ellis, R. (1980). Bioavailability to rats of iron and zinc in wheat bran: response to low phytate bran and effect of the phytate/zinc/molar ratio. J. Nutr. **110**: 2000-2010.

52. Nenmark, H. (1970). Volcani Institute of Agric. Res. Personal communication.

53. Nguyen, Q.S.; Luyen, L.T. and Binh, D.V. (2000). Feeding systems for tropical rabbit production emphasizing root and bananas. Workshop seminar ‘ Making better use of local feed resources’. SAREC-UAF, Janaury, 2000.

54. Noblet, J.; Fortuna, H.; Dupire, C. and Dubois, S. (1990). Valeur nutritionnelle de treize matieres premieres pourle porc en croissance. 1. Teneurs en energie digestible metabolizable et nettle. Consequences du choix du systeme energetique. Journees Recherche Porcine en France. **22**: 175-184.

55. NRC (1977). Nutrient requirement of rabbits. National Academy of Sciences, National Research Council, Washington, D.C., USA.

56. Oku, T.; Konish, F. and Hosoya, B. (1982). Mechanism of inhibitory effect of unavailable carbohydrate on

intestinal calcium absorption. J. Nutr. **112**: 410-415.

57. Oyenuga, V.A. and Fetuga, B.L. (1975). Chemical composition, digestibility and energy values of some varieties of yam, cassava, sweet potatoes and cocoyams for pigs. Nigerian J. Sci. Univ. Ibadan. **9**(1): 63-110.
58. Pote, L.M.; Cheeke, P.R. and Patton, N.M. (1980). Utilization of diets high in alfalfa meal by weanling rabbits. J. Applied Rabbit Res. **3** (4): 5-10.
59. Prasad, R.; Sankhyan, S.K. and Karim, S.A. (1999). Growth performance of broiler rabbits maintained on concentrate pellets and roughage in cafetaria system. Indian J. Anim. Sci. **69**(7) : 525-527.
60. Prawirodigdo, S.; Cheeke, P.R. and Patton, N.M. (1985). The use of waste cabbage with various levels of cassava root supplementation for feeding weaning rabbits. J. Applied Rabbit Res. **8**(4): 165-166.
61. Rao, D.R.; Sunki, G.R.; Johnson, W.M. and Chan, C.P. (1977). Post-natal growth of New Zealand White rabbit. J. Anim. Sci. **44** (6): 1021-1025.
62. Ravi, A.; Nedunzhiyan, M.and Rao, K.S. (2001). Effect of supplementation of sweet potato (Ipomoea batatus) vine in the diet of crossbred boars (LWY x Deshi) on the digestibility of nutrients. Cheiron. **30** (5&6): 157-158.
63. Ridzwan, B.H.; Fadzli, M.K.; Rozali, M.B.O.; Chin, T.F.; Ibrahim, M.B. and Furidnordin, B.I. (1993). Evaluation of cocoa-pod husks on performance of rabbits. Anim. Feed Sci. Tech. **40** (2-5): 267-272.
64. Ridzwan, B.H.; Ghufran, R.; Kaswandi, M.A. and Rozali, M.B.O. (1995). Performance and carcass yield of NZW rabbits fed cocoa-pod husks on performance of rabbits. Anim. Feed Sci.Tech. **40**(2-5): 267-272.
65. Rohilla, P.P.; Pal, D.T. and Choudhory, H. (2002). Growth performance of broiler rabbits under different levels of protein. Indian J. Anim. Sci. **72**(6): 516-517.
66. Rose, C.J. and White, G.A. (1980). Apparent digestibilities of DM, OM, CP, Energy and ADF of chopped raw sweet potato (Ipomoea batatas) by village pigs. Papua New Guinea Agril. J. **31** (1-4): 69-72.
67. Saikia, G. (1998). Evaluation of Ajar seed (Lagerstroemia flos-reginae) as a source of energy feed for rabbits. Ph.D. thesis, Assam Agril. Univ., Khanapara. Pp. 485.
68. Scott, G.J. (1991). Transforming traditional food crops: Product development for roots and tubers. Proceedings of the International Workshop on root and tuber crops processing, marketing and utilization in Asia, at CIP in April 22 to May 1, 1991. Pp. 5. In Production Development for Root and Tuber Crop: Vol. 1, Asia.
69. Singh, R.; Sawal, R.K. and Bhatia, D.R. (1994). Nutrient utilization by rabbits on diets containing Kudzuvine hay. Indian J. Anim. Nutr. **11**(4): 255-258.
70. Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods. 7th edn., Iowa State University Press, Iowa.
71. Spreadbury, D. and Davidson, J. (1978). A study of the need for fibre by the growing New Zealand White rabbit. J. Sci. Food Agric. **29**: 640-648.
72. Sreemannaryana, O.; Ramachandralah, K.; Kumar, K.M.S.; Ramanalah, N.V. and Ramaprasad, J. (1993). Utilization of azolla as rabbit feed. Indian Vet. J. **70**(3): 285-286.

73. Srinivas, B.; Biswas, J.C. and Somvanshi, R. (1994). Effect of different levels of protein feeding on dry matter intake, nutrient utilization, growth and carcass characteristics of broiler rabbits. IN: Current advances in Veterinary Science and Animal Production in India. Edited by Somvanshi, R. and Lokeshwar, R.R., 1994, Inter. Book Distr. Co., Lucknow, India.

74. Stephan, E. (1980). The influence of environmental temperature on meat rabbits of different breeds. Proc. World Rabbit Cong. 2nd Vol. I, pp. 399-409.

75. Sundaram, R.N.S.; Chakurkar, E.B. and Bhattacharyya, A.R. (1997). Voluntary feed intake and nutrient digestibility of exotic meat rabbit under tropical coastal climate. Indian Vet. J. **74**(1): 80-81.

76. Swarooparani, K.; Sastry, V.R.B.; Agarwal, D.K. and Katiyar, R.C. (1997). Nutritional efficiency of fryer rabbits fed different levels of protein and energy. Proc. VIII. Anim. Nutr. Res. Worker's Conf. Chennai 12-14th Dec,. 1997, pp. 27.

77. Szylit, O.; Durand, M.; Borgida, L.P.; Atinkpahoun, H.; Prieto, F. and Delort-Laval, J. (1978). Raw and steam-pelleted cassava, sweet potato and yam cayenensiss as starch sources for ruminant and chicken diets. Animal Feed. Sci. Tech. **3**: 73-87.

78. Takahashi, S.; Mori, A.; Jitsukawa, Y.; Himeno, K. and Morimoto, H. (1968). Studies on nutritive value of feedstuffs for pigs. 3. Brans and others. Bulletin of National Institute of Animal Industry. **17**: 15-19.

79. Talapatra, S.K.; Roy, S.C. and Sen, K.C. (1940). The analysis of mineral constituents in biological material. I. Estimation of phosphorus, chlorine, calcium, magnesium, sodium and potassium in feeding stuffs. Indian J. Vet. Sci. and A.H. **10**: 243.

80. Teguia, A.; Tchoumboue, J.; Mayaka, B.T. and Tankou, C.M. (1993). The growth of broiler chickens as affected by the replacement of graded levels of maize by sweet potato leaves (Ipomoea batatas) or Ndole (Vernonia sp.) in the finisher diet. Anim. Feed Sci. Tech. **40**: 233-237.

81. Tomita, Y.; Hayashi, K. and Hashizume, T. (1985). Palatability of pigs to sweet potato-silage and digestion trial by them. Bulletin of the Faculty of Agriculture, Kagoshima Univ. No**. 35**: 75-80.

82. Tortuero, F.; Rioperez, J. and Rodriguez, M.L. (1989). Nutritional value for rabbits of olive pulp and the effect on their visceral organs. Anim. Feed Sci. Tech. **25** (1-2): 79-87.

83. Voris, L; Marcy, L.F.; Thacker, E.J. and Wainio, W.W. (1940). Digestible nutrients of feeding stuffs for the domestic rabbit. J. Agric. Res. **61**: 673-683.

84. Wu, J.F. (1980). Energy value of sweet potato chips for young swine. J. Anim. Sci. **51**(6): 1261-1265.

85. Yadav, B.P.S.; Gupta, H.K. and Gupta, J.J. (1995). Sweet potato (Ipomoea batatus L.) as a component of swine ration. Indian J. Anim. Sci. **65**(4): 455-459.

86. Yoshida, M. and Morimoto, H. (1958). The nutritive value of sweet potato as carbohydrate source of poultry feeds. World Poult. Sci. J. **14**(3): 246.