Technical Bulletin No.: 47

CELEBRATING 25 Years Silver Jubilee Publication

Unconventional Feed Resources For Efficient Poultry Production

Compiled and Edited by

Bijaya Kumar Swain, Prafulla Kumar Naik and Narendra Pratap Singh

भा.कृ.अनु.प. - गोवा के लिए भा.कृ.अनु.प. का अनुसंधान परिसर
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ICAR - ICAR Research Complex for Goa
(Indian Council of Agricultural Research)
Old Goa - 403 402, Goa, India

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Foreword

Feed is one of the major constituent in poultry production. Feed constitutes about 60-70% of the total cost of poultry production. Seventy percent of Goan population is non-vegetarian. Hence, there is huge demand for non-vegetarian food especially poultry meat and egg. National Institute of Nutrition has recommended percapita consumption of 11 kg poultry meat and 180 eggs for India. Percapita consumption of poultry meat and egg in Goa are 3 kg and 80, respectively. There exists wide gap between the demand and supply. Enormous scope and opportunities exist for development of poultry in Goa. The major constraint is the lack of availability of conventional feed ingredients like maize and soybean meal locally and are transported from neighboring state adding to the cost of production to a great extent.

ICAR- ICAR Research Complex for Goa, Old Goa has the responsibility of increasing the poultry production and productivity of the state through strategic and applied research. Research has been conducted by the institute on utilization of unconventional feed resources like brewers' dried grain, cashew apple waste, broken rice, cowpea leaf meal, poultry hatchery product etc to formulate cost effective feed for different types of poultry to bring down the cost of production which can be adopted by the farmers to get the benefit.

I am happy that Scientists of this institute have taken initiatives to compile the research findings on utilization of unconventional feed resources in poultry published in annual reports, referred journals and magazines to publish in the form of a Technical Bulletin so that all the information will be available to the readers.

I congratulate all the authors for their untiring effort to publish this Bulletin which will be very useful resource material for the researchers, students, extension workers and finally the poultry farmers.

(Narendra Pratap Singh)
Director

गोवा के लिए भा.कृ.अनु.प. का अनुसंधान परिसर, ओल्ड गोवा.
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Preface

Feed contributes towards the major input cost involved in poultry production. Incorporation of conventional feed ingredients like maize, soybean meal, fish meat etc.in poultry feed has increased the cost of feed enormously. Attempts have been made to utilise locally available and cheap unconventional feed resources to reduce the feed cost which will benefit the endusers i.e. poultry farmers. Scientists of this institute have conducted significant research which are available in different annual reports, various journals and poultry magazines.

Therefore, effort was made to compile the results of the earlier research findings the institute on utilization of unconventional feed resources in poultry and to publish it in the form of a Technical Bulletin on "Unconventional feed resources for efficient poultry production" for easy reference of the readers. All the information about the chemical composition and feeding value of different unconventional feed resources has been given serially ingredient wise. The conclusion and references have been presented separately.

We anticipate that this Technical Bulletin would be useful in providing scientific information in one place for the reference of researchers, extension workers, students and farmers during planning their future work for the increased production of poultry meat and egg in the state.

- B.K. Swain, P.K. Naik and N.P. Singh

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Introduction

There is need to improve the scientific knowledge for utilizing low cost locally available agro-industrial by-products in poultry feed in order to reduce the feed cost. As feed constitutes 60-70 % of the total cost of production, any attempt to reduce the feed cost may lead to a significant reduction in the total cost of production. Poultry being the monogastric animal lack fibre degrading enzyme for breakdown of complex carbohydrates like cellulose, hemicellulose and lignin. Since, the complex carbohydrate is a major component of fibrous by-products like cashew apple waste, brewery waste, rice bran, wheat bran and sunflower cake etc, there is need to find ways and means for improvement in the utilization of these fibrous materials so as to incorporate these materials in the poultry feed without any adverse effect on their health and production. There is an opportunity to utilize locally available by-products for economic production of broilers, backyard poultry and Japanese quails. Hence, it was felt to evaluate these by-products for economic feeding of poultry to produce more meat and egg with less cost in Goa conditions. Considering the demand for egg and meat in the coming years, low cost poultry rearing is a boon for marginal farmers and landless poor in the coastal ecosystem. There is ever increasing demand for conventional feed ingredients for feeding of poultry. Incorporation of these feed ingredients in poultry feed has increased the cost of production enormously. Attempts to utilize locally available cheap by-products may benefit the end users in reducing the feed cost which in turn can reduce the total cost of production of meat and egg and making them easily available at cheaper cost in rural India. The traditional sources of vitamins and proteins used in poultry rations such as fish meal, meat and bone meal, soybean meal, groundnut cake etc. are becoming expensive in developed countries. The availability of such feed ingredients is not adequate because of the spiraling cost of raw materials and ever increasing competition with the human beings for the same food items. Hence, the search for alternative feed sources has become inevitable to reduce the feed cost.

The chemical composition of agro-industrial by-products i.e. brewers' dried grain, cashew apple waste, cashew nut shell, rice kani (broken rice) and other unconventional feed ingredients like cereals (bajra and ragi) , palm oil, poultry hatchery waste, protein source (sunflower meal) and legume green fodder (cowpea leaf meal) along with their feeding value in broilers, backyard poultry and Japanese quails are described here in brief for the use by students, professionals and ultimately poultry farmers to economize the cost of production.

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Brewers' Dried Grains

Brewer's dried grain is a valuable by-product of brewery which has a potential to be used as supplementary feed for livestock and poultry. It is a safe feed when it is used as fresh or properly dried form. These materials are considered to be good sources of un-degradable protein, energy and water-soluble vitamins. They have been used in feeding of both ruminant and monogastric animals (monogastrics using predominantly the dried forms). Brewer's grain is the material that remain after grains have been fermented during the beer making process. These materials can be fed as wet brewer's grains or dried brewer's grains. Brewers' dried grains (BDG) is a by-product of barley malt, corn or rice that is treated to remove most of the readily soluble carbohydrates, protein, fibre, linoleic acid, vitamins and minerals. Some breweries dry the brewer's grains and sell it as dried brewer's grains, while others sell it as wet brewer's grains. Both types have similar feeding characteristics if the wet brewer's grains are fed shortly after it is produced. Fermented local and industrial by-products of brewing have been used as non-conventional feedstuffs in broiler rations (Flores and Ganzalez, 1994) mainly as protein and energy supplements (Samanta and Mandal, 1988). Brewery wastes are available in plenty from the local breweries which can be a potential feed ingredient to economize the poultry production.

Fresh brewers' grains

Fresh brewers' grains

Brewers' dried grains

Ground brewers' dried grains

Formulated feed with inclusion of brewers' dried grains

The annual availability of brewers' grains is about 6000 metric tons in Goa (Anonymous, 2012). Brewery by-products like brewery waste grains and yeast's are worthy of consideration as potential non-conventional feeds to promote use of locally available feed ingredients. Since the BDG is rich in fibre, addition of fibre degrading enzyme may be useful in improving its feed value.

Chemical composition of BDG

Brewery waste collected from the local breweries has to be sun dried before inclusion in the poultry feed. Brewery waste when collected from the brewery contains about 75 % moisture which is a major constraint for storing and because of high moisture content it is not possible to feed poultry as it is and need complete drying without much loss of nutrients. After complete drying, the brewery waste is designated as brewers' dried grains (BDG). The nutritional content of the material may vary from plant to plant and depending upon the type of grain used (barley, wheat, corn, etc.) in the initial brewing process as well as proportions being fermented and fermentative process being used. The range values for different chemical constituents of BDG are given here in Table 1.

Table 1. Chemical composition of BDG

Chemical Constituents	Per cent Composition
Dry matter	90.10-93.00
Crude protein	11.00-30.89
Ether extract	7.00-11.05
Crude fibre	9.55-20.00
Total ash	3.09-11.04
Acid insoluble ash	1.37-1.96
Calcium	0.28-0.60
Total Phosphorous	0.43-1.00

Anonymous (2012); Fasuyi, 2005; Ironkwe and Bamgbose, 2012; Isikwenu, 2011; Swain et al. (2005a)

Feeding value of BDG in different poultry birds

High fibre content in BDG limits its inclusion in poultry rations at higher level. Higher level of BDG in the diet reduces the performance of chickens due to its high fibre content. Poultry being monogastric animal do not produce enzymes like cellulase, hemicellulase and B-glucanase which are required for digestion of fibre components in feed. Therefore, dietary addition of fibre degrading enzymes has got practical importance in improving the feed value of low energy and high fibre feedstuffs. Brewery waste protein can replace 20 % soya protein in the diet of chickens without causing significant differences in the growth and feed intake.

The data pertaining to previous studies indicated that brewery waste could be used as a complementary protein source in broiler chicken diets. Studies on the evaluation of BDG in commercial broilers are limited. Brewery waste can be collected from the local breweries and properly sun dried to reduce the moisture content up to a level of 8-10 %. After drying, this can be designated as brewers' dried grains (BDG). Because of the high fibre content its use in poultry ration is limited. However, with enzyme feed supplementation it can be used at a certain level. BDG with Kemzyme-HF @ 0.75 g/kg diet can be incorporated in broiler ration at a level of 5 % for economic production (Swain et al., 2005a). A study in Rhode Island Red chicks indicated that BDG could be incorporated at a level of 20 % in RIR chick ration without any adverse effect on their growth and feed efficiency. Practical diets formulated with inclusion of BDG for different types of poultry birds are presented in Table 2.

Table 2. Diets for different types of poultry birds with inclusion of BDG

Ingredients	Starter Diet (%) (0-3 wk)	Finisher Diet (4-6 wk)	Vanaraja chicks	RIR chicks
Yellow ground maize	55.00	60.00	43.00	50.00
Groundnut cake/ Soybean meal	20.00	17.60	21.00	12.00
Fish meal	10.00	10.00	_	10.00
Wheat bran	7.78	6.03	_	6.30
De-oiled rice bran	-	-	13.00	-
Brewers' dried grain	5.00	4.40	20.00	20.00
Dicalcium Phosphate	1.13	1.16	1.17	1.15
Common salt	0.40	0.40	0.50	0.40
L-Lysine HCl	0.36	0.22	0.03	0.02
DL-Methionine	0.14	-	0.06	-
Vitamin Mixture	0.04	0.04	0.04	0.04
Mineral Mixture	0.15	0.15	0.15	0.15

Performance commercial broilers fed BDG supplemented with Kemzyme

Performance, carcass traits, organ weights and serum biochemical constituents were evaluated in commercial broiler chickens from 1st day to 6 week of age (Swain et al., 2005a). Two basal diets were formulated (Table 3 and Table 4) containing maize, groundnut cake, fish meal and wheat bran with 228g/kg CP and 11.94 KJ/kg ME at starter phase (0-3 weeks) and 199g/kg CP and 12.16 KJ/kg ME at finisher phase (4-6 weeks). The broiler chicks fed with 5 diets where in 1st diet was control diet and other four diets contained 5 and 10 % BDG with or without enzyme supplement i.e. Kemzyme HF, a cellulase-complex with B-glucanase. Broiler chicks fed diet incorporated with 5 % BDG and kemzyme @ 0.75g/kg feed had similar body weight gain and feed conversion ratio to that of control group (Table 5). The feed intake was increased significantly in group fed BDG at 10 % level with

Kemzyme (Table 5). The values for eviscerated yield, relative weight of cut up parts and abdominal fat pad were similar for all the treatments. Significant increase in the relative weight of drumstick was recorded in chicks fed 5 or 10 % BDG with or without Kemzyme (Table 6). The values for relative weight of all the organs except heart were similar for all the treatments (Table 7). Relative weight of heart was significantly higher for chicks fed 10 % BDG with or without Kemzyme. Chicks kept on 5 % BDG with 0.75 g Kemzyme/kg feed consumed less feed to gain 1 kg body weight and earned maximum net profit (Table 8). Hence, it is suggested that 5 % BDG with Kemzyme-HF @ 0.75 g/kg diet could be incorporated in broiler feed for economic production (Swain et al., 2005a).

Table 3. Physical and chemical Compositions of starter (0-3 weeks) diets

Ingredients	D_1(Control)	D_2	D_3
Yellow Ground maize	55.00	55.00	55.00
Groundnut cake	25.00	20.00	15.00
Fish meal	10.00	10.00	10.00
Wheat bran	7.85	7.58	7.28
BDG	_	5.00	10.00
Soybean Oil	_	0.25	0.55
Dicalcium Phosphate	1.13	1.13	1.13
Common salt	0.40	0.40	0.40
L-Lysine HCl	0.34	0.36	0.36
DL-Methionine	0.13	0.13	0.13
Vitamin Mixture[a]	0.04	0.04	0.04
Mineral Mixture[b]	0.11	0.11	0.11
Chemical Compositions (% DM basis)			
Crude protein	22.80	22.10	21.35
Crude fibre	4.79	5.16	5.59
Calculated			
ME (Kcal/kg)	2800	2800	2800
Calcium	1.20	1.20	1.20
Avail.P	0.50	0.50	0.50
Lysine	1.20	1.20	1.20
Methionine	0.50	0.50	0.50

[a] Supplies per kg diet; Vitamin A, 8250 IU; vitamin D3, 1200 ICU; riboflavin, 5 mg; vitamin K, 1 mg; vitamin B1, 1 mg; vitamin B6, 2 mg; vitamin B12, 10µg; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg.

[b] Supplies per kg diet: MnSO4.H2O, 28 g; ZnSO4.7 H2O, 27 g; Fe SO4. 7H2O, 60 g; Cu SO4. 5H2O, 1.5 g and KI, 0.13 g.

Table 4. Physical and chemical composition of finisher (4-6 weeks) diets

Ingredients	D_1 (Control)	D_2	D_3
Yellow ground maize	60.00	60.00	60.00
Groundnut cake	22.00	17.00	12.00
Fish meal	10.00	10.00	10.00
Wheat bran	5.71	5.35	5.12
Brewers' dried grain	-	5.00	10.00
Soybean Oil	0.40	0.65	0.88
Dicalcium Phosphate	1.10	1.16	1.16
Common salt	0.40	0.40	0.40
L-Lysine HCl	0.17	0.17	0.17
Vitamin Mixture[a]	0.04	0.04	0.04
Mineral Mixture[b]	0.11	0.11	0.11
Chemical Composition (% DM basis)			
Crude protein	20.96	20.36	19.77
Crude fibre	4.41	4.73	5.11
Calculated			
ME (Kcal/kg)	2900	2900	2900
Calcium	1.00	1.00	1.00
Avail.P	0.50	0.50	0.50
Lysine	1.00	1.00	1.00
Methionine	0.50	0.50	0.50

[a] Supplies per kg diet; Vitamin A, 8250 IU; vitamin D3, 1200 ICU; riboflavin, 5 mg; vitamin K, 1 mg; vitamin B1, 1 mg; vitamin B6, 2 mg; vitamin B12, 10µg; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg.

[b] Supplies per kg diet: MnSO4.H2O, 28 g; ZnSO4.7 H2O, 27 g; Fe SO4. 7H2O, 60 g; Cu SO4. 5H2O, 1.5 g and KI, 0.13 g.

Table 5. Effect of feeding BDG on body weight, feed Consumption and feed efficiency of broilers

Treatments	Body weight (g)	Feed consumption (g)	Feed efficiency
T_1-Control	1356.4^{ab}	3109.9^{b}	2.374^{b}
T_2-5 % BDG	1306.1^{abc}	3062.2^{b}	2.460^{ab}
T_3-5 % BDG + 0.75 g Kemzyme /kg	1372.8^{a}	3138.7^{ab}	2.371^{b}
T_4 – 10 % BDG	1232.0^{cd}	3059.4^{b}	2.581^{a}
T_5- 10 % BDG + 0.75 g Kemzyme /kg	1288.6^{bcd}	3205.6^{a}	2.584^{a}
SEM	22.06	23.86	0.052

Means bearing different superscripts row wise differ significantly (P≤0.05)

Table 6. Effect of feeding BDG on carcass traits and abdominal fat content (expressed as % Evisc. yield) of broilers

Treatments	Evisc. yield (%)	Wt. of cut up parts (As % of evs. yield)						Abd. Fat
		Breast	Back	Thigh	Drumstick	Neck	Wing	
T_1-Control	76.38	20.30	15.36	13.64	11.73^{b}	4.37	7.17	2.813
T_2-5 %BDG	74.94	20.67	15.84	14.90	12.55^{a}	4.30	7.50	1.796
T_3-5 % BDG + 0.75 g Kemzyme/kg	75.32	20.09	15.93	15.05	13.07^{a}	3.97	7.50	1.769
T_4 – 10 % BDG	74.89	20.55	15.06	14.43	13.04^{a}	4.62	7.69	1.964
T_5- 10 % BDG + 0.75 g Kemzyme/kg	74.36	20.65	15.60	14.88	13.04^{a}	4.17	7.35	1.886
SEM	0.94	0.69	0.67	0.52	0.22	0.20	0.23	0.22

Means bearing different superscripts row wise differ significantly (P≤0.05)

Table 7. Effect of feeding BDG on the organ weights and giblets expressed as (% evisc. yield) of broilers

Treatments	Organ weights (as % of evsc. yield.)					
	Liver	Heart	Gizzard	Giblets	Bursa of Fab	Spleen
T_1-Control ©	2.543	0.598^{b}	3.197	6.397	0.359	0.203
T_2- 5 % BDG	2.567	0.664^{ab}	2.907	6.147	0.349	0.201
T_3-5 % BDG + 0.75 g Kemzyme /kg	2.937	0.771^{a}	3.280	6.990	0.336	0.199
T_4 – 10 % BDG	2.587	0.666^{ab}	3.020	6.257	0.378	0.210
T_5- 10 % BDG + 0.75 g Kemzyme /kg	2.763	0.766^{a}	3.630	7.500	0.343	0.200
SEM	0.089	0.037	0.324	0.378	0.017	0.008

Means bearing different superscripts row wise differ significantly ($P \leq 0.05$)

Table 8. Effect of feeding BDG on the economics of broiler production

Treatment	Net profit as % of sale value of 100 broilers	Feed cost/kg live wt. gain (Rs.)
T_1-Control ©	23.5	20.06
T_2- 5%BDG	24.8	20.61
T_3-5 % BDG + 0.75 g Kemzyme /kg	26.6	20.20
T_4 – 10 % BDG	22.4	20.65
T_5- 10 % BDG + 0.75 g Kemzyme /kg	23.0	21.06
SEM	1.22	0.76

Effect of feeding BDG on the performance and carcass characteristics of Vanaraja chicks

The effect of BDG on the performance and carcass characteristics was studied in Vanaraja chicks from 4th week to 9th week of age. Three diets were formulated by inclusion of BDG at 0, 10 and 20 % level by partly replacing maize, soybean meal and deoiled rice bran of the control diet (Table 9). Body weight gain of chicks was not affected ($P<0.05$) by the inclusion of BDG. The feed consumption of chicks increased significantly ($P<0.05$) due to incorporation of BDG at both levels (Table 10). Feed conversion ratio of chicks fed 20 % BDG increased significantly ($P<0.05$) compared to those fed other diets. The fat retention decreased significantly ($P<0.05$) in chicks fed diets incorporated with BDG at both levels. The eviscerated yield %, relative weight of neck, gizzard and thymus increased significantly ($P<0.05$) in chicks fed diet containing 10-20 % BDG (Table 11). The relative weights of drumstick, abdominal fat and caeca decreased significantly ($P<0.05$) in chicks fed BDG at 10-20 % level. Highest net profit was recorded on 20 % BDG diet. There was an increase of about 13 % net profit due to 20 % inclusion of BDG in the diet (Table 12). Hence, it is suggested that brewers' dried grain could be incorporated up to a level of 20 % in the diet of Vanaraja chicks for better carcass traits and higher profit margin without affecting growth performance (Swain et al., 2012).

Feeding of BDG in Vanaraja chicks

Table 9. Physical and composition of experimental diets

Ingredients	T_0	T_{10}	T_{20}
Yellow ground maize	50.0	46.00	43.00
Soybean meal	28.0	25.00	21.00
Deoiled ricebran	19.0	16.00	13.00
Brewers'dried grain	-	10.00	20.00
Dicalcium Phosphate	1.11	1.28	1.17
Ground Limestone	1.29	1.15	1.21
Common salt	0.50	0.50	0.50
L-Lysine HCl	-	-	0.03
DL-Methionine	0.07	0.07	0.06
Vitamin Mixture	0.04	0.04	0.04
Mineral Mixture	0.15	0.15	0.15
Chemical Composition (%)			
Dry matter	89.9	90.3	90.9
Crude protein	20.80	21.40	21.50
Crude fat	3.24	2.57	2.26
Crude fibre	6.78	8.26	9.24
Total Ash	7.80	7.65	7.56
Acid insoluble ash	1.49	1.47	1.55

Table 10. Effect of feeding BDG on the performance and nutrient utilization in Vanaraja chicks

Performance	Treatments*			
	T_0	T_{10}	T_{20}	SEM
Body weight (g)	1065.27	1063.87	1043.59	7.89
Feed consumption (g)	3086.2[a]	3184.7[b]	3177.8[b]	16.31
Feed conversion ratio	2.873[a]	2.995[a]	3.046[b]	0.024
Nutrient retentions (g/bird/3d)				
Dry matter	127.1	126.3	125.4	0.050
Protein	23.72	23.02	24.39	0.292
Fat	5.63[a]	4.52[b]	4.24[b]	0.216

Means bearing different superscripts column wise differ significantly (P<0.05)
* T_0- Control, T_{10}- 10 % BDG, T_{20}- 20 % BDG

Table 11. Effect of Feeding BDG on the carcass characteristics and organ weights in Vanaraja chicks

Performance	Treatments*			
	T_0	T_{10}	T_{20}	SEM
Carcass traits				
Eviscerated yield, % cut up part yields	63.9[b]	66.3[a]	65.8[a]	0.43
Breast	22.4	20.9	21.8	0.41
Thigh	15.83	16.03	15.23	0.17
Drumstick	16.20[a]	16.43[a]	14.87[b]	0.30
Back	21.1	20.6	22.4	0.36
Wing	8.83[ab]	9.43[a]	9.50[b]	0.19
Neck	4.00[b]	4.97[a]	5.07[a]	0.17
Abd. fat	2.047[a]	1.711[b]	1.676[b]	0.061
Caecal wt.	1.963[a]	1.611[b]	1.563[b]	0.015
Organ weights				
Liver	3.10	2.93	3.03	0.107
Heart	0.787	0.834	0.820	0.014
Gizard	2.73[b]	3.30[a]	3.50[a]	0.127
Spleen	0.276	0.261	0.278	0.006
Thymus	0.628[c]	0.753[b]	0.830[a]	0.031

Means bearing different superscripts column wise differ significantly (P<0.05)
* T_0- Control, T_{10}- 10 % BDG, T_{20}- 20 % BDG

Table 12. Cost benefit analysis of feeding BDG

Parameters	Treatments*		
	T_0	T_{10}	T_{20}
Feed consumed per 100 birds, kg	308.6	318.5	317.8
Cost of feed/kg,Rs	18.25	16.80	15.15
Total cost of feed, Rs	5631.95	5350.80	4814.67
Cost of 100 chicks, Rs	1000	1000	1000
**Total cost, Rs	7631.95	7350.80	6814.67
Weight of 100 birds, kg	122.2	122.1	120.0
Income from sale of birds (Rs)	9776	9768	9600
Misc. income (Rs)	361.5	369	374.5
Total income (RS)	10137.50	10137	9974.50
Net profit, Rs	2505.55	2786.20	3159.83
Profit, %	32.83	37.90	46.37

* T_0- Control, T_{10}- 10 % BDG, T_{20}- 20 % BDG

** Includes cost of electricity, medicine and labour

Influence of BDG on the performance of Rhode Island Red (RIR) chicks

Performance was evaluated (Annual Report, 2000-2001) in 112 numbers of Rhode Island Red (RIR) layer chicks from 1st day to 8 week of age. Basal diet was formulated containing maize, groundnut cake, fish meal and wheat bran with 20.2 % CP and 2668 KCal ME /kg diet. Four experimental diets were prepared by incorporation of brewers' dried grain (BDG) at levels of 0, 10, 15 and 20 % by replacing a part of ground nut cake and wheat bran in the basal diet(Table 13).

Table 13. Physical and Chemical compositions of experimental diets

Ingredients	D_1 (Control)	D_2 (10 %)	D_3 (15 %)	D_4 (20 %)
(A) Physical compositions				
Yellow ground maize	50.00	50.00	50.00	50.00
Groundnut cake	22.00	17.00	14.00	12.00
Fish meal	10.00	10.00	10.00	10.00
Wheat bran	16.33	11.31	9.31	6.28
BDG	--	10.00	15.00	20.00
Dicalcium Phosphate	1.08	1.11	1.11	1.15
Common salt	0.40	0.40	0.40	0.40
L-Lysine HCl	0.04	0.03	0.03	0.02
Vitamin Mixture[a]	0.04	0.04	0.04	0.04
Mineral Mixture[b]	0.11	0.11	0.11	0.04
(B) Chemical Composition (% DM basis)				
Crude protein	20.20	20.48	20.50	20.93
Crude fibre	5.94	6.59	7.11	7.05
Calculated				
ME (KCal/kg)	2668	2678	2675	2687
Calcium	1.00	1.00	1.00	1.00
Avail.P	0.50	0.50	0.50	0.50
Lysine	090	0.90	0.90	0.90
Methionine	0.35	0.35	0.35	0.35

[a]Supplies per kg diet; Vitamin A, 8250 IU; vitamin D3, 1200 ICU; riboflavin, 5 mg; vitamin K, 1 mg; vitamin B1, 1 mg; vitamin B6, 2 mg; vitamin B12, 10µg; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg.

[b]Supplies per kg diet: MnSO4.H2O, 28 g; ZnSO4.7 H2O, 27 g; Fe SO4. 7H2O, 60 g; Cu SO4. 5H2O, 1.5 g and KI, 0.13 g.

There were 4 replications per dietary treatment and each replicate had 7 numbers of chicks. There were no significant differences among the treatments for body weight gain and feed efficiency (Table 14). However, significant increase in feed consumption was recorded when the level of incorporation of BDG was increased to 20 %. There was a saving of Rs1.78 in feed cost per kg body weight gain of chicks. It is suggested that BDG could be incorporated in the diet of RIR chicks up to a level of 20 % without any adverse effect on their productive performance.

Table 14. Effect of feeding BDG on the performance of Rhode Island Red (RIR) chicks.

Treatments	Body wt. gain	Feed consumption	Feed efficiency	Feed cost /kg wt.gain
T_1 (Control)	685.3	2693.7^{b}	3.93	31.31
T_2 (10 % BDG)	658.6	2715.0^{b}	4.12	30.72
T_3 (15 % BDG)	678.7	2746.8^{ab}	4.05	30.42
T_4 (20 % BDG)	683.4	2797.5^{a}	4.09	29.53
SEM	8.30	22.07	0.05	0.51

Means possessing different superscripts row wise differ ($P \leq 0.05$) significantly.

Performance of the Vanaraja laying hens fed brewers' dried grain (BDG) supplemented with Natuzyme

A study was carried out to assess the effect of incorporation of BDG with or without supplementation of Natuzyme on the egg production performance and economics of production in Vanaraja laying hens for a period of 11 weeks. The control diet was formulated with maize, soybean meal and de-oiled rice bran. Four test diets were formulated with incorporation of BDG at 5 and 10 % level by replacing part of maize, soybean meal and de-oiled rice bran without or with supplementation of Natuzyme @ 1.5 g/kg diet (D1-control diet, D2- 5 % BDG, D3-10 % BDG, D4-5 % BDG+1.5g/kg Natuzyme, D5-10 % BDG+ 1.5g/kg

Feeding of BDG in Vanaraja laying hens

Natuzyme). Results (Table 15) indicated that that BDG could be incorporated as an alternative feed ingredient in the diet of Vanaraja laying hens at 10 % level for better economics of production keeping in view the cost of production per dozen egg. (Annual Report, 2012-2013).

Table 15. Effect of feeding BDG with or without enzyme supplementation on performance and egg quality of Vanaraja laying hens

Attributes	Treatments					
	D_1	D_2	D_3	D_4	D_5	SEM
Egg Production (Doz)	4.43^a	3.42^b	3.79^b	3.57^b	3.79^b	0.11
Feed intake (kg)*	8.53	8.55	8.55	8.56	8.55	0.005
FCR	1.941^a	2.508^b	2.254^b	2.411^b	2.256^b	0.059
Egg weight (g)*	53.9	54.9	54.6	53.5	54.4	0.270
Albumen, %*	53.65	53.13	53.85	51.97	52.15	0.534
Yolk, %*	36.13	34.18	33.79	35.46	33.80	0.539
Egg shell, %*	13.15	12.53	12.63	12.88	13.24	0.126
Shell thickness (mm)	0.340^a	0.358^{ab}	0.352^{ab}	0.370^{ab}	0.377^b	0.005
Specific gravity	0.978	0.995	0.995	0.984	0.982	0.003
Feed cost/dozen egg	47.11^a	58.47^c	50.37^a	57.01^{bc}	51.18^{ab}	1.35

Means possessing different superscripts in a row differ significantly (P<0.5)
* Non significant

Performance of the Japanese quails fed BDG supplemented with Natuzyme

A study was carried out to assess the effect of incorporation of BDG with or without supplementation of Natuzyme on the egg production performance and economics of production in Japanese quail laying hens for a period of 21 weeks. The control diet was formulated with maize, soybean meal and de-oiled rice bran.

Feeding of BDG in Japanese quails

Four test diets were formulated with incorporation of BDG at 5 and 10 % level by replacing part of maize, soybean meal and de-oiled rice bran without or with supplementation of Natuzyme @ 1.5 g/kg diet (D1-control diet, D2- 5 % BDG, D3- 10 % BDG, D4-5 % BDG+1.5g/kg Natuzyme, D5-10 % BDG+ 1.5g/kg Natuzyme). Results (Table 16) indicated that BDG could be incorporated as an alternative feed ingredient in the diet of Japanese quail laying hens at 10 % level without any adverse effect on egg production performance and economics of production (Annual Report, 2012-2013).

Table 16. Effect of feeding BDG with or without enzyme supplementation on performance and egg quality in Japanese quails

Attributes	Treatments					
	D_1	D_2	D_3	D_4	D_5	SEM
Egg Production (Doz)	8.028^{b}	7.885^{ab}	7.750^{ab}	7.477^{a}	7.649^{ab}	0.068
Feed intake (kg)	5.489^{a}	5.509^{ab}	5.559^{b}	5.480^{a}	5.519^{ab}	0.010
FCR	0.684^{a}	0.699^{ab}	0.718^{ab}	0.733^{b}	0.717^{ab}	0.007
Egg weight (g)*	10.28	10.01	10.16	9.96	9.90	0.057
Egg contents, %*	84.80	86.67	85.56	88.76	88.31	0.775
Albumen, %*	51.49	51.52	54.17	55.85	54.52	0.738
Yolk, %	33.31^{ab}	35.15^{a}	31.39^{b}	32.91^{ab}	31.79^{b}	0.510
Egg shell, %*	17.88	15.76	16.49	15.12	16.69	0.464
Shell thickness* (mm)	0.222	0.209	0.189	0.206	0.206	0.004
Shape index*	76.25	77.24	76.48	77.46	77.64	0.631
Specific gravity*	0.975	0.971	0.981	0.950	0.952	0.006

Means possessing different superscripts in a row differ significantly ($P<0.5$) * Non significant

3

Cashew apple waste

The cashew is native to northeast Brazil in the 16th Century; Portuguese traders introduced it to Mozambique and coastal India, but only as a soil retainer to stop erosion on the coasts. In India vast tonnages of cashew apples have largely gone to waste while it pioneered in the utilization and promotion of the nut. Cashew apple (*Anacardium occidentale L*) is a promising feed source, which could be used for dairy cows and monogastric animals to some extent. In 1995, the whole country had 200,000 ha of cashew trees. From this area, about 500,000 tons of cashew apple will be produced per year. There is commercial interest in processing the fresh apple as a source of sugar-rich juice for human consumption. The waste product from processing, after drying, has been fed to pigs and poultry with promising results. Cashew apple waste (CAW) is available in plenty in the coastal states with an annual production of about 3, 82,000 metric tons out of which Goa's share is about 80,000 metric tonnes. The annual availability of dried cashew apple waste in Goa is about 8000 metric tones. The average weight of fresh apple is about 74.33 grams having dry matter content of 10.22 per cent. CAW is obtained after extraction of fenny which can be used as a cheaper source feed ingredient for poultry by partially replacing costly energy source maize. The waste is usually sun dried and ground before incorporation in the feed. Similarly cashew nut shell is the outer covering of cashew nuts which is not usually used for human consumption but can be used as a cheaper source feed ingredient for poultry.

Fresh cashew apple

Dried cashew apple waste

Dried cashew apple waste

Chemical Compositions

The chemical composition of CAW varies according to the location and species from which the apple wastes are prepared. The range values (%) for the different chemical constituents of CAW and per cent composition of cashew nut shell (CNS) are given below in tabular form (Table 17).

Table 17. Chemical compositions of cashew apple waste

Parameters	% Composition	
	CAW	CNS
Dry matter fresh cows	18.40-22.50	-
Crude protein	6.45-11.40	5.00
Ether extract	3.35-11.04	11.7
Crude fibre	8.50-11.85	27.3
Total ash	3.51-6.15	1.39
Acid insoluble ash	1.26-1.42	0.20

Lakshmipathi et al., 1990; Sundaram, 1986; Swain et al., 2007a; Swain and Barbuddhe, 2007

Feeding value of CAW and CNS in Japanese of nail layers

The CAW can be used in layer chick ration by replacing up to 25 % maize in their diet without any adverse effect on growth, digestibility of dry matter and retention of protein and fat. However, CAW can replace 10 % of commercial layer diet by weight basis without any adverse effect on the egg production and egg weight with reduction on the feed cost. Economics analysis revealed that inclusion of CAW at a level of 20 % replacing maize reduced the feed cost by Rs1.43/- for production of 1 kg body weight gain of Vanaraja dual purpose bird. CAW can also be incorporated in the diet of Japanese quail chicks up to 4.5 % level by replacing the maize at 10 % level of the diet in order to reduce the feed cost (Table 18).

Table 18. Diets for Vanaraja growing chickens and Japanese quail chicks using CAW

Feed ingredients	Composition (%)	
	Vanaraja growing chickens	Japanese quails
Maize	40.00	45.00
Groundnut cake	22.00	36.00
Fish meal	10.00	10.00
Wheat bran	17.74	1.85
CAW	8.00	4.50
DCP	1.00	1.40
L-Lysine HCl	0.16	0.35
DL-Methionine	0.20	-
Common salt	0.40	0.40
Vitamin and Mineral mixture	0.50	0.50

Further, CAW can replace 10 % maize in the diet of Japanese quail layers to economize the feed cost without any adverse effect on the egg production and egg quality. Similarly, cashew nut shell (CNS) can replace 5 % of maize in the diet of Japanese quail layers in order to reduce the feed cost without affecting the egg production and feed efficiency. The practical diets with inclusion of CAW and CNS are given in Table 19.

Table 19. Diets for Japanese quail layers with inclusion of CAW and CNS

Ingredients	Diet 1 CAW (%)	Diet 2 CNS (%)
Yellow maize	45.00	45.00
Ground nut cake	36.00	36.00
Fish meal	10.00	10.00
Cashew apple waste	5.00	-
Cashew nut shell	-	5.00
DCP	1.40	1.40
Common salt	0.40	0.40
L-lysine HCl	0.30	0.30
DL-Methionine	0.05	0.05
Vitamin mixture	0.04	0.04
Mineral mixture	0.50	0.50

The nutritive value of CAW in broilers

An experiment was conducted using one hundred eighty commercial broiler chicks with diets replacing 0, 5, 10, 15 and 20 per cent of maize with CAW on weight by weight basis for a duration of six weeks (Swain et al., 2007a). There was no significant difference between the weight gains at six week of age of broilers. Feed consumption significantly reduced at 10 and 15 per cent level of replacement of maize by CAW. Feed efficiency was similar at all the levels of replacement except at 5 per cent level (Table 20). Carcass traits and organ weights did not show any significant variation between the treatments (Table 21 & 22). The results indicated that the net profit per bird was reduced progressively as the level of CAW was increased. (Table 23). Hence, it is suggested that inclusive of cashew apple waste could in the diet if broiler chicken resulted poor growth performance and less profit margin (Swain et al, 20901a).

Table 20. Performance of broilers as influenced by feeding of CAW

Treatments	Body weight	Feed consumption	Feed efficiency
T_1 (control)	1222	2819^a	2.348^b
T_2	1182	2864^a	2.424^a
T_3	1156	2819^b	2.440^a
T_4	1137	2790^b	2.448^a
T_5	1136	2781^b	2.452^a
SEM	42.19	52.50	0.07

Means possessing a common superscripts in a column do not differ significantly ($P \leq 0.01$)

Table 21. Carcass traits in broilers fed various levels of CAW as replacement of maize

Treatments	Dressing %	Breast	Back	Thigh	Drum-stick	Wing	Neck
T_1	59.19	23.27	17.45	18.29	14.02	9.54	5.87
T_2	60.19	22.72	19.36	17.63	14.21	9.41	6.45
T_3	62.21	22.70	18.70	18.32	13.54	9.24	5.99
T_4	63.55	22.50	19.13	17.87	14.35	9.46	5.93
T_5	60.78	23.06	19.84	18.04	13.28	9.15	5.66
SEM	1.325	0.769	0.683	0.360	0.409	0.316	0.200

Table 22. Relative weights of organs as influenced by feeding of CAW as a replacement for maize in the diet of broilers

Treatments	Liver	Gizzard	Heart	Giblets	Spleen	Bursa
T_1	3.646	3.726	0.932	8.304	0.285	0.420
T_2	3.593	3.921	0.812	8.328	0.310	0.403
T_3	4.443	4.211	1.055	9.710	0.275	0.340
T_4	3.967	4.168	0.973	9.109	0.273	0.343
T_5	3.969	4.107	0.810	8.885	0.265	0.265
SEM	0.201	0.229	0.056	0.373	0.010	0.059

Table 23. Economics of production

Treatments	Net Profit/bird (Rs.)	Cost/kg diet (Rs.)
T_1	8.22	9.27
T_2	6.81	9.12
T_3	6.45	8.97
T_4	6.37	8.82
T_5	6.22	8.67

Feeding value of cashew apple in Vanaraja layers.

Feeding trial was conducted (Annual Report, 2002-2003) with 4 treatments and 36 number of 20 weeks old Vanaraja layers. In each treatment there were 3 replications having 3 birds in each replicate. The commercial layer diet was the control and 3 experimental diets were prepared by replacing 10, 20 and 30 % of the commercial layer diet containing 18 % CP by cashew apple waste. Data were collected on weekly body weight gain, weekly feed consumption, daily egg production and egg weight for a period of 8 weeks. About 9 laying birds were kept on floor to compare the egg production performance. Results of the present study indicated that CAW can replace 10% layer diet by weight basis without any adverse effect on the egg production and egg weight (Table 24).

Table 24. Effect of feeding CAW on the egg production and egg weight of Vanaraja laying hens

Groups	Egg production (Rs.)	Egg weight (Rs.)
T_1 (control)	78.7	53.03
T_2 (10% of layer diet replaced by CAW)	77.0	52.27
T_3 (20% of layer diet replaced by CAW)	57.0	52.0
T_4 (30% of layer diet replaced by CAW)	42.0	50.6
SEM	8.51	0.95

Feeding value of CAW in Vanaraja chicks

A feeding trial was conducted (Annual Report, 2002-2003) for a period of 5 weeks to see the performance of vanaraja chicks fed diets in which maize was replaced with CAW at different levels. CAW replaced maize at 5, 10, 15 and 20 % by weight basis to formulate 4 experimental diets (Table 25). All the diets were made isonitrogenous and isocaloric. Two hundred numbers of Vanaraja chicks (3 weeks old) were weighed individually and distributed randomly in to 20 groups having equal average body weight. Data were recorded on weekly feed consumption and body weight gain. The Feed efficiency was also calculated.

Table 25. Physical Gross and Chemical compositions of experimental diets

Attributes	T_1 Control)	T_2 (5% maize replaced by CAW)	T_3 (10% maize replaced by CAW)	T_4 (15% maize replaced by CAW)	T_5 (20% maize replaced by CAW)
Physical Compositions (%)					
Maize	50.00	47.50	45.00	42.50	40.00
Groundnut cake	20.00	20.00	20.00	20.00	20.00
Fish meal	10.00	10.00	10.00	10.00	10.00
Wheat bran	17.85	17.50	17.14	16.84	16.44
Cashew apple waste (CAW)	-----	2.50	5.00	7.50	10.00
DCP	1.00	1.00	1.00	1.00	1.00
L-Lysine HCL	0.14	0.15	0.15	0.15	0.16
DL-Methionine	0.10	0.20	0.20	0.20	0.20
Soybean oil	0.16	0.40	0.76	1.06	1.45
Common salt	0.50	0.50	0.50	0.50	0.50
Vitamin and mineral mixture	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Chemical compositions, (DM bassis) CP %	28.00	18.60	18.10	17.90	18.4
ME (Kcal/kg, calculated)	2650	2650	2650	2650	2650

Results indicated that there was no significant differences in body weight gain, feed consumption and feed efficiency between the various treatment groups fed CAW at different levels replacing maize (Table 26). Feed cost per kg live weight gain were lowest for T_2 and T_5 (Table 27). It is suggested from this experiment that CAW could replace up to 20 % maize in the diet of Vanaraja chicks without any adverse effect on their performance.

Table 26. Effect of feeding CAW on the performance of Vanaraja chicks from 3 to 8 weeks of age.

Groups	Body wt. gain (g)	Feed consumption (g)	Feed efficiency
T_1 (control)	765.1	2742.9	3.595
T_2 (5% replacement of maize by CAW)	783.8	2727.2	3.493
T_3 (10% replacement of maize by CAW)	751.1	2732.6	3.611
T_4 (15% replacement of maize by CAW)	752.0	2745.4	3.653
T_5 (20% replacement of maize by CAW)	772.4	2759.4	3.561
SEM	12.90	7.39	0.061

Table 27. Economics of production

Treatment	Feed Cost/kg (Rs)	Feed cost/ kg live weight gain
T_1	8.64	31.06
T_2	8.44	29.47
T_3	8.47	30.58
T_4	8.47	30.93
T_5	8.32	29.63

Utilization of CAW with or without enrichment with *Pleurotus florida* as a substitute for maize

CAW was collected from local distillation unit, sun dried and analyzed for chemical composition. Enrichment was done through biodegradation by *Pleurotus florida* and both untreated and treated CAW (TCAW) were analyzed for the chemical composition (Table 28).

Table 28. Chemical Compositions (% DM basis)

Parameters	CAW	TCAW
Crude protein	11.00	17.00
Ether extract	3.65	4.10
Crude fibre	10.10	7.88
Total ash	13.96	9.82

An experiment was carried out for a period of 12 weeks to see the effect replacing maize by CAW with or without treated with *Pleurotus florida* (Annual report, 2003-2004). There were 3 treatments i.e. Control without CAW, 10 % maize replaced with CAW and 10 % maize replaced with TCAW (Table 29). Each treatment had 3 nos of replication and each replicate had 8 nos of laying Japanese quails with F:M ratio=5:3. The duration of the experiment was 12 weeks. Standard feeding and management procedures were followed throughout the experimental period. Results indicated that replacement of maize with TCAW or CAW at 10 % level significantly influenced the feed intake, egg production, feed efficiency and egg weight (Table 30). Significnat decrease in egg production was recorded when CAW (either treated or in untreated) replaced 10 % maize in the diet of quail layers compared to untreated CAW. The feed efficiency of quails was also increased significantly in quail layers fed diet with 10 % maize replaced by untreated and treated CAW. The egg weight was significantly improved in birds fed diet with treated CAW.

Table 29. Physical compositions of experimental diets

Ingredients	T_1 (Control)	T_2 (10 % repl.) by CAW	T_3 (10 % repl.) by TCAW
Maize powder	52.00	46.80	46.80
Deoiled GNC	26.00	26.00	26.00
Fish meal	10.00	10.00	10.00
Wheat bran	5.20	5.20	5.20
CAW	_	5.20	_
TCAW	_	_	5.20
DCP	1.50	1.50	1.50
LSP	4.60	4.60	4.60
Common salt	0.40	0.40	0.40
Vit & Min. Mix.	0.03	0.03	0.03

Table 30. Effect of replacing maize by CAW on the body weight, feed intake, egg production, egg weight and feed efficiency in Japanese quails.

Treatments	Body wt.	Feed intake (kg)	Egg prodn (Doz.)	Egg wt. (g)	Feed efficiency
T_1 (Control)	232.58	3.12	5.71	12.60	0.548
T_2(10% repl. with CAW)	236.67	2.85*	3.87**	12.58	0.740**
T_3 (10% repl. with TCAW)	243.00	2.94	4.56*	13.19*	0.645**
CD (0.05)		0.170	0.573	0.412	0.051
CD (0.01)			0.867		0.077

Effect of feeding cashew apple waste on the performance of Japanese quail chicks
The effect replacing a part of maize with CAW was studied in Japanese quail chicks for a period of 6 weeks (Annual report, 2003-2004). Ninety day old chicks were distributed to 3 treatments with 3 replications per treatment. Each replication had 10 chicks. The control diet contained maize and two experimental diets were formulated by replacing 5 and 10 % maize of the control diet with CAW (Table 31). Data on body weight gain and feed intake were recorded and feed efficiency was calculated at the end of 6 week. Results indicated that replacing maize with CAW at 5 and 10 % level had no significant influence on body weight gain, feed intake and feed efficiency in Japanese quail chicks (Table 32).

Table 31 Physical compositions of experimental diets

Ingredients	Control diet	T_1(5 % repl. of maize with CAW)	T_2 (10 % repl. of maize with CAW)
Maize	50.00	47.50	45.00
GNC	36.00	36.00	36.00
Fish meal	10.00	10.00	10.00
Wheat bran	1.31	1.31	1.31
CAW	-	2.50	5.00
Dicalcium phosphate	1.40	1.40	1.40
Common salt	0.40	0.40	0.40
Lysometh	0.35	0.35	0.35
Mineral mixture	0.50	0.50	0.50
Navmix (A, B_2, D_3, K)	0.01	0.01	0.01
B-complex	0.03	0.03	0.03

Table 32. Effect of replacement of maize by CAW on performance of Japanese quail chicks

Treatments	Body weight gain (g)	Feed intake (g)	Feed efficiency
Control	177.3	949.7	5.296
T_1 (5% maize repl. by CAW)	186.4	938.6	5.148
T_2 (10% maize repl. by CAW)	188.3	933.6	4.958

3

Rice kani

Rice (*Oryza sativa*) is a staple food of most of the Indian states including Goa. Rice is a staple crop in tropical cereal crop in Asia, accounts nearly 90 % of the World's total production of 480 million tones. During the milling of rough rice or paddy, several by-products become available and include polished rice (50-60 %), broken rice (1-17 %), polishings (2-3 %), bran (6-8 %) and hulls (20 %). Rice kani (broken rice) a by-product obtained through milling of rough rice or paddy is a potential unconventional energy source for poultry feeding. Therefore, there is tremendous scope for using rice kani as a substitute for high energy feed ingredient maize in poultry feed in order to reduce the feed cost as well as the competition with human beings for conventional energy source i.e. maize. Another additional advantage is that rice kani is not associated with aflatoxin which pose threat to the survivability of poultry and other livestock.

Chemical Compositions of rice kani

The chemical composition of rice kani varies as per the sources from where it is collected, processing conditions and storage period. The range values for the chemical constituents of rice kani are given below in tabular form (Table 33).

Table 33. Chemical compositions of rice kani

Attributes	% DM basis
Dry matter (fresh basis)	87.90-95.50
Crude protein	7.19-11.41
Ether extract	1.4-1.5
Crude fibre	0.7-2.52
Total ash	0.3-3.30

Rama Rao et al., 2000; Swain et al.(2005; 2006)

Feeding value of rice kani

Broken rice (Rice kani)

The rice kani is comparable to maize in crude protein and energy contents and has been exploited for its feeding value to poultry. Rice kani may be a potential alternative feed ingredient for poultry to substitute maize as an energy source due to its continuous availability and low price. The apparent metabolizable energy (AME) content of rice kani is comparable to that of maize.

Rice kani can be used at a level of 15 % in the diet of Vanaraja growing chickens in order to reduce the feed cost and economize the cost of production. In Japanese quails chicks, rice kani can replace maize up to a level of 20 % in the diet without any adverse effect on their performance with appreciable reduction in the feed cost. Similarly, rice kani can be used at a level of 7.2 % by replacing 15 % maize in the diet of Japanese quail layers to economize the feed cost without any adverse effect on egg production and efficiency of feed utilization. Practical diets for Vanaraja growing chicks and Japanese quails with inclusion of rice kani are given below in Table 34.

Table 34. Diets for Vanaraja growing chicks and Japanese quail layers with inclusion of rice kani

Ingredients (%)	Diet-1 Vanaraja chickens	Diet-2 Quail chicks	Diet-3 Quail layers
Ground yellow maize	35.00	40.00	40.80
Ground nut cake	23.00	32.00	36.00
Fish meal	10.00	10.00	-
Wheat bran	15.00	4.06	6.67
Rice kani	15.00	10.00	7.20
DCP	1.00	0.90	1.78
Limestone	-	-	6.66
L-Lysine HCl	0.14	0.03	0.01
DL-Methionine	0.01	0.01	0.09
Common salt	0.40	0.40	0.50
Mineral mixture	0.25	0.25	0.25
Vitamin mixture	0.04	0.04	0.04

Effect of feeding rice kani on the performance of growing Vanaraja chicks in coastal climate of Goa

One-hundred and twenty Vanaraja backyard growing chicks (8 weeks old) were given isocaloric and isonitrogenous grower rations containing 0, 10, 20, 30 and 40 % maize replaced with rice kani (Table 35) in a completely randomized design to observe their growth potential and economics of production during July-Aug month with average temperature of 30^{0}C and humidity 90-95 % (Swain et al., 2005b). Results showed that mean weight gain of chicks during 8-14^{th} week period were 966.69, 947.17, 1007.98, 1047.93 and 1003.83g, respectively for the diets containing 0, 10, 20, 30 and 40 % rice kani replacing maize (Table 36). Significant ($P \leq 0.05$) reduction in the feed intake was observed in groups of chicks kept on 20-40 % rice kani replacing maize. The expenditure on feed to gain 1 kg live weight was minimum on group 4 where 30 % maize of the grower diet was replaced by rice kani. Therefore, it is suggested that rice kani could replace 30 % of maize in the diet of growing vanaraja chicks for better economics of production in coastal climate (Swain et al., 2005 b).

Table 35. Physical and chemical compositions, per cent of experimental diets

Attributes	Control 0 % repl.	T_1 10 % repl.	T_2 20 % repl.	T_3 30 % repl.	T_4 40 % repl.
Physical compositions					
Maize powder	50.00	45.00	40.00	35.00	30.00
Groundnut cake	20.00	21.00	22.00	23.00	24.00
Fish meal	10.00	10.00	10.00	10.00	10.00
Wheat bran	18.30	16.62	15.82	14.79	13.72
Rice kani	_	5.00	10.00	15.00	20.00
DCP	1.17	1.17	1.22	1.22	1.24
Common salt	0.50	0.50	0.50	0.50	0.50
Soybean oil	_	0.43	0.18	0.21	0.26
Vitamin mixture[1]	0.01	0.01	0.01	0.01	0.01
Vitamin mixture[2]	0.02	0.02	0.02	0.02	0.02
Mineral mixture[3]	_	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Chemical compositions, (DM Basis), Analyzed					
OM	90.10	91.20	89.80	90.80	90.50
CP	17.52	17.70	17.80	17.91	17.98
EE	4.64	4.49	4.50	4.44	4.39
CF	5.37	5.30	5.22	5.15	5.10
Ca	1.03	1.04	1.08	1.10	1.13
P (Total)	0.79	0.78	0.78	0.80	0.78
Lysine (Cal.)	0.95	0.96	0.98	1.00	1.02
Methionine (Cal.)	0.36	0.36	0.36	0.37	0.37
ME (Kcal/kg) (Cal.)	2621	2613	2615	2614	2613

Table 36. Effect of replacing maize with rice kani on the performance of Vanaraja growing Chicks (8-14 weeks of age)

Treatments	Body wt gain (g)	Feed intake* (g)	Feed efficiency	Cost of feed / kg weight gain (Rs)
Control	966.69	3196.16^{c}	3.306	27.98
T_1	947.17	3197.57^{c}	3.376	29.49
T_2	1007.98	3121.55^{b}	3.099	27.33
T_3	1047.93	3115.07^{b}	2.972	26.45
T_4	1003.83	3007.72^{a}	2.996	26.91
SEM	41.07	19.95	0.126	1.098

Means possessing similar superscripts in a column did not differ significantly (P≤0.05).

Utilization of rice kani as a substitute for maize on the performance of Japanese quail chicks

An experiment was conducted (Annual report, 2003-2004) to see the effect of replacement of maize by rice kani on the performance of quail chicks from 3 week to 9 week of age. Two experimental diets were formulated by replacing maize of the control diet with rice kani at 10 and 20 % level(Table 37). Results indicated that replacement of maize by rice kani at 10 and 20 % level did not influence the body weight gain, feed intake and feed efficiency (Table 38). Hence, it is suggested that maize could be replace by rice kani at 20 % level in Japanese quail chicks' diet to reduce the cost of feed without affecting the performance of chicks.

Table 37. Physical composition of experimental diets

Ingredients	Control diet	T_1(10 % repl. of maize by rice kani)	T_2 (20 % repl. of maize by rice kani)
Maize	50.00	45.00	40.00
GNC	32.00	32.00	32.00
Fish meal	10.00	10.00	10.00
Wheat bran	4.06	4.06	4.06
Rice kani	-	5.00	10.00
Dicalcium phosphate	0.90	0.90	0.90
Common salt	0.40	0.40	0.40
Vit. & Min. mixture	0.30	0.30	0.30
L-Lysine HCl	0.24	0.24	0.24
DL-Meth.	0.10	0.10	0.10

Table 38. Effect of replacing maize partially by rice kani on the performance of Japanese quail chicks

Treatments	Body weight gain (g)	Feed intake (g)	Feed efficiency
Control	177.33	1207.9	7.252
T_1 (10% maize repl. by rice kani)	186.41	1300.2	7.314
T_2 (20% maize repl. by rice kani)	188.33	1366.6	7.998

Feeding value of broken rice for Japanese quail layers

An experiment was conducted to assess the feeding value of broken rice for laying Japanese quails (Swain et al., 2006). Quail layers (96; 10 weeks old) divided in to four equal groups (3 replicates of 8 quails each) were offered control diet or diet containing 2.4, 4.8 or 7.2 % broken rice by replacing 0, 5, 10 and 15 % maize w/w (Table 39). Egg production was significantly higher with better feed conversion ratio (Table 40). The economics of production was better in group fed 2.4 % rice kani. Hence, broken rice can be included at 2.4 % level in the diet of Japanese quail layers by substituting 5 % maize for better economics of production.

Table 39. Physical composition of experimental diets

Ingredients	Control diet	T_1(5 % repl. of maize by rice kani)	T_2 (10 % repl. of maize by rice kani)	T_3 (15 % repl. of maize by rice kani)
Maize	48.00	45.60	43.20	40.80
GNC	36.00	36.00	36.00	36.00
Wheat bran	6.70	6.70	6.70	6.70
Rice kani	-	2.40	4.80	7.20
Dicalcium phosphate	1.70	1.80	1.80	1.80
Limestone powder	6.70	6.60	6.70	6.70
Common salt	0.50	0.50	0.50	0.50
Vit. & Min. mixture	0.30	0.30	0.30	0.30
L-Lysine HCl	-	0.02	0.02	0.02
DL-Meth.	0.09	0.09	0.08	0.09

Table 40. Effect of replacing maize with broken rice on the performance of Japanese quail layers (10-26) weeks of age

Traits	C	T_1	T_2	T_3	SEM
Egg production, dozen	6.93^{b}	9.35^{a}	6.75^{bc}	6.47^{c}	0.18
Egg weight, g	12.49^{b}	12.97^{a}	11.83^{c}	12.04^{c}	0.17
Feed intake, kg	2.69^{ab}	2.72^{a}	2.56^{c}	2.43^{d}	0.04
Feed conversion ratio	0.39^{a}	0.29^{b}	0.38^{a}	0.37^{a}	0.01
Feed cost/dozen eggs, Rs	3.52	2.61	3.40	3.29	

FCR-Feed conversion ratio; Figures with different superscripts in a row differ significantly, ($p<0.05$)

5

Cowpea leaves

Cowpea (*Vigna unguiculata [L.] Walp.*) is an important grain and fodder legume crop grown in many parts of the world. Cowpea is used at all stages of its growth including as vegetables (Ofori and Stern, 1986). Harvested tender green cowpea leaves constitute an important leafy vegetable often prepared as salad like spinach, lettuce, amaranthus and cabbage for direct consumption.

Cowpea leaves

Table 41. Chemical Compositions

Attributes	% Composition
DM (Fresh basis)	12.00
CP	20.4
EE	1.24
CF	15.02
Total ash	11.72
Acid insoluble ash	0.92

Feeding value of Cowpea leaves

Cowpea leaves (fresh) were fed to Vanaraja laying hens at an inclusion level of 75 g and 125g per day, respectively by replacing part of whole standard layer ration(Annual Report, 2012-13). First group was given standard layer ration @ 75g/hen/day and fresh cowpea leaves 75g/hen/day and second group was given standard layer ration @ 62.5 g/hen/day and fresh cowpea leaves @ 125/hen/day. The result of this feeding trial was compared with the control group (Table 42). Results indicated that significant ($P<0.05$) reduction in egg production (dozen) was observed in group fed 125g cowpea leaves/ hen/day. However, laying hens fed 75g of fresh cowpea leaves and pods/hen/day produced eggs similar to that of control group. Egg production record (kg mass) followed the similar trend as that of egg production in dozen. The egg weight was not affected by the feeding of cowpea leaves. Feed intake was significantly ($P<0.05$) reduced based on the dry matter intake. Feed efficiency (feed intake in kg/dozen egg) was significantly improved ($P<0.05$) in 1st group fed cowpea leaves and pods @ 75g/hen/day. Feed conversion ratio (Feed intake in kg/egg production in kg) followed the similar trend. Feed cost to produce dozen egg was significantly lower ($P<0.05$) for both the experimental groups fed cowpea leaves. This study indicated that cowpea leaves can be fed to vanaraja laying hens for more income generation due to significant reduction in feed cost.

Feeding of cowpea leaves to Vanaraja layers

Table 42. Effect of feeding cowpea leaves and pods on the performance of Vanaraja laying hens

Parameters	T_1 (Control)	T_2(cowpea leaves, 75g / hen / day)	T_3(cowpea leaves, 125g / hen / day)	SEM
Egg production (dozzen)	1.709^{b}	1.646^{b}	1.292^{a}	0.084
Egg production (kg)	1.093^{b}	1.026^{b}	0.796^{a}	0.058
Egg weight (g)	53.30	51.96	51.30	0.471
Feed intake (kg)	4.063^{c}	3.343^{b}	2.967^{a}	0.204
Feed efficiency (kg feed/ dozen egg)	2.380^{b}	2.067^{a}	2.298^{b}	0.063
Feed efficiency (kg feed/kg egg)	3.720^{b}	3.316^{a}	3.832^{b}	0.093
Feed cost/dozen egg	47.27^{b}	34.57^{a}	33.63^{a}	2.899

Means bearing different superscripts columnwise differ significantly ($P>0.05$)

6

Palm oil

Palm oil (PAO) and palm kernel oil (PKO) are produced from the fruits of *Elaeis quineensis* tree. Fruits of this tree have been used for food for about 5000 years (Cottrel, 1991). Palm trees originated from West Guinea and were introduced to other parts of Africa, Southeast Asia, and Latin America along the Equator after the introduction of the slave trade in the 15^{th} century (Cottrel, 1991). Palm oil is the second most common vegetable oil produced in the world following soybean oil. The oil palm a perennial crop, is harvested throughout the year ; the fruit ripen in about 6 months , so two crops per year are obtained. The fruit has a higher proportion of pulp, which is a source of PAO; and smaller nut, is a source of PKO (Kromer, 1972). Palm oil is a rich source of Vitamin A and E. It is a stable oil at high temperature. Palm oil contains no cholesterol and trans fatty acids. Human studies have shown that palm oil does not ordinarily raise blood cholesterol level and in some cases has been found to lower harmful LDL cholesterol. Vitamin E has role both in fertility and immunity. Therefore, palm oil can be used as a source of energy and vitamins in poultry.

Feeding value of palm oil in Gramapriya laying hens.

A study was conducted to examine the effect of palm oil as an energy source on performance of Gramapriya laying hens during a period of 12 weeks (Annual report, 2009-10). 25 weeks old, 60 laying hens were randomly distributed into 5 equal groups (duplicated into 4 groups of 3 laying hens each) in wire mesh floored cages. Five experimental diets were prepared by replacing 0, 5, 10, 15 and 20 % maize of the control diet by palm oil on isocaloric basis (Table 43). The laying hens were fed either of the experimental diets *ad libitum*. The standard management practices were followed in rearing the layers throughout the experimental period. Data were recorded on weekly feed intake, daily egg production and egg weight. The egg quality parameters like shape index, shell thickness, albumen, yolk and shell percentage were recorded once in a week. The eggyolk cholesterol was estimated. Results indicated that egg production was significantly decreased when maize was replaced by palm oil at a level of 15 and 20 % on isocaloric basis (Table 44). However, at the same levels of replacement the egg weight was significantly increased. The feed consumption decreased significantly due to feeding of palm oil as an energy source replacing maize at levels more than 10 per cent. The feed efficiency increased significantly when the replacement of maize by palm oil exceeded 10 per cent level. The egg yolk cholesterol content increased significantly at all the levels of palm oil. The results indicated adverse effect on egg production, feed intake, feed efficiency and egg yolk cholesterol in layers when the palm oil replaced maize by 15 % and more. It is suggested that palm oil could be used in the diet of laying hens up to a level of 5.5 % replacing maize in the diet without affecting the egg production performance. However, the yolk cholesterol content increased due to incorporation of palm oil in the laying hens' diet.

Table 43. Physical and chemical composition experimental diets

Ingredients	Diet-1	Diet-2	Diet-3	D-4	D-5
Physical compositions					
Maize	55	52.25	49.5	46.75	44
Soybean meal	18	18	18	18	18
Fish meal	5	5	5	5	5
Sunflower oil cake	5	5	5	5	5
Deoiled rice bran	5	5	5	5	5
DCP	1.78	1.78	1.78	1.78	1.78
Limestone	7.35	7.35	7.35	1.35	1.78
Commen salt	0.40	0.40	0.40	0.40	0.40`
Vitamin AB2D3K	0.02	0.02	0.02	0.02	0.02
Vitamin B-complex	0.03	0.03	0.03	0.03	0.03
Mineral mixture	0.50	0.50	0.50	0.50	0.50
Palm oil (kg)	_	1.0	2.0	3.0	4.0
Chemical compositions					
Crude Protein, %	18.9	19.0	18.6		
Crude fat, %	3.41	3.10	3.26		
Crude fibre, %	6.75	8.08	9.35		
Total Ash, %	14.17	13.96	12.90		

Table 44. Effect on egg production performance

Treat-ment	Egg prod (dozen)	Egg wt. (gm)	Egg shell thickness (cm)	Sp. grain	Feed intake (kg)	Feed efficiency	Yolk chol (mg /100 gm)
1	5.19[c]	52.4[a]	0.350[c]	1.090[a]	10.80[c]	2.083[a]	187.4[a]
2	5.24[c]	53.2[ab]	0.363[bc]	1.069[b]	10.72[bc]	2.046[a]	232.1[b]
3	5.06[bc]	53.6[b]	0.359[c]	1.081[a]	10.53[ab]	2.087[a]	269.2[c]
4	4.77[ab]	55.4[c]	0.377[a]	1.068[b]	10.46[a]	2.238[b]	376.3 [d]
5	4.61[a]	58.1[d]	0.355[c]	1.063[b]	0.52[ab]	2.285[b]	510.6[e]
SEM	0.069	0.49	0.019	0.015	0.042	.026	31.02

Means possessing different superscripts rowwise differ significantly (P<0.05)

7

Sunflower oilcake

It is the residual cake remain after the expression of oil from sunflower seed and used chiefly as a livestock feed. It is a concentrated feed rich in protein and fats. In amino acid content and biochemical value oil cake proteins are superior to those of cereals; they contain more lysine, methionine, cystine, and tryptophan. Soybean oil cake is rich in amino acid lysine. The calcium and phosphorus contents are also higher. Like cereal feeds, oil cakes are poor in carotene but rich in vitamins of the B complex. Sunflower oil cake (SOC) is deficient in amino acid lysine but rich in sulphur containing amino acid methionine. The chemical composition of SOC is given in Table 45.

Table 45. Chemical composition

Chemical Constituents	% DM basis
Dry matter	98.60
Crude protein	26.95
Ether extract	0.39
Crude fibre	23.89
Total ash	6.54
Acid insoluble ash	1.20

Feeding value of sunflower cake in Gramapriya laying hens

Fifty four numbers of Gramapriya laying hens (25 weeks) old were distributed in to 18 groups. There were six dietary treatments where in Soybean oil cake was replaced with sunflower cake (SFC) at different levels i.e. 0, 10, 20, 30, 40 and 50 per cent (Table 46). The design of the experiment was CRD. Weekly body weight gain and feed consumption were recorded and feed efficiency was calculated.

Results indicated that sunflower cake could replace 20 % of soybean meal in the diet of Gramapriya laying hens with significant ($P \leq 0.05$) increase in egg production, better feed efficiency with cheaper cost of production per dozen eggs (Table 47). The parameter like egg weight, feed intake, shape index, specific gravity remained similar for different dietary treatments. Hence, it is suggested that sunflower cake could be incorporated at a level of 6.4 per cent in the diet of laying hens by replacing 20 % soybean meal on isonitrogenous basis for better egg production, feed efficiency and economics of production without affecting the overall performance (Swain et-al, 2007b).

Table 46. Physical compositions of experimental diets

Ingredients	D_1	D_2	D_3	D_4	D_5	D_6
Maize powder	48	48	48	48	48	48
Soybean meal	20	18	16	14	12	10
Fish meal	5	5	5	5	5	5
SFC	-	3.2	6.4	9.6	12.9	16.2
DORB	18	16.8	15	14.4	12.6	11.4
DCP	1.11	1.11	1.06	1.06	1.06	1.05
Limestone powder	7.10	7.26	7.25	7.26	7.24	7.10
Common salt	0.40	0.40	0.40	0.40	0.40	4.0
Mineral mixture	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin mixture	0.04	0.04	0.04	0.04	0.04	0.04

Table 47 Effect of feeding sunflower oil cake replacing soybean cake on the performance of Gramapriya laying hens

Treat-ment	Egg prod (dozen)	Feed cons. (g)	Feed efficiency	Egg wt. (g)	Shape ind.	Sp. gravity	Feed cost/kg (Rs)
T_1	2.52^{bc}	9769	3.878^{ab}	58.5	75.5	1.00	8.10
T_2	2.81^{ab}	9937	3.545^{a}	58.1	75.1	1.00	7.99
T_3	3.14^{a}	9655	3.100^{c}	59.3	76.7	1.00	7.83
T_4	2.65^{bc}	9583	3.607^{a}	57.6	75.4	1.00	7.75
T_5	2.39^{c}	9721	4.040^{b}	56.4	76.0	1.001	7.60
T_6	2.44^{c}	9881	4.150^{b}	58.3	76.8	1.00	7.49
CD	0.50	NS	0.54	NS	NS	NS	

8

Unconventional cereals

Chemical composition of bajra (*Pennisetum typhoides*) and ragi (*Eleusine coracana*)

Coarse cereals like bajra (*Pennisetum typhoides*) and ragi (*Eleusine coracana*) are abundantly available in most parts of India. The demand for maize has increased tremendously for use as human and other industrial use making it less available for animal feed. Millets grossly resemble maize in proximate composition except variation in protein and minerals. Replacement of maize with coarse cereals, reduces feed cost and pressure on use of maize. Bajra is a satisfactory feed ingredient for laying hens that can be included in unground form at moderate levels as per the results of research work conducted by earlier workers (Rama Rao et al., 2000). The chemical composition of the bajra and ragi is given in Table 48.

Table 48. Chemical compositions (%DM basis) of Bajra *(Pennisetum typhoides)* and ragi *(Eleusine coracana)*

Attributes	Bajra (*Pennisetum typhoides*)	Ragi (*Eleusine coracana*)
DM (Fresh basis0	90.09-91.30	90.54-91.00
CP	8.36-10.89	8.34-8.36
EE	3.86-5.24	1.16-3.38
CF	1.97-2.80	3.28-3.66
Total ash	1.68-6.39	3.16-6.73
Acid insoluble ash	0.19-2.08	0.26-2.73
Calcium	1.90	1.70

Effect of replacement of Maize with Bajra (*Pennisetum typhoides*) or Ragi (*Eleusine coracana*) on the performance of laying hens

Sixty three, 30 weeks old Gramapriya white laying hens were assigned to 21 groups with 3 laying hens in each group having approximately equal body weight. Seven experimental diets were formulated by replacing 50 and 100 percent of maize by unground and ground bajra and ragi. Data were recorded on egg production, egg weight, feed intake, feed efficiency, egg white and yolk contents, shape index ,shell contents and shell thickness. Egg production (kgs) and feed efficiency (kg feed/kg eggs) of hens fed bajra (ground and unground) and ragi (unground) by replacing maize completely were similar to those fed control diet with maize as a sole energy source (Table 49). The egg weights of hens fed ragi replacing 100 % maize and bajra (unground) by replacing 50 and 100 % maize were similar to the egg weight recorded on control groups. The shell percentage was significantly ($P \leq 0.01$) higher in hens fed diet with 50 and 100 % maize replaced by ragi. A significantly ($P \leq 0.01$) higher shell thickness was recorded in laying hens fed diet with 100 % maize replaced by ragi (Table 49). The shape index, % egg white and % yolk were similar in all the groups. Results suggested that unground bajra and ragi could replace maize completely in the diet of laying hens without affecting the egg production, egg weight, feed efficiency and other quality parameters in addition to production of stronger shell (Swain et.al, 2009).

Table 49. Effect of replacing maize by bajra *(Pennisetum typhoides)* or ragi *(eleusinecoracana)* on the performance of laying hens

Treat-ment	Egg wt. (gm)	Feed intake (kg)	Egg prod. (kg)	Feed eff. (feed in kgs / egg in kgs)	Shell (%)	Shell thickness (mm)
1	57.1^{cd}	8.28^{ab}	2.43^{b}	3.438^{a}	11.33^{a}	0.340^{b}
2	56.4^{bcd}	8.35^{b}	2.24^{b}	3.810^{a}	11.83^{ab}	0.337^{b}
3	55.7^{abc}	8.29^{ab}	2.54^{b}	3.277^{a}	11.57^{a}	0.333^{b}
4	55.6^{ab}	8.02^{a}	1.59^{a}	5.070^{b}	10.97^{a}	0.313^{a}
5	55.2^{ab}	8.25^{ab}	2.17^{b}	3.827^{a}	10.84^{a}	0.327^{ab}
6	54.2^{a}	8.18^{ab}	1.59^{a}	5.163^{b}	12.90^{bc}	0.340^{b}
7	57.5^{d}	8.32^{b}	2.35^{b}	3.557^{a}	13.80^{c}	0.360^{c}
SEM	0.29	29.56	0.09	0.18	0.24	0.0015

Means bearing different superscripts within a column are significantly ($P \leq 0.01$) different

Effect of replacing maize by Ragi (Finger millet) on the performance of Gramapriya White chicks (1-8 weeks)

A feeding trial was conducted in 120 nos of 1 day old Gramapriya chicks to see the effect of replacing maize by Ragi at various levels on their performance (Annual Report 2008-09). Four experimental diets were formulated by replacing 0, 25, 50 and 100 % of maize in the control diet with ragi. Each diet was fed to triplicate groups and each replicate had 10 nos. of chicks. The experiment was conducted in a completely randomized design and for a period of 8 weeks. Data were recorded on weekly body weight gain and feed consumption. Feed efficiency was also calculated. Result indicated that significant depression in body weight gain and deterioration in feed efficiency was observed in chicks fed diet with total replacement of maize by ragi (Table 50). However, the feed intake remained uninfluenced. The body weight gains and feed efficiencies of groups fed control diet and diets with 25 and 50 % maize replaced by ragi were similar statistically. Cost of feed per kg meat production was lowest in chicks fed diet with 50 % maize replaced by ragi. It may be concluded that ragi could replace up to 50 % maize in the diet of laying Gramapriya white chicks without any adverse effect on their body weight gain and feed efficiency.

Table 50. Effect of replacing maize by ragi on the production performance of Gramapriya white chicks

Treatment	Body wt. gain	Feed intake	Feed efficiency	Cost of feed /kg wt. gain
1	695.3[a]	2826.9	4.066[b]	59.04
2	697.4[a]	2827.5	4.055[b]	57.87
3	683.8[a]	2816.0	4.119[b]	57.74
4	640.2[b]	2803.7	4.380[a]	59.22
CD (0.05)	23.67	NS	0.160	--

9

Poultry hatchery waste

The Poultry hatchery waste (PHW) is the product left over in the poultry hatchery after the hatching process is completed. Poultry hatchery waste is primarily composed of dead chicks, infertile whole eggs and shells from hatched eggs (Hamm and Whitehead 1982). This material is usually incinerated, rendered, or taken to sanitary landfills and used for composting. Each of these disposal methods has particular regulatory or operational requirements or economic characteristics that may enhance or limit its use within a particular farm. Since, the moisture content of the fresh hatchery waste is high, it makes the disposal and incineration costly to the producer and it may be unsafe environmentally (Vandepopuliere *et al*. 1977, Miller 1984). Chemical composition of processed poultry hatchery waste is given in Table 51.

Table 51. Chemical composition of processed poultry hatchery waste

Chemical Constituents	% Composition
Crude protein	22.80-44.25
Ether extract	14.40-30.00
Crude fibre	0.90-8.06
Total ash	14.00-40.00
Calcium	7.26-22.60
Total Phosphorous	0.39-0.84

Ilian and Salman, 1986; Khan and Bhatti, 2001; Rasool et al., 1999;Swain et al., 2011;Wisman, 1964

Feeding value of processed Poultry hatchery waste in Vanaraja chicks

To study the effect of feeding processed poultry hatchery waste (PHW) on the growth performance in Vanaraja chicks. 120 (2 wk) Vanaraja chicks were randomly distributed in to 4 equal groups with 3 replicates and fed on diets prepared by inclusion 0, 2, 4 and 8 percent processed hatchery waste by replacing 0, 25, 50 and

100 percent fish meal of the control diet (Annual Report, 2009-10). The PHW was cooked at 120 lb for 30 min., dried in hot air oven and analysed for proximate composition. Results on performance study indicated significant ($P<0.01$) increase in body weight gain due to incorporation of processed hatchery waste at all the levels in the diet of chicks at 7 week of age by replacing fish meal at 0, 25, 50 and 100 % levels (Table 52). Significant ($P<0.01$) improvements in feed conversion ratio (FCR), protein efficiency ratio (PER) and performance index (PI) in chicks were observed due to feeding of PHW at all the levels. Maximum net profit was recorded due to feeding of 8 % PHW (Table 53, Swain et al., 2011).

Table 52. Effect of processed poultry hatchery waste (PHW) on the performance of chicks

Treatments	Body Wt. gain	Feed intake	FCR	PER	PI
T_1 (0)	454.4^a	1792.5	3.946^b	1.158^a	115.19^b
T_2 (2)	480.2^b	1791.3	3.731^a	1.233^b	128.77^a
T_3 (4)	491.2^b	1806.9	3.679^a	1.263^b	133.55^a
T_4 (8)	498.5^b	1799.7	3.627^a	1.310^c	137.48^a
SEM	5.33	3.35	0.004	0.034	5.358

Table 53. Cost benefit analysis

Parameter	Treatments			
	T_1 (0)	T_2 (2)	T_3 (4)	T_4 (8)
Feed consumed per 100 birds (kg)	179.3	179.1	180.7	180
Cost of feed/kg (Rs)	14.10	13.86	13.60	13.13
Total cost of feed (Rs)	2527.4	2482.7	2457.4	2363
Cost of 100 chicks (Rs)	900	900	900	900
*Total cost (Rs)	4106.7	4061.8	4038.1	3943
Income (Rs)	4181.1	4372.9	4445	4497.5
Net profit (Rs)	74.4	311.11	406.9	554.5
Profit (%)	1.8	7.7	10.1	14.1

*Includes cost of electricity, medicine and labour

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Conclusions

The agro-industrial by-products like brewery waste, cashew apple waste, cashew nut shell, rice kani (broken rice), alternative cereals like ragi, bajra and green fodder like cowpea leaves, are available in plenty locally. Presently these by-products are not exploited to full extent for inclusion in the poultry feed. These by-products and fodder leaves have good nutrient composition and reported to contribute to the productive value for egg and meat with reduction in cost of production. Hence, basied on chemical compositions and potential feeding value, these by-products can be incorporated in the poultry feed formulations to economise the feed cost and to increase the profit margin for the poultry farmers.

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