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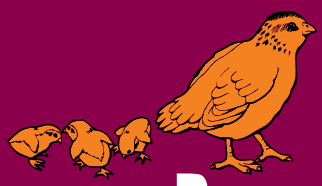

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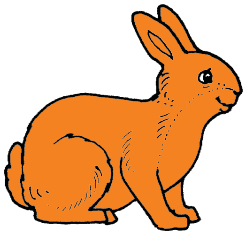

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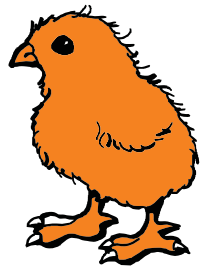

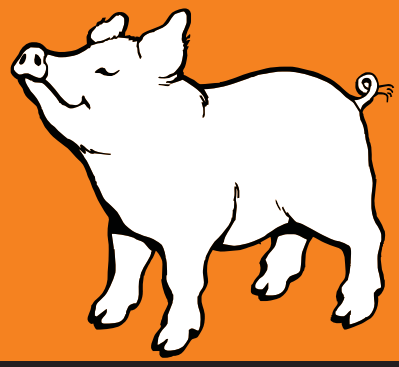

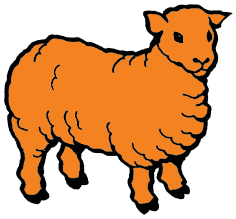

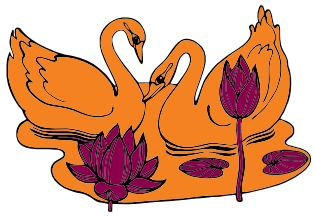

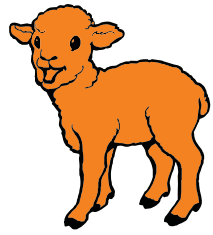

ICAR Research Complex for Goa
Old Goa– 403 402, Goa, India

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Correct Citation

Naik, P. K., Swain, B. K., Chakurkar, E. B. and Singh, N. P. (2011). 35 Years (1977-2011) of Research on Animal and Poultry Nutrition; ICAR Research Complex for Goa - A Scienitific Review. *Scientific Review No. 25, ICAR Research Complex for Goa, Old Goa - 403 402, Goa, India,* Pp. 1-82.

Printed at

Sahyadri Offset Systems,
Corlim, Ilhas, Goa - 403 110
Tel: 0832-2285905

भाकृअनुप
ICAR

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Message

Livestock has traditionally been an integral part of every farming family, as it plays an important role not only in farm production but also in augmenting rural economy and in recycling of farm wastes. In Goa state, about 80 thousand cattle and about 38 thousand buffalo constitute the milch animal group. Among cattle, mostly the local cattle and cross breeds of Jersy and Holstein Frasian with local, Gir and Sindhi are predominant. In the livestock sector important areas that need urgent attention are breeding of cattle and other meat animals, improvement of local breeds of cattle, scientific rearing of rabbits and goats, backyard poultry rearing, livestock feeding, nutrition and health care. To overcome shortage of milk and meat requirements, it is relevant to formulate a suitable breeding and nutritional policy so as to improve productivity of cattle population. Pig being the preferred local species, some of its value added products like sausages need to be promoted to meet the needs of tourists. Similarly, partial stall fed rearing of goats will be a high revenue earning propositions. Backyard rearing of fast growing poultry like Vanaraja, Giriraja and dual purpose poultry would be boon to rural areas.

Keeping above in view, scientists at ICAR – RC Goa have contributed significantly during the past 35 years on the development of feeding strategies towards economic production of milk, meat and poultry. However, the information was lying scattered and needed to be put in a format that is easily understandable by the stakeholders *i.e.* farmers and the policy planners. The authors have compiled the information in a format that would not only be useful for undertaking future research endeavours but also for the other stakeholders alike. The authors certainly deserve a high appreciation for undertaking this commandable job.

A.K.Singh

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Foreword

NUTRITION is the key determinant of the sustainability and economic viability of the livestock and poultry farming as it accounts about 75% of the total cost of farming. The livestock and poultry farming in Goa are facing major challenges due to shortage of feeds and fodder. As most of the feed ingredients are being imported from the neighbouring states, the profits in livestock and poultry farming in the state are marginal. In this situation, scientific efforts for effective usage of the existing feed resources and strategic approaches for adoption of new technologies are highly essential.

ICAR Research Complex for Goa was established by ICAR, New Delhi in April, 1976 under the administrative and technical control of CPCRI, Kasaragod. After functioning at different Govt. farms, it was finally shifted to its present location of Old Goa in 1982. The KVK, North Goa was established at the Research Complex in 1983 and ICAR, New Delhi finally upgraded this research complex to a full fledged Institute in April, 1989. The main focus of this Institute is on applied and strategic aspects in order to increase the agricultural production and productivity in Goa and Konkan region.

During past 35 years, scientists of this Institute have done commendable work on different aspects of livestock and poultry nutrition and the significant contributions have led to enhanced livestock and poultry production in the state. However, all the information is in scattered form and needs an urgent review and compilation for effective use for further research planning.

I am happy that scientists of this Institute have taken the initiatives to review and compile the 35 years (1977-2011) of research work on Animal and Poultry Nutrition of the ICAR Research Complex for Goa under different headings viz. status of livestock and poultry farming, feeds and fodder research, dairy nutrition research, goat nutrition research, pig nutrition research, rabbit nutrition research, poultry nutrition research, salient research findings/ interpretation, thrust areas for future research work and references in the form of a Scientific Review.

I congratulate the authors for this effort and am confident that this publication will be a very useful resource material for the researchers, extension workers, students and farmers during panning their future work.

(Narendra Pratap Singh)
DIRECTOR

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Preface

NUTRITION plays an important role in exploitation of the full genetic potential of the livestock and poultry and is the vital determinant of the cost effective livestock and poultry production. During last 35 years, scientists of this institute have done significant research works, which are available in different annual reports and journals. Research has been conducted on status of livestock and poultry farming, which includes assessment of potential animal and poultry feed resources, status of dairy farmers and dairy animals, feeds and feeding practices of animals. The research work on feeds and fodder includes different varieties of fodder, intercrop approach of fodder cultivation, exploration of un-conventional feed ingredients etc. The research on dairy animals, goats, pigs, rabbits and poultry includes various feeding trials to study the effect of different conventional and un-conventional feeds on their productive and reproductive performances.

Therefore, effort was made to review and compile the 35 years (1977-2011) of research work on Animal and Poultry Nutrition of the ICAR Research Complex for Goa and to present it in the form of a Scientific Review for easy and quick reference. All the information has been given in this Scientific Review under different headings like status of livestock and poultry farming, feeds and fodder research, dairy nutrition research, goat nutrition research, pig nutrition research, rabbit nutrition research and poultry nutrition research. Besides, for easy references and future research work, the key findings of the experiments have been presented separately as salient research findings/ interpretation along with thrust areas for future research work and references.

We anticipate that this bulletin would be useful in providing scientific information in one place for the researchers, extension workers, students and farmers during panning their future work for the enhancement of the livestock and poultry production of the state and Konkan region.

PK Naik, BK Swain, EB Chakurkar and NP Singh

Acknowledgements

We are grateful to Dr. N. P. Singh, Director, ICAR Research Complex for Goa, Goa for taking keen interest and encouraging for the compilation of the last 35 years of research work of this institute.

We are thankful to Dr. A. R. Bhattacharyya, Dr. D. G. Dhandar, Dr. P. G. Adsule and Dr. V. S. Korikanthimath, the Ex-Directors of this institute for providing facilities for nutritional research work during their respective tenure.

We record our deep appreciation to Dr. R. N. S. Sundaram, Principal Scientist (Animal Nutrition) (Retd.) and Late Dr. N. S. Nair, Senior Scientist (Poultry Science) for their significant contributions in the field of Animal Nutrition and Poultry Science, respectively.

We acknowledge all the scientists, technicians and supporting staffs of Animal Sciences Section for providing support always.

PK Naik, BK Swain, EB Chakurkar and NP Singh

Abbreviations

ADF : Acid detergent fiber
ADG : Average daily gain
ADL : Acid detergent lignin
AIA : Acid insoluble ash
AP : Available phosphorus
Avg : Average
BDG : Brewers' dried grains
BIS : Bureau of Indian standard
BW : Body Weight
Ca : Calcium
Cal : Calculated
CAW : Cashew apple waste
CD : Critical difference
CF : Crude fiber
CM : Concentrate mixture
CNS : Cashew nut shell
CP : Crude protein
CRD : Completely randomized design
CS : Common salt
CSC : Cotton seed cake
DCP : Dicalcium phosphate
D : Day
DE : Digestible energy
DGNC : Deoiled ground nut cake
DM : Dry matter
DOGNC: Deoiled ground nut cake
DORB : Deoiled rice bran
EE : Ether extract
FCE : Feed conversion efficiency
FCMY : Fat corrected milk yield
FCR : Feed conversion ratio
g : gram
GCA : Gross cropped area
GG : Grey Giant
GL : Goa Local
GNC : Ground nut cake
h : Hour
ha : hector
IU : International unit
Kcal : Kilo calorie
Kg : Kilogram
Km : Kilometer
KRD : Karad
KRD-PL: Karad treated with *Pleurotus florida*
L : Local
Lb : Pound
LBW : Live body weight
LSP : Limestone powder
M : Meter
Max : Maximum
ME : Metabolizable energy
Min : Minimum
MM : Mineral mixture
MY : Milk yield
NDF : Neutral detergent fiber
NFE : Nitrogen free extract
NZW : Newzealand White
P : Phosphorus
PAW : Pine apple waste
PER : Protein efficiency ratio
PHW : Poultry hatchery waste
PI : Performance index
PO : Palm oil
ppm : Parts per million
PS : Paddystraw
q : Quintal
R: C : Roughage: concentrate ratio
RB : Rice bran
RIR : Rhode Island Red
RK : Rice kani
RLU : Ruminant livestock unit
RP : Rice polish
SBM : Soybean meal
SC : Soviet Chinchilla
SDOC : Soya deoiled cake
Se : Selenium
SEM : Standard error of mean
SFC : Sun flower cake
SMS : Spent mushroom straw
SOC : Soybean oil cake
Sq : Square
SRBC : Sheep red blood cell
TA : Total ash
TDN : Total digestible nutrients
TP : Total phosphorus
t : Ton
VM : Vitamin mixture
WB : Wheat bran
WG : Weight gain
XB : Crossbred

Contents

Introduction

Goa is located in South-Western India in the region, also known as Konkan. It lies between 15048" and 14053" North latitude and between 74020' and 73040' East longitudes. Goa is cradled beetween Karnataka, Maharastra and the Arabian Sea. On the slopes of Western Ghats, it stretches out to a length of 105 km from north to south and is about 60 km wide from east to west. Goa has total area of 3702 sq km in which the forest cover is 2095 sq. km. The soil of Goa is mostly laterite with limited sandy soils in some coastal region. Goa is India's smallest state by area, 4th smallest by population, but is richest with a GDP per capita 2.5 times that of the nation. Blessed with a unique climate of 18-35^{0}C, 2500-4000 mm annual rainfall with humidity, it is a biodiversity hot spot and best suited for integreted farming system including animal husbandryt as a prominent component.

As per latest census (2001), Goa has a population of 13. 44 lakhs of which urban population is 49.8% and rural population is 50.2% and population density of 363 persons per sq. km. Further, being an important tourist spot, every year on an average 15.0 lakhs tourists visit the state. As per 17th livestock census (2003), state had 12000 crossbred cattle, 63000 indigenous cattle, 75000 total cattle, 37000 buffaloes, 112000 total bovines, 11000 goats, 87000 pigs, 565000 fowls and 1000 ducks. Goa had 0.04% of cattle, 0.04% of buffaloes and 0.65% of pig population of the country. In Goa, crossbred cattle increased sharply by 71.4% but indigenous cattle decreased by 22.2% during the period between 16th (1997) and 17th(2003) census. There is a decline of 14.8% in total cattle population during the inter-censal period. The buffalo and goat population has also decreased by 7.5% and 15.4%, respectively. Pig population of the state has decreased by 17.1%. The total livestock in the state has decreased from 0.246 million to 0.210 million between these two censuses showing a heavy decrease of 14.6%. There is heavy decrease in fowl population in the state during the inter-censal period. Fowl population has decreased by around 28.4% in the state.

Goa produces approximately only one-third of its requirement of milk and meat products and is solely dependant upon the neighbouring states for the additional demand. Even for feeding the livestock and poultry population, feeds and feed ingredients are being imported from the neighbouring states. As feed cost is approximately 75% of the total cost of production, nutrition plays vital role for a profitable livestock and poultry farming. In this situation, scientific efforts for effective usage of the existing feed resources and strategic approaches for adoption of new technologies are highly essential.

ICAR Research Complex for Goa, Goa has the responsibility of increasing the agricultural production and productivity by conducting applied and strategic research. Research has been conducted in this institute on various aspects of livestock and poultry nutrition. Further, in this Scientific Review, all information on research works conducted in last 35 years (1977-2011) in this institute has been compiled under different headings *viz.* status of livestock and poultry farming, feeds and fodder research, dairy nutrition research, goat nutrition research, pig nutrition research, rabbit nutrition research, poultry nutrition research and presented along with the salient research findings/ interpretation and thrust areas for future research work.

Status of Livestock and Poultry Farming

Cattle management practices and milk production in Goa *(Bhattarchya and Costa, 1977)*

In a survey conducted in Salcete Taluka of Goa, 37 dairy farmers were contacted. Amongst them, 22% farmers were maintaining both cows and buffaloes. Only 5% farmers were producing green fodder (*viz.* elephant grass, maize and cowpea) for their livestock. Besides, 87% and 50% of the farmers were do not feeding concentrate to their cows and buffaloes, respectively. During that particular time, only 14% of the cows were pregnant, which was extremely low (normally 60% should be pregnant).

Serum calcium and phosphorus profile of cattle in Goa *(Sundaram and Bhattacharya, 1985)*

Infertility and poor milk yield among crossbred cows were two major complaints received from the farmers in Goa. Low plane of nutrition was a major factor responsible for the decreased productivity emphasized by several workers. There were encouraging results obtained with tonophosphan injection in clinical trials among anoestrus cows. In view of this a survey was conducted to ascertain the mineral status of cattle in Goa particularly with reference to Ca and P.

Blood samples were collected from 43 lactating cows and 25 heifers having poor and inconsistent production and delayed maturity under field conditions. In the investigation, 43 cows of four different breeds were examined (Table 1).

The average Ca level was 8.40 mg% serum, which was marginally lower than the required normal level of 9-12 mg%. Breed wise analysis of the data indicated that lower level of Ca existed in H. Friesian and Sindhi cows. In Jersey crosses although Ca level (9.19 mg %) was within normal range, the ratio of Ca: P was wider indicating existence of mineral imbalance in this group. In heifers, subnormal level of Ca (7.76 mg%) was observed. Observations indicated prevalence of marginal deficiency of Ca or mineral imbalance of Ca: P in dairy animals under field conditions. Paddy straw was major source of feed for dairy animals in Goa. Since straw interfered with Ca intake, excess feeding of straw could possibly a major cause for mineral imbalance in these animals. Jersey crosses which had mineral imbalance due to low P level were treated with tonophsphan and prepalin forte injection (vitamin A) and encouraging results were obtained. For other animals which exhibited marginal deficiency of Ca, following preventive measures were suggested.

- Feeding MM containing Ca/P 30 g/ d/ animal. Limestone and sterilized bone meal can also be fed @ 20 g/ d / animal.

Table 1: Serum calcium and inorganic phosphorus level of dairy cattle

Breed	No of Animals	Ca (mg %) Range	Mean Ca (mg %)	P (mg %) Range	Mean P (mg %)	Ca: P ratio
Red Sindhi	8	5.00-9.40	7.89	3.65-5.60	4.50	1.75
Jersey	7	7.20-11.20	9.31	4.68-6.28	4.86	1.92
Jersey cross	12	7.85-10.60	9.09	3.48-6.28	4.09	2.22
Friesian cross	16	9.31-6.10	7.73	3.20-5.60	4.39	1.76
Heifers	25	14.00-4.40	7.76	3.50-5.76	4.71	1.65

- Fish meal and meat meal which are sources of Ca to be incorporated in concentrate mixture @ 5-10%.
- Legumes fodders like cowpea to be provided @10 kg/ animal/ d.
- Grazing animals in pasture for 4-6 h/d was also suggested to facilitate Ca intake.

Feeds and by-products resources for livestock feeding *(Sundaram and Bhattacharya, 1986)*

A survey was made to identify availability of various by-products and waste materials. Tterritory of Goa had about 35000 adult cows and 19000 buffaloes, which required 112 MT concentrate feed every daily. In addition, considerable amount of concentrate feed was also required for raising poultry and piggery. Although, 36% of the land was under cultivation, mostly rice was grown in this area. Coarse grains like maize, jowar etc which were essential ingredients in livestock feed were not commonly cultivated. Consequently, majority of feed ingredients were brought from neighbouring states. It was revealed that 82% of total maintenance expenditure in dairy units goes for feeding alone indicating necessity for identifying alternative methods to reduce feed costs. Several agro-industrial units and fish canning centers in Goa produced large amount of by-products and waste materials. Utilization of these unconventional materials in concentrate feed for partial replacement of costly ingredients will help to reduce feed cost.

Availability of various byproducts and their approximate cost is furnished in Table 2.

Table 2: Byproduct resources of Goa

Item	Availablity (MT)	Approx. Cost/ Kg
Rice bran	8000	0.70
Molasses	4000	0.10
BGW	300 (DM)	0.70
Fishmeal	5000	1.50-3.50
CAW	100	0.20

Fishmeal: The 100 km long coastal line of Goa acquired 25000 MT fish per annum; 5000 MT thrash fish was available, which was sun dried as fishmeal and exported to the neighbouring states. In addition, there were 15 fish canning units which provided 25 MT fish processing waste, which was discarded in surrounding area creating health hazards.

Molasses: The co-operative sugar factory with a crushing capacity of one lakh MT cane per annum produced 4000 MT molasses. This could be utilized for partial replacement of cereals like maize and jowar, which were brought from the neighbouring states to reduce feed cost.

Brewery grain waste: Sprouted barley grain is discarded as waste material after fermentation in breweries. It had 18% CP and 20% CF. Two large scale breweries located in the territory produced 1200 MT brewery grain waste per annum.

Rice bran: Paddy is the major food crop in Goa. About, 140000 ha land was under paddy cultivation. Annually, 8000 RB was available as by-product which was cheaper (half the price) than WB.

Cashew apple waste: It is a seasonal waste product available during summer months. Apple was used for extraction of fenni and the remnants were discarded. It had 10.2% CP and 14% CF. Annually, 100 MT waste was available, which could be fed to pigs and cattle. Dried waste had been incorporated at 10% level in cattle and satisfactory production performance had been obtained.

Flour mill wastes: There were two commercial flour mills producing atta and besan. Wastes from these factories were available for feeding pigs.

In addition to the above, fruits canning factory wastes like pine apple and mango wastes were available seasonally, which could be incorporated in pig mash to reduce the cost of feeding.

Besides, coconut oil cake and distillery wastes were also available in limited sources by adopting

the patented practices which were already available for incorporating these byproducts in concentrate feed and livestock maintenance expenditure could be reduced to an economic level. The chemical composition of different by-products is provided in Table 3.

Table 3 : Chemical composition of different byproducts

Para-meters	BWG	CAW	Bagg-asse	Fish-Meal
Moisture	80.90	77.30	11.20	9.20
CP	17.90	10.50	2.60	42.00
EE	3.50	4.00	2.60	4.00
CF	20.60	14.30	43.00	5.80
NFE	54.30	69.00	47.60	11.00
TA	3.70	2.50	4.20	37.20

Evaluation of potential feed resources for feeding of livestock and poultry in Goa *(Naik et al., 2010)*

A study on assessment of potential animal and poultry feed resources in Goa was made, so that it would be helpful in development of suitable feeding strategies for the livestock and poultry population. The livestock population and poultry population were recorded (Table 4).

Table 4: Livestock and poultry population of Goa

Parameters	North Goa	South Goa	Total
Total bovine population	65655	47529	113184
Cattle population as % of total bovine population	63.40	71.85	66.95
Female cattle as % of total cattle	57.15	52.36	55.00
Milch cattle as % female cattle	38.14	36.77	37.55
Milch cattle as % of total cattle	21.80	19.25	20.65
Crossbred cattle as % of total cattle	16.02	16.50	16.24
Crossbred female cattle as % of total crossbred cattle	88.11	85.16	86.76
Crossbred milch cattle as % of crossbred female cattle	46.97	46.68	46.84
Crossbred milch cattle as % of total milch cattle	30.42	34.07	31.95
Female buffaloes as % of total buffaloes	70.21	72.31	70.96
Milch buffaloes as % of female buffaloes	43.82	43.74	43.79
Milch buffaloes as % of total buffaloes	30.76	31.63	31.07
Total female bovine as % of total bovine	61.93	57.98	60.27
Total milch bovine as % of total female bovine	40.50	39.21	39.98
Total milch bovine as % of total bovine	25.08	22.74	24.10
Sheep	44	29	73
Goat	6992	4128	11120
Ruminant Livestock Unit (RLU)	43619	31666	75285
Pigs	27636	59788	87424
Broilers (5 batches)	750000	300000	1050000
Layers	50000	25000	75000
Geographical area (km2)	1736	1966	3702
RLU Density (RLU/ km^2)	25.13	16.11	20.34
Human population	758573	589095	1347668
Human density per km^2	437	300	364

Availability of feed resources was assessed indirectly based on mean values of last three consecutive years (2006-07, 2007-08 and 2008-09) data of land utilization pattern and crop production to minimize differences in yearly variations (Table 5).

Feed resources were categorized as green forages, crop residues and concentrates (grains, grain byproducts and oil seed cakes).

Table 5: Mean values of land utilization and crop production pattern

Parameters	North Goa	South Goa	Total
Land Utilization Pattern (ha)			
Gross cropped area	105099	64323	169422
Fallow land	5796	2579	8375
Permanent pasture land	629	676	1305
Miscellaneous tree crops	570	10	580
Cultivable waste land	17067	27103	44170
Forest area	35042	90431	125473
Crop Production Pattern (ha)			
Paddy	28965	22749	51714
Ragi	120	80	200
Pulse	7000	4130	11130
Groundnut	3100	500	3600

Availability of green forages was calculated based on following classifications and assumptions (i) Cultivated fodder: National average of 4% of GCA is under fodder production with primary grazing: Comprising of current fallow land and other fallow lands with an average annual yield of 1.0 MT/ ha (iii) Public primary grazing: Comprising of permanent pasture, miscellaneous tree crops and cultivated waste with an annual average yield of 5.0 MT/ ha (iv) Public secondary grazing: Comprising of forest area and on assumption that only 50% area is available for grazing with an annual yield of 3.0 MT/ ha. Appropriate conversion factors based on grain to straw ratios and extraction rates were used to calculate availability of crop residues, grains, grain-byproducts and oil seed cakes from crop production data (Table 6).

Table 6: Conversion factors for estimation of crop residues, oil cakes, brans and chunnies of various crops

Crop	*Conversion Factors*			
	Crop Residues	Oil Cakes	Grains	Brans & Chunnies
Paddy	1.30	---	0.02	0.08
Ragi	2.00	---	0.05	---
Pulses	1.70	---	---	0.03
Groundnut	2.00	0.7	---	---
Sugarcane	0.25	---	---	---
Coconut	---	0.0625	---	---

Fine straw included only paddy straw; while coarse straw included straw from ragi, groundnut and sugarcane tops. Yields from greens, crop residues and by-products were calculated on the basis of DM yield assuming 25%, 90% and 90% DM, respectively. For assessing requirements of feed resources by livestock, only ruminants (cattle, buffaloes, sheep and goat), pigs and improved poultry were considered, as they were major consumers of feed resources in Goa. Annual feed requirements of pigs and poultry were estimated and available concentrate was allocated to pigs and poultry on assumption that on an average pig and broiler would consume about 280 kg and 3.8 feed per their productive life; and layer would consume 40 kg feed/ year. Further, it was assumed that in a year, two batches of pig and five batches of broiler were reared. After allocating feed resources to the pig and poultry, remaining feed was allocated to ruminants for assessment of available feed resources. To overcome limitations of wide differences in live weight and production among ruminants (cattle, buffalo, sheep and goat) population, they were transformed to standard RLU of 350 kg BW adopting conversion factors (Table 7).

Table 7: Conversion factors for calculation of Ruminant Livestock Units (RLU)

Species	Category	Conversion Factor
Cattle	Below 1 year	0.11
	1-3 years	0.34
	Above 3 years	0.80
Buffalo	Below 1 year	0.17
	1-3 years	0.50
	Above 3 years	1.00
Sheep and Goats	---	0.10

The DM requirement of individual RLU was calculated @ of 3% of BW i.e. 10.5 kg/d. Status of livestock and potential animal feed resources from different resources in Goa is provided in Table 8.

Table 8: Potential Feed availability from different resources in Goa

Particulars	North Goa	South Goa	Total
Green Forage (MT)			
Cultivated fodder	168158	102917	271075
Private primary grazing	5796	2579	8375
Public primary grazing	91330	138945	230275
Public secondary grazing	52563	135647	188210
Total	317847	380087	697935
Total (on DM basis)	79462	95022	174484
Crop Residues (MT)			
Fine straw (paddy)	37655	29574	67229
Coarse straw (ragi, groundnut and sugarcane tops)	6507	1348	7855
Leguminous straw	11900	7021	18921
Total straw	56062	37943	94005
Total Straw (on DM basis)	50456	34149	84605
Concentrates (MT)			
Grains (paddy and ragi)	585	459	1044
Brans and chunnies (paddy and pulses)	2527	1944	3471
Oil seed cakes (groundnut and coconut)	2875	1246	4121
Total concentrates	5987	3649	9636
Total concentrates (on DM basis)	5388	3284	8672
Concentrates Consumed by Pigs and Poultry (MT)			
Pigs (2 batches)	15476	33480	48956
Broilers (5 batches)	2850	1140	3990
Layers	2000	1000	3000
Total concentrates	20326	35620	55946
Total concentrates (on DM basis)	18293	32058	50351
Feed Availability (kg/RLU/d)			
DM concentrate availability	- 0.81	- 2.49	- 1.52
DM green forage availability	4.99	8.22	6.35
DM crop residues availability	3.17	2.95	3.08

Goa had total bovine population of 113184 with higher population in North Goa than South Goa. Cattle population was higher in South Goa, while buffalo population was higher in North Goa. However, state had more cattle population than buffalo population. In both districts of Goa, cattle were kept for dual purpose *i.e.* for milk and draught purposes (to carry out agricultural operations), as evident from data of female cattle as percentage of total cattle. Cross bred cattle population of state, which was 16.24% of total cattle population was higher than figures of Northern Karnataka (5%), Karnataka state average (10%) and similar to Southern Karnataka region (16%). From composition of the female crossbred cattle and buffaloes, it was clear that these were mostly kept for milk production in both districts of Goa and state level, similar to Malnad region of Karnataka. Goat population in Goa was higher than sheep population, which was almost negligible, similar to coastal region of Karnataka. Total female bovines, milch bovines, sheep, goat, RLU density, broilers and layers in North Goa were higher than South Goa. However, pig population in South Goa (59788) was higher than North Goa (27636). The RLU density of Goa (20.34 RLU/ km^2) was lower than RLU density of coastal region of Karnataka (45.19 RLU/ km^2).

Goa had potential green forage availability of 174484 MT on DM basis including 79462 MT from North Goa and 95022 MT from South Goa. Major chunk of the potential green fodder availability in North Goa was contributed from GCA, which was similar to scenario of national level and Karnataka state level. In South Goa, major portion of the green forage was contributed from permanent pasture, miscellaneous tree crops, cultivated waste and forest area, which was similar to scenario of the Coastal Karnataka. In Goa, at state level, permanent pasture, miscellaneous tree crops, cultivated waste and forest area had similar potential contribution as GCA. Therefore, appropriate interventions should be made to enhance yield of green forage quantitatively and qualitatively.

Similarly, Goa had potential crop residues availability of 84, 605 MT on DM basis including 50, 456 MT from North Goa and 34, 149 MT from South Goa, of which major portion was contributed from fine straw followed by leguminous straw and coarse straw. Fine straw was fully contributed by paddy straw, which was predominant roughage source throughout coastal region of India. Paddy straw contains oxalate, which binds with Ca and hinders absorption in animals. Therefore, before feeding straw, it must be soaked in water for 3-4 h to reduce oxalate content and rations of animals must be supplemented with mineral mixture. Leguminous straw was contributed by pulses, while course straw mainly includes ragi, groundnut and sugarcane tops. Although, ragi straw was nutritionally superior to paddy straw, its availability was meager similar to Northern Karnataka region.

Potential DM available from green forages was higher than DM available from crop residues, which was similar to situation in coastal region of Karnataka, but in contrast to situation of national level or adjacent Karnataka state. Annual potential concentrates availability of Goa was 7,772 MT. Major portion of concentrates in North Goa were oil seed cakes contributed from groundnut and coconut followed by brans and chunnies contributed from paddy and pulses and then grains contributed from paddy and ragi; while in South Goa, major portion of concentrates included brans and chunnies followed by oil seed cakes and grains.

Total concentrates consumed annually by pigs and poultry had been estimated as 50351 MT, which indicates that in this scenario, Goa was not self sufficient in feed resources to take care of feed requirement of its pigs and poultry, even if all concentrates would be allocated to them. Further, major feed ingredients in poultry feed formulations were maize and soybean meal, which were not cultivated in this state and are procured from its bordering states. As per thumb rule, at least one-

third of DM requirement i.e. 3.5 kg/ RLU/ d should be contributed from concentrates. Potential green forage availability in South Goa was higher than North Goa, while DM crop residues availability in North Goa was higher than South Goa. Potential total DM availability (kg/ RLU/ d) only from roughage sources was 9.43 including 8.16 in North Goa and 11.17 in South Goa against requirement of 10.5 kg/ RLU/d. Thus, there was potential deficit of 2.59 kg DM/ RLU/ d in Goa including deficit of 3.15 kg DM/ RLU/ d in North Goa and 1.82 kg DM/ RLU/ d in South Goa.

Thus, it was concluded that there was a potential deficit of concentrate and roughages to fulfill nutritional requirement of livestock and poultry population in Goa. Therefore, need of hour was to enhance yield of various crop production and green forage quantitatively and qualitatively through suitable scientific interventions including intercropping approach in plantation, development of area specific year round production and feeding programme and improvement of nutritive value of cereal crop residues. Besides, reduction in number of male cattle population and increasing number of high yielding animals were highly essential to make Goa an agriculturally self-sufficient state.

Status of dairy farmers and dairy animals in Goa *(Naik, 2010-11; Naik et al., 2011a; Naik et al., 2011b)*

In a survey work, 66 farmers were selected randomly from different talukas of Goa, which included 1170 dairy animals. Comprehensive questionnaire was prepared and information was collected through personal visit to dairy farmers. During visits, feed samples were collected and analyzed for proximate principles. Socio-economic status of farmers was assessed by number of milch animals possessed and land holding size. Based on number of milch animals viz. < 5, 5-<10, 10-<20 and 20 or above, farmers were divided as marginal, small, medium and large dairy farmers, respectively. However, farmers were grouped as marginal, small, medium and large farmers based on land holding size viz., 0.01-1.00 ha, 1.01-2.00 ha, 2.01-4.00 ha and > 4.00 ha, respectively. Wet average of the dairy herd was calculated as total milk production divided by total number of milking animals; while herd average of dairy herd was calculated as total milk production divided by total number of milking plus dry animals.

Socio-economic and socio-cultural status of farmers with regard to occupational pattern revealed that only 8% farmers had dairying as primary occupation. Majority (74%) of farmers had agriculture or horticulture as primary occupation and 18% farmers had service or business as main occupation. Based on number of milch animals, 51.5, 27.3, 16.7 and 4.5, per cent farmers were marginal, small, medium and large, respectively; while based on land holding size, 37.9, 18.2, 16.7 and 27.3, per cent farmers were marginal, small, medium and large, respectively. Numbers of marginal farmers were highest both in terms of number of dairy animals or land holding size. It indicated that up to medium land holding size (4 ha), number of milch animals increased with land holding size of farmers, probably due to feed resources capacity of farmers. However, large land holding size farmers (>4.0 ha) did not prefer to keep more dairy animals, which might be due to their first priority for their agricultural or horticultural activities. Majority (90.9%) of dairy farmers had concrete housing and only 9.1% dairy farmers had mud housing for their dairy animals. Dairy farmers with fodder cultivation, chaff cutter and milking machine were only 47%, 24.2% and 21.2%, respectively. As dairy farming was mostly integrated with agricultural or horticultural activities, 40.9% of dairy farmers had biogas plant, but only 4.6% had generator set.

Importance of feed quality and minerals on production and reproduction in dairy animals was well established. Only 84.8%, 83.3% and 54.5% of dairy farmers were aware of feed quality, MM and common salt feeding, respectively. Advantage of fodder feeding, hay making and silage making was known by 77.3%, 24.2% and

10.6% dairy farmers, respectively. Only 4.5% and 3.0% dairy farmers were aware of bypass protein and bypass fat feeding technologies, respectively, which might be attributed to less number of high producing dairy animals in the state. Concept of total mixed ration and calf starter was known by respectively 16.7% and 33.3% of dairy farmers. Various nutritional technologies like urea molasses mineral block, urea ammoniation of crop residues and complete feed block feeding were known by only 15.2%, 4.5% and 4.5% dairy farmers of the state, respectively.

Number of indigenous cows was very less i.e. only 2.05% of total cattle population and population of crossbred cows was 50.42% of total animals. Very few dairy farmers were opted for female buffaloes (7.95% of total cattle population) for milk production. Less number of buffaloes might be attributed to more number of marginal dairy farmers of state and general trend in decrease buffalo population. Total milch animals and dry animals constitute 43.93 and 15.64, percent of total cattle population, respectively. Wet average was 7.62 kg/ day while herd average was 5.79 kg/ day. First calving age of cows and buffaloes were observed as 26.5 months and 46.3 months, respectively, while calving interval of cows and buffaloes were 14.9 months and 17.0 months, respectively. In 22.7% and 27.3% of dairy animals had reproductive problems like anoestrus and repeat breeding, respectively, which might be attributed to imbalanced ration in terms of energy, protein and minerals.

Grazing of animals is a traditional feeding practice since ancient time and is still continuing in many parts of the country. In the study, feeding traditions practiced by dairy farmers were either stall feeding or grazing or both. Exclusive stall feeding was practiced by 68.2% of dairy farmers, while other allowed their animals to graze for 5-8 h/ d. Complete ration of dairy animals consisted of concentrates and roughages. Roughages included green fodders and dry fodders or crop-residues. In the study, concentrate feeds were either purchased (ready-made) or home-made. Only 24.2% of dairy farmers used exclusively purchased concentrate feed, which were in pellet form and 1.5% dairy farmers used exclusively home-made concentrate feeds.

Physical composition of home-made concentrate feeds varied among dairy farmers, which was generally 1-3 ingredients based. Home made concentrate feed consisted of either exclusive ground maize or ground maize + RB/ WB or ground maize + CSC or RB/ WB + CSC or ground maize + CSC + RB/ WB; in approximately equal ratio. However, majority of dairy farmers (74.3%) used both purchased and home-made concentrate feeds mixed in ratio of 1:1-4:1. Among ingredients of home-made concentrate feeds, ground maize and CSC were most preferred for supplementation with purchased concentrate pellets. There was an impression among farmers that supplementation of home-made concentrate feeds with purchased concentrate feeds should be must to maintain milk yield. Major reasons behind this were inadequate quantity and quality of purchased concentrate feeds offered to dairy animals. Farmers of Goa preferred to feed their dairy animals CSC with perception that it was nutritionally better than other cakes. It is well established that cotton seed cake is a good source of by-pass protein, which is not degraded in rumen, but is digested in the lower part of digestive tract and improves quality and quantity of milk production. However, protein content of CSC was lower than other cakes like GNC or SBM. Therefore, scientific feed formulation was necessary to achieve optimum result. Some farmers soaked home-made concentrate feed for few hours (4-8 h) before feeding to dairy animals with impression that it would increase palatability and digestibility and reduces dustiness of feed. Impression of farmers on soaking of concentrate feeds before feeding had sufficient scientific validity and was supported by earlier workers.

Type and level of roughage in diet have significant effect on productivity of dairy animals, as they modify rumen microbial population and thus facilitate microbial enzymes secretion responsible

for digestibility of nutrients. Adequate feeding of green fodders decreases dependence on concentrate feeds, keeps dairy animals healthy and reduces cost of milk production. In the study, only 47% dairy farmers were cultivating green fodders for feeding of dairy animals round the year, while 53% dairy farmers were feeding only naturally grown grasses during rainy season. Naturally grown green grasses were abundantly available in fallow land, pasture land and forest area of Goa during July- November. During rainy season, naturally grown grasses fed to dairy animals are green karad grass and mixed grasses, which included road side grasses, tree leaves and edible weeds. Cultivated fodders were mostly non-leguminous (Hybrid Bajra Napier). However, seasonal non-leguminous crops like maize and Jowar were occasionally grown by some selected farmers for grain consumption and after harvesting crop residues were used for animal feeding as dry roughages. Very few farmers were using subabul tree leaves for animal feeding, grown on bonds of their fodder plots.

Traditional feeding of dairy animals is dependent upon the cropping pattern of particular area. As rice is staple food of Goans, paddy cultivation was very common and after harvesting the crop residues (straw) was used for animal feeding. Besides, karad grasses were naturally grown during unset of monsoon, which gradually became dry after rainy season and became available as dry roughages during month of December- February. Dry roughages used for feeding of dairy animals were paddy straw, dry karad grass and jowar straw (kadaba kutti). Paddy straw and dry karad grass were stacked outside in a dome shape, keeping a bamboo in middle as a support. However, some farmers were storing paddy straw and dry karad grass under polythene cover or under roof. One of the interesting finding was that although Jowar was not grown here, farmers purchased jowar straw (*kadaba kutti*) from neighbouring state (Karnataka) and prefer to feed their animals. Dry roughages were fed either exclusively or in combination of two. Paddy straw, dry karad grass and jowar straw (*kadaba kutti*) were fed exclusively by 25.8%, 22.7%, and 21.2% dairy farmers, respectively. Some farmers claimed that animals did not prefer paddy straw, still they had no choice as it was grown by themselves. 13.6%, 10.6% and 6.1% dairy farmers fed their dairy animals dry karad grass + *kadaba kutti*, paddy straw + *kadaba kutti* and dry karad grass + paddy straw, respectively. Very few dairy farmers were feeding their dairy animals maize stover and guar stovers, which were grown in their own fields.

Uses of un-conventional feeds are a part of traditional feeding system to reduce cost of production. In the study, 16.7% dairy farmers were feeding un-conventional feeds to their dairy animals. Among farmers using un-conventional feeds viz. brewers' grain, arecanut sheath (stalk), banana leaves and banana stems, maximum farmers (63.6%) were using brewers' grain and rest farmers (36.4%) were using arecanut sheath (stalk) or banana leaves or both. Most probable reason behind this was that Goa has many distilleries units for the preparation of cereal malt beverages and spent brewers' grains; by-product obtained during preparation of cereal malt beverages was generally discarded.

Dairy farmers had their own feeding schedule for dairy animals based on traditional knowledge. In morning, during milking dairy animals were provided with concentrate feeds followed by grazing or green fodder and dry roughages. Similarly in afternoon, concentrate feed was offered during milking followed by green fodder and then dry roughages. For economic dairy production, dairy animals should be offered feeds based on their milk production and lactational stage. However, in this study, only 47% and 25.8% of dairy farmers were feeding their dairy animals based on milk yield and lactational stage, respectively.

Farmers were unaware of nutrient requirements of dairy animals and animals were offered feed in group by their labourers approximately. However, feeds offered to milking animals were higher than dry animals. Concentrate feed offered varied

from 2-10 kg/ animal/ d in milch animals and 2-6 kg/ animal/ d in dry animals. Dairy farmers adjust supply of green fodders as per seasonal availability. Quantity of green fodder offered to dairy animals was more during rainy season as compared to other seasons, which might be due to abundant availability of green fodder during rainy season. During rainy season, both milch and dry animals were offered 10-20 kg green karad grass or mixed grass/ animal/ d. Less quantity of dry fodder and more green fodder was offered to dairy animals during rainy season due to surplus availability of green fodder. However, amount of cultivated green fodder offered varied from 3.0-30.0 kg/ milch animal/ d and 3.0-15.0 kg/ dry animal/ d. During scarcity period, first preference of feeding fodders was milking animals only. Dry roughages (paddy straw, dry karad grass or kadaba kutti) available to both milch and dry animals varied from 2-15 kg/ animal/ d. Paddy straw contains high silica and oxalates and should be chaffed and soaked in water before feeding to increase palatability and digestibility. However, paddy straw and dry karad grass were not chaffed and soaked in water by dairy farmers before offering to their animals, which need immediate interventions. Few farmers offered brewers' grain, areca nut sheath (stalk) and banana leaves 4-10 kg, 05-2.0 kg and 0.5-5.0 kg per animal per day, respectively.

There was large variation in chemical composition of feeds. As per specifications of BIS, compounded cattle feed (Type 1& II) should contain 20-22% CP (min), 2.5-3.0% EE (min), 7-12% CF (max) and 3-4% AIA (max). In the study, CP content of purchased concentrate feeds (17.3-20.8%) were lower than BIS specifications (20-22%), however, other parameters viz. EE, CF and AIA were towards close proximity to BIS specifications. The CP, EE, CF, NFE, TA and AIA of home-made concentrate feeds were 8.6-23.1, 1.3-15.3, 2.5-30.3, 35.6-84.2, 1.8-8.5 and 0.2-1.4, per cent respectively. Composition of home-made concentrate feeds was highly variable, imbalanced and was not fulfilling BIS specifications because of lacking in scientific blending in proper proportions with all type of feed ingredients. The TA contents of commercial feeds were higher than home-made concentrate feeds resulting in low organic matter content in former than later.

The CP content of cultivated green fodder varied from 6.7 to 19.6%, while CF content varied from 21.1 to 41.4%. This might be due to differences in varieties, harvesting stage and soil characteristics. The CP contents (%) of karad grass (4.5-5.4) and mixed grasses (6.0-9.4) were lower than cultivated fodders (6.7-19.6). The CP % of subabul tree leaves was 26.0-26.6%, which is a good source of protein.

Nutritive values of dry roughages are very poor (low CP and high CF) and provide only bulk to dairy animals. Among dry roughages, CP% of guar stover was lowest (1.3-2.5%). However, among predominantly used dry roughages, kadaba kutti contained highest CP (3.3-4.4%) and lowest CF (33.3-34.6%) than paddy straw (2.4-3.1%; 30.8-36.6%) and dry karad grass (2.4-3.1%; 42.7-46.3%), which might be the reason of its good palatability to animals as claimed by farmers.

Spent brewers' grain is a good source of protein but has high fiber content. The CP and CF contents of brewers' grain were 17.8-25.2% and 18.1-19.4%, respectively. Dry arecanut sheath contained 3.4% CP and 39.2% CF. The CP% of banana leaves (19.1%) was higher than stem (4.1%).

It was concluded that farmers should be made aware of scientific feeding of their animals to improve their socio-economic status. Besides, scientific interventions are needed in traditional feeding of dairy animals to make dairy farming more profitable venture. In this situation of scarcity of green fodders and high cost of concentrates, development of awareness for scientific feeding, encouragement for fodder cultivation, strategies for improvement in quality of existing feed resources and use of un-conventional feeds with supplementation of mineral mixture might be solution to improve productive and reproductive

performance and plane of nutrition of animals.

Status of goat farming in Goa *(Anonymous, 2004-05; 2005-06)*

Data on socio-economic status of goat farmers was collected from four talukas of Goa viz. Canacona (5), Pernem (11), Satari (8) and Bicholim (8). In 16 units goat rearing was a part time occupation combined with seasonal labour work and crop cultivation. Herd ranged from 5-300. In larger units, one-third of animals were disposed as surplus stock per annum. Net income through a unit of 100 goats was Rs. 4016/- per month in addition to increase in asset value of Rs. 21, 000/- per annum.

Particulars on goat rearing were collected from the units at Valpoi (5), Sanguem (3), Quepem (2) and Pernem (4). Units at Sanguem ranged from 10-30 animals as subsidiary occupation, with part time labour being other source of income. Units at Valpoi had 10-90 animals combined with crop cultivation. At Pernem, goat units with 15-40 animals were observed, where cashew cultivation is part time seasonal occupation. Two units with goat farming as only occupation were recorded in Mopa with herd strength ranging from 3-50 units. Ten crossbred goat kids of 7-8 kg LBW under a feeding trial for partial replacement of green fodder with supplementary feeding (300 g/ animal/ d) recorded LBW of 13.26 kg, with ADG of 75.65 g.

During project period (2001-2006), 76 units of goat farmers were contacted. Study revealed that only 6.97% goat farmers had land for cultivation. Further, 72.09% were engaged in part time labour for income generation and 29.26% of goat farmers were literate. Except one organized goat farm, others were rearing non-descript animals, grazing on fallow lands and in cashew plantations. Study showed that 44.18% had non-descript cattle ranging from 1-5 animals to supplement their income, while 37.2% had buffaloes. It was observed that numbers of units were becoming less due to restriction on free range grazing.

Constraint analysis of commercial poultry farming in Goa *(Swain et al., 2009)*

A study was conducted to know various constraints of poultry farmers. One hundred poultry farmers were selected in two districts of Goa i.e. North and South Goa. Out of 100 farms 90 % were engaged in broiler production and remaining 10 % were layer farmers. Study revealed that main problems encountered by farmers was high feed cost followed by competition with outside farmers, high labour cost, trading, high cost of electricity, high cost of chicks and non-availability of health services. Major suggestions were provision of subsidized feed, electricity and water and establishment of feed mill with subsided equipments, remunerative price for broiler and eggs through co-operative marketing.

Feeds and Fodder Research

Evaluation of different fodder crops *(Mandal and Bhattacharya, 1977; Bhattarchya and Sundaram, 1987)*

Fodders viz. Hybrid Napier (NB-21), BN-2, and Para grass; pasture grasses *viz. Cenchrus ciliaris, Chloris spp,* sudan grass, *Pennisetum pedicelliam*, *Chrysopogen fulvas*; Cereals *viz.* maize (Ganga -2), Teosinte, Jowar (CO-2, JS-20, Pusa Chari, NP Chari, Rio Jowar, ROM Jowar, V-60-1, SL-44), Bajra (CO-60); legumes viz. Cowpea (HFC-42-1, NP-3, No-1013, CO-1), NDRI type Guar – FS-277, Lucerne-FS-85, Sesbania, Velvet bean, Field bean, *Dolichos*, Stylo, Centrsome, Cliteria termate, Black soybean and Glyricidia; and root crops include Turnip (red and white), Tapioca were cultivated. Among cultivated fodders, both NB-21 and BN-2 produced profuse tillering and quick growth. Green fodder yield of NB-21 was 1.54 kg/sq m i.e. 15.4 MT/ ha during the first cutting. Among the fodder cereals, teosinte, NP Chari and Rio Jowar showed good growth at early stages, but then did not come up well at later stages. Among legumes, velvete beans germinated uniformly with vigorous and quick growth. It produced bumper foliage and thus appeared to be the good legume fodder under Goa conditions. Among Cow pea varieties, HFC 4-2-1 and NDRI Cowpea showed promising results in terms of growth habit and foliage. Among root crops, tapioca grew well under both rain fed and irrigated conditions. Hybrid Jowar CSH-5 had bumper growth and had only ear heads. Since most of the leaves of Hybrid Jowar remains green at harvest, it may serve as good green fodder at harvest and the grains may be used as concentrate livestock feed.

Green fodder production under subabul based cropping system was recorded. Maximum green fodder yield of 17.6 MT/ ha was obtained in subabul alone. Subabul + NB-21, Subabul + cowpea and subabul + tapioca recorded 15.4, 8.9 and 5.9 MT/ ha, respectively. Digestible dry matter yield was 3.13, 2.19, 1.70 and 1.06 MT/ ha for Subabul + NB-21, Subabul + cowpea and subabul + tapioca, respectively. Above trial indicated that subabul as a pure crop was more productive and intercrop combination with Napier grass, cowpea and tapioca was not found to improve fodder yield. Probably, reduction in fodder yield in intercrops plot may be due to limitations in soil moisture, since this cropping system was tested under rain fed conditions.

Production potential of different fodders in subabul based cropping system *(Bhattacharya, 1986)*

A subabul based cropping system with NB-21, tapioca and cowpea maize as intercropping was formulated. Green fodder yield was maximum with subabul + NB-21 grass (16.09 MT/ ha) followed by subabul alone (13.76 MT/ ha); however, the yield in terms of nutrients was little more in subabul alone than subabul + NB-21. In another study of subabul based cropping system, maximum green fodder yield of 17.6 MT/ ha was obtained in subabul alone. Subabul + NB-21, Subabul + cowpea and subabul + tapioca recorded 15.4, 8.9 and 5.9 tonne/ ha, respectively. Digestible DM yield was 3.13, 2.19, 1.70 and 1.06 tonne/ ha for Subabul + NB-21, Subabul + cowpea and subabul + tapioca, respectively. It was concluded that subabul as a pure crop was more productive and intercrop combination with Napier grass, cowpea and tapioca was not found to improve the fodder yield, which might be due to the limitations in soil moisture as cropping system was studied under rain fed conditions.

Production potential of fodder maize as intercrop with cashew *(Naik et al., 2011)*

Production potential of fodder maize as intercrop with cashew was studied. South African Tall fodder maize (*Zea mays L.*) was sown in line strips with spacing of 30 cm between lines in inter spaces with a five year old of cashew (variety Goa-I). Study indicated that in a cashew field, 56.72% of total area could be utilized for fodder cultivation with intercrop approach. Total yield of fodder maize on fresh basis was 2.13 MT (15.78 MT/ ha), which was 3.63 MT/ ha on DM basis, indicating good potential for crop cultivated. The CP, EE, CF, NFE and TA contents of cultivated fodder maize were 10.67, 2.27, 25.92, 51.78 and 9.36, percent, respectively. It was concluded that fodder cultivation as intercrop with cashew was a good approach to meet fodder scarcity for dairy production in coastal region particularly for Goa.

Chemical composition of locally available tree leaves and natural grasses *(Sundaram, 1989-90a; Sundaram, 1990-91a; Sundaram et al., 2003-04; Anonymous, 2004-05)*

Goa has a wide range of natural forages (tree leaves) which could be used as green fodder for livestock. The ranges of CP and CF content of tree leaves ranged from 8.72-14.4% and 9.90-24.71%, respectively and could be used as green roughages for dairy animals (Table 9).

Table 9: Chemical composition of different natural forages

Forages	CP%	CF%
Cashew leaf	10.50	23.54
Guava leaf	8.72	16.90
Mango leaf	9.22	23.20
Chinavar	10.50	21.97
Chillies (wild)	11.71	9.90
Gulmohar	12.15	14.63
Chunni	9.30	24.71
Bamboo leaf	14.20	21.55
Alibizzia lebek	12.40	13.85
Holmskioldia	13.12	17.95
Rungia	14.40	15.20

Three species of natural grasses *i.e. Themeda triandra, Chloris gayana and Cymbopagan citratus* available in forest land were identified and analyzed. The CP and CF content ranged from 3.5-5.7 percent and 26.4-32.5 percent, respectively. Nutritive value of *Chloris gayana* and *Cymbopagan citratus* were similar and better than *Themeda triandra* (Table 10).

Table 10: Chemical composition of natural grasses

Nutrient (%)	*Themeda triandra*	*Chloris gayana*	*Cymbopagan citratus*
CP	3.50	5.25	5.70
CF	32.40	30.70	27.62
NDF	73.80	51.77	64.20
ADF	41.50	44.80	39.26
TA	3.84	5.40	2.68

For goat feeding, eleven leaf and dry fodders collected from grazing field were analyzed for chemical composition (Table 11).

Table 11: Chemical composition of different leave and dry fodders for goat feeding

Sample	CP	EE	CF
Banana leaf	12.35	8.01	14.52
Mango leaf	06.20	2.43	22.81
Gulmohar leaf	15.29	1.96	03.52
Jack fruit leaf	09.13	1.82	12.32
Pineapple leaf	03.79	1.94	09.45
Karad grass	03.30	1.07	33.55
Glyricidia leaf	07.26	1.73	01.81
Groundnut hay	11.35	1.82	12.42
Cashew leaf	07.87	4.60	03.37
Centro	09.26	2.49	19.45
Grass	06.62	2.04	15.25

Nutritive value of Gulmohar leaf, banana leaf and mango leaves wrer better than others and could be used as livestock feed.

For goat feeding grass samples (5) and leaves (9) collected from grazing filed were analyzed for chemical composition. Among them, common weed mimosa *spp.* contained 17.31% CP. Tree leaves of subabul (26.33% CP), tamarind (8.23% CP), mango (6.89% CP) and cashew (7.88 CP%) were common dry foliages available in grazing field.

Effect of mushroom cultivation on paddy straw *(Sundaram, 1990-91b)*

Effect of mushroom cultivation on paddy straw was studied. The CF and NDF contents were lower in mushroom straw (14.10 and 54.52%, respectively) than in untreated straw (30.17 and 71.90%, respectively). There was poor intake of mushroom straw by male calves.

Enrichment of paddy straw by yeast and molasses treatment *(Sundaram, 1992-93a)*

Mushroom harvested paddy straw was enriched with yeast (2%) and molasses (5%) and fermented for one week (Table 12).

Table 12: Effect of yeast and molasses on spent mushroom straw

Substrate	CP	CF	ADF	Cellu-lose
Untreated paddy straw	4.00	28.40	58.42	30.15
Spent mushroom straw (SMS)	5.50	13.74	55.61	17.14
SMS + 2% yeast	7.80	14.33	55.78	17.15
SMS + 2% yeast and 5% molasses	10.50	21.87	56.66	15.30

Due to molasses and yeast treatment, CP% of spent mushroom straw increased from 5.5% to 10.5%.

Chemical composition and dry matter digestibility of karad hay (*Themeda quadrivalis*) *(Sundaram et al., 1987)*

Karad (*Themeda quadrivalis*) is a wild grass growing extensively in laterite soil of hilly region of Goa. It grows abundantly in forest land. Dry grass is harvested as hay in December-January and stacked for feeding cattle during summer months. It is an important substitute for paddy straw in this territory. Therefore, a study was made to ascertain nutritive value of karad hay to find out as to what extent this preserved fodder could be utilized.

The CP, EE and TA content of karad hay were 3.5, 1.68 and 10.5%, where as that of paddy straw were 3.21, 1.82 and 11.42%, respectively indicating that both roughages were similar with respect to nutrients mentioned above. However, CF content of karad hay was higher (36.9%) than that of paddy straw (31.71%). Higher CF content might be due to dry grass being harvested at post flowering stage. Increased CF content has also been reported for other natural grass hay like Anjan hay. The DM digestibility of karad hay in vitro was 43.02% with minimum and maximum digestibility of 41.49%, respectively. Paddy straw recorded a higher digestibility (48.95%) than karad hay. Increased CF content could be the possible factor responsible for lower digestibility in karad.

In vivo digestion trial was conducted on five Sindhi x Jersey crossbred bullocks of 4-6 years age. Animals were maintained on karad hay for 28 days which included 21 days preliminary period and 7 days collection period. The DM digestibility was estimated by indicator technique using AIA as indicator. Mean DM digestibility estimated was 37.81±3.19% with minimum and maximum digestibility of 35.62 ± 5.61% and 39.90 ± 5.54%, respectively. There was no significant difference between animals on DM digestibility.

Studies conducted on *in vitro* digestibility of natural grass hay (*Themeda quadrivalis*) in

comparison to popular dry roughage paddy straw indicated that karad hay was less digestible (43.02%) than paddy straw (48.95%). *In vivo* digestibility of hay estimated by indicator method also revealed poor digestibility (37.81%) of karad. Higher CF content could be the possible reason for the lower digestibility of karad hay.

Enrichment of karad grass by urea-ammoniation *(Sundaram, 1990-91c)*

Locally available karad hay had 3.5% CP and 34.10% CF. Hay was treated with 3% urea and ensiled for 21 days. Enriched karad was evaluated by conducting a feeding trial in male calves for 60 days. Urea treatment increased CP content of karad hay from 3.5 to 5.7%. The DM digestibility of urea treated karad was higher (59.41%) than untreated karad (48.65%).

Enrichment of karad grass by molasses and mushroom inoculation *(Sundaram, 1989-90b)*

Natural grass karad (*Themeda quadrivalis*) had low nutritive value and therefore, was enriched by adding molasses and mushroom inoculation. Mixture of 30% molasses and 70% karad was prepared and inoculated with edible mushroom spawn. Enriched karad was maintained at room temperature for 5 days. The CP content of treated karad was 8.7% as against 3.5% for untreated karad. In vitro DM digestibility of enriched karad was 50.3% and that of untreated karad was 41.5%. It was concluded that protein content of dry karad grass could be increased from 3.5% to 8.5% by adding molasses and mushroom inoculation.

Chemical composition of cashew apple waste and pine apple waste *(Sundaram and Bhattacharya, 1990-91d)*

Two fruit waste CAW and PAW were analyzed to find out the nutritive value for feeding pigs. (Table 13).

Table 13: Chemical composition of CAW and PAW

Constituent	CAW	PAW
Moisture%	73.45	85.97
CP%	9.62	5.80
CF%	15.29	20.93
NDF%	57.65	61.74
ADF%	21.70	32.84
EE%	3.70	1.04
TA%	3.45	---
NFE%	67.94	---
GE (kcal/ g)	4.20	---

Enrichment of agro-industrial by-products by Baker's yeast *(Sundaram, 1991-92)*

Baker's yeast (*Sacchromyces spp.*) was identified for microbial enrichment due to its availability commonly in market and suitability for aerobic fermentation. Four agro-industrial by-products *viz.* WB, RB, CAW and PAW identified for enrichment. The WB and RB treated with 10% molasses and 3% Baker's yeast were fermented for 8 days under aerobic condition at 66% moisture level (Table 14).

Table 14: Effect of fungal treatment on agro-industrial by-products

By-Products	CP%		CF%	
	Un-Treated	Treated	Un-Treated	Treated
WB	8.25	18.50	13.02	9.63
RB	6.62	8.75	22.46	21.60
CAW	8.75	11.82	12.64	11.89
PAW	6.10	9.62	20.93	20.64

Enrichment of agro-industrial by-products by fungi and yeast *(Sundaram, 1992-93b)*

Agro-industrial by-products *i.e.* coir dust, CAW and RB were inoculated with different fungi for biodegradation and enrichment. Among three species tested *viz. Ganoderma lucidum, Trichoderma viridi* and *Coprenus fimatarius*

at 50% moisture level. *Trichderma spp.* was established well in CAW. The by-product was further treated with yeast for enrichment. Due to yeast treatment, the CP% of CAW increased from 8.75% to 15.75% (Table 15).

Table 15: Effect of fungal treatment on cashew apple waste at 50% moisture level.

Substrate	CP	CF	ADF	Cellulose
CAW	8.75	18.67	21.70	26.17
CAW + 2% *T. Viridi*	12.25	15.12	18.93	23.40
CAW + 2% yeast	15.75	14.81	20.56	24.86

Effect of *Pleurotus florida* on solid state fermentation of coir dust *(Sundaram, 1993-94)*

Physical parameters important for solid state fermentation of coir dust viz. moisture%, fermentation period and substrate enrichment were studied by inoculating with Pleurotus florida spawn at different moisture levels from 40% to 80%. Fermented biomass was evaluated for ADF and Lignin content, after 20 days. Samples inoculated at 40% and 80% moisture level had ADF 77.30% and 73.82%, when compared to control (81.17%).

In another experiment, effect of fermentation period of *Pleurotus florida* inoculation on biodegradation of coir dust was studied on 0, 30, 60 and 90 days (Table 16).

Table 16: Effect of Pleurotus florida inoculation on solid state fermentation of coir dust

Days fermented	CP %	ADF %	Cellu-lose %	Lignin %
0	2.62	74.20	24.58	44.51
30	5.25	71.28	23.94	39.40
60	6.12	70.13	22.85	34.79
90	8.75	67.60	19.40	32.80

Effect of substrate enrichment on lignin biodegradability in coir dust with *Pleurotus spp* .was studied in 20 days fermented coir dust (Table 17).

Growth of mycelia in samples enriched maize was higher when compared to control and other treatments *viz.* WB and cellulose enriched samples.

Utilization of agro waste as feed resource for sustainable animal production *(Sundaram et al., 2000)*

Increasing human population demanded higher quantum of food production all over the world. Various estimates indicated an increase of 70-90 million people annually occurring in the countries not able to feed themselves. Major portion of crop land has been used for production of cereals and consequently fodder cultivation was grossly neglected.

On a conservative estimate, 6000 million coconuts were available in India per annum. In Goa alone, 24200 ha of land was under coconut cultivation and annual production was around 16 million nuts. Husk was used for coir production. About 4.5% by weight of the husk is available as coir dust, which was otherwise used as fuel.

Cashew (*Anacardium accidentale*) was grown in an area of 6.59 lakh ha in India. Apple after extraction of juice is discarded as waste. Considering annual cashew nut yield of 4.5 lakhs tons, as substantial amount of CAW equivalent to nut yield was available.

Karad hay (*Themeda quadrivalis*) is a naturally grown grass available in abundance in western region. It grows well in laterite soil. It was observed that about 10000 ha of waste land in Goa was under karad coverage in post-monsoon period and yield was estimated about 1.5 MT per ha per annum.

Industrial use of roughages for paper and board making and domestic burning of agro-waste for cooking is also on the rise. These altogether resulted with shortage of fodder without which livestock rearing would be un-economical. One of the ways to reduce feeding expenditure is to make use of natural resources and locally available agricultural and industrial waste materials. Some

Table 17: Effect of added substrate on coir dust fermentation

Substrate	CP		ADF		Lignin	
	Composition	% Reduced	Composition	% Reduced	Composition	% Reduced
Coir dust	2.62	---	76.12	---	44.02	---
Coir Dust (80%) + Maize (20%)						
Control	3.91	---	66.42	---	36.18	---
Inoculated	7.85	3.94	59.10	7.32	29.82	6.36
Coir dust + wheat bran						
Control	3.50	---	67.04	---	39.44	---
Inoculated	7.00	3.50	63.24	3.80	34.20	5.24
Coir Dust + Cellulose						
Control	2.33	---	69.41	---	38.06	---
Inoculated	5.25	2.92	65.18	4.23	37.82	0.24

of common agro waste available in tropical coastal region *viz.* coir dust, CAW and karad hay was studied for their suitability as animal feed. An attempt was also made to digest complex structure using fungus *Pleurotus florida*.

Chemical analysis indicated that coir dust contained 69.91% ADF and 20.25% cellulose. Substantially high quantity of lignin *i.e.* 39.91% by weight was also observed in coir dust. The ADF, cellulose and lignin content in CAW were 45.82%, 12.35% and 12.43%, respectively. Karad hay contained 33.75% cellulose, 12% lignin and 45.53% ADF. Fungal enrichment showed that the present reduction in ADF and lignin were 10.27% and 18.24%, respectively after 30 days of fermentation in coir dust. These observations indicated that maximum degradation has taken place in lignin content. Cellulose was also affected although it was reduced to lesser extent than lignin due to fermentation by *Pleurotus spp*. In CAW, ADF content was 45.82% and 44.06% for 0 and 30 days fermented samples. Lignin content decreased from 12.43% to 11.65% in 30 days. Cellulose was reduced from 12.35% to 9.63% in 30 days. In karad hay reduction in ADF was 23.17% after 30 days of fermentation. Lignin was reduced by 22.37% during same period. Cellulose reduction was lower when compared to lignin. It reduced by 12.09% after 30 days duration. The reduction of lignin was more in coir dust (18.24%) than in CAW (6.28%). However, reduction in cellulose content was more in CAW (22.02%) than in coir dust (14.02%) indicating that cellulose was more utilized by fungi in CAW than in coir dust. Perhaps, structural arrangement and nature of substrate could be the possible reasons for preferential use of cellulose and soluble carbohydrates by the fungus in CAW.

The DM digestibility increased from 69.5 to 74.02%, 73.39 to 79.41% and 77.63 to 79.08% in coir dust, CAW and karad hay, respectively with maximum increase in CAW due to *Pleurotus* treatment. The ADF digestibility increased from 15.62 to 16.0%, 22.19 to 29.29% and 10.63 to 18.58% in coir dust, CAW and karad hay, respectively with maximum increase in karad hay. Cellulose digestibility increased from 15.37 to 22.08% and 14.73 to 19.04% in coir dust and CAW, respectively where as, it decreased from 34.41 to 28.70 % in karad hay due to the nature of the substrate involved. Study indicated that natural resources like coir dust; CAW and karad hay could be suitably used at a level of 10% in rabbit feeding after fungal enrichment to reduce cost of feed considerably and also suggested potential use in other livestock.

Dairy Nutrition Research

Effect of different roughage: concentrate ratio on milk production of crossbred cows *(Bhattacharya, 1986a; Bhattacharya and Sundaram, 1987)*

Feeding trial was conducted on crossbred milch cows to study the effect of different R: C ratio (2:1 and 3:1) on sustainability of milk production. It was concluded that increased roughage feeding had no beneficial effect on milk production during declining phase of lactation.

Feeding schedule was formulated with two different proportions of roughage and concentrate to study effect on milk production in four dairy cows. During summer months (May-June), proportions of concentrate: roughage in the feeding schedule was 7:3. In the post monsoon period, schedule was reversed by increasing gradually fodder proportions. It was observed that milk yield was maintained without any adverse effect with increase of fodder up to 70%. Daily average milk yield with two feed regimes was 6.3 and 6.2 liters, respectively. Thus, it was concluded that when fodder wasavailable in plenty, ration could be reconstituted to contain more of roughages.

Low cost economic rations for dairy cattle suitable for coastal rice growing areas *(Sundaram et al., 1987)*

Economy of milk production directly depends upon feeding as feeding alone constitutes more than 80% of cost of milk production. Balanced concentrate feed for dairy cattle usually contains maize, WB and oil cakes as major ingredients. In areas, where these ingredients are not locally produced, cost of feeding is high because of dependence from outside agencies. In coastal belt, where wheat can not be grown because of hot humid climatic condition, rice is major cereal crop cultivated round the year. In same areas agricultural byproducts like RB, molasses, baggasse *etc.* are available in plenty. Incorporation of these byproducts and formulation of balanced livestock ration would facilitate cheaper livestock feeding in these areas.

Two test rations were prepared (Table 18) by completely replacing WB and partially replacing maize with RB and molasses.

Table 18: Physical compositions of test rations

Ingredients	Test Ration I Group A	Test Ration II Group B	Control Ration Group C
Maize	17	07	20
GNC	25	25	---
CSC	15	15	36
RB	30	40	---
WB	---	---	40
Molasses	10	10	---
MM	02	02	03
CS	01	01	01
Total	100	100	100
Cost Rs/kg	1.48	---	1.69

Feeding experiment was conducted at Govt. Livestock Farm, Goa for 90 days to test efficiency of the test rations. Eighteen crossbred cows (Jersey x Red Sindhi) in early lactation (60-90 days) having similar BW were selected and randomly allotted to three rations (six in each group). Feeding schedule was same in all three groups *i.e.* 2 kg karad hay, 10 kg green grass and 1.5 kg concentrate feed to meet production requirement.

There was not much difference in chemical composition except in CF (17.48% vs 13.36%)

and TA content (13.71% vs 7.36%), which were higher in test rations (Table 19), which could possibly be due to higher proportions of RB in test rations.

Table 19: Chemical compositions of the two test rations and control ration under trial

Parameters	Control	Ration I	Ration II
Moisture	8.11	9.81	9.61
CP	14.85	15.82	15.12
CF	13.36	13.82	17.48
EE	4.19	4.02	3.97
TA	7.36	11.01	13.71
NFE	52.13	45.52	40.11

All animals remained healthy throughout experimentation. From observations of feeding trial (Table 20), it might be observed that total DM intake (9.76, 9.03 and 9.12 kg) as well as concentrate feed intake among groups were not significantly different.

Table 20: Average feed intake, milk production and feed efficiency during trial period

Particulars	Control	Test Ration I	Test Ration II
DM intake/ cow/d (kg)	9.12	9.76	9.03
Concentrate feed intake/cow/d (kg)	4.48	5.12	4.40
Milk yield/ cow/d (kg)	4.98	6.23	5.05
Fat%	4.28	4.20	4.31
Efficiency of production (feed intake / kg milk production)	1.83	1.57	1.77
Feed cost/ kg milk production	1.65	1.32	1.31

This was indicative in that inclusion of RB and molasses did not adversely affect palatability or acceptability of ration.

The pattern of feed intake remained normal through out experimental period which showed that digestibility was normal although there were differences in ration ingredients. There was no significant differences among groups in daily average milk yield (6.35, 5.05 and 4.98 kg) or in butter fat% (4.20, 4.31 and 4.28). The difference in efficiency of production was also not significant. The pattern of lactation curve remained normal in all groups throughout experimental period. This indicated that inclusion of these cheap ingredients had adversely affected neither the quantity nor the quality of milk.

Feeding cost/ kg of milk production was 1.54/ kg in group fed with control ration and in group fed with test rations I and II, which were considerably lower *viz.* Rs 1.32 and Rs. 1.31, respectively. However, between test rations no appreciable differences were observed.

Results clearly indicated that by inclusion of locally available cheap ingredients like RB and molasses in place of costly items like maize and WB, cost of concentrate feed for dairy cattle could be reduced considerably without adversely affecting production. Therefore, for economic milk production in Goa as well as in other similar rice and sugar cane producing coastal areas, RB and molasses could be profitably included up to 40% and 10% levels, respectively for making balanced concentrate feed for milch animals.

Performance of dairy cows on fodder maize based ration *(Naik et al., 2010; Naik et al., 2010-11)*

Experiment was planned to find out the effect of feeding fodder maize as replacement of concentrate mixture on performance of dairy cows. Ten dairy cows (avg. 276.80 kg BW; avg. milk yield 4.90 kg/day; avg. lactation number 3.5, avg. 113 lactation days) were divided into two groups i.e. Control Group (CG) and Treatment Group (TG) of five animals in each, based on body weight, lactation number, lactation days and daily milk yield to find out the effect of feeding fodder maize as replacement of concentrate mixture on the performance of crossbred cows. Randomly, animals of the CG were offered daily four kg CM along with one kg fresh green fodder maize and

ad lib. jowar straw (*Kadaba kutti*); while in TG, half of CM as offered in CG was replaced by 20 kg fresh green fodder maize and thus, animals in TG were offered 2 kg CM along with 20 kg green maize and *ad lib.* jowar straw for 45 days.

Chemical composition of concentrate mixture wasas per BIS specifications of compounded cattle feed (Table 21).

Table 21: Chemical composition (on % DM basis) of feeds and fodder

Parameters	Concentrate Mixture	Fodder Maize	Jowar Straw
CP	21.68	11.14	3.40
EE	4.83	2.20	0.84
CF	8.39	22.25	34.19
NFE	58.27	53.54	52.43
TA	6.83	9.84	9.14
AIA	1.16	1.03	5.32

Intake of DM fodder maize in TG was higher (P<0.05) than CG; while intake of jowar straw was higher (P<0.05) in CG (9.11 kg/ d) than TG (4.80 kg/d). However, total DM roughage intake (9.20 to 9.33 kg/ d) was similar (P>0.05) in both groups (Table 22).

Table 22: Effect on feed intake, BW changes, milk production and milk composition

Parameters	Control Group	Treatment Group	SEM
DM Intake (kg/d)			
Concentrate mixture	4.00	2.00	---
Fodder maize	0.22	4.40	---
Jowar straw*	9.11^{b}	4.80a	0.22
Total Roughage	9.33	9.20	0.22
Total DM*	11.33^{a}	13.20^{b}	0.22
R:C ratio*	4.7: 1^{b}	2.3: 1^{a}	0.06
BW Chanages			
Initial	294.00	259.60	21.07
Final	307.19	270.74	22.72
Gain	13.19	11.14	13.07
Milk Yield (kg/day)			
Milk	4.69	4.72	0.36
FCM	4.28	4.00	0.20
Milk Composition (%)			
Fat	3.49	3.01	0.29
SNF	8.88	8.51	0.38

** Means bearing different superscripts in a row differ significantly (P<0.05).*

Total DM intake in TG (13.20 kg/ d) was higher (P<0.05) than CG (11.33 kg/ d), which might be due to higher palatability and stimulating effect of green maize for more feed intake. The R:C ratio in CG was higher (P<0.05) in TG. There was no difference (P>0.05) in BW changes and BW gain of animals between groups. Similarly, MY (4.69 to 4.72 kg/ d) and FCMY (4.00 to 4.28 kg/ d) of animals of CG were similar (P>0.05) to animals of TG and not affected by treatment. Milk compositions *i.e.* fat% (3.01 to 3.49) and SNF content (8.51 to 8.88, %) of milk of animals of both groups were within normal range. It was concluded that during feeding dairy cows yielding around five kg milk daily, one kg concentrate mixture could be replaced by ten kg fresh good quality green fodder as per availability without affecting daily milk yield, provided that bulk of animal should be fulfilled by *ad lib.* roughage like jowar straw (*Kadaba kutti*).

Utilization of cashew apple waste in dairy cattle feed *(Sundaram, 1986)*

Cashew apple, one of the most commonly available seasonal fruit in Goa is utilized for extraction of juice and remainder is discarded as waste. More than 100 tons of this byproduct (CAW) was available in Goa during the season (Feb – May). However, reports on its utilization as cattle feed were very limited, an attempt was made to evolve a ration incorporating CAW for dairy cattle and study the effect on milk production.

Fresh CAW collected from country distillation units were sun dried for four days, ground and stored for incorporation in cattle feed. Control

and experimental feeds were formulated (Table 23). In feeding trial, CAW partly replaced costly feed ingredient GNC to reduce feed cost without affecting feed quality.

Table 23: Ingredients of control and experimental concentrate feed

Ingredient	Feed (%)	
	Control	Experimental
Maize	07	07
GNC	25	15
CSC	15	15
RB	40	40
Molasses	10	9.5
CAW	---	10
Urea	---	1.5
MM	02	02
CS	01	---

Chemical compositions of control and experimental feeds was almost similar except CP, which was slightly higher in experimental feed (Table 24).

Table 24: Chemical composition (on % DM basis) of experimental feed

Paramters	CAW	Control CM	Experimental CM
CP	10.50	14.90	16.16
EE	4.04	3.44	2.83
CF	14.32	16.10	15.24
NFE	69.00	55.26	56.50
TA	3.72	10.28	9.40

Eight Gir cows in early lactation and with similar BW were selected and divided into two groups of four animals in each and were fed with control and experimental concentrate feeds respectively 105 days including 15 days preliminary period. Both groups were maintained under identical managemental conditions. Ration consisted of 2 kg straw, 22 kg green grass and 2-4 kg concentrate. Data on milk yield, DM intake and feed cost of milk production were recorded and statistically analyzed (Table 25).

Table 25: Production performance of experimental and control animals

Particulars	Control Group	Experimental Group
Avg. MY (kg/cow/d)		
Preliminary period	5.81±1.64	5.95±0.97
Exp. period	5.19±1.01	5.17±0.74
DM Intake (kg/d)		
Concentrate	2.67±0.10	2.71±0.04
Grass (NB-21)	4.46±0.03	4.44±0.12
Straw	1.80±0.01	1.80±0.02
Total	8.92±0.12	8.95±0.15
Cost (Rs) of feed/ kg milk production	1.94	1.77

Average daily milk yield of control and experimental groups during preliminary period was 5.81 and 5.95 kg where as during experimental period, it was 5.19 and 5.17 kg respectively indicating that there was no significant difference in milk yield between groups.

The DM intake (8.92 and 8.95 kg, respectively) was similar in both groups. Although cashew apple contained 0.35% tannin, incorporation of byproduct CAW at 10% level had no undesirable influence on health and production of animals during trial period, indicating that CAW could be utilized as an ingredient in dairy cattle feed.

Effect of replacement of rice bran by cashew apple waste *(Bhattacharya, 1986)*

There was adverse effect in male calves, when RB was replaced by CAW at 30% level.

Goat Nutrition Research

Effect of supplementary feeding on growth performance of goats
(Sundaram et al., 2003-04)

To study the effect of supplementary feeding on growth performance, concentrate feed was formulated with 20% CP. The ADG was 68.9 g (41.81 g/d to 121.32 g/d) for cross bred (Osmanabadi X Local nondescript) goat with supplementary feed given @ 300 g/ d.

Effect of stall feeding Vs free range grazing system on the performance of goats
(Anonymous, 2004-05)

Feeding trial was conducted on six goat kids under stall fed conditions for four months. The ADG was 77.48 g. The average concentrate intake/ animal/ d were 0.45 kg, while DM digestibility under stall fed conditions was 73.85%. Same animals were maintained under free range system for three months with 100 g concentrate supplement per animal to compare effect of intensive stall feeding and grazing under free range system. The BW gain was marginally higher in range system (83.60 g/d).

Effect of partial replacement of green fodder with supplementary feeding on growth performance of goats
(Anonymous, 2005-06)

Ten crossbred goat kids of 7-8 kg BW under a feeding trial for partial replacement of green fodder with supplementary feeding (300 g/ animal/ d) recorded BW gain of 13.26 kg, with ADG of 75.65 g.

Pig Nutrition Research

Performance of crossbred pigs in Goa *(Bhattacharya et al., 1990-91a)*

Growth performance of LWYS, Local x LWYS and Local x Landrace crosses was studied. The ADG was 206 g, 166 g and 140 g for LWYS, Local x LWYS and Local x Landrace crosses, respectively. Feed efficiency was 5.4 and 4.6 for Local x LWYS and Local x Landrace, respectively.

Performance of different breeds of piglets on standard starter diet in Goa *(Chakurkar, 2010-11; Chakurkar et al., 2011)*

Three groups *v.i.z.* LWYS pure, Local (L) pure and LWYS X L (50% cross) containing six piglets in each group were made based on age (avg. age 70 days) and BW (avg. BW 6.47 kg). A standard starter (creeper) CM containing maize 50, RP 22.5, SBM 25, MM 2 and CS 0.5; parts by weight was prepared. Animals in all groups were fed standard starter CM up to the attainment of 20 kg BW to fulfill nutrient requirements. The FCR was calculated as amount of total feed consumed divided by BW gain by pig during experimental period. Feeds offered were analyzed for proximate principles. Data were analyzed statistically for test of significance.

The CP, EE, CF, NFE, TA and AIA content of CM was respectively 19.60, 3.76, 4.92, 63.81, 7.91 and 0.80, per cent and met BIS specifications of starter pig feed. Although, DM intake of LWYS x L Cross group was higher (P<0.05) than LWYS group and L group, but when expressed as percentage of BW, it was similar and ranged between 7.24 to 7.62% of BW (Table 26).

Table 26: Performance of different breeds of piglets

Parameters	LWYS	Local	LWYS x Local	SEM
DM Intake				
Total (g/d)	969.93^{b}	903.20^{a}	982.75^{c}	8.46
As % BW	7.39	7.62	7.24	0.19
BW Changes (Kg)				
Initial	6.42	6.37	6.52	0.20
Final	21.70^{ab}	18.47^{a}	23.25^{b}	0.74
Total LBW gain (kg)	15.28^{b}	12.10^{a}	16.73^{b}	0.65
ADG (g)	363.89^{b}	288.10^{a}	398.41^{b}	15.40
FCR	2.45^{ab}	2.91^{b}	2.26^{a}	0.11

The growth rate (g/day) in LWYS group (363.89) and LWYS x L Cross group (398.41) was similar (P>0.05), but higher (P<0.05) than L group (288.10). The FCR in LWYS x L Cross group (2.26) was similar to LWYS group (2.45) and lower (P<0.05) than L group (2.91), indicating better FCR. It was concluded that in Goa condition, growth rate and FCR of LWYSxL (50% cross) piglets were better than pure LWYS and L piglets.

Effect of high energy diet on growth performance of pigs *(Sundaram and Chakurkar, 1998-99)*

Feeding trial was conducted on eight crossbreed LWYS pigs (Avg BW 9 kg) to study effect of high energy diet on growth performance. Two diets with 2600 kcal/ kg (control) and 2970 kcal/kg DE (experimental) were tested in two groups for comparative growth performance. The ADG of control and experimental groups was 200.84 g and 193.50 g, respectively (Table 27).

Table 27: Performance of crossbreed (50%) LWYS pigs on high energy diet

Fortnight					
1	2	3	4	5	Gain
2970 Kcal					
8.0	11.6	14.3	17.1	18.5	10.5
8.0	11.2	14.4	17.6	19.7	11.7
11.2	15.5	19.6	24.0	26.0	14.8
8.8	11.4	14.1	17.0	19.2	10.4
2600 Kcal					
9.3	12.0	16.2	20.4	22.7	13.4
10.3	12.8	16.2	19.9	21.6	11.3
11.3	13.7	17.3	21.1	23.1	11.8
7.5	9.4	12.8	14.5	16.7	9.2

Effect of feeding high protein diet on growth performance of pigs *(Bhattacharya et al., 1996-97)*

Effect of feeding high protein diet was studied through comparative growth rate in cross bred pigs. Control diet with 18% CP and 2600 kcal was compared with an experimental diet with 23% CP and 2650 kcal. Two groups of five crossbred pigs were selected and trial was conducted for 75 days. Study indicated that by increasing CP content through incorporation of GNC at 20% level in commercial feed, market weight of 32 kg could be obtained at an early age of six months (Table 28).

Table 28: Performance of pigs fed high protein diet

Observations	Control	Experimental Feed
Grower mash	100.0	80.0
GNC	---	20.0
CP%	17.5	23.0
DE	2800	2840
BW (Kg) Changes		
Initial	17.1	15.3
Final	25.1	33.0
Totalin 75 d	8.0	17.6
ADG (g)	106.6	236.0
Feed efficiency	7.3	5.4
Cost of feed (Rs)	6.0	6.5

Effect of replacement of maize by tapioca at 15% level on growth performance of pigs *(Bhattacharya, 1986a)*

Tapioca cultivation is gaining popularity in Goa as a result of introduction of promising varieties of this crop. Tuber available from crop can be an ideal feed source pigs. Economic pig ration was formulated incorporating tapioca (15%) replacing costly maize and was found suitable to maintain optimum growth rate in pigs (268 g/d).

Effect of incorporation of tapioca at 30% level on growth performance of pigs *(Bhattacharya et al., 1987)*

Tapioca was incorporated in a commercial pig feed at 30% level to enrich energy content of feed and effect on growth rate was studied for one month on weaned LWYS piglets, keeping a control group. The ADG was 218 g and 190 g for experimental and control groups, respectively.

Effect of incorporation of tapioca at 50% level on growth performance of pigs *(Sundaram and Bhattarchya, 1989-90)*

A low cost feed was formulated incorporating 50% tapioca in grower ration. Feeding trial conducted on eight weaned LWYS piglets for two months indicated suitability of tapioca incorporation in pig feeds (Table 29).

Table 29: Compositions of feed and growth performance of pigs on tapioca based ration

Composition/ Performance	Control Feed	Experimental Feed
Growth mash%	100.00	50.00
Tapioca%	---	50.00
CP%	11.00	18.60
CF%	4.30	6.50
ADG (g)	155.30	201.50
Cost of feed (Rs)/ kg	3.80	3.10

Performance of 50% crossbred GL X LWYS pigs fed on graded levels of BDG based starter feed *(Naik et al., 2011)*

Eighteen 50% crossbred (GL X LWYS) piglets (avg. 4.1 kg LBW) were divided into three groups of six animals in each, based on BW. Three isonitrogenous starter (creeper) feeds without BDG (BDG_0) and with inclusion of 10% BDG (BDG_{10}) and 20% (BDG_{20}) were prepared (Table 30) and offered randomly to piglets of three groups to fulfill their nutrient requirements for 56 days (up to attainment of 20 kg BW).

Table 30: Physical composition of different starter feeds with graded levels of BDG

Parameters	BDG_0	BDG_{10}	BDG_{20}
BDG	0.0	10.0	20.0
Maize grain	50.0	35.0	30.0
RP	22.5	33.0	32.5
SBM	25.0	19.5	15.0
MM	02.0	02.0	02.0
CS	0.50	0.50	0.50

The CP% (19.12-19.60) of all feeds was similar (Table 31).

Table 31: Chemical composition of different starter feeds with graded levels of BDG

Parameters	BDG_0	BDG_{10}	BDG_{20}	SEM
CP	19.60	19.12	19.35	0.12
EE*	3.89^a	5.04^{ab}	6.08^b	0.36
CF*	4.87^a	7.39^b	9.58^c	0.68
NFE*	63.74^a	60.17^b	56.55^c	1.06
TA	7.90	8.24	8.44	0.10
AIA	0.80	1.14	1.04	0.07

** Means in a row bearing different superscripts differ significantly (P<0.05).*

The EE% in BDG20 (6.08) was higher than BDG_0 (3.89), but both were similar (P>0.05) to BDG_{10} (5.04).

This indicated that with increase in level of BDG in feed, EE content of feeds increased, which might be attributed to high EE content (7.32%) of BDG. Similarly, with increase in level of BDG, CF% increased, while NFE% decreased, which might be high CF content (17%) of BDG. The TA and AIA contents of feeds remained similar (P>0.05) among groups. Control feed (BDG_0) and except CF content of experimental feeds (BDG_{10} and BDG_{20}), all parameters were as per BIS specifications for starter pig feed.

There was difference in DM intake among groups, being highest in BDG_{20} and lowest in BDG_{10} (Table 32).

Table 32: Performance of crossbred pigs fed on graded levels of BDG based starter feeds

Para-meters	BDG_0	BDG_{10}	BDG_{20}	SEM
DM Intake				
Total (g/d)	943.54^a	961.14^b	973.04^c	2.94
As % BW	8.52	8.24	8.36	0.47
BW (Kg) Changes				
Initial	4.07	4.03	4.03	0.22
Final	22.58	21.38	21.27	1.33
Total	18.52	17.35	17.23	1.21
ADG (g/d)	330.65	309.82	307.74	21.56
FCE	2.93	3.38	3.04	0.33

** Means in a row bearing different superscripts differ significantly (P<0.05).*

However, when DM intake was expressed on per cent BW basis, it was similar (P>0.05) among groups and ranged from 8.24 to 8.52%, indicating no adverse effect of BDG on the palatability of the feeds. There was no difference (P>0.05) in total BWgain among groups during experimental period (Fig. 1).

Growth rate (g/d) was similar among groups and ranged from 307.74 to 330.65. Inclusion of BDG had no adverse effect on FCR (2.93-3.38) of pigs, indicating better feed conversion efficiency.

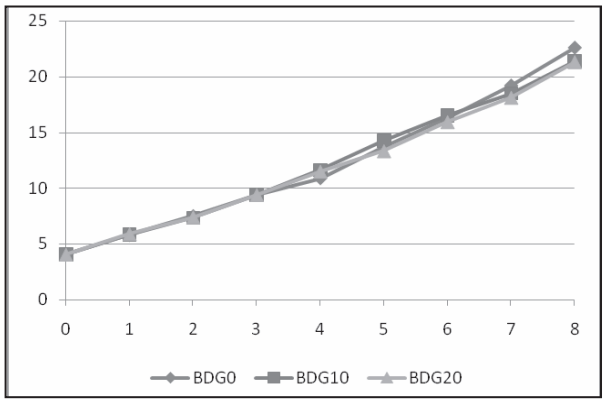

Fig. 1 Weekly BW changes of pigs fed on graded levels of BDG based starter feeds

It was concluded that brewers' dried grains could be incorporated in the starter feeds of 50% crossbred pigs (GL X LWYS) up to 20% level without affecting palatability, growth rate and FCR.

Effect of feeding cashew apple waste on LWYS pigs *(Bhattacharya, 1986b)*

An experimental pig feed was formulated with 30% CAW. Trial conducted on LWYS pigs showed no adverse effect on intake and digestibility due to inclusion of CAW. Cost of feed could be reduced by Rs 21-/ q.

Effect of feeding cashew apple waste on crossbred pigs *(Sundaram and Bhattacharya, 1990-91a)*

Low cost pig feed incorporating CAW at 30% level in commercial grower ration was formulated. Feeding trial was conducted in LWYS crossbred piglets for four weeks. The ADG was 126 g and 122 g for experimental and control feeds, respectively. The DM digestibility was 77.58 and 75.65 percent for experimental and control feeds, respectively.

Effect of feeding fermented cashew apple waste on crossbred pigs *(Bhattacharya et al., 1991-92)*

Feeding trial with fermented CAW in pig feed was conducted with six cross bred pigs. The CAW was fermented with 3% Baker's yeast for eight days, which increased CP content from 8.75 to 13.2%. Observation of 3 weeks indicated no adverse effect due to fermented CAW feeding in experimental group.

Effect of feeding pine apple waste on crossbred pigs *(Sundaram and Bhattacharya, 90-91b)*

Pig feed was formulated with 30% PAW replacing WB. There was no adverse affect on intake and digestibility and it was inferred that PAW could be incorporated in pig feed at 30% level to reduce the feed cost (Table 33).

Table 33 : Performance of pigs on pine apple waste based diets

Ingredient/ digestibility	Control Diet	Experimental Diet
Maize	40	40
GNC	30	30
WB	30	---
PAW	---	30
Avg DM intake/ day (kg)	1.61	1.98
Avg DM digested (kg)	1.30	1.55
DM digestibility (%)	81.00	78.41

Effect of feeding poultry hatchery waste on crossbred pigs *(Anonymous, 2008-09)*

An experiment was conducted in growing pigs to study effect of feeding PHW on performance of growing pig. Two breeds i.e. LWYS and GL X Duroc of eight weeks old were used in experiment. Each breed of piglets was divided into control and treatment groups with six piglets. Control group with normal grower ration and treatment group with grower ration supplemented with 300 g autoclaved PHW on DM basis was assessed. Piglets fed grower ration with PHW had significantly higher BW gain and better feed efficiency than control.

Traditional Vs scientific feeding practices of 50% crossbred (GL X LWYS) pigs in Goa *(Chakurkar, 2010-11)*

Twelve 50% cross bred (GL X LWYS) castrated male piglets (Avg. age 60 days, Avg BW 8.39 kg) were divided into four groups of three piglets in each group. Randomly, one group was maintained at institute farm as Control Group under scientific feeding practices. The other three groups were distributed to three pig farmers maintaining their units under different traditional feeding practices. Piglets of Control Group was offered a standard starter (creeper) CM containing maize 50, RP 22.5, SBM 25, MM 2 and CS 0.5; parts by weight to fulfill nutrient requirements. Under traditional feeding system adopted by respective farmers, piglets of treatment groups were randomly fed bakery waste (T_{BW}), kitchen waste (T_{KW}) and cooked broiler offal and WB mixed in the ratio of 100: 3 (T_{PO+WB}). Feeding trial was conducted for 150 days.

The chemical compositions of the control feed (Table 34) was as per the BIS specifications of starter and grower pig feed.

Table 34: Chemical composition (on % DM Basis) of different feeds

Para-meters	Control	T_{BW}	T_{KW}	T_{PO+WB}	SEM
CP*	19.70^{c}	9.69^{a}	14.49^{b}	36.15^{d}	3.01
EE*	3.69^{a}	14.66^{b}	14.97^{b}	15.22^{b}	1.48
CF*	4.97^{a}	4.14^{a}	4.40^{a}	21.85^{b}	2.27
NFE*	63.96^{b}	68.44^{c}	62.52^{b}	5.25^{a}	7.83
TA*	7.68^{b}	3.07^{a}	3.62^{a}	21.53^{c}	2.26

**Means bearing different superscripts in a row differ significantly (P<0.05)*

Higher (P<0.05) CP content of T_{PO+WB} (36.15%) feed was due to higher CP content of broiler offal, which is a rich source of protein. However CP of T_{BW} (9.69%) and T_{KW} (14.49%) was below BIS specifications. The EE percent of all treatment feeds were similar (14.66 -15.22) and higher (P<0.05) than control feed (3.69). This might be due to presence of oils and fats of bakery waste, kitchen waste and poultry offal. Higher (P<0.05) CF content of T_{PO+WB} (21.85%) than other three diets (4.14-4.97%), might be attributed to addition of WB with poultry offal as WB contains more(14%) CF. Lower NFE% of T_{PO+WB} (5.25) among group might be attributed to high CP and TA content. The TA content was of TPO+WB (21.53%) was higher than other feeds, which might be due to presence of bones and cartilages in poultry offal.

Similar(P>0.05) BW of pigs up to 30 days of experimental feeding might be due to adoption period required for proper utilization of feeds (Table 35).

Table 35: Body weight changes at different post-experimental period

BW (Kg)/ Post-Expt. days	Cont-rol	T_{BW}	T_{KW}	T_{PO+WB}	SEM
BW_{0}	8.40	8.10	8.87	8.17	0.571
BW_{30}	14.23	13.67	11.70	17.67	0.986
BW_{60}*	24.03^{b}	14.87^{a}	14.17^{a}	24.17^{b}	1.653
BW_{90}	36.67^{b}	17.17^{a}	18.33^{a}	32.00^{b}	2.731
BW_{120}*	46.63^{c}	21.37^{a}	21.67^{a}	37.67^{b}	3.374
BW_{150}*	54.67^{c}	25.03^{a}	25.57^{a}	43.83^{b}	3.849
Total Gain	46.27^{c}	16.93^{a}	19.70^{a}	35.67^{b}	3.839
ADG	308.44^{c}	112.89^{a}	111.33^{a}	237.77^{b}	25.592

**Means bearing different superscripts in a row differ significantly (P<0.05).*

From 30 days onwards up to 90 days, lower (P<0.05) BW of T_{BW} and T_{KW} than T_{PO+WB} and control might be due to lower CP content. However, with advancement of experimental feeding (from 120 days to 150 days), although BW of T_{PO+WB} was higher (P<0.05) than T_{BW} and T_{KW} but lower (P<0.05) than control. This indicated that in long term feeding, high CP content feed was not properly utilized by pigs. The ADG of T_{PO+WB} (237.77g) was higher (P<0.05) than T_{BW} (112.89) and T_{KW} (111.33), but lower than control group (308.44). In this study,

ADG in control group (308.44g) was higher ($P<0.05$) than other groups (111.33-237.77g) fed unconventional feeds. The ADG achieved in control group might be due to adequate nutrient content (energy, protein and minerals) content of control feed leading to better nutrient utilization. However, lower ADG in groups under traditional un-conventional based feeding practices might be due to inadequate and imbalance nutrient content (energy, protein and minerals) of feeds leading to improper nutrient utilization.

It was concluded that traditional feeding practices had to be developed based on nutritive value of existing feed resources to improve pig production.

Rabbit Nutrition Research

Feed intake and feed efficiency of exotic and local rabbits *(Bhattacharya, 1986)*

Average daily feed consumption and feed efficiency of four exotic breeds (SC, GG, WG and NW) and one local variety was noted. Average daily feed consumption was 109.45 g and 110.58 g for exotic (SC, GG, WG and NW) and local, respectively. Feed efficiency (at 75th day) for exotic and cross bred young ones was 3.87 and 4.64, respectively.

Performance of meat type rabbits *(Sundaram et al., 1987)*

Feed intake up to 90 days (age at slaughter) was 5.4, 4.2 and 4.3 kg to attain BW of 1.3, 1.2 and 1.3 kg in local, cross bred and exotic rabbits, respectively. Feed efficiency of exotic, crossbred and local rabbits up to 90 days of age was 3.3, 3.4, and 4.1, respectively.

Feed intake of Soviet Chinchilla at different stages of growth *(Sundaram et al., 1989-90a)*

To identify feed requirement of young SC rabbit, voluntary intake of greens and concentrate were recorded at different stages of growth (at 30, 60, 90 and 120 days age) in weaners. Total DM intake/ d/ animal was 38 g, 96 g, 127 g and 130 g on 30, 60, 90 and 120 days of age, respectively. The R: C was 1.7 at 30 days and 1.4 at 120 days indicating an increase in roughage intake as age advanced (Table 36).

Growth performance of exotic meat rabbit and its crosses under tropical coastal climatic condition *(Sundaram and Bhattacharya, 1991)*

Adult SC and local (L) rabbits were maintained under identical management conditions at this institute for production of young ones. All animals were provided 70 g concentrate and 350 g grass daily. Lactating does were given 120 g concentrate and green fodder *ad lib*. Breeding was programmed to produce three groups of rabbits *viz*. pure exotic (SCXSC), crossbred (XB) (LXSC) and pure local (LXL). Altogether 10 batches were produced in each group and weaning was done on 30th day of kidding. Total of 168 kids involving 70 SC, 52 XB and 46 local were available for growth study. Observations on litter size, litters weight and weekly weight gain up to marketing age of 16th week were recorded. Data on various growth parameters are presented in Table 37.

It could be observed that there were no appreciable differences in litter size at weaning between SC and XB animals. However, litter weight at weaning and weight to kid at 16th week was higher in SC than in other groups indicating its better growth rate. The ADG was also higher ($P<0.01$) in SC.

Table 36: Feed intake of Soviet Chinchilla at different stages of growth

Age	BW(g)	ADG (g)	*Avg Daily Feed Intake (g)*			R: C ratio
			CM	Roughage	Total	
30	326.50	12.81	24.51	14.33	38.84	1.7
60	1191.66	29.56	54.82	41.62	96.45	1.3
90	1833.25	19.15	76.50	50.52	127.02	1.5
120	2050.00	17.80	77.82	52.56	130.26	1.4

Table 37: Comparative growth performance of SC, XB and L rabbits

Parameters	SC	XB	L
Litter size at birth	7.00 ±1.24	5.20 ±1.03	4.60 ±0.90
Litter size at weaning	5.00 ±0.81	4.90 ±0.98	4.00 ±0.40
Litter weight at birth (kg)	0.38 ±0.03	0.27 ±0.05	0.21 ±0.04
Litter weight at weaning (kg)	2.10 ±0.44	1.73 ±0.45	1.77 ±0.28
Weight at 16th week (kg)	2.00 ±0.28	1.73 ±0.18	1.50 ±0.12
ADG (g)	17.37	15.03	13.31

It was interesting to note that ADG in SC was 16 g during the 4th week and 18 g during 16th week and in case of XB it was 14 g at beginning and 15 g at 16th week. Thus, it was apparent that in local rabbits high growth rate was maintained only for a short period up to weaning; where as in case of SC and XB, growth rate was maintained till marketable age as stated earlier. Considering growth rates of three groups, it was clear that maintenance of locals up to 16th week might not be profitable.

From overall studies, it was observed that under tropical climatic conditions, purebred SC performed better in comparison to XB. Thus, it could be interpreted that there was no advantage in cross breeding of meat type SC rabbits with local and it would be beneficial to go in for pure breeding for better growth under prevailing agro-climatic conditions.

Performance of exotic meat rabbit under tropical coastal climatic condition *(Sundaram and Bhattacharya, 1992)*

Four exotic meat breeds of rabbit *viz*. SC, NZW WG and WGG were maintained in individual cages under optimum managemental and hygienic conditions. Concentrate feed mixture prepared with 35 parts wheat and 65 parts pelletized feed (TDN 65% and digestible CP 17%) was provided @ 65 g/ animal/ d. Mixed green fodder containing erythrina, subabul and NB-21 grass was fed @350 g/ animal/ d. Various economic traits *viz*. kindling percent, litter size and litter weight were recorded for each kindling.

Performance of four exotic meat breeds (Table 38) indicated that kindling (78.5%) and growth rate (19.2 g) were higher in SC though litter size was higher in NW (6.7).

Overall performance of SC was found better than other breeds under local conditions. However, comparative performance of these breeds under sub-Himalayan region (Garsa) was superior for WG than others. In view of better performance of SC, further observations were made on this breed and result is presented in Table 39.

The performance of SC was satisfactory and comparable to their performance at the Himalayan region, which was indicative of that meat type rabbits particularly SC could be successfully reared under coastal climatic conditions.

Table 38 Performance of exotic meat breeds in Goa

Breed	No of Observations	Kindling Percent	Litter Size at Birth	Weight at Birth (g)	Gestation Period (days)	ADG (g)
SC	28	78.50	6.00	59.48	32.00	19.20
NW	17	41.20	6.70	64.00	31.30	14.10
WG	16	50.00	5.30	69.20	31.60	15.00
GG	11	54.54	5.00	61.30	32.30	14.20

Table 39: Performance of SC rabbits in Goa

Parameters	Observations
Gestation period (days)	32.3±0.82
Litter size at birth	6.0±2.40
Litter size at weaning (28 days)	4.40±1.50
Litter weight at weaning (kg)	1.95±0.37
Birth weight (g)	59.50±13.77
Weight at 16th week (kg)	2.10±0.36
BW at one year (kg)	---
Male	3.70±0.62
Female	3.60±0.72
ADG up to 16th weeks (g)	19.17±3.23

Voluntary feed intake and nutrient digestibility of exotic meat rabbit under tropical coastal climate *(Sundaram et al., 1997)*

Comparative feeding trial was conducted on two exotic meat breeds under identical management condition to find their daily feed requirement. Eight each of SC and NW rabbits of 45 days age were selected for trials. NB-21 grass and concentrate feed with 18.25% CP and 8.15% CF were fed *ad lib*. to individual animals. The ADG and feed intake per day were almost at par for both breeds. Digestibility of ADF was 40.02 and 40.03, where as that of CP was 62.06 and 65.66 for SC and NW breeds, respectively (Table 40).

Table 40: Performance of SC and NZW rabbits

Para-meters	SC	NZW
DM intake (g/d)	88.12±6.15	81.99±3.02
DM digested (g/d)	51.88±3.17	49.65±1.65
DM digestibility (%)	58.87±2.14	60.55±1.76
DM intake/ kg BW (%)	9.27±0.54	9.24±0.61
ADF digested (%)	40.02±2.04	40.03±1.13
CP digested (%)	62.06±2.81	65.66±1.96
Avg BW (g)	950.00	887.00
ADG (g)	24.60	24.38

Effect of feeding high energy diet on growth performance of rabbits *(Sundaram and Chakurkar, 1997-98a)*

Two experimental diets with isoprotein value and two calorie levels were prepared for young rabbits to study effect of high energy diet on growth and performance in rabbits. The DE content of feed was 2650 kcal for control diet and 3000 kcal for experimental diet. The CP% of the diet was 18.5 for both control and experimental feeds. There was no beneficial effect of high energy diet with respect to ADG (Table 41).

Table 41: Effect of high energy diet on the growth and performance of rabbits

Parameters	Control	Treatment
CP%	18.50	18.50
DE (kcal)	2650	3000
DWG (g)/ Animal		
1	8.24	4.39
2	8.79	7.08
3	7.14	9.34
4	7.14	8.79
5	8.79	9.24
6	4.39	8.24
ADG (g)	7.41	7.84

Feed intake of Soviet Chinchilla and crossbred rabbits *(Sundaram et al., 1991-92)*

To identify daily feed requirement of adult rabbit, a trial was conducted on 12 SC and 23 XB rabbits for 15 days. The DM intake/ kg BW was higher in crossbred rabbits than SC (Table 42).

Effect of varying dietary energy levels on performance of rabbits *(Sundaram et al., 2001-02a)*

In an experiment on 12 weaned rabbits for 8 weeks, an experimental high energy diet with 3210 kcal DE was formulated and compared with a control diet having 2910 kcal (Table 43).

Table 42: Feed intake of Soviet Chinchilla and Cross bred rabbits

Parameters	Soviet Chinchilla (SC)			Cross bred (SC x Local)			Mean
	Male	Female	Average	Male	Female	Average	
No of animals	7	5	---	9	14	---	---
BW (kg)	3.07	3.09	3.08	2.48	2.48	2.48	2.78
DMI (g/animal)	128.07	128.85	128.30	126.84	131.90	129.37	128.86
DMI (g/ kg BW)	41.71	41.69	41.70	51.14	53.18	52.16	46.93

Table 43: Effect of different energy levels on performance of rabbits

Composition	Control Diet	Experimental Diet
Maize%	30	50
GNC%	30	30
WB%	40	20
Feed cost/ kg (Rs)	6.80	7.00
CP%	19.80	19.60
DE kcal/ kg feed	2910	3210
ADG (g)	16.34	16.87
Initial BW (g)	405.33	411.00
Final BW (g)	1896.00	1957.00
BW gain (g)	1490.67	1546.00
Feed cost/ kg BW gain (Rs)	32.88	32.34

Effect of feeding different energy levels on performance of crossbred rabbits *(Sundaram and Chakurkar, 1998-99)*

Feeding trials were conducted on crossbred SC rabbits with three levels of energy in concentrate feed *viz*. 2740, 3000 and 3340 kcal DE per kg feed (Table 44).

Table 44: Composition of concentrate diets with different energy levels

Ingredient	D_1	D_2	D_3
Maize (parts)	20	40	60
GNC (parts)	20	20	20
WB (parts)	60	40	20
CP%	17.06	16.80	16.67
DE (kcal/ kg feed)	2740	3000	3340
Cost (Rs/kg)	5.00	5.80	6.60

All animals were given feed and grasses *ad lib.* daily and maintained under identical managemental conditions. Maximum BW gain was observed in group with 3000 kcal/ kg DE (Table 45).

Table 45: Effect of different energy levels on performance of rabbits

Parameters	*Energy Levels (kcal/ kg Feed)*		
	3000	2740	3340
Trial – I (70 days)	15.23	16.90	13.09
Trial – II (28 days)	8.30	9.88	---
Trial – III (43 days)	17.52	18.18	13.63
ADG (g)	14.98	13.98	13.36

Effect of varying dietary energy levels on performance of crossbred rabbits *(Sundaram and Barbuddhe, 1999-2000a)*

Feeding trial was conducted on three groups of crossbred SC rabbits (6X3) for 65 days to study effect of different energy levels on performance of rabbits (Table 46).

Table 46: Effect of different energy levels on the performance of rabbits

Parameters	T_1	T_2	T_3
Feed Composition			
Maize	60	45	25
WB	20	35	55
GNC	--	--	--
Nutrients			
DE kcal/ kg feed	3340	3040	2880
CP%	16.10	16.22	16.28

Digestibility Data			
Grass intake (g)	32.07	36.20	36.24
CM intake (g)	61.25	67.80	77.24
Total DM intake (g)	93.32	104.0	113.6
DM digested (g)	67.55	74.26	77.23
DM digestibility (%)	72.38	71.40	67.99
ADG (g)	14.35	13.33	13.20

T_1, T_2 and T_3 represents high, medium and low energy diets, respectively

All animals in three treatments were given 80 g concentrate feed and 200 g green grass/ d.

Feeding trial conducted on 12 crossbred young rabbits for 4 months indicated that there was no significant difference in ADG. The ADG of control and experimental group was 13.76 g and 14.10 g, respectively indicated that growth performance under dietary energy level of 3210 kcal/ DE was at par with control diet (2910 kcal) under local climatic condition.

Effect of different levels of crude protein on feed intake and growth performance of rabbits *(Sundaram and Chakurkar, 1997-98b)*

Two feeding trials were conducted for feeds with 16.5% and 18.5% CP levels for 2 months with 12 rabbits to study growth performance (Table 47).

Table 47: Growth performance of rabbits on diets with different protein levels

Parameters	Control	Treatment
CP%	16.50	18.50
DE (kcal)	2650	2650
DWG (g)/ animal		
1	12.50	11.60
2	15.17	15.17
3	15.17	16.07
4	14.28	13.39
5	13.39	18.75
6	14.28	13.39
ADG (g)	14.13	14.72

• *Mean value of six replications*

There was no significant difference in ADG between groups.

Effect of feeding varying levels of energy and protein on performance of rabbits *(Sundaram and Chakurkar, 1996-97)*

Two diets with isocaloric value and two protein levels were formulated. The DE/ kg of feed were 2875 kcal for control diet and 2940 for experimental diet. The CP of diet was 17.5% and 21.5% for control and experimental feed, respectively. Feeds were processed for pellet making and trials were conducted for prescribed schedule. Two feeding trials were conducted with 12 crossbred weaned rabbits of 1.0-1.5 kg BW. The ADG of control group was 15.66 g and that of experimental group was 21.3 g. Cost of control and experimental feed was Rs 5.05 and 5.66/ kg. Average DM intake/ d were 74.02 g and 67.83 g/ kg BW for control and experimental group, respectively. Feed efficiency for experimental group was 5.44, where as that of control group was 7.27 indicating higher feed efficiency with CP level at 21.5%.

Effect of different crude protein levels on occurrence of agalactia *(Sundaram et al., 1993-94a)*

Concentrate feeds with two levels of CP i.e. 13% and 18% were formulated and fed to adult does. The DM intake per day was 134 g and 147 g for control and experimental groups, respectively. Number of cases of agalactia recorded was over 28.57% in experimental group fed with 18% CP as compared to control group (53.33%). In rabbits, agalactia incidence could be reduced from 53.32% to 28.5% by increasing CP content in concentrate feed (Table 48).

Table 48: Effect of CP level on agalactia in rabbits

Feed ingre-dients	Energy level (kcal/ kg)	CP%	No of animals mated	No of aga-lactia cases	% agal-actia
Experimental Diet					
GNC 25% WB 50% Wheat 25%	2.65	18.00	14	4	28.57

Control Diet					
GNC 12% WB 63% Wheat 25%	2.58	12.93	15	8	53.33

Effect of different dietary protein levels on occurrence of agalactia and growth performance of rabbits *(Sundaram et al., 1994-95)*

Two different diets were formulated *i.e.* control feed (16% CP) and experimental feed (22% CP) and fed to 8 does for 90 days to find out effect of agalactia and average daily gain in rabbits. In rabbits, incidence of agalactia could be reduced and ADG could be increased by increasing CP content in concentrate feed (Table 49).

Table 49: Effect of CP level on agalactia in rabbits

Feed ingredients	DE (kcal/kg feed)	CP%	No of animals	No of agalactia	Avg litter size	ADG (g)
GNC 20% Wheat 25% WB 55%	2800	16.2	6	1	4.5	11.7
GNC 35% Wheat 25% WB 55%	2885	21.8	6	Nil	5.1	14.7

Effect of mineral supplementation on performance of weaned rabbits *(Sundaram and Chakurkar, 1997-98c)*

Effect of mineral supplementation on performance of weaned rabbits was studied for 8 weeks. Ostocalcium @ 5ml/ liter water was provided to experimental animals. Study indicated that an increase in ADG was observed in experimental group (Table 50).

Table 50: Effect of mineral supplementation on growth performance of weaned rabbits

Body Weight (kg)							
Animal No. / Week	E_1	E_2	E_3	E_4	E_5	E_6	Avg
Control Group							
1	1.90	1.55	1.65	1.75	1.85	1.75	1.74
2	1.90	1.65	1.70	1.75	1.85	1.85	1.78
3	2.00	1.75	1.75	1.80	1.90	1.90	1.85
4	2.15	1.75	1.75	1.80	1.90	2.00	1.89
5	2.15	1.80	1.80	1.80	1.95	2.00	1.92
6	2.25	1.85	1.85	1.85	2.00	2.05	1.98
7	2.25	1.95	1.95	1.90	2.00	2.20	2.04
8	2.30	2.00	1.95	1.95	2.00	2.20	2.07
Ostocalcium Group							
1	1.85	1.75	1.90	2.00	2.00	2.20	1.95
2	1.85	1.85	2.05	2.00	2.00	2.20	1.99
3	1.90	1.90	2.15	2.10	2.05	2.20	2.05
4	1.90	2.00	2.40	2.20	2.15	2.30	2.16
5	1.95	2.00	2.35	2.20	2.15	2.35	2.16
6	2.00	2.05	2.45	2.20	2.20	2.35	2.21
7	2.00	2.20	2.45	2.25	2.20	2.35	2.24
8	2.10	2.20	2.40	2.25	2.30	2.35	2.27

Effect of supplementation of ayurvedic preparation on performance of weaned rabbits *(Sundaram et al., 1993-94b)*

To overcome environmental stress an ayurvedic preparation was added in rabbit diet @ 1 tablet/ kg feed and feeding trial was conducted on eight young rabbits. The ADG was higher (16.78 g) in experimental group than in control group (15 g). The DM digestibility for experimental group and control group was 69.96% and 69.02%, respectively indicating that incorporation of anti-stress tablet marginally increased daily BW gain.

Performance of crossbred rabbits fed soybean flour waste *(Sundaram et al., 1992-93)*

Soybean flour waste, an industrial by-product available locally has 18.4% CP and 12.10% CF. Experimental rabbit diet incorporating this waste material was formulated and feeding trial was conducted on two months old cross bred rabbits. The ADG for control and experimental animals were 20.45 g and 18.91 g, respectively.

Effect of replacement of wheat by maize grit on Soviet Chinchilla rabbits *(Sundaram et al., 1989-90b)*

Low cost feed was formulated incorporating maize grit in rabbit diet to replace wheat. Feeding trial was conducted on six weaned SC rabbits for one month. The DM digestibility was similar in experimental and control diet indicating suitability of maize grit as a low cost feed ingredient in rabbit diet (Table 51).

Table 51: Effect of replacement of wheat by maize grit on SC rabbits

Composition/ Performance	Control Feed	Experimental Feed
GNC (%)	20.0	20.0
Maize grit (%)	---	40.0
WB (%)	40.0	---
Pellet feed (%)	40.0	40.0
ADG (g)	12.0	10.4
DM digestibility (%)	71.5	69.2

Performance of rabbits fed on fermented rice bran *(Sundaram et al., 1993-94c)*

To enhance nutritive value of RB, ingredient was fermented with 5% molasses and 2% Baker's yeast for five days. The CP and ADF content of treated RB was 8.56% and 30.16%, respectively as compared to 6.30% and 37.44% in untreated RB. Enriched RB was incorporated in rabbit feed at 25% level and feeding trial was conducted on 8 adult rabbits for four weeks (Table 52).

Table 52: Growth performance of rabbits fed fermented rice bran

Feed Composition	Control Group	Experimental Group
Wheat	25.00	25.00
GNC	25.00	25.00
WB	25.00	25.00
RB + MM	25.00 (untreated)	25.00 (enriched)
DM intake (g/d/animal)	87.99	97.25
DM digested (g/d/animal)	60.48	70.03
DM digestibility (%)	68.73	72.01
DM intake/ kg BW gain (g)	56.00	60.00

Performance of rabbits fed brewers' dried grains replacing wheat bran *(Sundaram et al., 2001-02b)*

With a view to improve growth performance of young rabbits, experimental diet were formulated and evaluated through feeding trials. Low cost feed was formulated incorporating BDG at 25% level as replacement for WB. Incorporation of BDG at 25% level had no adverse effect on growth performance of rabbits (Table 53).

Table 53: Growth performance of rabbits fed brewers' dried grains

Composition	Control Diet	Experimental Diet
Maize%	40	40
GNC%	20	20
WB%	40	15
BDG%	--	25
Feed cost/ kg (Rs)	6.40	5.45
CP%	16.40	18.65
DE kcal/ kg feed	3040	2990
ADG (g)	15.82	17.32
Initial BW (g)	594.0	596.0
Final BW (g)	2177.0	2328.7
BW gain (g)	1582.7	1732.0
Feed cost/ kg BW gain (Rs)	30.84	23.81

Performance of rabbits fed CAW at 25% level replacing Wheat bran *(Sundaram and Barbuddhe, 1999-2000b)*

With a view to reduce cost in high energy diet, dried CAW, a seasonal byproduct available from fenni industry during summer months was incorporated at 25% level in rabbit feed as replacement for WB. Experimental feed with 30% maize, 25% WB, 25% CAW and 20% GNC was formulated and compared with control feed having 30% maize, 50% WB and 20% GNC. Feed intake and growth performance was studied in adult and young cross bred rabbits in two separate trials. The ADG in young rabbit was 14.01 g and 12.62 g for control and experimental groups, respectively. In adult animals, ADG was 6.39 g and 7.58 g for control and experimental group, respectively. Observations indicated that there was no adverse effect in adult rabbits when CAW was incorporated at 25% level in feed.

Performance of rabbits fed CAWat 15% and 30% levels replacing wheat bran *(Sundaram et al., 2000-01a)*

Experimental rabbit feed was formulated incorporating locally available CAW @ 15% and 30% as a substitute for WB. A feeding trial was conducted for 8 weeks on 18 XB rabbits (6X3) to study feed intake and digestibility. It was indicated that there was no adverse effect on digestibility by incorporating CAW in feed at 30%. The feed cost was reduced from Rs 6.80 to Rs 5.08/ kg (Table 54).

Table 54: Feed intake and digestibility in rabbits fed cashew apple waste

Ingredient Composition %	T_1	T_2	T_3
Maize	40	40	40
GNC	20	20	20
WB	40	25	10
Dried CAW	0	15	30
CP%	16.4	16.51	16.55
CF%	7.62	7.94	8.85
Average BW	1653.0	2111.3	1757.7
Total DM intake/ day (g)	102.29	129.88	116.66
DM digestibility %	66.56	67.75	66.29
DM intake/ kg BW/ day (%)	6.18	6.15	6.63
Feed cost (Rs/kg)	6.8	5.93	5.08

Effect of feeding fermented CAW on digestibility of rabbits *(Sundaram, 1995-96a)*

The effect of fermented CAW on digestibility of adult rabbits was studied by conducting a feeding trial. It was concluded that DM digestibility was increased by feeding fermented CAW in comparison to non-fermented CAW (Table 55).

Table 55: Effect of fermented CAW on digestibility of adult rabbits

Parameters	Control Feed with CAW	Experimental Feed with Fermented CAW
ADF%	12.79	10.52
Lignin%	5.16	4.66
DM intake (g)/ animal/d	70.11±7.04	75.19±13.26
DM digested (g)	48.80±5.82	58.92±10.45
DM digestibility (%)	70.99±1.40	78.34±2.64
DM intake (g)/ kg BW (%)	3.28	3.66
Feed		
Wheat %	25	25
Wheat bran %	25	25
Ground nut cake %	25	25
Cashew apple waste %	25	25
+ Mineral and vitamin supplement		

Performance of crossbred rabbits fed brewers' dried grains and cashew apple waste *(Sundaram et al., 2000-01b)*

In another trial, BDG and CAW were used separately at 25% level in formulation of economic rabbit feeds. Feeding trial was conducted for three months in 18 young SC cross bred rabbits.

It was indicated that there was no adverse effect on digestibility, when BDG was incorporated at 25% in concentrate feed (Table 56).

Table 56: Feed intake and digestibility in rabbits fed BDG and CAW

Ingredient Composition %	Control	CAW_{25}	BDG_{25}
Maize	40	40	40
GNC	20	20	20
WB	40	15	15
CAW	0	25	0
BDG	0	0	25
CP%	16.4	16.52	18.90
DE kcal/ kg feed	3040	3000	2890
Initial BW (g)	680	514	854
Final BW (g)	2254	1840	2248
ADG (g)	17.87	15.06	15.84
Total DM intake/ day (g)	102.07	98.89	112.83
DM digestibility %	66.68	67.09	73.05
DM intake / kg BW/ day (%)	5.05	5.35	5.01
Feed cost (Rs/kg)	6.80	5.20	5.35

Performance of rabbits fed fermented karad hay *(Bhattacharya et al., 1996-97)*

Karad hay was processed and inoculated with *Pleurotus florida* and fermented for 30 days. To develop a low cost protein enriched feed, experimental diets with fermented and non-fermented karad hay was formulated. The karad hay was incorporated at 20% level in control ration replacing WB to reduce cost of rabbit feed (Table 57).

The digestion trial with karad hay was conducted on weaned rabbits for 21 days. The average DM digestibility for control, treated and untreated karad hay feed was 79.5 g, 72.71 g and 65.66. The DM intake per kg BW for control and fungal treated and untreated karad incorporated diet was 50.1, 42.19 and 46.25 g respectively.

Performance of crossbred rabbits fed yeast enriched straw *(Sundaram, 1992-93a)*

A feeding trial was conducted for 30 days on young SC crossbred rabbits with yeast enriched straw at 20% level. The DM digestibility and ADG in rabbits fed on experimental feed were lower than the control feed (Table 58).

Table 58: Performance of Soviet Chinchilla crossbred rabbits on yeast enriched straw

Particulars	Control feed	Experimental Feed
Ingredients (%)		
Maize	30	30
GNC	30	30
WB	40	20
Enriched mushroom straw	---	20
Digestibility		
DM intake (g)/ animal/ day	52.28	65.57
% DM digested	74.05	72.97
DMI/ kg BW	6.70	7.15
ADG (g)	14.81	14.16
Cost/ kg feed (Rs)	5.60	4.65

Table 57: Chemical composition of control and Pleurotus treated karad hay and feed

Parameters	Control	KRD PL-20	KRD-20	KRD	KRDPL
NDF	17.32	24.7	28.7	64.76	58.41
ADF	12.70	16.12	19.74	46.92	36.05
CEL	10.76	14.06	14.74	33.75	29.67
LIG	6.82	8.72	8.17	14.62	11.35
CP	18.0	17.35	16.50	3.75	5.65
DE	2725	2625	2675	1900	1825

Effect of feeding fermented coir dust on feed intake and digestibility of rabbits *(Sundaram, 1995-96b)*

The by-product coir dust was treated with urea-molasses or potassium salt to enhance the biodegradation. The substrate which was treated with 5% molasses and 1% urea or potassium salt was autoclaved at 20 lbs pressure for 30 minutes, cooled and inoculated with 5% *Pleurotus spawn*. The biomass fermented for 30 days was analyzed for various proximate principles (Table 59).

Table 59: Chemical composition of coir dust fermented with additives

Nutrient	DM Loss (%)	ADF%	Lignin %	Cellu-lose (%)
Control (Non-fermented)	4.24	16.46	19.42	18.74
Fermented-5% Molasses + 1% Urea	72.7	66.26	69.14	64.17
Fermented-KH_2PO_4	38.86	33.71	31.12	34.21
Fermented-Without Additives	16.78	16.62	18.14	17.93

Feeding trials were conducted on 8 adult rabbits with fermented by-products. An experimental feed was formulated with 25% fermented coir dust, 25% wheat, 25% GNC and 25% WB. Data collected from individual animal for seven days were analyzed statistically (Table 60).

Table 60: Effect of feeding fermented coir dust on feed intake

Parameters	Control Feed with Coir Dust	Experimental Feed with Fermented Coir Dust
ADF%	18.93	16.44
Lignin (%)	8.66	4.16
DM intake/ animal/ day	91.11 ±8.64	73.28 ±12.25
DM digested (g)	55.65 ±3.98	48.46 ±4.83
DM digestibility (%)	61.07 ±2.29	70.22 ±2.36
DM intake (g)/ kg BW	46.7	34.4

Pelleting machine *(Sundaram, 1992-93b)*

Pellet feeding is advantageous in rabbits to avoid wastage. It also provides exercise for teeth. The available pelleting machine in market is suitable for only large scale production and is expensive. Hence, a small unit was fabricated. The unit consisted of a worm screw, pulley, motor and feed hopper. In this unit, when concentrate feed mixture is loaded through hopper, it passed through worm screw compressed and extruded as pellet. The pellet was of 4 mm diameter size with medium hardness. The production rate was 70 kg/ hour.

Poultry Nutrition Research

Effect of different vegetable protein sources on performance and immunity of growing chicken *(Swain et al., 2007a)*

A study was conducted in growing chicks (n=72) from 2 to 14 weeks to study the effect of replacing costly CP i.e. SBM by other protein sources like GNC and SFC (Table 61) on their performance and immunity. The BW gain, feed intake and feed efficiency during 2-14 weeks were significantly different in birds fed diets with different vegetable protein sources. The birds fed combination of SFC and GNC replacing 20 % SBM protein exhibited higher body weight gain and they had significantly better feed efficiency compared to other groups (Table 62). Highest feed consumption was recorded in chicks fed SFC as sole vegetable protein source. The expenditure on feed for one kg live weight was significantly lower on diet containing combination of SFC+GNC making it most economical diet. It was concluded that combination of GNC+SFC replacing 20 % of SBM protein could exhibit better performance, immunity and economics of production in growing chicks.

Table 61: Gross and chemical composition (%) of experimental diets

Ingredients	D_1	D_2	D_3	D_4
Maize	55	55	55	55
SBM	35	28	28	21
GNC	-	7.5	-	7.5
SFC	-	-	12	12
DORB	6.08	5.54	1.15	0.60
DCP	1.90	1.90	1.83	1.83
LSP	1.18	1.21	1.21	1.24
CS	0.40	0.40	0.40	0.40
DL-Methionine	0.15	0.16	0.12	0.14
MM	0.25	0.25	0.25	0.25
VM	0.04	0.04	0.04	0.04
Chemical Composition				
DM	90.6	91.2	90.8	91.2
CP	21.6	21.5	21.1	21.0
EE	2.37	2.40	2.42	2.45
CF	4.48	4.91	6.75	6.43
TA	7.74	7.57	7.30	7.10
GE (Kcal/ Kg)	3804	3785	3758	3776

Table 62: Effect on performance, immunity and cost of production

Treat-ments	BW gain	Feed intake	Feed effici-ency	Ab (log2 titre)	Feed cost /Kg wt. gain
T_1	1768.0^{b}	6985.7^{b}	3.953^{a}	9.75	38.71^{a}
T_2	1763.7^{b}	7108.7^{b}	4.033^{a}	9.25	37.65^{ab}
T_3	1769.7^{b}	7362^{a}	4.161^{a}	9.75	35.44^{b}
T_4	1871.7^{a}	6986^{b}	3.715^{b}	10.50	33.04^{c}
SEM	78.1	202.6	0.30	-	3.34

Means Possessing similar superscripts column wise do not differ significantly ($P<0.05$)
T_1 (SBM); T_2 (SBM rep. GNC); T_3 (SBM rep. SFC); T_4 (SBM rep. SFC + GNC)

Effect of different vegetable protein sources on performance of Vanaraja chicks *(Anonymous, 2005-06a)*

A study was conducted in one hundred eight Vanaraja day old chicks to study the effect of different vegetable protein sources either singly or in different combinations on the performance of Vanaraja chicks. There were six dietary treatments with different vegetable protein sources either alone or in different combinations (Table 63).

Table 63: Gross and chemical composition of experimental diets

Ingre-dients	D_1	D_2	D_3	D_4	D_5	D_6
Maize powder	40	40	40	40	40	40
SDOC	22	-	-	12	14	-
GNC	-	25	-	12	-	18
SFC	-	-	40	-	20	15
DORB	35.52	32	15.5	33.17	22.44	23.66
Soybean Oil	-	-	1.95	-	1.00	0.65
DCP	0.61	0.67	0.44	0.61	0.44	0.61
LSP	1.12	1.41	1.29	1.44	1.41	1.21
CS	0.40	0.40	0.40	0.40	0.40	0.40
L-Lysine HCl	-	0.13	0.13	0.01	-	0.12
DL-Methio-nine	0.06	0.10	-	0.08	0.02	0.06
MM	0.25	0.25	0.25	0.25	0.25	0.25
VM	0.04	0.04	0.04	0.04	0.04	0.04

Each dietary treatment had 3 replicates with 6 chicks in each replicate. Weekly BW gain, feed consumption were recorded and feed efficiency was calculated. Body weight increased ($P<0.05$) and feed efficiency input and in chicks fed combination of SBM and GMC (Table 65). It was concluded that combination of SBM and GNC was superior to other combinations and individual protein sources in the diet of Vanaraja chicks with significant improvement in body weight gains and feed efficiency over other treatments.

Table 64: Proximate composition of experimental diets (DM basis)

Exp. diets	DM	CP	EE	CF	TA	NFE	GE (Kcal/ Kg)
D_1	91.3	19.5	1.90	7.8	8.1	64.3	3557
D_2	90.8	19.1	1.95	8.4	7.7	63.8	3617
D_3	91.5	19.6	2.05	10.5	7.5	62.1	3578
D_4	90.5	19.2	1.94	7.2	8.9	63.8	3590
D_5	91.0	19.0	1.98	9.5	7.9	62.6	3794
D_6	91.2	18.9	2.03	9.8	7.2	62.1	3677

Table 65: Effect on performance of Vanaraja chicks

Treatments	BW gain	Feed intake	Feed efficiency
T_1	1017.7^{c}	3502.2^{b}	3.464^{bc}
T_2	1057.2^{b}	3577.7^{a}	3.385^{c}
T_3	1021.3^{c}	3601.4^{a}	3.526^{b}
T_4	1104.7^{a}	3598.9^{a}	3.258^{d}
T_5	1062.7^{b}	3607.9^{a}	3.396^{c}
T_6	983^{d}	3618.1^{a}	3.681^{a}
SEM	42.27	58.78	0.136

T_1:SBM; T_2: GNC; T_3: SFC; T_4: SBM+ GNC; T_5: SBM+ SFC; T_6: GNC+ SFC

Effect of different vegetable protein sources on the laying performance of Vanaraja *(Anonymous, 2005-06b)*

An experiment was conducted in laying hens to evaluate the mixture of vegetable protein sources in terms of their egg production and egg weight. Forty five laying hens (28 weeks old) were randomly distributed to 15 groups. There were 5 treatments i.e. control with SOC as sole protein sources (TSOC), GNC as sole protein source (TGNC), combination of SFC and SOC (T(SFC+SOC)), combination of sunflower cake and groundnut cake (T(SFC+GNC)) and combination of GNC and SOC (T(GNC+SOC)) (Table 66).

Table 66: Composition (%) of experimental diets

Ingre-dients	D_1	D_2	D_3	D_4	D_5
Maize	33	32	40	35	40
SDOC	21	-	16	12	-
GNC	-	23	-	12	18
SFC	-	-	20	-	20
DORB	35.92	34.47	11.8	30.9	10.5
Soybean Oil	-	-	1.7	-	1.2
DCP	0.61	0.61	0.72	0.72	0.78
LSP	8.40	8.68	8.40	8.26	8.40
CS	0.40	0.40	0.40	0.40	0.40
DL-Methio-nine	0.03	0.08	-	0.05	-
MM	0.50	0.50	0.50	0.50	0.50
VM	0.04	0.04	0.04	0.04	0.04

The proximate composition of experimental diets is presented in Table 67.

Table 67: Proximate composition (on % DM basis) of experimental diets

Exp. diets	DM	CP	EE	CF	TA	NFE	GE (Kcal/ Kg)
D_1	91.3	17.5	1.63	7.01	13.6	59.8	3231
D_2	90.8	17.1	1.69	8.30	13.4	58.5	3275
D_3	91.5	17.6	1.93	7.06	12.5	60.3	3166
D_4	90.5	17.2	2.01	8.28	12.8	58.7	3243
D_5	91.0	17.0	1.74	7.72	13.5	59.1	3300

Each treatment had 3 replicates with 2 laying hens in each replicate. The experiment was conducted in a completely randomized manner. Results indicated that birds fed with combination of GNC and SFC performed better in terms of egg production and egg weight whereas birds given SOC as a sole protein source produced heavier eggs but with less number.

Table 68: Effect of different vegetable protein sources on performance of Vanaraja layers

Treat-ments	Egg production	Egg weight	Feed intake	Feed efficiency
T_1	28.7^{b}	57.9^{a}	7836	3.294^{b}
T_2	22.7^{b}	54.0^{b}	7640	4.215^{a}
T_3	26.7^{b}	53.3^{b}	7706	3.511^{ab}
T_4	40.7^{b}	57.3^{a}	7715	2.299^{c}
T_5	23.3^{b}	51.7^{b}	7709	3.998^{ab}
SEM	7.123	2.970	-	0.779

Means possessing similar superscripts in a column differ significantly (P<0.05)

Effect of varying levels of Vitamin A on performance and immunity of Vanaraja chicks *(Anonymous, 2007-08)*

An experiment was conducted to study the effect of dietary supplementation of Vitamin A at various levels on the growth performance and immunity of Vanaraja growing chickens during 8-15 weeks of age. Eight weeks old, 90 growing chicks were randomly distributed into 6 equal groups (duplicated into 3 groups of 5 each). Six diets were formulated by supplementing 0, 4000, 8000, 12000, 16000 and 20000 IU/Kg Vitamin A to the control diet. Control diet composed of maize, 55 %; SBM, 20 %; SFC, 10 %; Fish meal, 5 %; DORB, 11.2 %; DCP, 1.2 %; LSP, 1.3 %; CS, 0.5 %; MM, 0.5 %; indomix, 0.02 % and ventribee, 0.03 %.

The design of the experiment was CRD. The chicks were fed either control diet or diet supplemented with Vitamin A at various levels. On completion of 6 week of age 0.5% suspension of SRBC was inoculated into two chicks in each replicate at a dose rate of 0.1ml. Blood serum was collected after 5 days of inoculation to measure the serum antibody titre against SRBCs. The results indicated that the BW gain and feed conversion ratio improved numerically by supplementation of 12000 IU/Kg vitamin A (Table 69).

Table 69: Effect of supplemental vitamin A on performance of growing Vanaraja chickens

Treatments	BWgain (g)	Feed intake (g)	Feed efficiency
1	982	4328	4.406^{abc}
2	977	4361	4.466^{ab}
3	1022	4389	4.297^{c}
4	1007	4403	4.374^{bc}
5	993	4400	4.434^{ab}
6	971	4389	4.521^{a}
SEM	-	-	0.127

Addition of vitamin A beyond this level did not show any beneficial effect on performance of chicks. It was concluded that supplementation of vitamin A had no significant influence on the immunity of growing chicks.

Effect of different levels of vitamin E and Se on performance and immunity of Gramapriya White chicks *(Anonymous, 2008-09a)*

An experiment was conducted to study the effect of dietary supplementation of combination of vitamin E and Se at various levels on the body weight gain, feed consumption, feed efficiency and immunity of Gramapriya white growing

chicks from 4 to 10 weeks of age. Six diets were formulated by supplementing combination of vitamin E and Se at various levels (0,0; 25 IU/Kg, 0.25 ppm; 50 IU/kg, 0.50 ppm; 75 IU/kg, 0.75 ppm; 100 IU/kg, 1.000 ppm and 125 IU/Kg, 1.25 ppm) to a control diet . Control diet composed of maize, 45 %, SBM, 20 %, GNC, 10 %, Fish meal, 5 %, DORB, 16.34 %, DCP, 1.33 %, LSP, 1.18 %, CS, 0.4 %, MM, 0.5 %, indomix, 0.2 % and ventribee, 0.30 %. The diets were fed to 108 nos. of 4 week old chicks in triplicate. Each replicate had 6 no. of chicks. Feed was given ad libitum and water was available all the times. Data were collected on weekly body weight gain, feed intake and feed consumption. On 9th week 0.5% suspension of SRBC was inoculated to six chicks per treatment at a dose of 0.1ml. Blood serum was collected after 5 days of inoculation to measure the serum antibody titre against SRBC.

Results indicated that there were no significant differences in BW gain and feed efficiency due to the supplementation of vitamin E and Se at various levels (Table 70).

Table 70: Effect of vitamin E and Se on performance and immunity of Gramapriya white chicks

Treat-ments	BW gain	Feed intake	Feed efficiency	Ab. titre
1	537.9	2269.2^{a}	4.226	5.750^{bc}
2	554.2	2228.3^{ab}	4.020	5.500^{c}
3	502.1	2128.0^{c}	4.238	6.250^{bc}
4	520.3	2107.3^{c}	4.052	6.250^{bc}
5	530.3	2135.6^{bc}	4.030	7.500^{a}
6	519.8	2154.8^{bc}	4.416	6.500^{b}

Data on antibody titre indicated that chicks fed diet supplemented with 100 IU/Kg vitamin E and 1.0 ppm Se exhibited significantly higher humoral immunity in terms of higher antibody titre.

It was concluded that supplementation of additional vitamin E and Se might not be necessary for optimum growth but higher level of supplementation had beneficial effect on immune response which reflects on better disease resistance capacity.

Effect of different sources of Ca on performance of Rhode Island Red laying hens *(Swain et al., 2005a)*

An experiment was conducted to study the effect of providing additional Ca from different sources over and above that present in commercial layer feed on the performance of RIR laying hens. There were 4 treatment groups i.e.T_1-Control –without additional Ca, T_2-1 % additional Ca from DCP, T_3-1 % additional Ca from $CaCO_3$ and T_4-1 % additional Ca from LSP. Twenty four number of RIR pullets of 20 weeks age were housed in individual cages and randomly allotted to 4 treatment groups. Each group consisted of 6 pullets. The experiment was conducted for a period of 20 weeks. Addition of 1% extra Ca from LSP improved ($P<0.05$) feed efficiency and egg production (Table 71-72).

It was concluded that 1% Ca from LSP might be added to commercial poultry feed for better egg production with moderate size, early sexual maturity and better efficiency of feed utilization.

Table 71: Effect of different sources of Ca on daily feed and Ca intake of RIR layers

Treatments	Feed intake (g/h/d)	Ca intake (g/h/d)	20 week BW(g)	40 week BW(g)
T_1	128.67^{a}	3.860^{c}	1261.7	1434.5
T_2	128.05^{ab}	5.122^{a}	1363.3	1498.3
T_3	125.63^{c}	5.023^{b}	1281.0	1398.0
T_4	126.10^{bc}	5.043^{b}	1253.7	1394.2
SEM	0.4683	0.0183	36.10	76.90

Means bearing common superscripts column wise differ significantly ($P\leq0.05$)
T_1: Control); T_2: C+1 % Ca from DCP; T_3: C+1 % Ca from $CaCO_3$; T_4: C+1 % Ca from LSP

Table 72: Effect of feeding different sources of Ca on egg production of RIR laying chickens

Treat-ments	Egg number	Egg weight	Age at 1st egg	% egg prod-uction	FCE
T_1	87.3^{ab}	46.0^{b}	156.2^{a}	59.4^{bc}	2.444^{ab}
T_2	99.3^{a}	44.5^{c}	152.3^{ab}	65.90^{ab}	2.17^{bc}
T_3	86.7^{b}	47.4^{a}	156.7^{a}	56.5^{c}	2.470^{a}
T_4	100.3^{a}	44.7^{bc}	147.7	68.8^{a}	2.073^{c}
SEM	3.23	0.32	2.2	2.12	0.09

Means bearing common superscripts column wise differ significantly (P<0.05)
T_1: Control (C); T_2: C+1 % Ca from DCP; T_3: C+1% Ca from $CaCO_3$; T_4: C+1 % Ca from LSP)

Effect of supplementation of *Clomiphene citrate* on egg production *(Bhattacharya, 1986)*

A trial was conducted in laying hens to study the effect of clomiphene citrate on egg production. Supplementation of clomiphene citrate @ 1mg/ bird improved the egg production by 28.45%, which increased further to 42.13% on continuous feeding.

Assessment of problend supplementation on performance and economics of production of Vanaraja chickens *(Swain and Chakurkar, 2009)*

An experiment was conducted to study the effect of dietary supplementation of Problend, a mixture of probiotics, enzymes and yeast on the growth performance, nutrient utilization and economics of production in Vanaraja chickens during 3-14 weeks of age. Three weeks old, 160 growing chicks were randomly distributed into 4 equal groups (duplicated into 4 groups of 10 each). Four diets were formulated by supplementing 0, 200, 300 and 400 mg problend to the control diet. The chicks were fed either control diet or diet supplemented with 200, 300 and 400 mg Problend per kg diet. The BW gain increased (p<0.01) and FCR improved (p<0.01) by supplementation of Problend up to a level of 400mg/kg diet (Table 73).

Table 73: Effect of supplementation of problend on performance of growing chicks

Treat-ment	T_1	T_2	T_3	T_4	SEM
BW gain (g)	1300.7^{a}	1333.3^{a}	1365.7^{ab}	1429.7^{b}	55.67
Feed intake (g)	4814.7	4829.0	4835.7	4849.3	25.22
Feed effici-ency	3.703^{b}	3.623^{ab}	3.542^{ab}	3.393^{a}	0.138
Nutrient Retentions (g/bird/ 3d)					
DM	227.0^{a}	232.8^{ab}	238.1^{b}	239.2^{b}	5.78
Pro-tein	42.4^{a}	44.1^{b}	45.1^{b}	47.2^{c}	1.89
Fat	11.30^{a}	12.57^{b}	13.14^{bc}	13.94^{c}	1.05

Means bearing different superscripts Column wise adiffer significantly (P≤0.01)

The retentions of DM was increased significantly (P<0.01) due to supplementation of Problend at a level of 300 and 400 mg/Kg diet. The protein and fat retentions were increased (P<0.01) in birds fed diet supplemented with probiotics and enzymes at levels. Improvement in the cost of meat production was achieved at a supplementation level of 400 mg/kg diet (Table 74).

Table 74: Cost benefit analysis for different groups of growing chicks of 3-14 weeks and age

Parameters	Treatments			
	T_1	T_2	T_3	T_4
Feed consumed per100 birds (kg)	481	483	484	485
Cost of feed/100 kg (US $)	22.08	22.53	22.80	22.98
Cost of feed (US $)	106.3	108.8	110	111.5
Cost of problend (US $)	0	2.18	3.28	4.38
Cost/ 100 chicks, US $	30	30	30	30
*Total Cost (US $)	155	159.7	162	164.6

Income (US $)	162.5	166.3	170.6	178.8
Net profit (US $)	7.5	6.6	8.6	14.1
Profit %	4.8	4.1	5.3	8.6

**Includes cost of labour, electricity and day old chick in each group.*

It was concluded that dietary supplementation of Problend at a level of 400 mg/Kg diet in terms of improved BW gain, FCR, nutrient utilization and economics of production.

Maxigro supplementation on production performance of Vanaraja hens *(Swain and Chakurkar, 2011a)*

The present investigation was carried out to see the effect of replacing SBM by SFC in isonitrogenous diets along with Maxigro (*Lactobacillus acidophilus*, *Lactobacillus sporogenes*, *Saccharomyces cerevisiae*, α-amylase, cellulase, β-glucanase, protease, pectinase, xylanase, phytase) supplementation on the performance of Vanaraja laying hens. 54 number of 25 weeks old Vanaraja laying hens were fed 9 diets (3 basal diets, D_1-D_3, by replacing 0, 20 and 40 % SBM in D1 by SFC on isonitrogenous basis and supplemented with 0, 1 and 1.5 g/Kg Maxigro). The egg production and feed efficiency improved (P<0.01) in laying hens fed D_4 and D_7 supplemented with Maxigro at the rate of 1.0 and 1.5 g/Kg feed (Table 75).

Shell thickness was (P<0.01) increased and age at 1st egg significantly (P<0.01) reduced in hens fed D_7 added with 1.5 g/kg Maxigro compared to hens fed D_1. It was concluded that supplementation of Maxigro at a rate of 1.5 g/Kg feed improved production performance and net profit in laying hens fed sunflower based diet by partial replacement of SBM.

Effect of probiotics on performance of Gramapriya chicks *(Swain et al., 2011a)*

An experiment was conducted to study the effect of dietary supplementation of Bioved, a probiotic product containing *Lactobacillus sporogenes* and vitamins on the growth performance and economics of production in Gramapriya growing chickens. Two weeks old, 120 growing chicks were randomly distributed into 4 equal groups (duplicated into 3 groups of 10 chicks each). They were given 0, 0.5, 1.0 and 1.5g of bioved per liter of drinking water, respectively. Data was being recorded on weekly

Table 75: Effect of Maxigro (M) supplementation on production performance of Vanaraja laying hens

Treatment	Egg production (dozen)	Egg weight (gm)	Egg shell thickness (mm)	Feed intake (gm)	Feed efficiency	Age at 1st egg (days)
D_1(0 % repl. of SBM by SFC)	4.16^{b}	57.4^{ab}	0.350^{c}	11.89^{a}	2.858^{abc}	203.5^{bcd}
D_2 (D_1+1.0g M/Kg)	4.15^{b}	56.0^{ab}	0.363^{bc}	12.19^{b}	2.934^{c}	205.0^{cd}
D_3 (D_1+1.5g M/Kg)	4.34^{bcd}	58.2^{b}	0.359^{c}	12.29^{b}	2.834^{abc}	201.0^{abcd}
D_4(20 % repl. of SBM by SFC)	3.75^{a}	55.8^{ab}	0.377^{a}	11.99^{ab}	3.201^{d}	203.0^{bcd}
D_5 (D_4+1.0g M/Kg)	4.22^{bc}	57.1^{ab}	0.355^{c}	12.20^{b}	2.890^{bc}	200.5^{abc}
D_6 (D_4+1.5g M/Kg)	4.14^{b}	56.6^{ab}	0.373^{ab}	12.28^{b}	2.966^{c}	199.0^{ab}
D_7 (40 % repl. of SBM by SFC	3.71^{a}	54.5^{a}	0.379^{a}	12.07^{ab}	3.253^{d}	205.5^{d}
D_8 (D_7+1.0g M/Kg)	4.54^{cd}	57.9^{b}	0.374^{ab}	12.16^{ab}	2.678^{a}	201.0^{abcd}
D_9 (D_7+1.5g M/Kg)	4.50^{cd}	56.7^{ab}	0.383^{a}	12.21^{b}	2.713^{ab}	197.5^{a}
SEM	0.203	2.18	0.019	0.137	0.38	2.08

Means bearing similar superscripts within a column did not differ significantly ((P≤0.01)

BW and daily feed consumption. Results indicated that addition of Bioved (probiotics + vitamins) @ 1.5 g/L of drinking water improved (P<0.05) growth performance (Table 76) and net profit (Table 77) of Gramopriya chicks.

Table 76: Growth Performance of Gramapriya chicks

Treatments	BW	Feed Intake	FCR	PER	Performance Index
T_1	426.8[a]	1692[a]	3.966[a]	1.230[a]	107.6[a]
T_2	439.1[ab]	1738[b]	3.960[a]	1.232[a]	110.9[a]
T_3	452.1[b]	1784[c]	3.947[a]	1.236[a]	112.9[a]
T_4	494[c]	1815[c]	3.675[b]	1.328[b]	134.5[b]
SEM	15.65	28.99	0.080	0.003	6.55

Means possessing different superscripts in a column differ significantly (P < 0.05).

T_1 (C); T_2 (0.5g/L); T_3 (1.0g/L); T_4 (1.5g/L)

Table 77: Cost benefit analysis for chicks

Parameters	Treatments			
	T_0	$T_{0.5}$	$T_{1.0}$	$T_{1.5}$
Feed consumed per100 birds (kg)	169.2	173.8	178.4	181.5
Cost of feed/kg (₹)	14.45	14.45	14.45	14.45
Total Cost of feed (₹)	2445	2511	2578	2623
Cost of 100 chicks - 3 week old (₹)	1600	1600	1600	1600
Cost of Biovet (₹)	--	16	33	49.5
*Total cost (₹)	4645	4727	4811	4873
Income (₹)	5100	5055	5220	5475
Net profit (₹)	455	328	409	603
Profit (%)	8.9	6.5	7.8	11

** Includes cost of electricity, medicine and labour*

It was concluded that supplementation of Bioved @ 1.5 g per kg was benefician to the Gramapriya chicks the terms of better growth performance and net profit.

Effect of probiotics and yeast supplementation on performance of Vanaraja laying hens *(Swain, 2010-11a)*

An experiment was conducted to study the effect of dietary supplementation of improval (mixture of probiotic, *Lactobacillus sporogenes*, $5X10^7$ cfu/g and yeast, *Saccharomyces cerevisiae,* $1.5X10^8$ cfu/g) on performance of Vanaraja laying chickens during a period of 14 weeks. Five experimental diets were formulated by supplementing 0, 0.5, 1.0, 1.5 and 2.0 g of probiotic and yeast (improval)/Kg control diet. Results indicated that supplementation of probiotics and yeast did not affect the egg production and feed conversion efficiency. Feed intake was decreased (P<0.05) due to addition probiotics and yeast @ 1.5 or 2.0 g/kg diet. (Table 78).

The egg weight, shell thickness, shell per cent, albumen and yolk per cent increased (P<0.05) due to probiotic and yeast supplementation @ 1.5 or 2.0g/Kg diet. Highest net profit was recorded in laying hens fed probiotics and yeast @ 1.5g/Kg diet (9.2 %) compared to that of control diet (Table 79).

It was concluded that supplementation of probiotics and yeast @ 1.5-2.0 g/Kg diet in Vanaraja laying hens is beneficial in terms of better egg size, shape index, shell thickness, shell per cent and albumen percent and more net profit.

Table78: Effect of probiotic and yeast on performance and egg quality characteristics of Vanaraja laying hens

Parameters	T_0	$T_{0.5}$	$T_{1.0}$	$T_{1.5}$	$T_{2.0}$	SEM
	Performance					
Egg production (dozen)	5.69	5.52	5.27	5.46	5.48	0.256
Egg weight (g)	55.60^{a}	55.17^{a}	55.36^{a}	56.57^{ab}	57.70^{b}	0.320
Egg shell thickness (mm)	0.352^{c}	0.370^{bc}	0.370^{c}	0.380^{a}	0.393^{a}	0.004
Feed intake (kg)	11.18^{c}	11.10^{c}	10.99^{b}	10.87^{a}	10.98^{b}	0.026
Feed efficiency	1.971	2.015	2.087	2.000	2.007	0.026
Shape index	72.77^{a}	75.33^{b}	73.33^{a}	77.03^{c}	75.70^{c}	0.452
Egg Components						
Egg contents	87.38	88.40	87.81	86.88	87.66	0.219
Moisture	74.77	74.78	74.32	73.80	74.30	0.160
Yolk	33.95^{c}	33.42^{bc}	31.68^{a}	32.32^{ab}	31.55^{a}	0.314
Albumen	53.43^{a}	54.79^{ab}	55.59^{ab}	54.56^{ab}	56.37^{b}	0.361
Shell %	11.20^{a}	12.30^{b}	12.30^{b}	12.80^{b}	12.27^{b}	0.157

Means bearing similar superscripts in a column differ significantly (P≤0.05)

Table 79: Cost benefit analysis

Para-meters	T_0	$T_{0.5}$	$T_{1.0}$	$T_{1.5}$	$T_{2.0}$
Feed intake, Kg	11.18	11.10	10.99	10.87	10.98
Cost of feed (₹)	171.95	171.50	170.57	169.46	171.95
Cost of bird (₹)	80	80	80	80	80
Cost of lab & elect (₹)	7.5	7.5	7.5	7.5	7.5
Total cost (₹)	259.45	259	258.07	256.96	259.45
Weight of bird (kg)	2.194	2.191	2.281	2.338	2.233
Income from sale of bird (₹)	109.7	109.6	114.1	116.9	111.7
Income from sale of eggs (₹)	170.7	165.6	158.1	163.8	164.4
Total income (₹)	280.4	275.2	272.2	280.7	276.1
Net profit/ bird (₹)	20.95	16.20	14.13	23.74	16.65
Net profit (%)	8.08	6.26	5.48	9.24	6.42

Effect of supplementation of probiotic and yeast on performance of broilers *(Swain, 2010-11)*

Growth Performance, carcass traits, organ weights and economics of production were evaluated in commercial broiler chickens from 1st day to 6 weeks of age. Basal diets (Table 80) were formulated containing maize, SBM and RP with CP, 22.8 % and ME 2900 KCal/ Kg at starter phase (0-3 weeks) and CP 19.9 % and ME 3000 kcal/ Kg at finisher phase (4-6 weeks).

Table 80: Ingredient and nutrient composition (%) of basal diets

Ingredients	Starter	Finisher
Yellow ground maize	52.0	64.0
SBM	35.0	28.0
RP	8.4	3.0
LSP	1.9	1.54
DCP	1.82	2.70
Common salt	0.50	0.50
L-Lysine HCl	0.03	0.02
DL-Methionine	0.16	0.05
VMa	0.04	0.04
MMb	0.15	0.15
Nutrient Composition (%), Calculated		
*Crude protein	22.8	19.9
ME (Kcal/Kg)	2900	3000
Ca	1.2	1.2
Available P	0.5	0.5
Lysine	1.2	1.0
Methionine	0.5	0.35

*aSupplies 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, 10 □g; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg. bSupplies 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. * Analyzed values*

The broiler chicks were fed basal diet supplemented without (T_0) and with improval (mixture of probiotic and yeast) @ 0.5g ($T_{0.5}$), 1.0g ($T_{1.0}$) and 1.5 g ($T_{1.5}$) per kg diet. The BW gain and feed efficiency of broilers fed diet supplemented with probiotics and yeast mixture @1g/Kg were better (P<0.05) than those recorded on control diet (Table 81).

Table 81: Effect on growth performance and economics of production

Parameters	Treatments				
	T_0	$T_{0.5}$	$T_{1.0}$	$T_{1.5}$	SEM
Body weight (g)					
3rd W	579.0	589.1	591.1	578.4	4.21
6th W	1893.0[a]	1918.8[a]	1968.3[b]	1916.0[a]	9.33
Feed Consumption (g)					
3rd W	802.3	800.7	801.1	801.1	0.28
6th W	3604.7	3578.2	3592.3	3610.8	7.93
Feed Conversion Ratio					
3rd W	1.386	1.360	1.357	1.385	0.010
6th W	1.904[b]	1.865[b]	1.825[a]	1.885[b]	0.010
Expenditure/bird (₹)	100.1[a]	99.4[ab]	100.1[ab]	100.6[b]	0.19
Income/bird (₹)	155.5[a]	157.5[a]	161.4[b]	157.2[a]	0.74
Net profit (₹)	55.3[a]	58.1[b]	61.3[c]	56.3[ab]	0.77
Benefit cost ratio	1.55[a]	1.59[bc]	1.61[c]	1.57[ab]	0.008

Means bearing different superscripts column wise differ significantly (P<0.05)

Higher (P<0.05) dressing% and breast yield were observed in chicks fed diet added with 1g/kg improval (Table 82).

Table 82: Effect on carcass characteristics and organ weights

Parameters	Treatments				
	T_0	$T_{0.5}$	$T_{1.0}$	$T_{1.5}$	SEM
Eviscerated yield (%)	63.97[a]	64.40[a]	66.97[b]	64.97[a]	0.38
Cut up Part Yields					
Breast	27.75[a]	27.64[a]	30.85[b]	30.47[b]	0.46
Thigh	17.77[b]	16.14[a]	16.49[a]	16.12[a]	0.24
Drumstick	15.86	15.23	15.28	15.28	0.12
Back	18.52[bc]	19.27[c]	17.33[a]	17.53[ab]	0.27
Wing	7.42	7.58	7.69	7.44	0.05
Neck	4.53	4.39	4.26	4.32	0.07
Abd. Fat	1.934[b]	1.669[a]	1.709[a]	1.652[a]	0.036
Caecal	1.044[d]	1.004[c]	0.917[a]	0.970[b]	0.015

Organ Weights					
Liver	3.080[a]	3.567[b]	4.000[c]	3.500[b]	0.108
Heart	0.752[a]	0.811[b]	0.823[b]	0.853[b]	0.012
Gizard	3.426[b]	2.952[a]	3.096[a]	3.069[a]	0.059
Giblets	7.257[a]	7.330[a]	7.920[b]	7.422[a]	0.102
Spleen	0.240[a]	0.246[a]	0.293[b]	0.234[a]	0.007
Bursa of Fab	0.283[a]	0.321[b]	0.337[b]	0.317[b]	0.007
Thymus	1.689	1.722	1.726	1.749	0.011

Means bearing different superscripts column wise differ significantly (P<0.05)

The abdominal fat content was reduced (P<0.05) due to probiotic and yeast supplementation at all levels. The relative weights of liver, heart, spleen and bursa were higher for chicks fed probiotic and yeast mixture at all levels. The relative weight of ceaca was decreased (P<0.05) due to addition of probiotic and yeast in the diet @ 1g/kg diet.

It was concluded that supplementation of probiotic and yeast mixture @ 1g/Kg diet improved the BW gain, feed efficiency, carcass yields, organ weights, leanness of meat and net profit in broiler chickens.

Effect of feeding rice kani on performance of growing Vanaraja chicks in coastal climate of Goa *(Swain et al., 2005b)*

Vanaraja backyard growing chicks (120; 8 weeks old) were given isocaloric and isonitrogenous grower rations (Table 83) containing 0, 10, 20, 30 and 40 % maize replaced with RK in a CRD to observe their growth potential and economics of production during July-Aug month with average temperature of 30^{0}C and humidity 90-95 %.

Table 83: Physical composition of diets

Ingredients	Control (0 % repl.)	T_1	T_2	T_3	T_4
Maize	50.00	45.00	40.00	35.00	30.00
GNC	20.00	21.00	22.00	23.00	24.00
Fish meal	10.00	10.00	10.00	10.00	10.00
WB	18.30	16.62	15.82	14.79	13.72
RK	--	5.00	10.00	15.00	20.00
DCP	1.17	1.17	1.22	1.22	1.24
CS	0.50	0.50	0.50	0.50	0.50
Soy-bean oil	--	0.43	0.18	0.21	0.26
VM[1]	0.01	0.01	0.01	0.01	0.01
VM[2]	0.02	0.02	0.02	0.02	0.02
MM[3]	--	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Chemical Composition (% DM Basis)					
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
TP	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

1Vitamin mixture, 1g contains vitamin A acetate, 82,500 IU; Vitamin B2, 50 mg; Vitamin D3, 16500 ICU; Vitamin K3, 50 mg 2 Vitamin mixture, 1 g contains vitamin B1, 4 mg; vitamin B6, 8 mg; vitamin B12, 40 µg; vitamin E, 40 mg; Ca-pantothenate, 40 mg; Niacin, 60 mg 3Mineral mixture, 1 g contains Ca, 328 mg; Copper, 0.8 mg; Iodine, 0.4 mg; Fe, 3 mg: Mn, 11 mg; Zn, 6 mg.:

T_1: 10 % repl; T_2: 20 % repl; T_3: 30 % repl.; T_4:40 % repl.

Each treatment was having 4 replications and each replication had 6 number of 8 weeks old growing chicks and the feeding trial was conducted from 8 weeks to 14 weeks of age. Daily feed intake, weekly BW gain and feed efficiency were measured. Results showed that mean BW gain of chicks during 8-14th week period were 966.69, 947.17, 1007.98, 1047.93 and 1003.83 g, respectively for diets containing 0, 10, 20, 30 and 40 % RK replacing maize (Table 84).

Table 84: Effect of replacing maize with rice kani on performance of Vanaraja growing Chicks

Treat-ments	BW gain (g)	Feed Intake (g)	Feed Effici-ency	Cost of Feed (Rs)/ Kg BW
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).

Significant (P<0.05) reduction in the feed intake was observed in groups of chicks kept on 20-40 % RK replacing maize. Expenditure on feed to gain one kg live weight was minimum on group 4 where 30 % maize of the grower diet was replaced by RK.

It was concluded that RK could replace 30 % of maize in the diet of growing Vanaraja chicks for better economics of production in coastal climate.

Effect of feeding sunflower cake replacing soybean meal on performance of Gramapriya laying hens *(Anonymous, 2006-07)*

A study was conducted in Gramapriya laying hens (54; 25 weeks old) distributed in to 18 groups. There were six dietary treatments where in SOC was replaced with SFC at different levels i.e. 0, 10, 20, 30, 40 and 50 per cent (Table 85).

Table 85: Composition of Experimental diets

Physical Composition of Diets						
Ingre-dients	D_1	D_2	D_3	D_4	D_5	D_6
Maize	48	48	48	48	48	48
SBM	20	18	16	14	12	10
FM	5	5	5	5	5	5
SFOC	-	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
LSP	7.10	7.26	7.25	7.26	7.24	7.10
CS	0.40	0.40	0.40	0.40	0.40	0.40
MM	0.25	0.25	0.25	0.25	0.25	0.25
VM	0.04	0.04	0.04	0.04	0.04	0.04
Chemical Composition of Diets						
Diets	DM	CP	EE	CF	TA	AIA
D_1	91.3	17.3	2.37	7.01	13.6	2.12
D_2	90.8	17.2	2.26	8.30	13.4	2.20
D_3	91.5	16.9	2.24	7.06	12.5	2.25
D_4	90.5	16.8	2.19	8.28	12.8	2.35
D_5	91.0	16.5	2.17	7.72	13.5	2.43
D_6	91.2	16.4	2.16	7.54	14.98	2.54

Each dietary treatment had 3 replicates with 3 laying hen in each replicate. The design of the experiment was CRD. Weekly body weight gain, feed consumption were recorded and feed efficiency was calculated.

Results indicated that SFC could replace 20% of SBM in the diet of Gramapriya laying hens with increase (P<0.05) in egg production, better feed efficiency with cheaper cost of production per dozen egg (Table 86).

Table 86: Effect on the performance of Gramapriya laying hens

Treatments	Egg Prod.	Feed Intake	Feed Efficiency
D_1	2.52^{bc}	9769	3.878^{ab}
D_2	2.81^{ab}	9937	3.545^{a}
D_3	3.14^{a}	9655	3.100^{c}
D_4	2.65^{bc}	9583	3.607^{a}
D_5	2.39^{c}	9721	4.040^{b}
D_6	2.44	9881	4.150^{b}
$CD_{0.01}$	0.50	NS	0.54

The parameters like egg weight, feed intake, shape index, specific gravity remained similar for different dietary treatments. Hence, it was concluded that SFC could be incorporated at a level of 6.4% in the diet of laying hens by replacing 20% SBM on isonitrogenous basis

for better egg production, feed efficiency and economics of production without affecting the overall performance.

Utilization of brewery waste in layer ration *(Sundaram et al., 1980)*

Proximate analysis indicated that brewery waste contains a higher percentage of CP (17.9%) than maize, but it contains more CF (20.90%). In order to find out its effect on egg production and feed efficiency, a feeding trial was conducted with 54 WLH layers for a period of 28 days with ration containing 10% and 20% brewery waste as replacement of maize. It was observed that the egg production and feed efficiency in control group with standard ration and in group fed with 10% replacement ration were at par. On the other hand there was significant reduction in egg production and lowering of feed efficiency in the group fed with 20% brewery waste. The result thus indicated that maize can be replaced to the extent of 10% with brewery waste in layer ration, which could be minimize the cost of production to the sizable amount of four paise per egg.

Low cost economic rations for poultry using locally available materials *(Nair and Sundaram, 1986)*

Feeding trials were conducted to test the nutritive value and safe level of inclusion of newly identified items viz. BDG and wheat rejects. It was observed that these items could be included safely up to 10% level in poultry rations.

Low cost poultry rations based on ingredients available in Goa; 1. Starter rations for egg type chicks *(Nair et al., 1987a)*

Two test rations for layer type chicks were prepared incorporating local ingredients (Table 87).

Table 87: Physical composition of test rations

Ingredients	Percentage Inclusion	
	Test Ration I	Test Ration II
Yellow maize	25	25
RB	28	18
BDG	--	10
GNC	25	25
Fish meal	12	12
Molasses	06	06
Shell grit	02	02
Bone meal	01	01
MM and VM	01	01

A commercial chick ration was taken as a standard ration for comparison. All the three rations were analyzed and the results are presented in Table 88.

Table 88: Chemical composition of chick rations

Rations	CP	EE	CF	NFE	TA
Standard Ration	19.36	3.50	7.80	47.03	13.36
Test Ration I	17.66	3.21	10.02	46.55	12.76
Test Ration II	18.26	3.48	11.41	46.19	13.42

Table 89: Comparative efficiency of chick rations

Chick Ration	Bi-weekly BW (g)				BW gain (g)	feed Intake (kg)/Bird	Feeding Cost (Rs/bird)
	II	IV	V	VIII			
Standard Ration	54.7[a]	120.6[a]	201.0[a]	266.5[a]	236.5	2.7[a]	5.21
Test Ration I	53.7[a]	103.8[b]	136.9[b]	163.5[a]	233.5	3.0[a]	4.74
Test Ration II	47.7[b]	95.4[b]	191.2[a]	265.4[a]	235.4	2.4[a]	3.76

Average within the same column having same superscripts are not significantly different (P<0.05).

A feeding trial was conducted for a period of 08 weeks. Seventy five one day old NH 260 chicks (WLH strain cross) were randomly allotted to two test groups and a standard group having 25 chicks each. The results of the feeding trial was represented in Table 89.

The average bi-weekly BW showed differences ($P<0.05$) among the groups up to the 6th week. But, it was interesting to know that there was no difference during the 8th week. This was indicative of a slower growth rate of both the test ration groups at the initial stages. This lower growth rate in the initial stages might be due to less utilization of test rations by the baby chicks probably because of their higher fiber content. However, improved BW gain from 6th week compensated the initial slow growth rate and this could possibly due to the attainment of better digestive ability and adoptability of the chicks to the type of feed with increase in age.

The feed consumption was higher in the group fed with test ration I followed by the standard ration. The lowest feed intake was observed in the group fed with test ration II, But these differences were not significant ($P<0.05$). The feeding cost calculated had indicated that test ration II was most economical (28% more than standard). The test ration I was the least efficient. However, it was found more economical (9%) more than the standard ration. The mortality was within the normal range and no significant differences among the group were observed.

The overall results had shown that rations formulated with local ingredients were more economical than the conventional poultry feeds. The ration incorporating RB and BDG was most efficient and economical; and that could be suitable ration for the economic poultry production in the territory.

Low cost poultry rations based on ingredients available in Goa; 1I. Grower ration *(Nair et al., 1987b)*

Two low cost grower ration (GR-I and GR-II) were formulated incorporating the locally available cheap ingredients like RB, BDG, fish meal, molasses and shell grit. To reduce the cost of feed incorporation of the costly ingredient namely maize was brought down from 15% in GR-I to 10% in GR-II with simultaneous increase of brewery grain waste from 10% (GR-I) to 15% (GR-II). A commercial grower ration was taken as standard for comparison.

The physical composition of standard and test rations is furnished in Table 90.

Table 90: Physical composition of grower rations

Ingredients	Percentage Inclusion	
	GR-I	GR-II
Yellow maize	15	10
Rice bran	31	31
BDG	10	15
GNC	20	20
Fish meal	10	10
Molasses	10	10
Shell grit	02	02
Bone meal	01	01
CS-MM + VM premix	01	01

White Leghorn grower chicks (72; 08 weeks old) from same flock will randomly divided into three groups of 24 chicks each. These groups were fed with Group-I (GR-I), Group-II (GR-II) and standard ration (SR), respectively for a period of 10 weeks.

Bi-weekly BW and feed intakes were recorded and the feeding cost per bird was calculated group wise for comparison. After the 18th week the birds of all the three groups were fed with the same type of standard layer ration and maintained under identical management conditions in layer cages for a further period of 08 weeks to find out

Table 91: Proximate Composition of experimental diets (DM basis)

Rations	CP	EE	CF	NFE	TA
GR-I	16.32	3.26	10.42	47.37	12.52
GR-II	17.41	2.77	12.96	47.31	10.91
SR	16.25	3.86	08.41	48.10	13.10

Table 92: Comparative efficiency of grower ration

Rations	Average BW gain (g)						Feed intake (kg)/ bird	Feeding Cost (Rs)/ bird	Age at 1st Egg (days)	Egg Production
	8th	10th	12th	14th	16th	18th				
Control	581.5[a]	591.1[a]	655.4[a]	753.9[a]	886.1[a]	1002.6[a]	5.0[a]	9.15[a]	131	18.2
GR-I	539.4[a]	35.1[a]	702.9[a]	773.1[a]	950.9[b]	1097.9[b]	5.8[b]	7.66	125	24.2
GR-II	536.8[a]	616.1[a]	666.0[a]	670.7[b]	849.9[a]	950.9c	6.4[c]	7.87	140	17.6

any adverse effect in egg production. The data on egg at 1st egg and average egg production was recorded during the extended period.

The chemical composition of rations and details of the comparative efficiency of the grower rations are furnished in Table 91 & Table 92, respectively. Average within the same column having same superscripts are not significantly different ($P<0.05$).

From the Table, it could be seen that GR-I group was the best with respect to all criteria studied. The BW in this group was higher through out the experimental period but the difference was significant only from the 16th week onwards. With respect to the cost of feeding, GR-I was 16.28% more economical than the standard ration. The better efficiency of GR-I was also evident from the findings of the early maturity (age at 1st egg – 125 days), which was six days earlier than the control and 15 days earlier than the GR-II groups. The average egg production up to 26 weeks was the highest (24.1/ hen) in the same group. Feeding cost calculated for the group was lowest (Rs 7.60). Further, it could be seen from the table that GR-II was inferior to both GR-I and SR as GR-II group had lowest average BW at 18 weeks (950.9 g) and delayed maturity (age at 1st egg 140 days). However, from the cost point of view, GR-I was slightly cheaper than the SR. Low efficiency of GR-II might be due to comparatively higher CF content in the ration. From the results, it was concluded that locally available by-products like RB and BDG could be profitably incorporated in grower rations, particularly replacing costlier maize to bring down the cost of feeding in replacement pullets considerably.

Effect of feeding brewers' dried grains with enzyme supplement on the performance of broilers *(Swain et al., 2005c)*

Performance, carcass traits and organ weights were evaluated in 150 commercial broiler chickens from 1st day to 6 week of age. Proximate composition of BDG is provided (Table 93).

Table 93: Proximate composition of BDG

Nutrients (%)	BDG
DM	24.48 ± 0.35
CP	7.32 ± 0.11
EE	7.32 ± 0.11
CF	17.00 ± 0.30
TA	3.09 ± 0.03
AIA	1.37 ± 0.04

Two basal diets were formulated containing maize, GNC, fish meal and WB with 22.8 % CP and 2800 KCal/Kg ME at starter (0-3 weeks) phase (Table 94) and 19.9 % CP and 2900 KCal/ Kg ME at finisher (4-6 weeks) phase (Table 95).

Table 94: Physical and chemical composition (%) of starter diets

Ingredients	D_1	D_2	D_2
Yellow Ground maize	55.00	55.00	55.00
GNC	25.00	20.00	15.00
Fish meal	10.00	10.00	10.00
WB	7.85	7.58	7.28
BDG	--	5.00	10.00
Soybean Oil	--	0.25	0.55
DCP	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

VM[a]	0.04	0.04	0.04
MM[b]	0.11	0.11	0.11
Chemical Composition (% DM basis)			
CP	22.80	22.10	21.35
CF	4.79	5.16	5.59
Calculated			
ME (Kcal/Kg)	2800	2800	2800
Ca	1.20	1.20	1.20
AP	0.50	0.50	0.50
Lysine	1.20	1.20	1.20
Methionine	0.50	0.50	0.50

D_1: Control; D_2: 20 % repl.; D_2: 20 % repl.
[a]Supplies per Kg diet; Vitamin A, 8250 IU; vitamin D_3 1200 ICU; riboflavin, 5 mg; vitamin K, 1 mg; vitamin B_1, 1 mg; vitamin B_6, 2 mg; vitamin B_{12}, 10 µg; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg. [b]Supplies per Kg diet: $MnSO_4.H_2O$, 28 g; $ZnSO_4.7\ H_2O$, 27 g; Fe $SO_4.\ 7H_2O$, 60 g; Cu $SO_4.\ 5H_2O$, 1.5 g and KI, 0.13 g.

Table 95: Physical and chemical composition (%) of finisher (4-6 weeks) diets

Ingredients	D_1	D_2	D_3
Yellow ground maize	60.00	60.00	60.00
GNC	22.00	17.00	12.00
Fish meal	10.00	10.00	10.00
WB	5.71	5.35	5.12
BDG	--	5.00	10.00
Soybean Oil	0.40	0.65	0.88
DCP	1.10	1.16	1.16
CS	0.40	0.40	0.40
L-Lysine HCl	0.17	0.17	0.17
VM[a]	0.04	0.04	0.04
MM[b]	0.11	0.11	0.11
Chemical Composition (% DM basis) Analyzed			
CP	20.96	20.36	19.77
CF	4.41	4.73	5.11
Calculated			
ME (Kcal/ Kg)	2900	2900	2900
Ca	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

aSupplies 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, 10 µg; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg. bSupplies 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. D_1 (Control); D_2 (20 % repl.); D_3 (20 % repl.)

The broiler chicks of 5 groups were fed with 5 diets where 1st diet was control and other four diets contained 5 and 10 % BDG with (@ 0.75g/Kg feed) or without enzyme supplement Kemzyme HF (a cellulase-complex with β-glucanase). The BW and feed efficiency of broilers fed diet incorporated with 5% BDG and Kemzyme-HF were comparable to that of control diet (Table 96).

Table 96: Effect of feeding BDG on performance of broilers

Treatments	BW (g)	Feed Consumption (g)	Feed Efficiency
T_1	1356.4^{ab}	3109.9^{b}	2.374^{b}
T_2	1306.1^{abc}	3062.2^{b}	2.460^{ab}
T_3	1372.8^{a}	3138.7^{ab}	2.371^{b}
T_4	1232.0^{cd}	3059.4^{b}	2.581^{a}
T_5	1288.6^{bcd}	3205.6^{a}	2.584^{a}
SEM	22.06	23.86	0.052

T_1- Control ©2; T_2- C+5% BDG; T_3- 5% BDG + 0.75 g Kemzyme /kg; T_4 – 10 % BDG; T_5-10% BDG + 0.75 g Kemzyme/kg
Means bearing different superscripts column wise differ significantly ($P \leq 0.05$)

Carcass traits did not show significant difference among the treatments except drumstick weight, which was significantly ($P<0.05$) higher in chicks fed 5% and 10% BDG with or without Kemzyme (Table 97).

Organ weights also showed similar response as that of carcass traits barring relative weight of heart, which was significantly ($P<0.05$) higher in chicks fed 5 and 10% BDG with kemzyme compared to control group (Table 98). Highest net profit was recorded in chicks fed 5% BDG (Table 99).

Table 97: Effect of feeding BDG on carcass traits and abdominal fat content of broilers

Treatments	Evisc. Yield (%)	*Wt. of cut up Parts (As % of Evs. yield)*						Abd. Fat
		Breast	Back	Thigh	Drumstick	Neck	Wing	
T_1	76.38	20.30	15.36	13.64	11.73[b]	4.37	7.17	2.813
T_2	74.94	20.67	15.84	14.90	12.55[a]	4.30	7.50	1.796
T_3	75.32	20.09	15.93	15.05	13.07[a]	3.97	7.50	1.769
T_4	74.89	20.55	15.06	14.43	13.04[a]	4.62	7.69	1.964
T_5	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 column wise differ significantly (P≤0.05)
T_1: Control; T_2: C + 5% BDG; T_3: 5% BDG + 0.75 g Kemzyme /Kg; T_4: 10 % BDG; T_5: 10 % BDG + 0.75 g Kemzyme /Kg

Table 98: Effect of feeding BDG on organ weights and giblets of broilers

Treatments	*Organ Weights (as % of Evsc. Yield)*					Spleen
	Liver	Heart	Gizzard	Giblets	Bursa of Fab.	
T_1	2.543	0.598[b]	3.197	6.397	0.359	0.203
T_2	2.567	0.664[ab]	2.907	6.147	0.349	0.201
T_3	2.937	0.771[a]	3.280	6.990	0.336	0.199
T_4	2.587	0.666[ab]	3.020	6.257	0.378	0.210
T_5	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 column wise differ significantly (P≤0.05).
*T_1-Control ©; T_2- 5% BDG; T_3-5 % BDG + 0.75 g Kemzyme /Kg; T_4 – 10 % BDG; T_5- 10% BDG+**0.75 g Kemzyme /Kg***

Table 99: Effect of feeding BDG on economics of broiler production

Treatment	Net profit/ broiler	Feed cost/kg live wt
T_1	14.34	20.06
T_2	14.62	20.04
T_3	16.50	19.68
T_4	12.44	20.11
T_5	13.34	20.49
SEM	1.17	0.43

*T_1-Control ©; T_2- 5% BDG; T_3-5 % BDG + 0.75 g Kemzyme /Kg; T_4 – 10 % BDG; T_5- 10% BDG+**0.75 g Kemzyme /Kg***

Incorporation of 5% BDG with kemzyme @ 0.75g/kg feed was suggested for economic production.

Influence of brewers' dried grains on the performance of *Rhode Island Red* chicks *(Swain and Sundaram, 2000-01)*

Performance was evaluated in 112 RIR layer chicks from 1st day to 8 week of age. Basal diet was formulated containing maize, GNC, fish meal and WB with 20.2% CP and 2668 kcal ME /Kg diet. Four experimental diets were prepared by incorporation of BDG at levels of 0, 10, 15 and 20% by replacing a part of GNC and WB in the basal diet (Table 100).

Table 100: Physical and chemical composition of experimental diets

Ingredients	D_1	D_2	D_3	D_4
Physical Composition (%)				
Yellow maize	50.00	50.00	50.00	50.00
GNC	22.00	17.00	14.00	12.00
Fish meal	10.00	10.00	10.00	10.00
WB	16.33	16.33	16.33	16.33
BDG	--	10.00	15.00	20.00
DCP	1.08	1.11	1.11	1.15
CS	0.40	0.40	0.40	0.40
L-Lysine HCl	0.04	0.03	0.03	0.02
VM[a]	0.04	0.04	0.04	0.04
MM[b]	0.11	0.11	0.11	0.04
Chemical Composition (% DM basis)				
CP	20.20	20.48	20.50	20.93
CF	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	0.90	0.90	0.90	0.90
Methionine	0.35	0.35	0.35	0.35

D_1 (Control); D_2 (10 % repl.); D_3 (15 % repl.); D_4 (20 % repl.)
[a]Supplies per Kg diet; Vitamin A, 8250 IU; vitamin D_3 1200 ICU; riboflavin, 5 mg; vitamin K, 1 mg; vitamin B_1, 1 mg; vitamin B_6, 2 mg; vitamin B_{12}, 10 µg; pantothenic acid, 10 mg; niacin, 12 mg; choline chloride (60 %), 400 mg.
[b]Supplies per Kg diet: $MnSO_4H_2O$, 28 g; $ZnSO_4$ 7 H_2O, 27 g; Fe SO_4 7H_2O, 60 g; Cu SO_4 5H_2O, 1.5 g and KI, 0.13 g.

There were 4 replications per dietary treatment and each replicate had 7 chicks. There were no significant differences among the treatments for BW gain and feed efficiency. However, significantly increase in feed consumption was recorded when the level of incorporation of BDG was increased to 15-20 % (Table 101). There was a saving of Rs. 1.78/- in feed cost per Kg BW gain of chicks. It was concluded that brewery dried grain could be incorporated in the diet of RIR chicks up to a level of 20 % without any adverse effect on their productive performance.

Table 101: Effect of feeding BDG on performance of RIR chicks

Treat-ments	BW gain	Feed Consum-ption	Feed Effici-ency	Feed Cost/ kg wt. gain
T_1	685.3	2693.7[b]	3.93	31.31
T_2	658.6	2715.0[b]	4.12	30.72
T_3	678.7	2746.8[ab]	4.05	30.42
T_4	683.4	2797.5[a]	4.09	29.53
SEM	8.30	22.07	0.05	0.51

Means possessing different superscripts column wise differ ($P<0.05$) significantly. T_1 (Control); T_2 (10 % BDG); T_3 (15 % BDG); T_4 (20 % BDG)

Effect of feeding cashew apple waste replacing maize on performance of broilers *(Swain et al., 2007b)*

An experiment was conducted using commercial broiler chicks (180) with diets replacing 0, 5, 10, 15 and 20 per cent of maize with CAW (Table 102) on weight by weight basis for a duration of six weeks.

Table 102: Physical and chemical composition (% DM basis) of experimental diets

Ingre-dients	*Diets*				
	T_1	T_2	T_3	T_4	T_5
Ground maize	55	52.25	49.50	46.75	44
GNC	28	28	28	28	28
Fish meal	10	10	10	10	10
CAW	--	2.75	5.50	8.25	11
WB	4.10	3.85	3.54	3.18	2.87
DCP	1.11	1.11	1.11	1.11	1.11
Soybean Oil	0.70	0.95	1.26	1.62	1.93
Sodium Chloride	0.50	0.50	0.50	0.50	0.50
L-Lysine HCl	0.24	0.24	0.24	0.24	0.24
DL-Methio-nine	0.15	0.15	0.15	0.15	0.15

VM & MM	0.20	0.20	0.20	0.20	0.20

Vitamin mixture (Supplies per Kg): Vitamin A, 8000 IU; VitaminB2, 10 mg; Vitamin D3, 1200 ICU, VitaminB1,1mg; VitaminB6,2mg; VitaminB12,20 mcg; VitaminE, 10mg; Niacin,35mg; Ca-pantothenate, 15 mg; Choline Chloride, 300 mg; Copper, 4mg; Iodine, 2mg; Zinc, 30 mg; Iron, 15 mg; Mn, 55 mg

Proximate composition showed that CAW contained more CP than maize (Table 103).

Table 103: Proximate composition (DM basis) of CAW

Proximate constituents	% Composition
DM	18.40 ± 0.09
CP	11.48 ± 0.77
EE	3.67 ± 0.12
CF	8.49 ± 0.15
TA	3.51 ± 0.06
AIA	1.26 ± 0.05
NFE	72.85 ± 0.85

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 (Table104).

Table 104: Effect of feeding cashew apple waste on the performance, carcass traits and organ weights of broilers at six weeks of age

Treatments	T_1	T_2	T_3	T_4	T_5	SEM
Body weight gain	1222	1182	1156	1137	1136	42.19
Feed consumption	2869	2864	2819	2790	2781	52.50
Feed efficiency	2.348	2.424	2.440	2.448	2.452	0.07
Net profit /bird (Rs)	8.22	6.81	6.45	6.37	6.22	
Carcass traits (dressing % and weight of cut up parts)*						
Dressing %	59.2	60.2	60.2	63.6	60.8	1.3
Breast*	23.3	22.7	22.7	22.5	23.1	0.8
Back*	17.5	19.4	19.4	19.1	19.8	0.7
Thigh*	18.3	17.6	17.6	17.9	18.0	0.4
Drumstick*	14.0	14.2	14.2	14.4	13.3	0.4
Wing*	9.5	9.4	9.4	9.4	9.2	0.3
Neck*	5.9	6.5	6.5	5.9	5.7	0.2
Relative weight of organs						
Liver*	3.65	3.59	4.44	3.97	3.97	0.20
Gizzard*	3.73	3.92	4.21	4.17	4.11	0.23
Heart*	0.93	0.81	1.06	0.97	0.81	0.06
Giblets*	8.30	8.33	9.71	9.11	8.89	0.37
Spleen*	0.28	0.31	0.28	0.27	0.27	0.01
Bursa*	0.42	0.40	0.34	0.34	0.26	0.06

T_1 (control); T_2 (5 % CAW); T_3 (10 % CAW); T_4 (15 % CAW); T_5 (20 % CAW) Means possessing different superscripts row wise differ significantly ($P \leq 0.01$)
** Expressed as % of dressed weight*

Carcass traits and organ weights did not show any significant variation between the treatments. The results of the present trial indicated that the net profit per bird was about 30 per cent higher than the control in groups where 20 per cent maize was replaced by CAW. Hence, it was concluded that CAW could replace 20 per cent maize in the diet of broilers without any adverse effect on the performance and carcass traits.

Effect of feeding cashew apple waste on production performance of Vanaraja layers *(Swain et al., 2002-03a)*

Feeding trial was conducted with Vanaraja layers (36; 20 weeks old). Four experimental diets were prepared by replacing 0, 10, 20 and 30 % of the commercial layer diet (18 % CP) by

CAW. The diets were fed to either of the four treatment groups ad libitum. Data were collected on weekly BW gain, weekly feed consumption, daily egg production and egg weight for a period of 8 weeks. About 9 laying birds were kept on floor (fed the control diet) to compare the egg production performance. The CAW contained 18.4 % DM, 11.4 % CP, 3.67 % EE, 8.5 % CF, 3.51 % TA, 1.26 % AIA. Results indicated that there was no significant difference in egg production and egg weight among the various treatments (Table 105).

Table 105: Effect of feeding CAW on egg production and egg weight of Vanaraja laying hens

Groups	Egg Production	Egg Weight
T_1	78.7	53.03
T_2	77.0	52.27
T_3	57.0	52.0
T_4	42.0	50.6
SEM	8.51	0.95

T_1: control; T_2: 10% of layer diet replaced by CAW; T_3: 20% of layer diet replaced by CAW; T_4: 30% of layer diet replaced by CAW

Numbers of eggs produced were 78, 77, 57 and 42 for T_1, T_2, T_3 and T_4 groups, respectively without much variation in the egg weight.

It was concluded that CAW can replace 10 % layer diet by weight basis without any adverse effect on the egg production and egg weight of Vanaraja laying hens.

Effect of feeding cashew apple waste replacing maize in the diet of Vanaraja chicks *(Swain, 2002-03b)*

A feeding trial was conducted for a period of 5 weeks to study 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 106).

Table 106: Gross and chemical composition (%) of experimental diets

Ingredients	T_1	T_2	T_3	T_4	T_5
Maize	50.00	47.50	45.00	42.50	40.00
GNC	20.00	20.00	20.00	20.00	20.00
FM	10.00	10.00	10.00	10.00	10.00
WB	17.85	17.50	17.14	16.84	16.44
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
CS	0.50	0.50	0.50	0.50	0.50
VM and MM	0.25	0.25	0.25	0.25	0.25
Chemical Composition					
CP (%)	28.00	18.60	18.10	17.90	18.4
ME (Kcal/kg, calculated)	2650	2650	2650	2650	2650

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

All the diets were made isonitrogenous and isocaloric. Vanaraja chicks (200; 3 weeks old) were weighed individually and distributed randomly in to 20 groups having equal average BW. Data were recorded on weekly feed consumption and BW gain. The Feed efficiency was also calculated. Results (Table 107) indicated that there was no significant differences in BW gain, feed consumption and feed efficiency between the various treatment groups fed CAW at different levels replacing maize.

Table 107: Effect of feeding CAW on the performance of Vanaraja chicks

Parameters	T_0	T_5	T_{10}	T_{15}	T_{20}
BW gain	765.1	783.8	751.1	752.0	772.4
Feed consumption	2742.2	2727.2	2732.6	2745.4	2759.4
Feed efficiency	3.595	3.493	3.611	3.653	3.561
Feed cost/ kg (Rs)	8.64	8.44	8.47	8.47	8.32
Feed cost/ g BW gain	31.06	29.47	30.58	30.93	29.63

It was concluded that CAW could replace up to 20 % maize in the diet of Vanaraja chicks without any adverse effect on their performance from 3-8 weeks of age.

Replacement of soybean meal by fishmeal in growing Vanaraja chickens *(Swain and Chakurkar, 2011b)*

Vanaraja chicks (144; one week old; average weight of 70 grams) were randomly distributed into 6 groups and offered six diets, in which fish meal was included at 0 (T_1) or 5 (T_2) or 7.5 (T_3) or 10 (T_4) or 12.5 (T_5) or 15 (T_6), percent level by replacing SBM (Table 108).

Table 108: Physical composition of experimental diets

Ingredients	T_1	T_2	T_3	T_4	T_5	T_6
Maize	50	50	50	50	50	50
SBM	30	25	22.5	20	17.5	15
Fish meal	--	5.0	7.50	10	12.5	15
WB	16	17	17.8	18.5	19	19
DCP	1.83	0.89	0.44	--	--	--
LSP	1.47	0.94	0.70	0.46	--	--
CS	0.40	0.40	0.40	0.40	0.40	0.40
MM	0.25	0.25	0.25	0.25	0.25	0.25
VM	0.04	0.04	0.04	0.04	0.04	0.04
Total	100	100	100	100	100	100

The chemical composition of experimental diets is presented in Table 109.

Table 109: Chemical composition (% DM basis) of experimental diets

Nutrients	T_1	T_2	T_3	T_4	T_5	T_6
DM	7.14	7.01	7.39	6.45	6.94	6.47
CP	19.28	19.60	19.30	19.52	20.01	19.41
EE	3.17	3.43	3.31	3.41	3.19	3.26
CF	8.20	8.15	8.36	8.14	8.37	9.14
TA	9.07	9.61	9.77	9.88	10.20	10.30
AIA	1.73	2.16	2.09	2.29	2.33	2.41
Ca	1.03	1.00	1.01	1.02	1.02	1.19
Total P	0.91	0.87	0.86	0.84	0.91	0.99

There was decrease ($P<0.05$) in the weight gain of the chicks, when SBM was replaced by FM at 15% level (Table 110).

Table 110: Growth performance

Treatment (Fish meal)	BW Gain (gm)	Feed intake (gm)	Feed efficiency	Ab log2 titre	Feed cost/ Kg wt.gain (Rs)
T_1	583.5^{a}	2234.7	3.865^{c}	4.6^{a}	34.09^{c}
T_2	547.2^{a}	2296.3	4.225^{bc}	9.2^{b}	36.50^{bc}
T_3	539.1^{a}	2298.0	4.264^{b}	9.4^{b}	36.41^{bc}
T_4	538.3^{a}	2355.7	4.417^{b}	9.4^{b}	37.42^{b}
T_5	533.7^{a}	2344.7	4.298^{a}	10.8^{b}	36.40^{bc}
T_6	462.1^{b}	2339.3	5.061^{a}	10.8^{b}	42.81^{a}
SEM	65.35	--	0.515	1.50	4.44

Means possessing different superscripts in a column differ significantly ($P < 0.05$).
T_1: 0; T_2: 5.0; T_3: 7.5; T_4: 10; T_5: 12.5; T_6: 15

Poor feed efficiency was observed when fish meal was used beyond 5 per cent level. The feed cost

per kg live weight gain increased (P<0.01) at higher (15%) level of fish meal inclusion. Inclusion of fish meal up to a level of 12.5% did not affect (P>0.05) the feed cost per kg live weight gain.

It was concluded that fish meal could be incorporated up to a level of 5% in the diet of Vanaraja growing chick by replacing SBM on CP basis without any adverse effect on growth performance.

Effect of replacement of maize with bajra (*Pennisetum typhoides*) or ragi (*Eleusine coracana*) on performance of laying hens *(Swain et al., 2009)*

Gramapriya white laying hens (63; 30 weeks old) were assigned to 21 groups with 3 laying hens in each group having approximately equal BW. Seven experimental diets were formulated by replacing 50 and 100 percent of maize by unground and ground bajra and ragi as per nutrient requirement. 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 111).

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<0.01) higher in hens fed diet with 50 and 100 % maize replaced by ragi. A significantly (P<0.01) higher shell thickness was recorded in laying hens fed diet with 100% maize replaced by ragi. The shape index%, egg white and % yolk were similar in all the groups. It was concluded 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.

Effect of replacing maize by ragi (*Finger millet*) on performance of Gramapriya white chicks *(Anonymous, 2008-09b)*

A feeding trial was conducted in Gramapriya chicks (120; one day old) to study the effect of replacing maize by ragi at various levels on their performance. Four experimental diets were formulated (Table 112) by replacing 0, 25, 50 and 100, per cent maize in the control diet with ragi. Each diet was fed to triplicate groups and each replicate had 10 chicks. The experiment was conducted in a completely randomized design

Table 111: Effect of replacing maize by bajra or ragi on performance of laying hens

Treatments	Egg Weight (gm)	Feed Intake (gm)	Egg Production (kg)	Feed Efficiency (feed in kg /egg in kg)	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}	11.83ab	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<0.01) different.

and for a period of 8 weeks. Data were recorded on weekly body weight gain, feed consumption and feed efficiency was calculated.

Table 112: Composition (%) of experimental diets

Ingredients	D_1	D_2	D_3	D_4
Ground maize	50	37.5	25	0
SBM	20	20	20	20
Fish meal	05	05	05	05
DORB	06	06	06	06
WB	06	06	06	06
DCP	1.33	1.33	1.33	1.33
LSP	1.18	1.18	1.18	1.18
CS	0.40	0.40	0.40	0.40
MM	0.50	0.50	0.50	0.50
Meriplex	0.25	0.25	0.25	0.25
Ventribee	0.25	0.25	0.25	0.25

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 113).

Table 113: Effect of replacing maize by ragi on the production performance of Gramapriya white chicks

Treat-ment	BW gain	Feed Intake	Feed Effici-ency	Cost of Feed/Kg BW gain
T_1	695.3	2826.9	4.066	59.04
T_2	697.4	2827.5	4.055	57.87
T_3	683.8	2816.0	4.119	57.74
T_4	640.2	2803.7	4.380	59.22

However, feed intake remained uninfluenced. The body weight gains and feed efficiencies of groups fed control diet and diets with 25 and 50, per cent maize replaced by ragi were similar. Cost of feed per kg meat production was lowest in chicks fed diet with 50 % maize replaced by ragi.

It was 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.

Effect of feeding processed poultry hatchery waste on performance of Vanaraja chicks *(Swain et al., 2011c)*

To study the effect of feeding cooked PHW on the growth performance, 120 (2 weeks) Vanaraja chicks were randomly distributed in to 4 equal groups with 3 replicates and fed on diets prepared by inclusion 0 (T_1), 2 (T_2), 4 (T_3) and 8 (T_4) percent PHW by replacing 0, 25, 50 and 100 percent fish meal of the control diet. The PHW was cooked at 120 lb for 30 min., dried in hot air oven and analyzed for proximate composition.

Higher values for CP and Ca contents were recorded is present study compared to those reported by earlier workers. Results (Table 114) on performance study indicated significant ($P<0.01$) increase in body weight gain due to incorporation of processed PHW 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 114: Effect of processed PHW on performance of chicks

Treat-ments	BW Gain	Feed Intake	FCR	PER	Perfor-mance Index
T_1	454.4 ^{a}	1792.5	3.946^{b}	1.158^{a}	115.19^{b}
T_2	480.2^{b}	1791.3	3.731^{a}	1.233^{b}	128.77^{a}
T_3	491.2^{b}	1806.9	3.679^{a}	1.263^{b}	133.55^{a}
T_4	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

Means bearing different superscripts within a column differ significantly ($P\leq0.01$) [A]-Bracketed values are the per cent of PHW used

Significant ($P<0.01$) improvements in FCR, PER and PI in chicks were observed due to feeding of PHW at all the levels. Maximum net profit (Table 115) was recorded due to feeding of 8% PHW. It was concluded that inclusion of processed poultry hatchery waste at 8 % by replacing fish meal in the diet of Vanaraja chicks is beneficial in terms of improved growth, feed efficiency and profit margin.

Table 115: Cost benefit analysis for chicks

Parameters	Treatments[A]			
	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*
[A]-Bracketed values are the per cent of PHW used

Effect of feeding palm oil on performance of Gramapriya laying hens *(Anonymous, 2009-10)*

An experiment was conducted to study the effect of PO as an energy source on performance of Gramapriya laying hens during a period of 12 weeks. 25 weeks old, 60 laying hens were randomly distributed into five equal groups (duplicated into 4 groups of 3 laying hens each) in wire mesh floored cages. Five experimental diets were prepared (Table 116) by replacing 0, 5, 10, 15 and 20 % maize by PO of the control diet on isocaloric basis.

Table 116: Composition experimental diets

Ingredients	D_1	D_2	D_3	D_4	D_5
Maize	55	52.25	49.5	46.75	44
SBM	18	18	18	18	18
Fish meal	5	5	5	5	5
SFC	5	5	5	5	5
DORB	5	5	5	5	5
DCP	1.78	1.78	1.78	1.78	1.78
LSP	7.35	7.35	7.35	7.35	7.35
CS	0.40	0.40	0.40	0.40	0.40
Vitamin AB_2D_3K	0.02	0.02	0.02	0.02	0.02
Vitamin B-complex	0.03	0.03	0.03	0.03	0.03
MM	0.50	0.50	0.50	0.50	0.50
PO (Kg)	--	1.0	2.0	3.0	4.0

The laying hens were fed either of the experimental diets *ad lib*. 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 serum cholesterol was estimated. The egg production decreased ($P<0.05$) and egg weight increased ($P<0.05$) when maize was replaced by PO at a level of 15-20% on isocaloric basis (Table 117).

Table 117: Effect of palm oil on performance of Gramapriya laying hens

Treatment	Egg Prod (Dozen)	Egg Wt (Gm)	Egg Shell Thickness (mm)	Sp. gr	Feed Intake	Feed efficiency Chol.(mg/100g)	Yolk
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}	10.52^{ab}	2.285^{b}	510.6e
SEM	0.069	0.49	0.019	0.015	0.042	0.026	31.02

Means possessing different superscripts in a column differ significantly ($P<0.05$)

Feed consumption decreased (P<0.05) due to feeding of PO by replacing maize beyond 10 % level. The feed efficiency deteriorated when the replacement of maize by PO exceeded 10 % level. The egg cholesterol content increased (P<0.05) at all levels of replacement. It was concluded that PO could be used in the diet of laying hens up to a level of 10% replacing maize in the diet of Gramapriya laying hens without affecting performance except the egg cholesterol content which increased due to inclusion of palm oil.

Japanese Quail (*Coturix coturnix japonica*)

Utilization of rice kani as substitute for maize on performance of Japanese quail chicks *(Swain et al., 2003-04a)*

An experiment was conducted in Japanese quail chicks (99; 4 weeks old) in a CRD from 4-9 weeks. There were 3 treatments including the control diet. Control diet was having the maize as the sole energy source whereas in experimental diets (T_2 and T_3), 10 and 20 % of maize was replaced with RK (Table 118).

Table118: Composition of experimental diets (%)

Ingredients	Control	T_1	T_2
Maize	50.00	45.00	40.00
GNC	32.00	32.00	32.00
Fish meal	10.00	10.00	10.00
WB	4.06	4.06	4.06
RK	--	5.00	10.00
CS	0.40	0.40	0.40
DCP	0.90	0.90	0.90
MM & VM	0.30	0.30	0.30
L-Lysine HCl	0.24	0.24	0.24
DL-Meth	0.10	0.10	0.10

T_1: 10 % replacement; T_2: 20 % replacement

Each treatment had 3 replications with 11chicks/ replicate. Data on BW gain and feed intake was recorded and the feed efficiency calculated. Results indicated that replacement of maize with RK at 10 and 20 % level did not influence the body weight gain, feed intake and efficiency of feed utilization (Table 119).

Table 119: Effect of replacing maize partially with rice kani on performance of Japanese quails

Treatments	Body Weight Gain (g)	Feed Intake (g)	Feed Efficiency
Control	177.33	1207.87	7.252
T_1	186.41	1300.20	7.314
T_2	188.33	1366.60	7.998

T_1: 10 % replacement; T_2: 20 % replacement

Hence, it is suggested that maize could be replaced with RK up to a level of 20 % in the diet of Japanese quail chicks without any effect on their performance.

Feeding value of broken rice for Japanese quail layers *(Swain et al., 2006)*

An experiment was conducted to assess the nutritional worth of broken rice for laying Japanese quails (96; 10 weeks old) for a period of 4 months. Four experimental diets (RK_0, RK_5, RK_{10} and RK_{15}) were formulated (Table120) by addition of 0, 2.4, 4.8 and 7.2% broken rice replacing 0, 5, 10 and 15% maize w/w. Each dietary treatment was allocated to 3 groups (3 replicates).

Table 120: Composition of experimental diets

Feed ingredients	RK_0	RK_5	RK_{10}	RK_{15}
	Ingredient Composition %			
Yellow maize	48.00	45.60	43.20	40.80
GNC	36.00	36.00	36.00	36.00
WB	6.68	6.74	6.67	6.67
RK	--	2.40	4.80	7.20
DCP	1.72	1.78	1.78	1.78
LSP	6.72	6.58	6.66	6.66
CS	0.50	0.50	0.50	0.50
L-Lysine HCl	--	0.02	0.02	0.02

DL-Methionine	0.09	0.09	0.08	0.09
MM[1]	0.25	0.25	0.25	0.25
VM[1]	0.01	0.01	0.01	0.01
VM[2]	0.03	0.03	0.03	0.03

Each replicate had 8 laying Japanese quails. Chemical composition of different diets is presented in Table 121.

Table 121: Chemical composition of different diets

Parameters	RK	RK_0	RK_5	RK_{10}	RK_{15}
OM	90.00	89.75	90.26	90.16	90.77
CP	8.30	23.35	22.90	22.97	22.83
EE	1.20	2.15	2.65	2.99	3.11
CF	0.96	5.11	5.08	5.04	5.00
Ca	0.12	3.08	2.96	3.00	3.00
P	0.74	0.74	0.76	0.76	0.77
Lysine*	0.74	0.74	0.74	0.74	0.74
Methionine*	0.34	0.34	0.34	0.33	0.34
ME* Mcal/Kg	2.60	2.60	2.60	2.59	2.59

*RK-Rice kani ; [1]MM: Ca, 328 mg; Copper, 0.8 mg; Iodine, 0.4 mg; Fe, 3 mg: Mn, 11 mg; Zn, 6 mg/g; [1]VM: Vitamin A acetate, 82,500 IU; Vitamin B2, 50 mg; Vitamin D3, 16500 ICU; Vitamin K3, 50 mg/g [2] VM: Vitamin B1, 4 mg; Vitamin B6, 8 mg; Vitamin B12, 40 µg; Vitamin E, 40 mg; Ca-pantothenate, 40 mg; Niacin, 60 mg/g *, calculated values*

Data were collected on egg production, egg weight, feed intake and feed efficiency (feed consumed per dozen egg produced). Egg production was significantly higher ($P<0.05$) with significantly ($P<0.05$) better feed efficiency and better economics of production in groups fed diet RK_5 (Table 122). It is concluded that broken rice could substitute maize at 5% level in the diet of laying Japanese quails for better egg production and economics of production taking in to consideration the feed conversion ratio and feed cost.

Table 122: Effect of replacing maize with RK on performance of Japanese quail layers

Treatments	RK_0	RK_5	RK_{10}	RK_{15}	SEM
Egg production (Dozen)	6.93^b	9.35^a	6.75^b	6.47^b	0.178
Egg weight (g)	12.49^{ab}	12.97^a	11.83^c	12.04^{bc}	0.174
Feed intake (Kg)	2.69^{ab}	2.72^a	2.56^{bc}	2.43^c	0.037
FCR	0.387^a	0.291^b	0.380a	0.366^a	0.010

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

Effect of replacing a part of maize with cashew apple waste on performance of Japanese quail chicks *(Swain et al., 2003-04b)*

A study was conducted in ninety number of day old Japanese quails distributed in to 3 treatment groups with each treatment having 3 replications and each replicate having 10 chicks on an equal average BW basis. The experiment was conducted for a period of 6 weeks. During the entire experimental period feed and water were provided ad libitum. The design of experiment was CRD. The control diet contained maize and 5 and 10% maize were replaced by CAW to formulate 2 experimental diets T_1 and T_2 (Table 123).

Table 123: Composition of experimental diets (%)

Ingredients	Control	T_1 (5 % Replacement)	T_2 (10 % Replacement)
Maize	50.00	47.50	45.00
GN cake	36.00	36.00	36.00
Fish meal	10.00	10.00	10.00
WB	1.31	1.31	1.31
CAW	--	2.50	5.00
DCP	1.40	1.40	1.40
CS	0.40	0.40	0.40

Lysometh	0.35	0.35	0.35
Min. Mix	0.5	0.5	0.5
Navmix	0.01	0.01	0.01
B-complex	0.03	0.03	0.03

T_1: 5 % replacement; T_2: 10 % replacement

Data on weekly BW gain and feed intake was recorded and feed efficiency was calculated. Results indicated that replacing maize partially with CAW at a level of 5 and 10 % had no influence on BW gain, feed consumption and feed efficiency at 6 weeks of age (Table 124).

Table 124: Effect of feeding CAW replacing part of maize on performance of Japanese quail chicks

Treatments	Body weight gain	Feed Consum-ption	Feed Efficiency
T_1	177.3	949.7	5.296
T_2	186.4	938.6	5.148
T_3	188.3	933.6	4.958

However, numerically higher weight and better feed efficiency were recorded in chicks fed diet containing 5 and 10 % maize replaced by CAW. It was concluded that CAW can replace 10 % of maize in the diet of Japanese quail chicks up to 6 week of age without any adverse effect on their performance.

Effect of feeding cashew apple waste on the performance of Japanese quail in F_1 generation *(Swain et al., 2003-04c)*

A study was conducted to evaluate the effect of dietary inclusion of CAW on the performance of Japanese quail layers in F1 generation. The CAW was replaced with maize at 5 and 10% level substituting maize to formulate 2 experimental diets (Table 125).

Table 125: Composition of experimental diets

Ingredients	T_0	T_1	T_2
Maize powder	50.00	47.50	45.00
DOGNC	40.00	40.00	40.00
WB	0.84	0.84	0.84
CAW	--	2.50	5.00
DCP	1.70	1.70	1.70
LSP	6.30	6.30	6.30
MM	0.25	0.25	0.25
CS	0.50	0.50	0.50
L-lysine Hcl	0.30	0.30	0.30
DL-Methionine	0.07	0.07	0.07
B-Complex	0.03	0.03	0.03
Indomix	0.01	0.01	0.01

T_0: Control; T_1: 5 % replacement; T_2: 10 % replacement

Diet without CAW was served as control diet. There were 3 treatments and each treatment was further replicated thrice with 6 adult quails in each replicate at a Male: Female ratio of 2:4. The experiment was carried out for a period of 20 weeks. Data were recorded on weekly BW and feed intake and daily egg weight. The feed efficiency was calculated as a ratio of feed intake and dozens of egg produced. Results revealed that replacement of maize by CAW at both the levels (5 and 10 %) had no effect on BW and feed intake (Table126).

Table 126: Effect of replacing maize by CAW on performance of Japanese quails

Treat-ments	BW	Feed intake (Kg)	Egg prodn (Doz.)	Egg wt.(g)	Feed effici-ency
T_1	232.60	4.11	8.727	12.250	0.471
T_2	239.61	4.14	8.683*	12.733*	0.477
T_3	235.69	4.34	7.717*	12.890*	0.563
$CD_{0.05}$		0.846		0.388	0.034

T_0: Control; T_1: 5 % replacement; T_2: 10 % replacement

The feed efficiency remained uninfluenced at a level of 5 % maize replaced by CAW. However, significantly poor egg production and feed

efficiency were recorded in chicks fed diet having 10 % maize replaced with CAW. The egg weight was significantly higher (P<0.05) at both the level of replacement indicating beneficial effect of replacement with CAW. It was concluded that replacement of 5 % maize by CAW could be beneficial in terms of overall performance of quail layer chicks.

Effect of feeding cashew apple waste and cashew nut shell on performance of Japanese quail layers *(Swain and Barbuddhe, 2007)*

Two feeding trails were conducted to evaluate CAW and CNS as replacement of maize in the diet of Japanese quail laying hens. In the 1st experiment three experimental diets were prepared by replacing 0, 5 and 10% maize of the control diet with CAW (Table 127).

Table127: Physical composition (%) of experimental diets (Experiment 1)

Ingredients	D_1	D_2	D_3
Yellow maize	50.00	47.50	45.00
GNC	40.00	40.00	40.00
WB	0.84	0.84	0.84
CAW	--	2.50	5.00
DCP	1.70	1.70	1.70
LSP	6.30	6.30	6.30
CS	0.50	0.50	0.50
L-lysine Hcl	0.07	0.07	0.07
DL-Methionine	0.05	0.05	0.05
MM	0.25	0.25	0.25
VM	0.04	0.04	0.04

There were three treatments having 4 replicates per treatment and each replicate had 6 laying quail. The experiment was conducted for a period of 4 months. In the 2nd experiment, three experimental diets (Table 128) were prepared by replacing 0, 5 and 10% maize of the control diet with CNS.

Table128: Physical composition (%) of experimental diet (Experiment 2)

Ingredients	D_1	D_2	D_3
Yellow maize	50.00	47.50	45.00
GNC	40.00	40.00	40.00
WB	0.84	0.84	0.84
CNS	--	2.50	5.00
DCP	1.70	1.70	1.70
LSP	6.30	6.30	6.30
CS	0.50	0.50	0.50
L-lysine Hcl	0.30	0.30	0.30
DL-Methionine	0.05	0.05	0.05
MM	0.25	0.25	0.25
VM	0.04	0.04	0.04

There were three treatments having 4 replications per treatment and each replicate had 6 laying quails. The experiment was conducted for a period of 2 months. The proximate composition of CAW was comparable to that of maize except the CF value which was higher for CAW (Table 129).

***Table 129:* Chemical Composition (on % DM basis)**

Attributes	CNS	D_1	D_2	D_3
CP %	11.5	22.30	22.6	22.8
EE %	3.7	3.45	3.06	3.97
CF %	8.5	4.73	4.87	5.02
TA %	3.5	8.67	8.82	8.97
AIA %	1.3	1.07	1.22	1.30
Ca %	0.12	2.98	3.01	3.08
TP %	0.38	0.72	0.73	0.74
Calculated ME (Kcal/kg)	2300	2700	2675	2650
Cost of feed (Rs/Kg)	2	9.98	9.85	9.73

The CNS was poor in CP. However the values for EE, CF and total ash were higher than that of maize (Table 130).

Table 130: **Chemical Composition (on % DM basis)**

Attributes	CNS	D_1	D_2	D_3
CP %	5.02	22.0	21.85	21.60
EE %	11.70	4.34	4.65	4.80
CF %	27.3	5.85	6.56	7.30
TA %	13.9	9.20	10.10	9.50
AIA %	1.8	1.70	1.40	1.50
Ca %	0.22	2.98	3.11	3.18
TP %	0.31	0.70	0.72	0.73
Calculated ME (Kcal/kg)	2500	2700	2680	2660
Cost of feed (Rs/Kg)	1.0	9.78	9.63	9.48

Results indicated that CAW and CNS could replace 10 and 5% maize, respectively in the diet of Japanese quail layers without any adverse effect on their production with better economics of egg production (Table 131 and 132).

Table 131: Production performance of Japanese quail as influenced by different levels of CAW

Parameters	T_1	T_2	T_3
Egg production^{NS} (Dozen)	7.07	6.56	6.65
Egg weight ^{NS} (g)	12.643	12.270	13.017
Feed intake ^{NS} (Kg)	5.28	5.25	5.10
Feed efficiency ^{NS}	0.751	0.767	0.794
Feed cost/dozen egg (Rs)	7.50	7.82	7.46

NS-Non-significant; T1 (Control); T2 (5 % maize replaced with CAW); T3 (10 % replaced with CAW)

Table 132: Production performance of Japanese quail as influenced by different levels of CNS

Parameters	T_1	T_2	T_3	SEM
Egg production (Dozen)	2.423^a	2.187^{ab}	1.793^b	0.413
Egg weight (g)	12.233	11.710	12.407	--
Feed intake ^{NS} (Kg)	2.107	2.097	2.067	--
Feed efficiency	0.879^b	0.949^b	1.155^a	0.195
Cost of feed per dozen egg (Rs)	8.30^b	8.96^b	11.13^a	1.539

Means possessing different superscripts column wise differ significantly (P≤0.05)

Utilization of cashew apple waste with or without *Pleurotus florida* in diet of Japanese quail *(Swain et al., 2003-04d)*

An experiment was carried out for 12 weeks to study the effect replacing maize by cashew apple waste (CAW) with or without Pleurotus florida. There were 3 treatments *i.e.* Control without cashew apple waste (CAW), 10% maize replaced with CAW and 10% maize replaced with treated CAW. The composition of experimental diets is given in Table 133.

Table 133: Composition of Experimental diets

Ingredients	T_0	T_1	T_2
Maize	52.00	46.80	46.80
DGNC	26.00	26.00	26.00
Fish meal	10.00	10.00	10.00
WB	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
CS	0.40	0.40	0.40
VM	0.03	0.03	0.03

T_0: Control; T_1: 10 % replacement by CAW; T_2: 10 % replacement by TCAW

Cashew apple waste was treated with *Pleurotus florida*. Each treatment had replication and each replicate had 8 laying Japanese quail with F: M ratio=5:3. Standard feeding and management practices 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 134).

Table 133: Effect of replacing maize by CAW on performance of Japanese quails

Para-meters	T_1	T_2	T_3	CD* 0.05	CD** 0.01
Body weight	232.58	236.67	243.00	0.170	
Feed intake	3.12	2.85*	2.94	0.573	0.867

Egg production (Kg)	5.71	3.87**	4.56*	0.412	
Egg weight. (Doz.)	12.60	12.58*	13.19*	0.051	0.077
Feed efficiency (g)	0.548	0.740**	0.645**		

T_1: Control; T_2: 10 % replacement with CAW; T_3: 10 % replacement with TCAW

There was no beneficial effect of treatment of CAW with Pleurotus florida. However, numerical increase in egg production was recorded when treated CAW replaced 10 % maize in the diet of quail layers. The feed efficiency became poor due to replacement of maize by CAW either treated or untreated. The egg weight was significantly improved in birds fed either of the diet with treated or untreated CAW. Feeding of treated CAW with Pleurotus florida had no effect on production performance of Japanese quails.

Salient Research Findings/ Interpretation

Feeds and Fodder Research

- Subabul as a pure crop was more productive and intercrop combination with Napier grass, cowpea and tapioca did not improve fodder yield.
- In a cashew field, approximately 57% of total area can be utilized for fodder cultivation with intercrop approach.
- Tree leaves like Gulmohar, Bamboo, *Alibizzia lebek*, Holmskioldia, Rungia and banana contain more than 12% crude protein and can be used as livestock fodder.
- Mushroom cultivation on paddy straw decreased fiber (crude fiber and neutral detergent fiber) content but also simultaneously decreased palatability.
- The crude protein content of paddy straw could be increased from 4.0% to 5.5% by mushroom cultivation. However, crude protein content of spent mushroom straw could be further increased to 7.80% by yeast treatment, which could be increased again to 10.5% by 5% molasses treatment.
- The crude protein content and dry matter digestibility of dry karad grass could be increased by urea ammoniation from 3.5% to 5.7% and from 48.65% to 59.41%, respectively.
- The crude protein content of dry karad grass could be increased from 3.5% to 8.5% by adding molasses and mushroom inoculation.
- The crude protein content of agro-industrial byproducts *viz.* cashew apple waste and pine apple waste could be increased by Baker's yeast (*Sacchromyces spp.*) treatment from 8.75% and 6.10% to 11.82% and 9.62%, respectively.
- Among three species (*Ganoderma lucidum, Trichoderma viridi* and *Coprenus fimatarius*), *T. viridi* was well established in cashew apple waste. Due to treatment of cashew apple waste by *Trichoderma spp* and yeast, crude protein% could be increased from 8.75 to 12.25 and 15.75, respectively.

Dairy Nutrition Research

- During feeding dairy cows yielding around five kg milk daily, one kg standard concentrate mixture can be replaced by ten kg good quality fresh green fodder without affecting daily milk yield, provided that bulk of animal should be fulfilled by *ad lib*. roughage like jowar straw (*Kadaba kutti*).
- There was adverse effect on total dry matter intake and digestibility in male calves with a ration replacing rice bran by 30% cashew apple waste.

Goat Nutrition Research

1. Goats achieved higher growth performance under free range grazing system with supplementary feeding than intensive stall feeding.

Pig Nutrition Research

- In Goa condition, growth rate and feed conversion efficiency of Large White Yorkshire x Local (50% cross) piglets are better than pure Large White Yorkshire and pure Local piglets.

- Feeding of high energy diet (2970 kcal/ kg DE) had no beneficial effect in terms of daily body weight gain in crossbred pigs in compare to control diet (2600 kcal/kg).
- Tapioca can be incorporated up to 50% level in diets of pigs to economize ration.
- Cashew apple waste can be incorporated at 30% level in diets of growing pigs without any adverse effect.
- Pine apple waste can be incorporated in pig feed at 30% level to reduce feed cost.
- Feeding piglets grower ration with autoclaved poultry hatchery waste (300g daily) had beneficial effect in terms of body weight gain.

Rabbit Nutrition Research

- Dry matter intake as well as energy intake was higher in local rabbits than exotic animals.
- Average daily gain in Soviet Chinchilla was higher than New Zealand White.
- Among different types of rabbits, feed intake and feed efficiency of crossbred and exotic rabbits were almost similar but less than local rabbits.
- Feeding high energy diets (3210-3340 kcal/ kg) had no beneficial effect on rabbits in terms of body weight gain.
- At higher dietary crude protein level (21.5%), there was higher feed efficiency in rabbits in comparison to 16.50, 17.50 and 18.50, per cent dietary crude protein.
- Incidence of agalactia in exotic and crossbred rabbits could be reduced by increasing crude protein content of concentrate feed to 18%.
- Incidence of agalactia in rabbits could be reduced and average daily gain could be increased by increasing crude protein content of concentrate feed to 22%.
- Dietary supplementation of minerals (Ostocalcium) @ 5 ml/liter water to rabbits had positive effect on average daily body weight gain.
- Incorporation of anti-stress tablets (1 tablet/ kg feed) in diet of rabbits marginally increased daily body weight gain.
- Feeding of soybean flour waste, an industrial byproduct to rabbits had no beneficial effect on average daily body weight gain.
- Wheat can be replaced by maize grit in diet of Soviet Chinchilla rabbits without affecting growth rate.
- Enriched (fermented with 5% molasses and 2% Baker's yeast) could be incorporated in rabbit feed at 25% level without adversely affecting feed intake and digestibility.
- Incorporation of brewery dry grain at 25% level as a replacement of wheat bran had no adverse effect on growth performance of rabbits.
- Cashew apple waste can be incorporated at 30% level as a substitute for wheat bran in diet of rabbits without any adverse effect on performance.
- At 25% level of incorporation, fermented cashew apple waste was more digestible than non-fermented cashew apple waste in rabbits.
- There was no adverse effect on digestibility of feeds, when brewers' dry grain or cashew apple waste was incorporated at 25% level in diet of rabbit concentrate feed.
- Incorporation of karad hay treated with *Pleurotus florida* in rabbit feed at level of 20% had no beneficial effect.
- Incorporation of yeast enriched straw in rabbit feed at 20% level had no beneficial effect in terms of digestibility and daily body weight gain.

- Incorporation of fermented coir dust in rabbit feed at 25% level had no beneficial effect.

Poultry Nutrition Research

- Combination of GNC+SFC replacing 20 % of SBM protein gave better performance, immunity and economics of production in growing chicks.
- Combination of soybean meal and groundnut cake (SBM+GNC) was superior to other combinations i.e. (GNC+SFC) or (SBM + SFC) and individual protein sources (SBM, GNC or SFC) in diet of Vanaraja chicks with improvement in body weight gains and feed efficiency.
- Layers fed combination of GNC and SFC performed better in terms of egg production and egg weight compared to those given soybean cake as a sole protein source.
- Supplementation of additional vitamin E and Se (100 IU/Kg, 1.0 ppm) is not necessary for optimum growth but it has beneficial effect on immune response.
- 1 % Ca from LSP can be added to commercial poultry feed for better egg production with moderate size, early sexual maturity and better efficiency of feed utilization.
- Supplementation of Problend @ 400 mg/Kg diet is beneficial in terms of improved body weight gain, feed conversion ratio, nutrient utilization and economics of production in Vanaraja growing chicks
- Dietary inclusion of Maxigro at a rate of 1.5 g/ Kg feed improved production performance and net profit in laying hens fed sunflower based diet by partial replacement of soybean meal.
- Addition of Bioved (probiotics+vitamins) @ 1.5 g/L of drinking water is beneficial in better utilization of feed nutrients leading to significant improvement in growth and feed conversion ratio in Gramapriya chicks.
- Dietary inclusion of probiotics and yeast @ 1.5-2.0 g/Kg diet in Vanaraja laying hens is beneficial in terms of better egg size, shape index, shell thickness, shell per cent, albumen percent and more net profit.
- Supplementation of probiotic and yeast @ 1g/Kg diet improved the body weight gain, feed efficiency, carcass yields, organ weights, leanness of meat and net profit in broiler chickens.
- Rice kani can replace 30 % of maize in the diet of growing Vanaraja chicks for better economics of production in coastal climate.
- Sunflower cake can 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.
- Brewers' dried grain can be incorporated in diet of RIR chicks up to a level of 20% without any adverse effect on their productive performance.
- Cashew apple waste can replace 20 per cent maize in diet of commercial broilers without any adverse effect on performance and carcass traits.
- Fish meal can be incorporated up to a level of 5% in diet of Vanaraja growing chick by replacing SBM (on protein basis) without any adverse effect on growth performance.
- Ungrounded bajra and ragi can replace maize completely in diet of laying hens without affecting egg production, egg weight, feed efficiency and other quality parameters in addition to production of stronger shell.
- Inclusion of processed poultry hatchery waste at 8% by replacing fish meal in diet of Vanaraja chicks is beneficial in terms of improved growth, feed efficiency and profit margin.

- Palm oil can be used in diet of laying hens up to a level of 10 % replacing maize in diet of Gramapriya laying hens without affecting performance except increase in egg cholesterol content.
- Maize can be replaced with rice kani up to a level of 20 % in the diet of Japanese quail chicks without any adverse effect on their performance.
- Cashew apple waste and cashew nut shell can replace 10 and 5% maize, respectively in diet of Japanese quail layers without any adverse effect on their production with better economics of egg production.
- Broken rice can substitute maize at 5 % level in diet of laying Japanese quails for better egg production and economics of production taking in to consideration feed conversion ratio and feed cost.
- Cashew apple waste can replace 10% of maize in diet of Japanese quail chicks up to 6 week of age without any adverse effect on their performance.
- Replacement of 5% maize by CAW is beneficial in terms of overall performance of quail layer chicks.

Thrust Areas for Future Research

Livestock Nutrition

- Evaluation of locally avialble un-conventional feed ingrtedients as alternate feed resources
- Introduction of intercropping and hydroponic technology for fodder production, evaluation of new fodder varieties and conservation of surplus fodder
- Enrichment of crop residues
- Development of feeding strategies (bypass protein and bypass fat feeding technology) for high yielding dairy animals
- Use of feed additive and feed supplements to improve productive performance of livestock.

Poultry Nutrition

- Use of probiotics, probiotics, synbiotics, functional food and neutraceuticals for enhancing better nutrient utilization
- Utilization of unconventional feed resources as alternative feed ingredients.
- Exploitation of locally available agricultural and industrial by-products to reduce feed cost.
- Rearing of alternate poultry species like Japanese quails and ducks to meet growing demand for meat and egg.
- Value addition of poultry products for better keeping quality and higher market value

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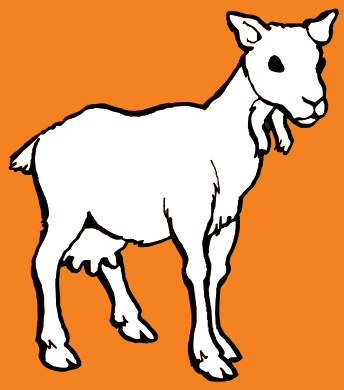

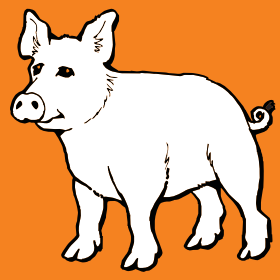

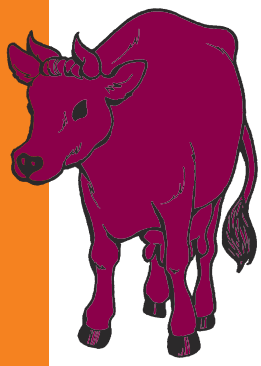

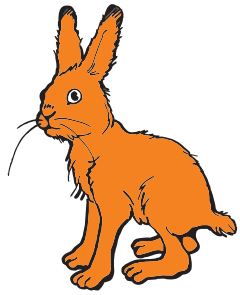

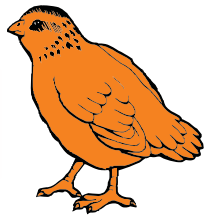

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