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INTRODUCTION

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

The chemical composition of agro-industrial by-products i.e. brewery waste, cashew apple waste, cashew nut shell and rice kani (broken rice) along with their feeding value in broilers, backyard poultry and Japanese quails are described here in brief for the use by poultry farmers to economise their cost of production.

Brewery waste

Brewer's spent grain is valuable as a potential supplementary feed for livestock. It is a safe feed when it is used fresh or

properly stored. These materials are considered to be good sources of un-degradable protein, energy and water-soluble vitamins. They have been used in feeding both ruminant and monogastric animals (monogastrics using predominantly the dried forms). Brewer's grain is the material that is remaining after grains have been fermented during the beer making process. These materials can be fed as wet brewer's grains or dried brewer's grains. Brewers dried grain (BDG) is a by-product of barley malt, corn or rice that is treated to remove most of the readily soluble carbohydrates, protein, fibre, linoleic acid, vitamins and minerals. Some breweries dry the brewer's grain and sell it as dried brewer's grain, while others have it available as wet brewer's grain. Both types have similar feeding characteristics if the wet brewer's grain is fed shortly after it is produced. Fermented local and industrial by-products of brewing have been used as non-conventional feedstuffs in broiler rations mainly as protein and energy supplements. Brewery wastes are available in plenty from the local breweries which can be a potential feed ingredient to economise the poultry production. In Goa, the annual availability of brewers grain is about 1200 metric tons. Brewery by-products like brewery waste grains and yeast's are worthy of consideration as potential non-conventional feeds to promote use of locally available feed ingredients. Since the brewery dried grain in rich in fibre, addition of fibre degrading enzyme may be useful in improving its feed value.

Brewery waste

Chemical Composition

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

constituents of brewery dried grain is given here in tabular form.

Chemical Constituents	% Composition
Dry matter	90.10-93.00
Crude protein	15.50-30.89
Ether extract	7.00-11.05
Crude fibre	9.55-20.00
Total ash	3.09-11.04
Acid insoluble ash	1.37-1.96
Calcium	0.28-0.60
Phosphorous, Total	0.43-1.00

Feeding value

High fibre content in brewery waste limits its inclusion in poultry rations at higher level. Higher level of brewery waste in the diet reduces the performance of chickens due its high fibre content. Poultry being monogastric animal do not produce enzymes like cellulase, hemicellulase and ß-glucanase which are required for digestion of fibre components in feed. Therefore, dietary addition of fibre degrading enzymes has got practical importance in improving the feed value of low energy and high fibre feedstuffs. Addition of commercial enzyme mixtures containing cellulase, amylase, lipase, protease and pectinase at the rate of 1.5 g/ Kg feed to a diet containing corn, soybean meal, wheat bran, rice bran and sunflower cake improved the feed value in terms of increased weight gain and feed efficiency in chicks compared to control diet without added enzyme. Supplementation of cellulase (0.008 %) to corn-soybean diet containing 20 % wheat bran improved the feed efficiency of broilers. Brewery waste protein can replace 20 % soya protein in the diet of chickens without causing significant differences in the growth and feed intake. The data pertaining to previous studies indicated that brewery waste could be used as a complementary

Use of brewery dried grain for feeding of broilers

protein source in broiler chicken diets. Studies on the evaluation of BDG in commercial broilers are limited. Brewery waste should be collected from the local breweries and properly sun dried to reduce the moisture content up to a level of 8-10 %. Because of the high fibre content its use in poultry ration is limited. However, with enzyme feed supplementation it can be used at a certain level. BDG with Kemzyme-HF @ 0.75 g/Kg diet can be incorporated in broiler ration at a level of 5 % for economic production. The practical diet for broilers with inclusion of brewery dried grain is given in Table 1.

Cashew apple waste

The cashew is native to northeast Brazil. In the 16th Century Portuguese traders introduced it to Mozambique and coastal India, but only as a soil retainer to stop erosion on the coasts. In India, vast tonnages of cashew apples have largely gone to waste while it pioneered in the utilization and promotion of the nut. Cashew apple (*Anacardium occidentale*) is a promising feed source, which could be used for dairy cows and monogastric animals to some extent. In 1995, the whole country had 200,000 ha of cashew trees. From this area, about 500,000 tons of cashew apple was produced per year. There is commercial interest in processing the fresh apple as a source of sugar-rich juice for human consumption. The waste product from processing, after drying, has been fed to pigs and poultry with promising results. Cashew apple waste (CAW) is available in plenty in the coastal states with an annual production of about 3,82,000 metric tons out of which Goa's share is about 80,000 metric tonnes. The annual availability of dried cashew apple waste in Goa is about 8000 metric tones.

Table1. Practical diet for broiler chicks with inclusion of brewery dried grain.

Ingredients	Diet (%)
Yellow ground maize	55.00
Groundnut cake	20.00
Fish meal	10.00
Wheat bran	7.087
Brewery dried grain (BDG)	5.00
Dicalcium Phosphate	1.013
Common salt	0.40
L-Lysine HCl	0.36
DL-Methionine	0.14
Vitamin Mixture	0.04
Mineral Mixture	0.11

The average weight of fresh apple is about 74.33 grams having dry matter content of 10.22 per cent. CAW is obtained after extraction of fenny which can be used as a cheaper source feed ingredient for poultry by partially replacing costly energy source like maize. The waste is usually sun dried and ground before incorporation in the feed. Similarly cashew nut shell is the outer covering of cashew nuts which is not usually used for human consumption but can be used as a cheaper source feed ingredient for poultry.

Fresh cashew apple harvested for juice extraction

Cashew apple waste after extraction of juice

Chemical Composition

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

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

Feeding value

Cashew apple waste can be used in layer chick ration by replacing up to 25 % maize in their diet without any adverse effect on growth, digestibility of dry matter and retention of protein and fat. However, Cashew apple waste can replace 10 % of commercial layer diet by weight basis without any adverse effect on the egg production and egg weight with reduction on the feed cost. Economic analysis revealed that inclusion of CAW at a level of 10 % replacing maize reduced the feed cost by Rs1.43/- for production of 1 Kg body weight gain of Vanaraja dual purpose bird. Cashew apple waste can also be incorporated in the diet of Japanese quail chicks up to 5 % level by replacing the maize of the diet in order to reduce the feed cost (Table 2).

Table 2. Practical diets for Vanaraja growing chickens and Japanese quail chicks using cashew apple waste.

Feed ingredients	Composition %	
	Vanaraja growing chickens	Japanese quails
Yellow ground maize	40.00	45.00
Groundnut cake	22.00	36.00
Fish meal	10.00	10.00
Wheat bran	15.74	1.35
CAW	10.00	5.00
DCP	1.00	1.40
Lysine HCl	0.16	0.35
DL-Methionine	0.20	-
Common salt	0.40	0.40
Vitamin and Mineral mixture	0.50	0.50

Further, cashew apple waste can replace 10 % maize in the diet of Japanese quail layers to economise the feed cost without any adverse effect on the egg production and egg quality. Similarly, cashew nut shell can replace 5 % of maize in the diet of Japanese quail layers in order to reduce the feed cost without affecting the egg production and feed efficiency. The practical diets with inclusion of CAW and CNS are given in Table 3.

Table 3. Practical diets for Japanese quail layers with inclusion of cashew apple waste and cashew nut shell.

Ingredients	Diet 1 Cashew apple waste (%)	Diet 2 Cashew nut shell (%)
Yellow ground maize	45.00	47.50
Ground nut cake	40.00	40.00
Wheat bran	0.84	0.86
Cashew apple waste	5.00	-
Cashew nut shell	-	2.50
DCP	1.70	1.70
Limestone powder	6.30	6.30
Common salt	0.50	0.50
L-lysine HCl	0.30	0.30
DL-Methionine	0.07	0.05
Vitamin mixture	0.04	0.04
Mineral mixture	0.25	0.25

Use of cashew apple waste for feeding of broilers

Use of cashew apple waste and cashew nut shell for feeding of backyard dual poultry Vanaraja

Rice kani

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

Rice kani

Chemical Composition

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

Chemical constituents	% Composition
Dry matter	87.90-95.50
Crude protein	7.19-8.70
Ether extract	1.4-1.5
Crude fibre	0.7-1.2
Total ash	0.3-3.30

Feeding value

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

Rice kani can be used at a level of 15 % in the diet of Vanaraja growing chickens in order to reduce the feed cost and economise the cost of production. In Japanese quails chicks, rice kani can replace maize up to a level of 20 % in the diet without any adverse effect on their performance with appreciable reduction in the feed cost. Similary, rice kani can be used at a level of 7.2 % by replacing 15 % maize in the diet of Japanese quail layers to economise the feed cost without any adverse effect on egg production and efficiency of feed utilization. Practical diets for Vanaraja growing chicks and Japanese quails with inclusion of rice kani are given below in Table 4.

Table 4. Practical diets for Vanaraja growing chicks and Japanese quail layers with inclusion of rice kani.

Ingredients	Diet 1 Vanaraja Chickens	Diet2 Quail Chicks	Diet3 Quail layers
Maize powder	35.00	40.00	40.80
Ground nut cake	23.00	32.00	36.00
Fish meal	10.00	10.00	-
Wheat bran	15.00	4.06	6.67
Rice kani	15.00	10.00	7.20
DCP	1.00	0.90	1.78
Limestone	-	-	6.66
L-Lysine HCl	0.14	0.03	0.01
DL-Methionine	0.01	0.01	0.09
Common salt	0.40	0.40	0.50
Mineral mixture	0.25	0.25	0.25
Vitamin mixture	0.04	0.04	0.04

Feeding of rice kani in Japanese quails

Feeding of rice kani in farmer's backyard

Perspective

The agro-industrial by-products like brewery waste, cashew apple waste, cashew nut shell and rice kani (broken rice) are available in plenty locally. Presently these by-products are not exploited to full extent for inclusion in the poultry feed. Keeping their chemical composition and potential feeding value in consideration, these by-products can be incorporated to some level in the poultry feed formulations to economise the feed cost and to increase the profit margin for the poultry farmers.