



***Colocasia esculenta* (L.) Schott as an Alternative Energy Source in Animal Nutrition**

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Authors' contributions

All authors contributed to the work.

Review Article

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ABSTRACT

Aims: This review was undertaken to examine the potential use of taro (*Colocasia esculenta*) and its by-products as an alternative energy source for feeding animals.

Previous Study: Previous studies indicated that raw sundried taro meal contained about 87.90-90.57 percent dry matter, about 4.93-7.07 crude protein, 2.70-3.90 percent crude fibre, 2956 – 2966 (Kcal/kg) metabolisable energy. Taro is not a common food for man, and its use in animal nutrition is however limited by the presence of anti-nutritional factors such as oxalates, saponin, phytate, and tannins.

Conclusion: Taro (*Colocasia esculenta*) is a less well known source of energy which is not in great demand for human food. The use of taro (*Colocasia esculenta*) in animal nutrition should be maximally exploited as a way of reducing the competition between man and animals for maize utilization, since the quantity of grains produced in tropical Africa is not sufficient to feed the increasing human population. Heat treatment and protein supplementation are however recommended for optimal use of *Colocasia esculenta* in animal nutrition.

Keywords: Alternative; animal; energy; nutrition; taro.

1. INTRODUCTION

The two most important nutrients required in animal nutrition are energy and protein. In Nigeria, energy and protein constitute about three-quarters of the total cost of formulated

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feed [1]. Cost of feeding in livestock production in Nigeria is rather too exorbitant [2,3]. High cost of feeding livestock is attributed to low production of grains as well as increase in human population. Low production of grains has resulted in competition between human and animals for feed ingredients. This, if continued unchecked will pose a threat to global food security. Food security is defined to exist as situation when all the people at all times have physical, social, and economic access to sufficient, safe and nutritious food which meets their dietary needs [4]. Some of the factors stressing food security are poverty, climate change, animal pests and diseases [5,6]. Poverty is the cause and consequence of food insecurity [7]. Maize which is a food security crop is in high demand by human and animals. Maize is the major cereal that is involved in animal nutrition, representing the main energy source and constituting about 60 percent of the diet of monogastric animals [8].

Many livestock farmers in Nigeria feed agro industrial by-products to their animals due to high cost of conventional feed ingredients [9]. Agro industrial by-products are however of low nutritive value, and non-conventional feed stuffs such as taro can be fed in place of agro-industrial by-products which are of low nutritive value. Two types of crops that share the name cocoyam are *Xanthosoma sagittifolium* and *Colocasia esculenta* [10]. Taro has been said to have the potential of being used in ruminant nutrition [3]. It has been fed to snails [11]; fish [12]; pigs [13,14]; and poultry [15,16,17].

The use of taro in animal nutrition is however limited by the presence of anti-nutritional factors such as tannins, saponins, oxalates, phytates, and hydrocyanide [15,18]. Processing techniques such as boiling or cooking, soaking, ensiling and drying have been shown to reduce the effects of these anti-nutritional factors on the animals [17,18,19]. Taro is not a too popular crop and its potential not fully utilized. The paper therefore aims to review the potential values and constraints to the increased use of taro (*Colocasia esculenta*) and its by-products in animal nutrition.

2. PRODUCTION OF TARO

Cocoyam in most African countries is mainly cultivated by small-scale farmers [20]. Taro has not received pronounced research attention to enhance its production and utilization potentials despite its nutritional composition, resulting in under utilization of the potential for the development of value added cocoyam products [21,22].

Taro is an herbaceous plant which belongs to the family Araceae. The most available members of the family are taro (*Colocasia esculenta*) and *Xanthosoma sagittifolium*. The top world producers of taro (*Colocasia esculenta*) are Nigeria, China, Cameroon, and Ghana. The world's total production of taro in 2011 was 9,532,427 tons while more than 74 percent of the total production comes from Africa [23]. Nigeria being the leading world's producer of taro produced more than 27 percent of the total world's production in 2011. Cocoyam yields vary from place to place. The major determinants of the variation are the conditions under which they are cultivated. Table 1 refers to the selected taro producers in the world.

3. NUTRITIVE VALUES OF TARO

Tables 2, 3, 4 and 5 show the nutrient composition of taro, chemical characteristics of taro leaves, mineral contents of *Colocasia esculenta* and *Xanthosoma sagittifolium* and chemical composition of differently processed taro leaves respectively. *Colocasia esculenta* is one of the six most important root and tubers crops worldwide [24]. Corms of cocoyam are known

to supply easily digestible starch, substantial amount of protein, thiamine, vitamin C, riboflavin, niacin, as well as significant amounts of dietary fiber [25]. Leaves of taro are eaten as vegetable by human, having β carotene, iron, protein, vitamins and folic acid which protects against anemia [26,27,28]. The major nutrient in taro corms is dietary energy [26, 29,30]. The most abundant minerals in *Colocasia esculenta* are potassium, phosphorus, magnesium, and calcium [30]. Nutritional composition of roots and tubers vary from place to place depending on climatic conditions, variety of crop cultivated, as well as soil conditions [26]. The result of the study carried out by [15] revealed that taro meal contained 7.87% crude protein, 31% dry matter, 4.75% crude fiber, and 3214.91 Kcal/kg metabolisable energy on dry matter basis. The result of proximate analysis carried out on *Colocasia esculenta* by [31] showed that *Colocasia esculenta* contained 89.53-90.57% dry matter, 4.93-5.17% crude protein, 0.50-0.57% ether extract, 2.70-2.97% crude fiber, 78.7-79.0% carbohydrate and 2.47-2.87% ash content on dry matter basis. *Colocasia esculenta* in its raw form is toxic. The toxin is however destroyed by processing techniques such as cooking, soaking, ensiling and drying [18,19,31]. Cooking has however been shown to reduce the protein content of cocoyam [18,19]. [31] noted that the physico-chemical properties of sun-dried sample of *colocasia esculenta* were more acceptable than oven-dried and cabinet-dried samples, having greater values in most physico-chemical properties considered. It was said that sun-dried sample retained the best starch structure.

4. ANTI-NUTRITIONAL FACTORS IN TARO

Colocasia esculenta is a cheaper carbohydrate source than grains [19,32]. It has low production cost, high caloric yield per hectare and are not easily susceptible to pests and disease attack. Its major limitations in its use in animal nutrition are storage and the presence of anti-nutritional factors such as tannins, saponins, phytates, oxalates it contains. Residual anti-nutritional factors in differently processed taro are shown in table 6. Some anti-nutritional factors serve as defense mechanisms against pests and diseases. For example, oxalates have been observed to play defense role in plant as well as storage reserve for calcium [33].

A toxicant is a substance which under practical circumstances can impair some aspect of animal metabolism and produce adverse biological or economic effects in animal product [34]. Anti-nutritional factors are however described as substances in the diets which by themselves or their metabolic products arising in the system interfere with the feed utilization, thereby reducing production or affect the health of the animals. Toxicants can be classified based on their chemical properties of effect of their utilization on nutrients as alkaloids, glycosides (such as saponins, cyanogens), phenols (gossypol, tannins), mycotoxins, metal binding (oxalates) and proteins (protease inhibitors and haemoglutinins).

4.1 Saponins

Saponins are known with distinctive foaming characteristics. They are bitter and are known to reduce feed palatability. Saponins have been reported to cause bloat in ruminants [34]. Bloat is a distension of the rumen resulting from the inability of the animal to get rid of gases produced in normal processes to rumen fermentation.

4.2 Tannins

Tannins are a high molecular weight polyphenolic substances. There are hydrolysable and condensed tannins. Hydrolysable tannins are easily hydrolysed in water, acids, enzymes or bases to yield gallotannins and ellagitannins [34]. Condensed tannins on the other hands are flavonoid polymers of flavonol. They are astringent in nature and bind with protein, thereby reducing protein availability to animals. They are known to inhibit cellulose digestibility as well as reduction of digestion of crude fiber. Soaking and cooking have however been reported to reduce tannin content [34]. Moderate level of tannins (usually less than 4%) in forages has been reported to improve growth and milk yield while levels exceeding 6% of the diet has been observed to reduce growth rate and milk production in ruminants.

4.3 Oxalates

[35] reported that oxalate levels were higher in petioles of taro cocoyam than in leaves. The authors reported further that sun-drying, soaking, cooking, and ensiling reduced the concentration of oxalate. The effects were however most pronounced for cooking and ensiling. Oxalates are known to precipitate calcium in the gastrointestinal tract as insoluble calcium oxalate. Diets containing oxalate have been shown to cause calcium deficiency in cattle, which consequently resulted in poor milk production and growth. Fresh leaves of taro contain about 3.08% of oxalate on dry matter basis [36]. The authors reported that the process of ensiling the taro leaves was more effective than sun-drying in reducing the content of calcium oxalate.

4.4 Phytate

Phytate has been observed to decrease the utilization of several mineral elements such as phosphorus, calcium, and magnesium, being the most abundant minerals in *colocasia esculenta* by forming insoluble compounds which are excreted in faeces. Supplementation of enzyme phytase is recommended in poultry to make phosphorus available [34].

5. USE OF *Colocasia esculenta* IN ANIMAL NUTRITION

The result of the study by [37] revealed an apparent reduced digestibility for pigs fed diets containing ensiled taro leaves as against the higher values recorded in the findings of [36]. The variation was however attributed to the differences in fibre level of the energy sources used in the studies. Studies on boiled taro cocoyam in the diets of weaned pigs carried out by [13] revealed that there was no significant difference in feed intake, weight gain and feed efficiency between the diets containing boiled taro corms. It was exactly opposite with the diets contained unboiled taro, especially at levels more than 50% replacement of maize. In another study by [14] feed intake, rate of live weight gain and feed conversion ratio were poorest in pigs fed fresh taro leaves and stem, better responses were obtained for pigs fed cooked taro leaves and stem, while the best results were obtained for those fed ensiled taro leaves and stem.

[3] observed that the energy content and proximate metabolisable energy content of *Colocasia esculenta* corms indicated that *Colocasia esculenta* is a potential useful energy supplement in ruminant feeding. The result of a study carried out by [11] showed that sun-dried taro meal can replace maize up to 50% in the diet of *Achatina achatina* without adverse effects on reproductive traits. The authors however recommended that inclusion of

taro in the diet of animals at higher levels should be processed. [12] fed one hundred and forty juveniles of *Clarias gariepinus* with diets containing graded levels of raw and differently processed cocoyam corms at 25% and 50% substitution levels for maize meal. The result showed the mean weight gain, relative growth rate and specific growth rate had the highest value recorded for the control followed by those fed diet containing 25% boiled cocoyam. The least value was however recorded for those fed diet containing 50% of fermented cocoyam. The authors reported significant lower values for all blood parameters recorded in the raw cocoyam meal diet. The result indicated that fish fed with boiled cocoyam diet gained higher weight than those fed raw cocoyam diet.

[17] reported that boiling of *Colocasia esculenta* resulted in an improvement over the raw in broiler finishers fed differently processed *Colocasia esculenta*, having no adverse effects on hematological parameters of the birds. [15] recommended that proper processing of *Colocasia esculenta* meal will effectively replace maize in the diets of broiler finishers at 25% for raw sundried taro cocoyam meal and 50% for boiled sundried taro. It has also been observed that silage made from taro leaves and petioles replaced up to 60 % of rice bran in diets for growing ducks without any decrease in performance, growth and with positive effects on carcass quality [38]. Also, boiled sun-dried taro cormels had been reported to replace up to 50 % of maize (8.4 % of the total diet) in the diets of Japanese quails [39].

However, [16] concluded that boiled peeled sundried taro meal can replace maize in the diets of broiler finishers at 100% inclusion level, without any significant adverse effects on the performance characteristics of the birds.

6. COST IMPLICATION OF USING TARO COCOYAM IN ANIMAL NUTRITION

Energy sources, especially maize are the most important and expensive feedstuffs, which account for about 50-55% of poultry diet [40]. High cost of maize has been observed to result from declining production condition and keen competition for its use by man and animals [41,42]. Hence, in seeking replacement for maize in animal nutrition, cost implication of the use of the potential non-conventional feedstuffs should be considered. The results of the previous studies revealed that taro is a cheap source of carbohydrates in animal nutrition [19,32]. [12] also concluded that there was economic decrease in price of feed with the inclusion of cocoyam meal.

Table 1. Selected taro producers

Countries	Production (tonnes)	Percentage of world's total	Percentage of Africa's production
Nigeria	2,593,860.00	27.21%	36.67%
China	1,754,100.00	18.40%	24.80%
Cameroon	1,470,000.00	15.42%	20.78%
Ghana	1,354,000.00	14.20%	19.14%
Japan	153,500.00	1.61%	2.17%
Egypt	119,379.00	1.25%	1.69%
Rwanda	185,964.00	1.95%	2.63%
Thailand	76,700.00	0.80%	1.08%
Gabon	55,000.00	0.58%	0.78%
Liberia	16,900.00	0.18%	0.24%

Source: UN FAO's FAOSTAT (2012)

Table 2. Nutrient composition of taro

Parameters	Raw oven dried	Raw sundried	Raw cabinet-dried	SWCC	CWCC	FWCC
Dry matter (%)	90.57	88.42-89.53	89.87	88.06	88.64	87.90
Crude protein (%)	5.17	4.93-7.07	5.07	6.56	6.13	7.44
Crude fiber (%)	2.97	2.70-3.90	2.83	3.75	3.55	3.45
Ether extract (%)	0.57	2.47-2.93	0.50	2.86	2.76	2.63
Ash (%)	2.87	0.50-1.10	2.77	0.95	0.75	0.88
Carbohydrate (%)	79.00	73.43-78.93	78.70	73.90	75.46	73.50
ME (Kcal/kg)	NA	2958.34	NA	2943.70	2966.82	2956.52

SWCC= soaked taro; CWCC= cooked taro; FWCC= fermented taro

Source: Olajide et al. (2011);

Ndabikunze et al. (2012)

Table 3. Chemical characteristics of taro leaves

Parameters	Ensiled taro leaves	Dried taro leaves
Dry matter (%)	18.30-22.60	92.20
As % in dry matter		
Crude protein (%)	25.90-26.30	26.70
Crude fiber (%)	17.10	15.20
Organic matter	8.30-8.53	8.70
Calcium oxalate	0.11	1.10

Source: Chhay et al. (2007);

Pheng et al. (2008)

Table 4. Mineral contents (mg/100g DM) of *Colocasia esculenta* and *Xanthosoma sagittifolium*

Mineral content	<i>Xanthosoma sagittifolium</i>	<i>Colocasia esculenta</i>
Potassium	908.25	715.39
Phosphorus	207.50	134.30
Copper	0.63	0.19
Iron	4.54	3.48
Zinc	2.72	4.32
Manganese	1.55	3.68
Calcium	110.17	68.67
Magnesium	90.62	83.76
Sodium	23.98	13.18

Source: Ndabikunze et al. (2011)

Table 5. Chemical composition of differently processed taro leaves

Processing	Dry matter (%)	Crude protein (%)	Crude fiber (%)	Ash (%)	Oxalates (mg/100g)
Fresh leaves	13.70	25.30	11.40	10.50	760.00
Drying by sunlight	88.40	25.60	11.30	13.30	600.00
Soaking	17.20	25.60	11.50	10.50	570.00
Cooked	9.60	25.60	11.30	10.40	360.00
Ensiled	17.00	25.30	11.00	10.50	350.00

Source: Hang and Preston (2010)

Table 6. Residual anti-nutritional factors in differently processed taro cocoyam

Parameters	Raw taro	Cooked taro	Soaked taro	Fermented taro
Phytate (g/100 gDM)	1.01	0.26	0.08	0.05
Oxalate (g/100 gDM)	0.53	0.28	0.21	0.14
Hydrolysable tannin (g/100 gDM)	0.13	0.05	0.04	0.04
Condensed tannin (g/100 gDM)	0.28	0.22	0.18	0.16
Saponin (g/100 gDM)	0.31	0.16	0.22	0.18
Hydrocyanide (mg/kg)	17.13	7.30	7.50	7.20

Source: Olajide et al. (2011)

7. CONCLUSION

Taro (*Colocasia esculenta*) is a less well known source of energy which is not in great demand for human food. The use of taro (*Colocasia esculenta*) in animal nutrition should be maximally exploited as a way of reducing the competition between man and animals for maize utilization, since the quantity of grains produced in tropical Africa is not sufficient to feed the increasing human population. Heat treatment and protein supplementation are however recommended for optimal use of *Colocasia esculenta* in animal nutrition.

COMPETING INTERESTS

Authors declare that there are no competing interests.

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