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In vitro nutritional evaluation of chaya (*Cnidoscolus aconitifolius*) for use as livestock feed

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ABSTRACT

Chaya (*Cnidoscolus aconitifolius*, family-Euphorbeaceae), an underutilized perennial vegetable shrub was introduced in India in 2006 to test its feasibility for use as a fodder plant. The leaves and fodder chaya contained on dry matter basis, respectively, crude protein (27.40 and 17.96%), NDF (27.76 and 30.82%), ADF (21.47 and 24.33%), lignin (5.9 and 6.6%), ether extract (9.27 and 3.61%), ash (11.88 and 9.84%) and starch (0.41 and 5.31%). The macro minerals in leaves and fodder chaya were, respectively, estimated as, viz. calcium (1.78 and 1.92%), phosphorus (0.31 and 0.28%), potassium (2.34 and 1.44%), magnesium (0.60 and 0.54%) and sodium (0.20 and 0.29%). The micro mineral contents (ppm) in leaves and fodder chaya were respectively, zinc (46.60 and 22.13), copper (5.61 and 3.74) and manganese (131.47 and 85.48). The nutrient content of chaya leaves as well as fodder chaya is superior to that of the leguminous fodder currently used to feed livestock. Initial estimates indicated a yield of fodder chaya in the range of 1000 to 2000 q/ha. It was concluded that chaya has a good nutritional profile and can be a potential source of quality feed for livestock.

Key words: Chaya, *Cnidoscolus aconitifolius*, Fodder chaya, Protein supplement, Underutilized plants

Chaya (*Cnidoscolus aconitifolius*, family Euphorbeaceae), a perennial plant native of Mesoamerica (Central America) was introduced in India at the Indian Grassland and Fodder Research Institute, Jhansi. It is also known as 'tree spinach' and is an important vegetable for the indigenous people of the Maya region of Guatemala, Belize, south-east Mexico, Yucatan peninsula and parts of Honduras (Martin and Ruberte 1978). Chaya is a fast growing perennial shrub which grows to a height of 3 m and is well adapted to diverse climatic conditions. Chaya is not only high in nutrient content but is also used as a vegetable, medicinal plant, living fence and an ornamental plant. It has been classified as an underutilized vegetable plant (Roys 1931, NAS 1975, Williams and Haq 2002, Ross-Ibarra and Molina-Cruz 2002) and its potential use was recognized long ago. But changing the dietary habits of people and getting it accepted in an alien culture is a difficult and time consuming process, especially in the regions where there are a range of vegetables already available.

Chaya is also very drought tolerant and given ideal growing conditions, it can produce copious amount of green fodder. Based upon the observations on leaf/stem ratio in the plants growing at Jhansi, an early estimate gives the production potential of green fodder from chaya between 1000 to 2000 q/ha/yr (Kumar *et al.* 2009). The livestock production in India is constrained by lack of quality feed and fodder and there exists a huge gap in demand and supply. In 2010, the deficit of green and dry fodder is expected to reach 63% (666 mMt) and 23% (138 mMt), respectively (IGFRI 2007). Therefore, researchers have been looking for non conventional feed resources. The plant grows well in the summer and this makes it most ideal to supply green fodder during the dry season.

MATERIALS AND METHODS

Chaya was introduced in India in 2006 at IGFRI, Jhansi. Stem cuttings of chaya, were imported from Florida (USA), through National Bureau of Plant Genetic Resources, New Delhi (NBPGR) and planted at Jhansi. The cuttings quickly took root and mature plants were obtained in 1 year, from which it was further multiplied and now over 1000 plants are growing at the central research farm of IGFRI.

Leaf samples and chaya fodder (succulent stem and leaves) were harvested, chopped and dried in an oven at 70°C till constant weight was achieved. The dried samples were

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ground and analyzed in triplicate for nutrient composition, viz. DM, OM, CP, ash, EE, lignin, ADF and vitamin A (AOAC 1996), neutral detergent fibre (NDF) (Mertens 2002), soluble CP (Licitra *et al.* 1996) and starch concentration (Hall 2000). NDF digestibility was done using *in vitro* technique for 0, 3, 24 and 48 h (Ankom Technology Method 3, 1997) and NDF degradation rate (kd %/h) was calculated (Van-Amburgh *et al.* 2003). P was determined as per AOAC (1996) and the other minerals (Ca, K, Mg, Na, Zn, Mn and Cu) by AOAC (1996) using commercial kit.

RESULTS AND DISCUSSION

Chemical composition

The results of the chemical analysis of chaya leaves and chaya fodder are presented in Table 1. The DM content was 16.77 and 13.43% in leaves and fodder, respectively. The leaves contained a high concentration of protein (27.4%) and in fodder chaya it was 17.96%. The CP in chaya leaf meal was reported in the range of 24.29 to 38.78% by various workers (Kuti and Torres 1996, Donkoh *et al*. 1999, Sarimento-Franco *et al.* 2003). The majority of the reports indicate CP in leaves to be about 29%. The CP of chaya fodder has not been reported earlier in the literature. However, the CP value in leaves and fodder chaya compares favourably with many fodders (at flowering stage) e.g. lucerne (alfalfa) (20.0%), berseem (17.67%), cowpea (20.24%), leucaena leaf meal (25.9%) (Ranjhan 1977). The ether extract and lignin in chaya leaves were 9.27 and 5.73%, respectively. The EE value obtained in the leaves is higher than the other reports, which gives it in the range of 3.89–8.5%. Similarly, NDF and ADF (20.55%) values obtained in the chaya leaves are also higher than the reports of earlier workers (Ranhotra *et al.* 1998, Donkoh *et al.* 1999, Sarimento-Franco *et al.* 2003). The higher NDF and ADF values observed in samples grown at Jhansi may be due to the entirely different growing conditions of Jhansi as compared to other reports. The ash content in the leaves (11.88%) was similar to the earlier reports.

There are a few studies on feeding chaya leaf meal (CLM) to poultry indicating that it could be used in the ration of poultry (Donkoh *et al.* 1999, Sarmiento-Franco *et al.* 2002). But feeding trials using ruminants have not yet been reported. The EE, lignin, NDF and ADF and ash contents in the chaya fodder were 3.61%, 4.10%, 27.85%, 21.20% and 9.84% respectively. The NDF content in chaya fodder is lower than lucerne (43.64%), berseem (49.58%) and cowpea (49.78%) (Ranjhan 1977). Similarly, lignin was also lower in chaya fodder as compared to other important fodders, which have lignin in the range of 9–11%. Soluble protein is defined as protein soluble after 1 h in borate-phosphate buffer at 39°C. It contains non-protein nitrogen, amino acids and peptides (Van Soest 1994). Soluble protein is degraded instantaneously in the rumen. The soluble protein content in chaya fodder was 27.93% of CP, which is lower than lucerne (40% of CP) (CPM-Dairy 2008, Sniffen *et al.* 1992). Thus, chaya fodder contains more potential ruminal by-pass protein than lucerne. The *in vitro* digestibility of NDF conducted for 0, 24 and 48 h indicated that 55.5% of NDF was digested by 24 h in leaves and 52.6% in chaya fodder. The rate of digestion (kd) of NDF in chaya fodder was 7.99%/h.

Mineral status

Contents of minerals (Table 1) in the leaves of chaya are in agreement with Sarimento-Franco *et al.* (2002) and Booth *et al.* (1992). Calcium levels in leaves and fodder chaya were 1.78 and 1.92%, respectively. The phosphorus was 0.31 and 0.28% respectively, in leaves and fodder. The Ca and P content in leaves and fodder are similar to lucerne hay (1.53% Ca and 0.31% P) (CPM-Dairy 2008, Sniffen *et al*. 1992).Potassium in leaves and fodder was similar to that of lucerne hay. Magnesium in leaves (0.60%) and fodder (0.54%) were almost double than that of lucerne (0.31%). Sodium was a little higher than that of lucerne. Among micro minerals, the zinc was found higher but copper was lower as compared to lucerne. Manganese in chaya was unusually high (leaves, 131.4 ppm and fodder, 85.5 ppm) than that of lucerne hay (50 ppm).

The observations of the present investigation indicate that the nutrient content of chaya leaves as well as fodder chaya is comparable to the most commonly fed leguminous fodder

Table 1. Chemical composition (% of dry matter) of chaya leaf meal and chaya fodder

Component	Chaya leaves		Chaya fodder	
	Mean	±SD	Mean	±SD
% of dry matter				
Protein (N×6.25)	27.40	±0.59	17.96	±0.25
Soluble protein	10.44	±0.79	5.02	±1.34
Acid detergent fibre	20.55	±0.35	21.20	±0.42
Neutral detergent fibre	29.62	±1.48	27.85	±0.13
Lignin	5.73	±0.68	4.10	±0.42
Fat	9.27	±0.31	3.61	±0.34
Ash	11.88	±0.06	9.84	±0.30
Starch	0.41	±0.14	5.31	±1.04
NFC*	21.89	±2.29	40.64	±0.11
ME (mCal/kg) #			2.18	
Vitamin A (IU/100 g)	9145	±261.63	4465	±318.20
Minerals				
Calcium (%)	1.78	±0.01	1.92	±0.05
Phosphorus (%)	0.31	±0.01	0.28	±0.01
Potassium (%)	2.34	±0.01	1.44	±0.06
Magnesium (%)	0.60	±0.01	0.54	±0.01
Sodium (%)	0.20	±0.01	0.29	±0.01
Zn (ppm)	46.60	±7.44	22.13	±4.64
Manganese (ppm)	131.47	±2.78	85.48	±1.14
Copper (ppm)	5.61	±0.17	3.74	±0.21

* NFC=100 - (NDF + CP + ether extract + ash); #Estimated using CPM-Dairy (2008), not estimated for chaya leaves.

in India. Preliminary observations indicate that 1000 – 2000 q/ha/year green fodder could be obtained depending on the growing condition provided to the plant (Kumar *et al*. 2009). While the fodder chaya could be fed to ruminants and pigs, the leaf meal prepared from chaya could be incorporated in the poultry diets. Since the plant remains green throughout the year and grow vigorously in summer, harvesting can be scheduled to obtain green fodder even during the dry season.

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