Nutritional Evaluation of
Non-Conventional Feed available in Chattogram
[A review]

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A production report submitted as per approved styles and contents

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Table of contents

List of Tables

List of Abbreviations

Abbreviation	Elaboration
CVASU	Chattogram Veterinary and Animal Sciences University
DVM	Doctor of Veterinary Medicine
et al.	et alia (and others)
e.g.	Exempli gratia
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
%	Percentage
DM	Dry Matter
OM	Organic Matter
DOM	Digestibility Organic Matter
CP	Crude Protein
CF	Crude Fiber
NDF	Neutral Detergent Fiber,
ADF	Acid Detergent Fiber
EE	Ether Extract
NFE	Nitrogen Free Extract
ME	Metabolisable Energy, MJ/Kg
GE	Gross Energy, MJ/Kg
IVGPT	In Vitro Gas Production Technique
N.D.	Not Detected

ABSTRACT

Being an agricultural country, livestock is an important part in the economy of Bangladesh but there is a huge gap between demand and supply of animal feed. The concentrate production or availability is far below than the animal requires, and the deficit is 79.8% compared to its demand. Similarly, DCP production deficiency is 71.2%, and only 22.5% of the demand is available. In this scenario the requirement should be met from nonconventional feeds. For the purpose of this review, the chemical composition and nutritional value of NCFR include agro-industrial by products, some common tropical browse plants, concentrate, roughages and leaf meals, fruit and vegetable wastes potentially available in Chattogram were included. Most of these wastes have high acceptability and palatability and also can be as replacement or as a supplement in the nutrition of livestock. There is a need to monitor pesticide and its residues, toxins, heavy metals and anti-nutritional factors before using these vegetable products in animal diets. In conclusion, the results obtained of this review suggest that all the by-products can contribute to ruminant diets without adverse effects on feed intake, growth rate and apparent nutrient digestibility coefficients. These resources are yet untapped, and their efficient use will enlarge the feed resource base, enhance feed availability, and bring the wasted food back to the human food chain. Judicious incorporation of these non-conventional feeds in the rations of livestock will help to minimise the feed deficiency and help to achieve maximum production, reduce the cost of production which will ultimately result in growth of livestock population in Chattogram.

Key words: Non-conventional feed resources, Nutritional evaluation, Economic rearing, Chattogram

Chapter 1: Introduction

1.1 Background of the Study:

The livestock consist of 25.8 million bovines, 17.3 million caprines and ovines and 135.1 million of poultry (BBS, 2012) contributes about US$ 2309.0 million as animal farming GDP sharing 18.6, 56.3, 19.8, 2.68 and 2.64%, respectively by dairy, meat, egg, hides and skin and others (BBS, 2011).The highest per hectare availability of livestock unit is in Chattogram and lowest in Chattogram Hill Tracts (CHT). All regions experienced an increase in the stock of livestock over time but at a variable rate, with the highest rate of increase is in CHT (Rahman et al, 2012). The ruminant animal in the country is mostly raised on fibrous crop-residues and cereal milling by-products. The total roughage production in the country is estimated to be 51056x10^3 ton in 2012, of which 5781x10^3 ton comes from cut and carry and road-side grazing (considering daily availability of 1.0 Kg green grass per head). This results in a ratio of 89:11 for fibrous residues of crop to green biomass. About 27316 x10^3 ton (53.5%) of the fibrous biomass produced in the country is available to animals as feed, and the rest bulk is gone off, and used otherwise. Cereal milling by-products, grains and oil-cakes are the three major types of ingredients that constitute concentrate feed in the country. Based on the extraction rates of by-products of different cereals shown by (Huque and Amanullah, 2009), the annual availability of the three types of concentrate is about 2916 x10^3 ton (58.0%), 2042x10^3 ton (40.6%) and 67.6 x10^3 ton (1.34%), respectively (Huque and Sarker, 2014). The country requires 73800.0 million Kg total dry matter (DM) annually to feed existing ruminant animals. An average ruminant diet sharing roughage and concentrate DM at a ratio of 2:1 that will make a total demand of 49200 x10^3 ton and 24608x10^3 ton, respectively of the two feeds. The total annual roughage DM production is 51056x10^3 ton surpassing by 3.77% of its total annual demand. But, its annual availability to animal is 27316x10^3. This results in a deficit of 56.2% of the total demand. The demand and supply situation of concentrate feed is very poor in the country. The total demand is met only 19.4% by its annual availability of 5025.4 x10^3 ton, and a very negligible amount (164.2x10^3 ton) is used otherwise. The total annual demand of million MJME and million Kg DCP for the existing ruminant animals is calculated to be 457265.0 and

3332.0, respectively, and the production from the feed produced in the country is 397224.8 million MJME and 959.8 million Kg DCP, respectively (Huque and Amanullah,2009). This data shows a production deficit of 13.13% and 71.2%, respectively for the two nutrients. Considering feed availability about 250217.0 million MJME and 748.9 million Kg DCP are available to animals. The availability of the two nutrients is low and it is found to be 63% and 78%, respectively compared to production, and 54.7% and 22.5%, respectively compared to their demand. The concentrate production or availability, on the other hand, is far below than the animal requires, and the deficit is 79.8% compared to its demand. Similarly, DCP production deficiency is 71.2%, and only 22.5% of the demand is available. (Huque and Sarker, 2014). To meet the nutrient requirements of livestock and to sustain their productivity under these conditions seems rather impossible; unless and until new non-conventional alternate feed resources are explored depending on their nutrient content, availability and acceptability to animals, provided it is economical compared to conventional feed ingredients (Bakshi and Wadhwa, 2013; Ezeldin et al., 2016) . The country produces 6.54.0x10^3 ton of cotton seed cake and around 96.5.0x10^3 ton of fruit and vegetable wastes, posing a big problem for their disposal, which are dumped in the landfills/road sides, causing environmental hazards. But such non-conventional resources can act as excellent source of nutrients and these feeds may effectively be used for premixed feed production that can bridge the gap between demand and supply of nutrients for livestock to a great extent and can economize dairy farming (Bakshi and Wadhwa, 2013).

1.2 Non-conventional feed resources (NCFR) and its *Quality/Characteristics:*

Generally, NCFR refers to all those feeds that have not been traditionally used for feeding livestock and are not commercially used in the production of livestock feeds. Several known examples include palm leaf meals, palm press fiber, cassava foliage, spent brewer's grains, sugar cane bagasse, rubber seed meal, vegetables from the processing of food for human consumption and some aquatic plants (Chadhokar, 1984).

According to reports (FAO, 1985), non-conventional feed resources like conventional feed resources have several characteristics worthy of note.

a) They are the end products of production processes and consumption that have not been used, recycled or salvaged.

b) They are mostly of organic origin and can be obtained either in a solid, slurry or liquid form.

c) The economic value of these non-conventional feed resources is usually less than the cost of their collection and transformation for use and consequently, they are discharged as wastes.

d) Feed crops which generate valuable NCFR are usually excellent sources of fermentable nutrient molecules such as cassava and sweet potato and this is an advantage to livestock especially ruminants due to their ability to utilize inorganic nitrogen and non-protein nitrogenous sources.

e) Fruit wastes such as banana rejects and pineapple pulp by comparison have sugars which are energetically beneficial.

f) The majority of feeds of crop origin are bulky poor-quality cellulosic roughages with high crude fiber and low nitrogenous content which are suitable for feeding mostly ruminants.

g) Some of these feeds contain anti-nutritional components which have deleterious effects on the animals and not enough is known about the nature of the activity of these components and ways of alleviating their effects.

h) Non-conventional feed resources have considerable potential as feed materials and for some; their value can be increased if there were economically viable technological means for converting them into some usable products.

i) Substantial information is required on chemical composition, nutritive value, the presence of anti-nutritional components and value in feeding systems.

1.3 Importance of non-conventional feed resources:

There are serious shortages in animal feeds of the conventional type. The grains are required almost exclusively for human consumption. With increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, future hopes of feeding the animals and safeguarding their food security will depend on the better utilization of nonconventional feed resources which do not compete with human food. The availability of feed resources and their rational utilization for livestock represents possibly the most compelling task facing planners and animal scientists in the world. The situation is acute in numerous developing countries where chronic annual feed deficits and increasing animal populations are common, thus making the problem a continuing saga.

Thus, non-conventional feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost, and contribute to self-sufficiency in nutrients from locally available feed sources. It is therefore imperative to examine for cheaper non-conventional feed resources that can improve intake and digestibility of low quality forages.

1.4 The specific objectives of the review study:

a. Evaluation of the nutritive value of energy and protein rich NCFR available in Chattagram Metropolitan area.

b. Knowledge of this review will help farmers to incorporate different prominent NCFR in ration in respect of economy and environmental benefits.

c. Unveiling the cheaper NCFR that can improve intake and digestibility of low quality feeds and can be acceptable as food and nutritional supplements.

Chapter 2: Materials and methods

2.1. Feedstuffs samples and chemical analysis:

2.1.1. Sample collection:

The review was done based on the nonconventional feed sample commonly not used but cheap and available in different parts of Chattogram. Samples of various feedstuffs like concentrates, dry and green roughages, cultivated fodders, salt tolerant plants, crop residues and browse plants, tree leaves, fruit and vegetable waste products which can be used for feeding ruminants locally, were selected for nutritional evaluation. All the feedstuffs were cut into small pieces to facilitate easy handling and uniform sampling for analysis.

2.1.2. Methods for Chemical Analysis:

2.1.2.1.Analysis of Concentrates—

All the feeds (except mung bean meal, soybean hull and peanut hull) samples were ground to pass through 1 mm screen and analysed in triplicate for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash contents as per the methods of AOAC (1995).

ME value of concentrates and roughages were calculated by using the prediction equations of Menke and Steingass (1988), whereas, TDN was calculated from ME value as per the equation of NRC (1989) (Garg et al., 2012)

For mung bean meal, soybean hull and peanut hull; all samples were ground through a 1 mm screen for the in vitro gas production technique incubation and chemical analysis. The samples were determined Dry Matter (DM), Crude Protein (CP) and ash content (AOAC, 1990). Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) of samples were assayed using the method proposed by Van Soest et al. (1991).

In vitro digestibility of dry matter and organic matter were measured at 24 and 96 h after incubation. Metabolizable energy was calculated as ME, MJ kg treatment). DM = 2.20+(0.136×Gv)+(0.057×%CP), Menke et al. (1979), where Gv = gas volume at 24 hr, CP = %crude protein in feedstuffs.

(Chumpawadee et al., 2007)

2.1.2.2. Analysis of Dry roughages —

All the fodder samples were ground to pass through 1 mm screen and analyzed in triplicate for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash contents as per the methods of AOAC (1995).

ME value of concentrates and roughages were calculated by using the prediction equations of Menke and Steingass (1988), whereas, TDN was calculated from ME value as per the equation of NRC (1989).

(Garg et al., 2012)

***2.1.2.3.* Analysis of Green roughages—**

All the fodder samples were ground to pass through 1 mm screen and analyzed in triplicate for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash contents as per the methods of AOAC (1995).

ME value of concentrates and roughages were calculated by using the prediction equations of Menke and Steingass (1988), whereas, TDN was calculated from ME value as per the equation of NRC (1989).

(Garg et al., 2012)

For azolla meal the dried leaves were then milled using a hammer mill to produce leaf meal, which was then stored in sacs until used for feeding. For water hyacinth samples were dried in a hot, dry air force oven at 65 °C for 72 h and weighed. The samples were then ground to pass through a 1 mm screen for in vitro incubation and chemical analysis.

Proximate composition: The samples were subjected to proximate analysis according to standard methods of AOAC, (1990). Nitrogen-free extract (NFE) was obtained by difference. Nitrogen content was estimated by the micro Kjeldahl method. Gross energy value was determined using a Gallenkamp adiabatic oxygen bomb calorimeter.

Fibre analysis: The method of Goering and Van Soest, (1970) was used to determine the neutral detergent fibre (NDF) and the acid detergent fibre (ADF).

(Alalade et al., 2006 &Chumpawadee et al., 2005)

2.1.2.4. Analysis of Tree leaves—

Samples were dried, grinded, passed through a 1 mm sieve and stored in polythene bags at room temperature. Chemical analysis Feed samples were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash by standard analytical methods after AOAC (1990).Fibre fractions like acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents were analyzed using the Van Soest et al. (1991) procedure. Gross energy content was measured by using a Bomb calorimeter (IKA.-C400) and (Sergio and Filho, 2005). GP, corrected for blank and the appropriate reference standard), at 24 hours incubation, metabolizable energy (ME, MJ/ kg dry matter) and digestibility of organic matter (DOM) were calculated by using the following mathematical equations adopted from Menke et al. (1979) and Menke and Steingass (1988). (khanum et al., 2007 & Khan et al., 2008)

2.1.2.5. Analysis of Fruit waste—

In case of fruit waste, viz. pineapple waste, cashew apple waste, banana stem waste and jackfruit waste were procured. The proximate analysis of the above feeds was determined by standard procedure (AOAC 2016). In vitro total gas production technique (IVGPT) as described by Menke and Steingass, (1988) was conducted to estimate metabolisable energy (ME) and digestible organic matter (DOM) content in them. (Raseel et al., 2018)

For banana peels and watermelon peels, were procured free of cost, to assess their nutritional worth. The finely ground samples in triplicate were analyzed for CP and total ash (AOAC 1995) and NDF, ADF by Robertson and Van Soest (1981). (Bakshiand Wadhwa, 2013)

For orange peel,at the laboratory, wet feed materials were dried at 60°C to constant weight in a forced draft oven. Oven dried and air dried samples were ground to pass through a 1 mm screen and analyzed for dry matter (DM), ether extract (EE) and total ash using the Weende method (AOAC, 1980). Nitrogen content of the feed was determined using the Kjeldahl procedure. Gross energy (GE) was determined by a bomb calorimeter. NDF, acid detergent fiber (ADF), and in vitro dry matter digestibility (IVDMD) were determined according to Goering and Van Soest (1970). (Mekasha et al., 2001)

Desiccated coconut waste meal was collected wet; this was dried under shade for 4-7 days until the product became brown. During the period the product was continuously turned for even drying and proper aeration. The AOAC (1995) method was used for the analyses of desiccated coconut waste meal and cocoa shell feed ingredients. Dry matter was determined by drying at 102°C for 24 h, ash by firing at 600°C for 24 h, protein by the micro-Kjeldahl procedure (N×6.25). Gross energy (MJ/kg DM) was determined by an adiabatic bomb calorimeter (Parr Instrument Co., Moline, IL) using thermochemical benzoic acid as standard. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the procedures of Van Soest et al. (1991). (Aregheore et al., 2003)

While Papaya fruits *(Carica papaya L.)*, mature fresh watermelon (*Citrullus vulgaris*) and guava (*Psidium guajava*) seeds as by-products (wastes) were obtained: All seeds were manually separated from fruit pulps, cleaned, washed with distilled water, air dried, shelled manually to remove seed coats and the resulting kernels were dried at 50°C in an air oven. The dried kernels were milled in laboratory to pass through 60 mesh sieve. All resulting flours were packed into clean airtight polyethylene bags and kept at 4°C until utilization. Analytical Methods Chemical Analyses: crude protein (N x 6.25), ether extract, crude fiber and ash were determined according to AOAC (2000).Mineral Contents: Ca, Mg, K and Na contents were determined by using Perkin Elmer Atomic Absorption Spectrophotometer (Mode 119 CL) (El-Safy et al., 2012)

2.1.2.6. Analysis of Vegetable Waste —

Vegetable waste samples were air dried. The peeled roots were diced into chips approximately 1.5 mm in thickness with a Hobart slicer (Model 1612, Hobart Corporation) The chips were then blanched at 90°C for 1 minute in a steam-jacketed pan and dried in an electric air draught oven (Isotemperature Oven, Fisher Scientific) at 60°C to constant weight. The dried chips were ground in an electric grinder (Braun Model 1021), passed through a 150-μm mesh sieve, and stored in glass containers at 4°C for further analysis. (Mahmoud El Anany, 2014) Dry matter (DM) content was determined by drying the samples at 105°C overnight and ash by igniting the samples in muffle furnace at 525°C for 8 hs and crude protein content was measured by the Kjeldahl method, AOAC(1990) Ether extracts (EE) were determined by the method of AOAC(1990) Crude fiber (CF) was determined according to the method of AOAC,2007. When crude protein, fat, water, ash, and fiber are added and the sum is subtracted from 100, the difference is NFE = DM– (%Moisture + %CF + %CP + % EE + %Ash).(Mahmoud and El Anany, 2014;Bakshi et al.,2016 &Ezeldin et al. 2016)

Chapter 3: Results and Discussion

3.1. Chemical Composition and Energy Values Non-Conventional Feedstuffs (% DMB):

The chemical composition of different feeds are presented in Tables. Generally, wide variations existed in the chemical composition of the investigated feedstuffs.

3.1.1. Amongst concentrate feeds:

a) Chemical analysis—

CP content ranged from 8.10% for jowar grain to 43.30% for groundnut meal. EE content ranged from 0. .56 % for de-oiled rice bran to 9.30% for cottonseed meal. Total ash content ranged from 2.67 % for jowar to 13.21% for de-oiled rice bran. The chemical composition of concentrate feeds observed is in accordance with that of NRC (2001) and Mandal et al. (2003); (Garg et al., 2012), (Table 1.0).

Table- 1.0: Chemical composition (%) of concentrates:

Parameter	**DM**	**ME**	**TDN**	**CP**	**EE**	**CF**	**Ash**
1.Jowar (*Sorghum bicolor*)	92.09	13.76	83.97	8.10	2.53	11.09	2.67
2.Bajra (*Pennisetum glaucum)*	92.00	12.61	77.79	11.20	3.50	10.45	4.90
3.Deoiled rice bran (*Oryza sativa)*	92.20	8.03	53.22	15.10	0.56	18.00	13.21
4. Rapeseed meal (*Brassica napus*)	93.49	10.62	67.12	37.62	0.84	8.51	8.89
5. Groundnut meal (*Arachishypogaea*)	92.00	10.43	66.07	43.30	1.20	13.27	6.50

6. Cottonseed meal (*Gossypium spp*.)	92.00	9.87	63.08	38.50	9.30	7.47	8.10
7. Sunflower meal (*Helianthus annuus*)	92.00	8.80	57.50	26.85	6.84	25.45	10.50
8. Maize bran (*Zea mays*)	88.90	8.50	55.22	9.60	3.04	8.05	2.40
9.Maize gluten (*Zea mays*)	92.9	9.06	N.D.	21.9	07.00	01.3	7.8
10. Soybean flakes (*Glycine max)*	93.88	10.54	66.71	13.38	5.04	27.07	4.93

(Garg et al., 2012)

b) Energy values—

Amongst concentrate feeds, deoiled rice bran had lowest ME and TDN values, whereas, jowar had highest ME and TDN values (Table 1.0). Bajra, Rapeseed meal and Soybean flakes also had higher ME value in concentrates. Our results are in agreement with that of Ranjhan (1998) and Khanum et al. (2007). (Garg et al., 2012) The highest crude protein content observed in peanut hull and the lowest in soybean hull which is completely opposite for Ash content. Lowest neutral detergent fiber (NDF) and acid detergent fiber (ADF) were observed in peanut hull whereas, highest in soybean hull. (Chumpawadee et al., 2007) (Table 1.1)

Table-1. 1: Chemical composition (%) of concentrates:

Parameter	DM	ME	CP	NDF	ADF	Ash
11.Mung bean meal	92.05	5.24	18.05	43.50	29.66	4.66
12.Soybean hull	91.73	6.18	17.99	49.71	32.22	5.41
13.Peanut hull	96.11	4.48	18.48	27.63	13.05	4.02

(Chumpawadee et al., 2007)

c) ***Factors affecting chemical composition & energy values***—

There are many factors affecting chemical composition and energy value of concentrate feedstuffs such as stage of growth maturity, species or variety (Von Keyserlingk et al., 1996; Agbagla-Dohnani et al., 2001 & Promkot and Wanapat, 2004), drying method, growth environment (Mupangwa et al., 1997) and soil types (Thu and Preston, 1999). Those factors may partially explain differences in chemical composition between our study and others.Estimated Metabolizable Energy (ME): Metabolizable energy predicted by the equation of Menke et al. (1979) is as follows ME, MJ/kgDM = 2.20 + (0.136 x Gv) + (0.057 x % CP) where Gv = gas volume at 24 h (mL), CP = crude protein in feedstuff (%). Menke and Steingass (1988) reported a strong correlation between ME values measured in vivo and predicted from 24 h in vitro gas production and chemical composition of feed. The in vitro gas production method has also been widely used to evaluate the energy value of several classes of feed (Getachew et al., 1998; Getachew et al., 2002; Aiple et al., 1996). Krishnamoothy et al. (1995) also suggested in vitro gas production technique should be considered for estimated ME in tropical feedstuffs. Because evaluation of ME by other techniques requires labor, cost, time and complexity.

(Chumpawadee et al., 2007)

3.1.2. Amongst dry roughages:

a) Chemical analysis—

CP content ranged from 2.85% for wheat straw to 12.00% for groundnut straw. EE content ranged from 1.02% for wheat straw to 2.32% for groundnut straw. Total ash content ranged from 6.99% for groundnut straw to 19.45% for paddy straw (Table 2.0).

Table-2.0: Chemical composition (%) of dry roughages:

Parameter	**DM**	**ME**	**TDN**	**CP**	**EE**	**CF**	**Ash**
1.Paddy straw (*Oryza sativa*)	90.85	6.01	42.36	3.54	1.65	42.58	19.45
2.Wheat straw (*Triticum* spp.)	92.87	6.25	44.56	2.85	1.02	35.47	10.48
3.Jowar straw (*Sorghum bicolor*)	91.58	8.14	51.91	3.94	1.84	34.58	12.41
4. Bajra straw (*Pennisetum* spp)	92.45	6.31	45.41	3.54	1.24	35.24	10.58
5. Maize straw (*Zea mays*)	91.24	6.40	47.44	3.68	1.84	33.24	11.24
6. Sugarcane tops (*Saccharum* spp)	93.36	6.10	43.61	5.73	1.32	32.00	8.50
7. Groundnut straw (*Arachis hypogaea*)	85.47	8.93	58.62	12.00	2.32	32.99	6.99
8. Masoor straw (*Lens culinaris*)	93.98	6.29	42.99	5.51	1.99	36.87	8.25
9.Rice husk (*Oryza sativa*)	89.78	4.48	22.23	1.15	2.94	28.01	15.38

(Garg et al., 2012)

These results of chemical composition of straws corroborate the earlier reports of NRC (1982), (Ranjhan, 1998; Mandal et al., 2003; Kumarmath et al., 2004 & Garg et al., 2012).

b) *Energy values*—

Rice husk had lowest ME and TDN value, whereas, groundnut straw had highest ME and TDN value (Table 3). Ranjhan (1998) and Mandal et al. (2003) also reported similar ME and TDN values of straws as observed in present study (Garg et al., 2012).

3.1.3. Amongst green roughages:

***a) Chemical analysis*—**

CP content ranged from 5.84% for Rhodes grass to 30.98% for mustard. EE content ranged from 1.84% for bamboo leaves to 4.89% for mustard. Total ash content ranged from 5.99% for butterfly pea to 13.88 % for bamboo leaves (Table 3.0). (Ranjhan 1998, Kumarmath et al. 2004, Datt et al. 2009) (Garg et al., 2012).

Table-3. 0: Chemical composition (%) of green roughages:

Parameter	**DM**	**ME**	**TDN**	**CP**	**EE**	**CF**	**Ash**
1.Bamboo leaves (*Filgueiras arenicola*)	93.99	5.05	37.23	15.47	1.48	27.48	13.88
2.Butterfly pea (*Centrosema molle*)	37.44	7.24	47.52	18.69	2.27	26.64	5.99
3.Rhodes grass (*Chloris gayana*)	33.68	6.44	44.69	8.85	2.12	25.99	11.18
4.Cowpea (*Vigna unguiculata*)	21.35	7.71	51.48	23.80	2.59	16.46	9.52
5.Mustard (*Brassica* spp.)	24.15	8.76	57.10	30.98	4.89	7.53	12.90

(Garg et al., 2012).

Similarly, bamboo leaves had highest CF content (27.48%) which is lowest in mustard(7.53%) but bamboo leaves had less ME and TDN values whereas, mustard had highest ME (8.76 MJ/kg DM) and TDN (57.10%) value (Table 3.0). The ME and TDN values of green roughages observed in present study are in agreement with that of Aka and Kamalu (2004),Jadhav et al. (2007) andDatt et al. (2009) (Garg et al., 2012)

Again, chemical analysis showed that azolla meal (AZM) contains higher CP, NDF, ADF, EE and ash than water hyacinth respectively (Table 3.1) (Chumpawadee et al. 2005&Alalade et al., 2006).

Table-3. 1: Chemical composition (%) of few selected green roughages:

Parameter	**DM**	**CP**	**NDF**	**ADF**	**Ash**
6.Azolla (*Azolla pinnata*)	N.D.	21.4	36.88	47.08	16.2
7.Water hyacinth (*Eichornia crassipes)*	15.00	12.97	69.23	42.69	14.30

(Chumpawadee et al. 2005&Alalade et al., 2006).

3.1.4. Tree leaves:

a) *Chemical analysis—*

Leaves of M. oleifera had the highest and A.indica had the lowest DM content (Table 4.0), (khanum et al., 2007; Khan et al., 2008 & Roy et al., 2016).

Table-4. 0: Chemical composition (%) of some tree leaves and shrubs (salt-tolerant plants) (g/lOOg DM):

Parameter	**DM**	**ME**	**DOM**	**CP**	**EE**	**CF**	**Ash**
1.Siamese Rough Brush (*Streblus asper*)	44.83	7.16	50.32	14.56	1.21	16.70	16.21
2.Sacred fig (*Ficus infectoria)*	42.35	4.25	31.85	12.70	2.15	28.94	14.88
3.Mango (*Mangifera indica*)	46.27	4.79	34.77	8.46	1.71	31.36	10.89
4.Indian coral tree *Erythrina indica)*	38.63	7.49	46.96	23.25	3.99	41.37	5.24
5.Siris/Koroi tree *(Albizia spp.)*	39.42	4.63	36.54	22.74	1.29	21.60	20.54
6.Jackfruit tree (*Artocarpus* spp)	41.60	6.73	47.07	11.64	1.23	24.54	13.57
7.Drumstick foliage (*Moringa oleifera)*	85.52	28.35	62.84	18.62	N.D.	N.D.	7.87
8.Ipil-Ipil (*Leucaena leucocephala*)	36.48	7.19	53.17	27.72	3.68	16.26	7.53
9.Indian jujube (*Ziziphus mauritiana* ; Var- BAU Kul -1)	37.71	5.07	36.92	12.69	1.78	27.82	8.71
10.Neem (*Azadirachta indica)*	33.3	N.D.	N.D.	12.2	2.6	14.8	33.3

(khanum et al., 2007; Khan et al., 2008 & Roy et al., 2016).

Dry matter content of all the tree leaves was in agreement with the findings of Brenda et a1. (1997). The CP varied considerably among the plants. Highest value for CP was observed in L. leucocephala and lowest for M. indica. Except these 2 leaves, the CP content of others ranged from 11.6 to 23.2%. CP for 10 plant leaves was higher compared to other tropical grasses, which seldom exceed a level of 15% (Reynolds et al., 1992). The average CP compares positively with that of good quality legume forages and far exceeds the minimum protein requirement of ruminants (10 to 12%) estimated by ARC (1985). But, some variations were observed in respect of L. leucocephala (Nasrullah et al. 2003), who obtained higher values for these. Concentration of EE approximated those of Common forages, although considerable variation occurred among species. Highest value observed in L. leucocephala and lowest in S. asper. Ash content for the leaves ranged from 5.2 to 20.5%. (Bakshi and Wadhwa; 2007) indicated that tree leaves supplemented with mineral mixture and common salt, could serve as an excellent complete feed for small ruminants. (Abdulrazak et al.; 2000) concluded that based on the moderate to high CP values and the degradation characteristics, these species have potential as livestock fodder.

b) Fibre and fibre fractions—

A wide range of CF concentrations observed in our study (Table 4). But the CF of the leaves was lower when compared with other tropical grasses, which may be as high as 45% during advanced stages of growth (Uwechue; 1990). The leaves of F. infectoria and *M. Alba* was lowest in this parameter. But, Nguyen and Ngoan (2003) found higher value for *L. leucocephala*. So, it is clear that all tested leaves contained crude fiber fraction within the range of good quality forages. (Arigbede and Tarawali, 1997)

c) Digestibility and energy values—

Among the leaves studied *L. leucocephala* and S. asper were high in DO%, which categorize these plant leaves as high quality feeds for ruminants. A wide variation was observed in ME, where the highest was observed in *E indica* and lowest in *F. infectoria*. Considering the nutritional value as discussed above, it may be recommended to use *L. leucocephala* and *S. asper* as feed for ruminant animals. But, it would be under consideration to study the effect on growth and productive performances of animals due to their feeding (khanum et al., 2007; Khan et al., 2008 &Roy et al. 2016).

3.1.5. Fruit waste:

a) *Discussion on Chemical analysis and energy values—*

The proximate analysis (crude protein, crude fibre, ether extract and total ash) and the results of IVGPT (ME, DOM) are given in Table 5.0 Higher energy was found in pineapple waste and banana stem waste, with a ME of 9.66 and 8.20 MJ/kg. (Raseel et al., 2018)

Table-5. 0: Chemical composition (%) of fruit wastes:

Parameter	**ME**	**DOM**	**CP**	**CF**	**EE**	**Ash**
1.Pineapple waste	9.66 ±0.34	67.65 ±2.07	11.43	14.07	1.98	4.20
2.Cashew apple waste	5.47 ±0.35	50.81 ±9.16	15.55	17.33	2.18	4.61
3.Banana stem waste	8.20 ±0.09	54.91 ±4.07	10.71	31.77	0.37	10.99
4.Jackfruit waste	7.52 ±0.51	57.88 ±2.88	12.58	12.46	4.90	3.58

(Raseel et al., 2018)

The proximate chemical composition of the by-products (Table 5. 1) is within values reported by Abiola and Tewe (1990) for CS and Aregheore (2000); Aregheore and Tunabuna (2001) for DCWM.

Table-5. 1: Chemical composition (%) of fruit wastes and by- products:

Parameter	**GE**	**OM**	**CP**	**NDF**	**ADF**	**EE**	**Ash**
5.Banana peel	16.0	75.0	8.3	38.4	26.4	6.08	11.1
6 Orange peel	28.1	94.6	5.8	19.9	19.3	1.6	N.D.

7.Watermelon Peels	N.D.	92.2	7.9	33.8	33.7	1.78	7.9
8.Cocoa shell	17.6	84.0	16.0	52.6	28.5	5.2	N.D.
9.Desiccated coconut waste meal	20.4	94.7	16.5	49.8	28.2	29.3	N.D.

(Mekasha et al., 2001; Bakshi and Wadhwa, 2013 &Aregheore et al., 2003).

The higher NDF and ADF digestibility values than others obtained cocoa shell diets is possibly due to a longer retention time in the reticulo-rumen than others. It has been suggested that the longer the retention time the higher the digestibility of a diet (Aregheore, 2000); Aregheore and Tunabuna, 2001). It therefore seems that DCWM and CS diets had a longer residence time in the digestive tract and this subsequently led to higher digestibility of available nutrients compared to others. It has also been observed that the higher the OM digestibility in orange peel and DCWM, the higher the expected GE, and therefore, the feed with higher OM digestibility is expected to provide more energy and therefore more production, i.e. high live weight gain. The daily growth rate on different byproduct diets may have been influenced by the contents of OM and GE present in the diets (Aganga and Monyatsiwa, 1999).The low values of OMD obtained in the cocoa byproducts may be attributed to the presence of theobromine, an anti-nutritive factor present in CS. Oyenuga (1968) reported that the beans and shell of cocoa are high in the alkaloid; theobromine and this may have inhibited the action of rumen microbes to effectively digest these byproducts. The rate of digestion and the amount which is potentially degradable together, determine how much of the material will be digested during the time the food is exposed to rumen fermentation (Ørskov, 1991). The rate and potential extent of digestion will influence, therefore, both digestibility and rumen volume and hence, voluntary intake, (Ørskov et al., 1988). Also Pirie (1987) hypothesized that if several enzymes in vitro readily digest a feed nutrient, it is reasonable to expect that it will be digested in the digestive system. And if it is not digested in vitro, it will still be digested in vivo as a result of simultaneous actions of several enzymes and the possible cooperation from rumen flora. EE is highest in DCWM (29.3%) which is lowest in orange peel (1.6%). (Mekasha et al., 2001; Aregheore et al., 2003 &Bakshi and Wadhwa; 2013)

Table-5. 2: Chemical composition (%) and minerals contents of tested seed and kernel flours (mg/100g dry weight flour):

Parameter	CP	CF	CL	Ash	Ca	Mg	K	Na
10.papaya seed	31.26	5.16	32.50	8.89	42.89	2.34	25.13	35.49
11.guava seed	7.90	64.67	16.20	0.96	172.36	158.65	895.1	750.86
12.watermelon seed	30.11	3.47	45.05	3.75	86.75	1118.0	598.95	90.35

(El-Safy et al., 2012)

Table 5.2 shows the proximate and mineral composition of tested seed. Among the studied seed and in their contents of crude protein, crude fiber, ash. Regarding crude protein, papaya and watermelon seed flours contained significantly higher levels of protein (30.11-31.26%) than other seed flours, concerning lipids watermelon seed flours contained significantly higher levels 45.05%, which reflect the importance of such seeds for oil production. These results are in agreement with the foundations of (Galal; 1992), (Mabaleha et al., 2007) and (Alobo; 2003). Also, from the same table it could be noticed that guava seeds had the highest amount of crude fiber (64%) therefore; guava seeds could be considered as a good source of dietary fiber while water melon seed flours showed the lowest dietary fibercontents. Regarding the ash content papaya seed flours were contained the higher contents while guava seed flour contained lowest ash content among them. Regarding calcium, guava seed flours showed significantly higher contents when compared with all tested seed flour while papaya seed flour contained the lowest value. Concerning magnesium, guava seed flours showed significantly higher values than all tested seed flours while papaya showed the lowest value. Regarding potassium, guava seed flour showed superior value, while papaya seed flour showed the lowest value when compared with other seed flours. Concerning sodium content, guava seed flour showed the highest content while papaya seed flour contained the lowest value. All these results are in good agreements with the foundations of El-Adaway and Taha (2001), Eyidemir and Hayta (2009), Ozcan and Juhaimi (2011)and Adesuyi and Ipinmoroti (2011). (El-Safy et al., 2012)

Judicious incorporation of these nonconventional feeds in the rations of dairy cows will help to meet the roughage deficiency and help to achieve maximum production, reduce the cost of production of milk which will ultimately result in growth of cattle population. However, the level of inclusion and anti-nutritional factors present should be taken into account before incorporation the ration (Raseel et al., 2018).

3.1.6. Amongst vegetable waste:

a) *Chemical analysis and energy values—*

CP content ranged from 4.94 % for sweet potato to 59.6% for pumpkin oil meal. OM content ranged from 25.5 % for drumstick tree to 95.2 % for potato and tomato pomace. EE content ranged from 0.4% for potatoes to10.8% for Tomato pomace. Total ash content ranged from3.84% for sweet potato to 22.1% for Radish leaves (Table 6.1 and 6.2).

Table-6. 0: Chemical composition (% DM basis) of vegetable wastes and by-products

Parameter	DM	OM	CP	NDF	ADF	EE	Ash
1.Cabbage leaves (*Brassica oleracea*)	10.0	84.2	19.9	33.7	22.6	2.6	15.8
2.Cauliflower leaves (*Brassica oleracea*)	13.0	86.4	17.0	27.5	19.4	4.2	13.7
3.Peavines (*Pisum sativum*)	13.5	89.9	11.8	60.0	49.9	2.4	10.0
4.Radish leaves (*Raphanus sativus*)	8.8	77.9	19.4	27.9	21.9	4.5	22.1
5.Baby corn husk (*Zea mays*)	10.0	94.8	11.6	60.9	28.8	5.2	1.8
6.Bottle gourd pulp (*Lagenaria siceraria*)	12.3	90.7	24.3	50.6	40.2	2.4	9.3

7.Carrot (*Daucus carota*)	10.1	91.8	9.9	9.0	8.0	1.4	8.2
8.Carrot pulp (*Daucus carota*)	9.50	92.5	24.0	7.2	20.0	1.8	7.5
9.Cucumber (*Cucumis sativus*)	37.0	88.7	16.3	16.8	2.50	1.30	11.3
10.Cucumber peels *(Cucumis sativus)*	7.88	90.30	14.3	37.0	23.0	3.0	9.70
11.Jackfruit seeds (*Artocarpus heterophyllus*)	45.85	90.50	39.6	12.2	20.8	4.10	9.50
12.Peapods (*Pisum sativum*)	14.1	92.0	19.8	48.1	35.4	1.0	8.04
13.Peavines ensiled (*Pisum sativum*)	25.0	91.0	13.1	59.0	49.0	3.3	9.0
14.Drumstick tree (*Moringa oleifera*)	94.0	25.5	13.4	19.3	11.3	N.D.	13.4
15. Potato (*Solanum tuberosum*)	12.0	95.2	9.5	N.D.	N.D.	4.8	4.8
16.Potatovines (*Solanum tuberosum*)	11.7	N.D.	(19.4–26.1)	(28.6–35.9)	(23.0–30.0)	N.D.	(12.0–18.0)
17.Pumpkin waste (*Cucurbita pepo*)	18.23	94.58	15.1	26.0	9.6	4.0	5.42
18.Pumpkin oil meal *(Cucurbita pepo)*	92.2	91.50	59.6	N.D.	N.D.	1.30	8.50

19.Tomato pomace (Solanum *lycopersicum)*	25.3	94.0 - 95.2	19.0-22.1	50.04	36.62	10.8	4.8 – 6.0

(Al-masri 2003 &Bakshi et al., 2016)

Carrot had lowest NDF (9.0%) and ADF value (8%), whereas, Baby corn husk (60.9%) had highest NDF and Peavines (49.9%) ADF value (Table 6.1). Similarly, Onion peel had the highest CF (44.5%) value and Sweet potato had the lowest CF (1.52%) value (Table 6.2).

Table-6. 1: Chemical composition (% DM basis) of vegetable by-products and wastes:

Parameter	DM	CP	CF	NFE	EE	Ash
20.Onion peel	91.3	8.66	44.5	21.58	1 .0	15.56
21.Sweet potato	94.60	4.94	1.52	N.D.	0.61	3.84

(Mahmoud and El-Anany, 2014 &Ezeldin et al., 2016)

Drying and ensiling are the attractive means to conserve vegetable wastes and by-products in Chattogram. Both of these processes improve their shelf-life and make their incorporation in animal feed easier. The feeding of such products economises the feeding of livestock. These can be fed fresh in the vicinity of vegetable processing plants or wholesale vegetable markets. However, transportation to distant places will add to the cost and can be a major bottleneck. Setting up of small scale feed manufacturing units in the vicinity of the places of availability of wastes and by-products could be an attractive option for their efficient utilization. These products have the potential to reduce food losses thus furthering food security. Further research is needed to make the efficient use of these products as safe animal feed. (Al-masri, 2003; Mahmoud and ElAnany; 2014; Bakshi et al.; 2016 &Ezeldin et al.; 2016)

Limitations

Several factors may account for the limited use of NCFR, among which the findings may not reflect the whole country as the study was restricted on Chattogram. Moreover, their limited available information, low nutritive value, Seasonal availability, high cost of handling, unremunerated prices and presence of anti-nutritional factors. Above all, due the movement restrictions of COVID 19, very scanty of lab works were done considering the safety and wellbeing to mankind.

Conclusion

The use of non-conventional feed resources in Chattogram should be increased for better livestock management. The urgency relates to ongoing drop in animal production performance, inadequate utilisation of the available feed ingredients and poor efficiency of existing animal production systems. Feed and vegetable wastes and by-products are good sources of both CP and energy, especially for ruminant animals in Chattogram which is also cost-effective. World Organization for Animal Health (formerly the Office International des Epizooties, Paris) has also developed safety guidelines and good practices for using agricultural wastes as animal feed. Besides regular monitoring of the potential toxic agents is advocated before the wastes and by-products are used in animal feeds. The data on the levels at which these products could be used in animal diet, generated through this study, would be useful for studies on assessment of risks due to possible presence of the contaminants in animal diet. So, it can be concluded that nutritive evaluation of NCFR available in Chattogram revealed in this study will help to create a nutrient profile of nonconventional feeds which can be recommended to incorporate in ration for economic production and also for agro-industrial waste utilization.

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Biography

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