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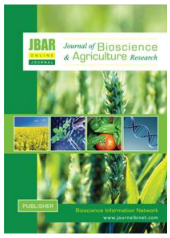

Wet rice straw ensiling with biogas slurry: A prospective feed preservation technique for higher protein content and metabolizable energy

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ABSTRACT

Bio-slurry, a byproduct of biogas plant is not using properly and most of the cases causing environmental and social hazard by discharging it in public places though it rich in nutrients especially protein (16-20% CP) and produced through beneficiary anaerobic microorganisms. On the other hand, Straw is highly fibrous residue having low protein (CP <3%) content which mostly indigestible. The poor digestibility of straw is further caused by the presence of high amount of inhibitory mineral element called silica. The combination of low intake, low degradability, low nitrogen content and an imbalanced mineral composition means that rice straw alone may not even meet the animal's maintenance needs. Therefore, the animals are suffering from nutrients deficiencies resulting in poor health and productivity of these animals reared on straw based ration. Under this situation, it is essential to find out the ways and means to increase the supply and quality of feed to livestock to fulfill their deficiencies. So, the way to improve the crude protein, metabolizable energy and preservation quality, wet rice straw can be ensiled with biogas slurry. The principles of ensiling process of straw are maintenance of anaerobic conditions throughout the ensiling and rapid decline in pH value by lactic acid bacteria. Ensiling of wet rice straw along with biogas slurry may produce a good quality ensilage for feeding cattle having desire palatability, nutrient content and digestibility and also reduce the environmental pollution.

Key Words: *Biogas slurry, Wet rice straw, Protein content, Metabolizable energy, Feed preservation technique and Future prospects.*

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I. Introduction

Preservation technique is known "as the science which deals with the process of prevention of decay or spoilage of food thus allowing it to be stored in a fit condition for future use". Food preservation usually involves preventing the growth of bacteria, fungi (such as yeasts), or other micro-organisms (although some methods work by introducing benign bacteria or fungi to the food), as well as

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retarding the oxidation of fats that cause rancidity. Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction. Maintaining or creating nutritional value, texture and flavor is an important aspect of food preservation, although, historically, some methods drastically altered the character of the food being preserved (Akinloye *et al.*, 2015). There are two basic measures to preserve any kind of fresh product that are to prevent the activity of the enzymes present in the product and to protect the product from "external deterioration factors" such as bacteria, molds, yeasts, insects, rodents, etc. Straw has been an important crop residue for livestock feeding virtually all over the world. Ruminants, particularly cattle and buffaloes in our country meet their appetite mainly from rice straw. The production of straw in our country is about 16.9 million ton (Tareque and Saadullah, 1988). Wet weather leads to serious losses in the quantitative and qualitative availability of straw due to heavy rainfall. A post-harvest loss of rice straw during wet season due to spoilage is a major contributing factor to the subsequent feed shortage. To minimize the feed shortage and improve the nutritional value, we need to think about the rice straw as ruminant feed and if processed and ensiled for some duration then can be supplied to the animal during feed scarcity period. Rice straw alone couldn't maintain an animal because of its palatability deficiency in nutrient and low level of intake by the bovine animals (Weston, 1982). Therefore to the increase its utilization by the animal it needs treatment or supplementation (Jackson, 1977; Preston, 1984) which may be done by adoption of physical, chemical or biological means. Rice straw can be preserved by physical means that is soaking, grinding, pelleting and by chemical means that is Sodium hydroxide, Calcium hydroxide, Potassium hydroxide, Ammonium hydroxide, Urea/Ammonia, Sodium Chloride and biological means that is addition of enzymes, white rot fungi, mushrooms. Biogas slurry is a by-product of anaerobic digestion that produced from biogas plant and also produces biogas (combustible methane gas) that is used for cooking, lighting and running engines. Biogas slurry is a fermented product produced by anaerobic fermentation of animal waste which free of salmonella type microorganisms and parasitic nematodes, free of noxious odors, palatable to livestock, and economically competitive as an animal feed. In addition conversion of animal waste to biogas slurry eliminates its notorious role in polluting water and air. Biogas slurry can be used in animal feed with other feed ingredients having high palatability. During the fermentation process in the biogas digester there may be the production of microbial proteins, and several simple molecules in the usable form (Sikka, 2008).

In Bangladesh population and their demand are increasing for the improvement of their livelihood now a day. As a result land is decreasing due to industrialization and urbanization to meet up growing populations demand. Shortage of quality feed resources and nutrition are the main constraints to ruminant production in Bangladesh. Of the technologies developed to improve the nutritive value of crop residues, more attention has been given to chemical treatment of cereal straws than to supplementation (Devendra, 2001). On the other hand, environment specialists are concerned about the wastes disposal. The utilization of the waste as feed for ruminant became a convenient option of disposing of the waste (Mavimbela, 2000). Ruminant have the ability to digest low quality feedstuffs that are not usable by other livestock species. One such feedstuff is biogas slurry, which will be nutrient rich feed source. The cow dung and other wastes related to animal production are expensive to dispose safely. Feeding of biogas slurry is a means of disposing of waste products while concurrently supplying a low-cost protein feed to ruminant. Ensiling wet rice straw with biogas slurry and molasses will increase crude protein (Sarker *et al.*, 2018) and other nutritive value of the diet lowering the pH value and produce lactic acid producing bacteria which will facilitate the natural preservation. So, ensiling of wet rice straw along with biogas slurry and molasses may produce a good quality ensilage for feeding cattle having desire palatability, nutrient content and digestibility and also reduce the environmental pollution.

II. Ensiling

Ensiling is a natural preservation method used for both feed and food. Ensilage occurs under airtight, oxygen free conditions, mainly using lactic acid forming bacteria. The purpose of ensiling is to achieve a stable storage pH whereby the feed's nutrient value is retained. It can be done under anaerobic conditions in a structure known as silo. Silage furnishes high quality forage in any desired season of the year at a low expense. Silage conserves 85% or more of the feed value of the crop, whereas hay making will conserve significantly less percentage of nutrients. It is the most economic form in which the whole stalk of maize or sorghum can be processed and stored. The ensiling process kills practically

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all weeds that are present in the field because of their harvest before seed formation and thereby stopping dissemination of their seeds. It is a very palatable feed and slightly laxative in nature. Silage is the product formed when grass or other green fodder with sufficient moisture contents is stored anaerobically, typically in the silo after wilting, to prevent spoilage by aerobic microorganism. The fundamental principles of silage process are maintenance of anaerobic conditions throughout the ensiling and rapid decline in pH value by lactic acid bacteria. Silage is a better source of protein and of certain vitamins, especially carotene, and perhaps some of the unknown factors, than dried forage. It makes for less waste, the entire plant being consumed, which is an important consideration with coarse, stemmed forage. For production of a unit of quantity silage less space is required than dry fodder of the same quantity. . It helps to control weeds and which are often spread through hay or fodder. It reduces the occurrence of parasitic infestation to animal than directed grazing specially in low land (Banerjee, 1998). So, silage can be an effective means for ensiling the wet rice straw in Bangladesh for increasing utilization as animal feed.

Advantages of Ensiling:

Ensiling is the biological process of making the silage, where silage is the fermented feed resulting from the storage of high moisture crops. Utilization and preservation of by-products is especially important in developing countries, where most farmers are smallholder cattle owners and don't have enough capital to invest in modern means of making silage (Caluya, 2000; Chedly and Lee, 2000; Machin, 2000). Silages made of biogas slurry with forage, grain or other agricultural residues may offer other advantages such as enhancing the nutritive value of conventional or conventional feedstuffs, reducing effluent losses, dustiness and improving palatability (Islam and Hossain, 1990). There were no indications of harmful effects on humans consuming meat, milk or milk products from animals fed ensiled wet rice straw with biogas slurry. In addition, no disease problems were encountered from including biogas slurry silage in rations of growing cattle, sheep and kids and/or lactating cows and ewes (Fontenot and Jurubescu, 1981; Hadjipanayiotou, 1984). Therefore, preservation of forage crops would enable cows to be fed throughout the year, increase milk yields considerably and this might have a great economic and social impact in developing countries. There is a multiple benefit in the use of biogas slurry with wet rice straw for ensiling, providing animal feed, improving the quality feed, reduction of waste disposal cost and reducing environmental pollution.

III. Feed preservation and preservation techniques

Food preservation is the process of treating and handling food to stop or slow down food spoilage, loss of quality, edibility, or nutritional value and thus allow for longer food storage microorganisms. It consists of the application of science-based knowledge through a variety of available technologies and procedures, to prevent deterioration and spoilage of food products and extend their shelf-life, while assuring consumers a product free of pathogenic microorganisms.

General feed preservation techniques

Drying: Drying is the oldest method of food preservation. This method reduces water activity which prevents bacterial growth. Drying reduces weight so foods can be carried easily. Sun and wind are both used for drying as well as modern applications like Bed dryers, Fluidized bed dryers, Freeze Drying, Shelf dryers, Spray drying and commercial food dehydrators and Household oven. Meat and fruits like apples, apricots and grapes are some examples of drying with this method.

Freezing: Freezing is keeping prepared food stuffs in cold storages. Potatoes can be stored in dark rooms but potato preparations need to be frozen.

Smoking: Smoking is the process that cooks, flavours and preserves food exposing it to the smoke from burning wood. Smoke is antimicrobial and antioxidant and most often meats and fish are smoked. Various methods of smoking are used like Hot smoking, Cold smoking, Smoke roasting and Smoke baking. Smoking as a preservative enhances the risk of cancer.

Vacuum packing: Vacuum packing creates a vacuum by making bags and bottles airtight. Since there is no oxygen in the created vacuum bacteria die. Usually used for dry fruit.

Salting and Pickling: Salting also known as curing removes moisture from foods like meat. Pickling means preserving food in brine (salt solution) or marinating in vinegar (acetic acid) and in Asia, oil is used to preserve foods. Salt kills and inhibits growth of microorganisms at 20% of concentration.

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There are various methods of pickling like chemical pickling and fermentation pickling. In commercial pickles sodium benzoate or EDTA is added to increase shelf life.

Sugar: Sugar is used in syrup form to preserve fruits or in crystallized form if the material to be preserved is cooked in the sugar till crystallization takes place like candied peel and ginger. Another use is for glazed fruit that gets superficial coating of sugar syrup. Sugar is also used with alcohol to preserve luxury foods like fruit in brandy.

Lye: Lye also known as Sodium hydroxide turns food alkaline and prevents bacterial growth.

Canning and bottling: Canning and bottling means sealing cooked food in sterile bottles and cans. The container is boiled and this kills or weakens bacteria. Foods are cooked for various lengths or time. Once the can or bottle is opened the food is again at risk of spoilage.

Jellying: Jellying is preserving food by cooking in a material that solidifies to form a gel. Fruits are generally preserved as jelly, marmalade or fruit preserves and the jellying agent is pectin that is naturally found in fruit. Sugar is also added.

Potting: Potting is a traditional British way of preserving meat by placing it in a pot and sealing it with a layer of fat.

Jugging: Jugging is preserving meat by stewing it in an earthenware jug or casserole. Brine or wine is used to stew meat in and sometimes the animal's blood.

Burial in the ground: Burial in the ground preserves food as there is lack of light and oxygen and it has cool temperatures, pH level, or desiccants in the soil. Used to preserve cabbages and root vegetables.

Pulsed Electric Field Processing: It is a new method of preservation that uses brief pulses as strong electric field to process cells. This is still at an experimental stage.

Modified atmosphere: Modified atmosphere preserves food by operating on the atmosphere around it. Salad crops that are difficult to preserve are packaged in sealed bags with an atmosphere modified to reduce the oxygen concentration and increase the carbon dioxide concentration.

Controlled use of organism: It is used on cheese, wine and beer as they are preserved for a longer time. This method uses benign organisms to preserve food by introducing them to food where they make an environment which is not suitable for harmful pathogens to grow.

High pressure food preservation: It is a method that presses foods inside a vessel by exerting 70,000 pounds per square inch or more of pressure. This disables microorganisms and prevents spoilage but food retains its appearance, texture and flavor.

Modified Atmosphere Packaging: It extends the shelf life of fresh food products. The atmospheric air inside a package is substituted with a protective gas mix which ensures that the product will stay fresh for as long as possible.

Demerits of conventional feed preservation

Fresh food needs to be eaten right away even if refrigerated most fresh foods will not last longer than a week. Enzymes cause nutrient and color loss in fruits and vegetables. Frozen foods that are not properly packaged can pick up the smells of other items around it in the freezer. The longer feeds are stored, the lower the nutritional value. Vitamins B and C are lost in the freezing process. Antioxidants are also lower in frozen feeds than they are in fresh feeds. Processing foods often involves nutrient losses, which can make it harder to meet your needs if these nutrients aren't added back through fortification or enrichment. For example, using high heat during processing can cause vitamin C losses. Another example is refined grains, which have less fiber, vitamins and minerals than whole grains. Eating refined grains, such as those found in many processed foods, instead of whole grains may increase your risk for high cholesterol, diabetes and obesity (Newby *et al*., 2007).

IV. Rice straw ensiling

Chemical composition and nutritive value of straw

The nutritive value of a feed is generally assessed by its chemical composition, digestibility, and level of intake. Straw is one of the most available ruminant feeds in developing countries but it is classified as poor quality roughage because of its low nitrogen content, poor palatability, low digestibility, low

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intake, high fiber content and high insoluble ash (Table 01). A characteristic of straw is that it mainly consists of highly lignified cell wall material, which often constitutes up to 80% of the dry matter (Mahesh and Mohini, 2013). This consists of major proportions of cellulose, hemicellulose and lignin which occur in the ratio 4:3:3, respectively (Theander and Aman, 1984), while the rest comprises of nitrogenous compounds and ash. The cell walls are mainly built up of structural polysaccharides and lignin. Plant cell walls contain three types of structural polysaccharides, e.g. cellulose, hemicellulose and pectin polysaccharides. The cellulose of straw is associated with lignin forming lignocelluloses complex, which is highly indigestible. Lignin cannot be broken down in the rumen, even if it can be degraded there, it will not be able to provide the animal with energy (Schiere and Ibrahim, 1989).

Table 01: Proximate components and nutritive value of straw

Items	Chemical composition (kg/100kg DM)						Mcal/kg DM	
	CP	CF	NFE	EE	DCP	TDN	DE	ME
Rice straw	3.4	30.0	47.5	1.7	0.2	45.9	1.9	1.5
Wheat straw	3.2	34.9	43.8	1.5	0.1	48.4	2.1	1.7
Barley straw	2.2	47.4	41.4	0.9	0.8	46.9	2.0	1.7
Sorghum straw	3.8	35.6	51.0	1.3	1.2	56.4	2.5	2.0
Maize straw	3.6	33.2	51.9	0.8	-	-	-	-
Pearl millet straw	3.5	37.8	47.9	1.1	0.9	53.4	2.4	1.9

Source: Rahman *et al.* (2010).

Cell characteristics of straw

The nutritive value of treated straw will depend on the morphological components of the straw as well as the chemical composition, and the type and extension of the treatment. An important characteristic of straw is that it is composed of highly lignified cell wall material, which often constitutes up to 80% of the dry matter. Readily available carbohydrate, proteins are present in much lower amount in straw. The main limitation of straw as feed for animals is the low digestibility and this is because straw contains high fiber with low protein and also due to lack of available energy and essential minerals (Ca and P). Due to low digestibility animals will tend to eat less. According to El-Masry (1983) rice straw contains cellulose, hemicellulose and lignin at the rate of 43%, 20% and 16% respectively. Cell characteristics of different cereal straws are given in Table 02.

Table 02: Cell characteristics of some crop residues (Jackson, 1977)

Crop residue	Cell characteristics (g/100g DM)					
	Cell content	Cell wall	Cellulose	Hemicellulose	Lignin	Silica
Rice straw	21	79	33	26	7	13
Wheat straw	20	80	39	36	10	6
Oat straw	27	73	41	16	11	3
Barley straw	19	81	44	27	7	3

Devasia *et al.* (1976) reported that straw from the high yielding varieties showed higher percentage of CP, EE and lower concentrations of CF and NFE and ash as compared to the values for local varieties of rice. In contrast, Saadullah *et al.* (1982) observed no significant difference in respect of crude protein and ash contents among the different varieties of rice straw from Bangladesh. According to NRC (1984) ME values of rice straw and wheat straw are 1.70 and 1.74 Mcal per kg DM, respectively. The average gross energy (GE) is almost similar for rice and wheat straw. Straw is a poor quality feed, because it contains less than 7.5 MJ ME/kg DM (Blach, 1977). He also stated that rice straw contains 4.0, 1.8 and 1.48 of GE, DE and ME Mcal/kg DM, respectively. Egan (1987) stated that nutritive value of straws is highly influenced by stage of maturity at harvest, the method of grain harvesting and the post-harvest storage conditions. He also reported that variations in cutting height, growing conditions, harvesting and threshing procedures can results in large differences in the nature of leaf and stem material collected at the threshing site.

Advantages of Rice straw ensiling

Rice straw is highly fibrous residue having low protein (CP<3%) content. By ensiling process the lignocellulose bond of rice straw is loosen. It increases the crude protein and other nutritive value of

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the diet lowering the pH value and produce lactic acid producing bacteria which will facilitate the natural preservation. On the other hand, when straws are preserved as grass silage losses of the proteins, vitamins, and other nutrients are usually much smaller than when preserved as hay. Livestock can be induced to consume forage preserved in the form of ensilage that they will refuse to eat as hay. Thus, forage of poor quality is likely to be utilized more fully when preserved as ensilage than when made into hay. Considerably less space is required to store straw silage than to store loose hay. If equal amounts of dry matter were to be stored, it would require three to three and a half times more space for loose hay and almost twice as much space for baled or chopped hay as for grass silage. Furthermore, where adequate silo space isn't available, a good quality of straw silage can be made in pits, tranches, and stacks without excessive loss from spoilage.

Various ensiling process

Ensiling is a forage preservation method based on a spontaneous lactic acid fermentation under anaerobic conditions. The epiphytic lactic acid bacteria (LAB) ferment the water-soluble carbohydrates (WSC) in the crop to lactic acid, and to a lesser extent to acetic acid. Due to the production of these acids, the pH of the ensiled material decreases and spoilage micro-organisms are inhibited. Once the fresh material has been stacked and covered to exclude air, the ensiling process can be divided into 4 stages (Weinberg and Muck, 1996; Merry *et al.,* 1997).

Phase 1 - Aerobic phase. In this phase - normally taking only a few hours - the atmospheric oxygen present between the plant particles is reduced, due to the respiration of the plant material and aerobic and facultative aerobic micro-organisms such as yeasts and enterobacteria. Furthermore, plant enzymes such as proteases and carbohydrates are active during this phase, provided the pH is still within the normal range for fresh forage juice (pH 6.5-6.0).

Phase 2 - Fermentation phase. This phase starts when the silage becomes anaerobic, and it continues for between several days and several weeks, depending on the properties of the ensiled forage crop and the ensiling conditions. If the fermentation proceeds successfully, LAB develop and become the predominant population. Due to the production of lactic and other acids, the pH decreases to 3.8-5.0.

Phase 3 - Stable phase. For as long as air is prevented from entering the silo or container, relatively little occurs. Most micro-organisms of phase 2 slowly decrease in numbers. Some acid-tolerant micro-organisms survive this period in an almost inactive state; others, such as clostridia and bacilli, survive as spores. Only some acid-tolerant proteases and carbohydrates and some specialized micro-organisms, such as *Lactobacillus buchneri*, continue to be active at a low level. The activity of *L. buchneri* will be discussed in more detail later in this paper.

Phase 4 - Feed-out phase or aerobic spoilage phase. This phase starts as soon as the silage is exposed to air. During feed-out this is unavoidable, but it can start earlier due to damage to the silage covering (e.g. by rodents or birds). The process of spoilage can be divided into two stages. The primary spoilage stage is the onset of deterioration due to the degradation of preserving organic acids by yeasts and, occasionally, by acetic acid bacteria. This will cause a rise in pH, and thus the second spoilage stage is started, which is associated with increasing temperature, and activity of spoilage micro-organisms such as bacilli. The last stage also includes the activity of many other (facultative) aerobic micro-organisms, such as moulds and enterobacteria. Aerobic spoilage occurs in almost all silages that are opened and exposed to air. However, the rate of spoilage is highly dependent on the numbers and activity of the spoilage organisms in the silage. Spoilage losses of 1.5-4.5% DM loss per day can be observed in affected areas. These losses are in the same range as losses that can occur in airtight silos during several months of storage (Honig and Woolford, 1980).

V. Biogas slurry

The mixture of dung and water which enters the biogas plant in semi liquid form is called biogas slurry. The undigested slurry undergoes a series of anaerobic digestion processes or fermentation in a biogas digester and is converted into combustible gas called "biogas." The residue of the fermentation comes out as sludge which is known as "digested bio-slurry."

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Digested dung slurry as feed for farm animal
The composition of bio-slurry depends on the feeding and the amount of water added to the dung. When the dung is mixed with equal amounts of water, after digestion the composition of slurry is recorded as: water 93% and dry matter 7%. The Nitrogen (N), Phosphorus (P) and Potassium (K) are the most required nutrients to the plants. NPK content in liquid slurry is 0.25%, 0.13% and 0.12% respectively. The chemical composition and nutritive value of cow dung and digested dung slurry are higher than those of very common feed ingredients such as rice straw, wheat bran, maize or rice polishes few of its CP content and much comparable with ideal complete feed for cattle (Table 03).

Table 03: Chemical composition and nutritive value of cow dung and digested dung slurry

Common name	Chemical composition (%) DM basis						
	CP	CF	EE	NFE	Ash	Ca	P
Cow dung	8-18	25-52	1-3	14-48	3-21	0.9-5.3	1.6
Digested dung slurry	16-20	22.5	1.2	32	29.1	1.5	1.0

Source: Koriath, (1975).

It can be speculated that dung slurry may be used as the replacement of these feed ingredients several reports showed that biogas slurry can be fed to the animal as chief unconventional source of protein (Sikka, 2008). In growing large white Yorkshire pigs 20% of biogas slurry could be incorporated in the diet replacing maize and rice bran on nitrogen equivalent basis (Sikka, 2008). At Maya farms in tile Philippines solids of biogas slurry are recovered in settling tanks and dried in the sun. The feed material from the sludge provides 10-15% of the total feed requirement of pigs and cattle, and 50% for ducks. At this concentration weight gain was higher in pigs than a control group (Maramba, 1978). He also found that dried sludge could be substituted in cattle feed with satisfactory weight gains and savings of 50% in the feed concentrate used.

The major effects that have been observed from feeding of liquid slurry have been an apparent decrease in the digestibility of-dry matter, N, ash and gross energy (in sheep) and decreased total ruminal volatile fatty acid concentration in cattle (Wise, 1981). Because of the low efficiencies and the high capital and operational costs associated with centrifuging (Hashimoto *et al.,* 1981), other methods to recover the nutrients in the biomass were investigated. Hashimoto *et al*., (1981) found negative effects on consumption. On the other hand, Marchaim *et al*. (1981), used process effluent of much higher solid content (up to 12%) and found that 25% of the total dry matter in the diet of Holstein heifers can be replaced, while retaining normal performance. Experiments with feeding calves were continued in Israel, and showed a saving of 20-30%. This could be done only when a cheap source of metabolic energy is used (e.g. grain dust): when corn or grains have to supply the missing energy, the saving is lower. This was more pronounced when beef cattle were fed up to 25% dry matter of digested slurry, and gained a little less weight. The main reason for that is probably the adaption period of the cattle to the diet, influencing performance.

Utilization of farm wastes as animal feed
A large quantity of waste is generated at dairy and poultry farm. These wastes may create public health problems. Transmission of infectious diseases to other animals and humans, environmental pollution and health effects through feeding of the raw wastes are identifiable problems (Smith, 1971). The wastes may be sources of contamination to water supplies and a risk to human health and comfort, unless they are handled judiciously. However, the wastes contain nutrients which may be utilized by plants and animals. In the past animal wastes have been used mainly as fertilizer, but at least under some economic conditions the plant nutrient value of the wastes is not high enough to justify the cost of hauling and spreading (Wadleigh, 1968). Furthermore, land disposal or use as fertilizer may be difficult, if not impossible, for large concentrated animal production systems. Since wastes have nutritional value for certain phases of animal production, feeding should be a more economically feasible approach than disposal or use as fertilizer. The relative value of the nitrogen in animal waste is higher if used as feed than fertilizer (Fontenot and Jurubescu, 1980). Cattle manure can be fed either in dry form, chemically treated fresh manure or ensiled with forages, crop residues and other feed ingredients or wastes (Albin *et al.,* 1975). The requisites for utilization of farm wastes are (a) nutritive value, (b) safety to animals, and (c) the safety of animal products consumed by humans and the economic and technical feasibility of re-feeding is assured (Smith, 1973).

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Proper utilization of biogas slurry

Biogas slurry is a by-product obtains from the biogas plant after the digestion of dung or other biomass for generation of methane rich gas. It supplies essential nutrients, enhance water holding capacity, soil aeration, accelerates root growth and inhibit weed seed germination. It contains appreciable amounts of organic matter (20 to 30%) (Khan *et al.*, 2015). Biogas slurry proved to be of high quality organic manure compared to the FYM, digested sludge tends to have more nutrients. However, nutrients in FYM, especially nitrogen, are lost by volatilization when exposed to sunlight (heat) and by leaching due to rain. It can be used as ensiling with wet rice straw for increasing the protein content and metabolizable energy of wet rice straw. After being stored for a few days or mixed in a 1:1 composition with water, bio-slurry can be applied directly to vegetables or fruit crops around the household. Bio-slurry application along with installation of regular irrigation channels is beneficial for the growth of vegetables especially root vegetables, paddy, sugarcane, fruit trees, and nursery saplings. Mushroom cultivations also benefits greatly from bio-slurry application.

VI. Conclusion

Preservation of feed is very important to improve the nutritional contents. For wrong preservation of feed, the nutritional value of feed is damaged and on the other hand, animals are affected by its baleful effects. Therefore, ensiling is a good preservation technique to increase the nutrient contents of the low quality feed (e.g. wet rice straw) and to reduce the waste disposal cost and environmental pollution as well.

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