Recycling Banana byproduct for production of low input cost Silage

Introduction

In high banana production and processing countries, tons of byproducts are wasted annually, thus creatinges an opportunity for livestock farmers that are close to this extensive plantations. Many of these organic materials contain a potential for the reduction of malnutrition of livestock production. The nutritional composition of banana fruits are presented in table 1. Some limiting factors need to be taken in consideration like the low protein content and high water moisture. Although the low protein and high water moisture can be minimized through adjustments in the formulation of the smaking a silage or by adding a complements to the banana byproduct silage that will be discussed in the feeding value section. The purpose of this article is to find the potential of banana byproduct as a sustainable low cost alternative to reduce the malnutrition that many farmers face in developing countries.

Many smallholders who rely on livestock as a mainstay are not looking for commercial markets, but instead, they are focused on survival. They face many feeding challenges: high cost of animal feed, limited availability of quality forage, and growing incidence of animal diseases (Clarisse Umutoni, Augustine Ayantunde and Germain Jérôme Sawadogo, 2015). The barriers inhibit them to obtain benefits of a growing livestock industry. It is time to find a sustainable livestock production that will allow farmers to obtain a good quality feeding that is accessible and easy of implementing. According to the FAO, approximately 25% of global banana production originates in Latin America and the Caribbean. In 2019, in 1,000 metric tons, the distribution of productions was as follows: South America produced 17,591, Central America produced 10,144, and the Caribbean 1,999 (Statista, 2019). Banana industries generate high amount of wasted biomass every year due to the high export standard. It is estimated that 220 tons of by-products are produced per hectare annually (Shah et al. 2005); indeed it requires an innovative idea to turn these readily available resource into a value added products. This abundance of bananas waste as a ¨fruit of rejection¨ raises a question such as “What can be done with the large volumes of fruit rejection? Although the harvest happens when the fruit is green or immature, banana ripe rapidly during exportation because they use a chemical compound called ethylene. Those situations will accumulate the rejected banana biomass and even generate environmental issues (Essien et al. 2005; Shah et al. 2005; Yabaya and Ado 2008). Therefore, proper agricultural waste management practice on banana waste is required.

A solution is to use the byproducts of banana in animal feeding in two possible ways: one way is a direct form (chopped in fresh state) and the other, by storage of the raw material, with which ensures the stability of the product and its continuous availability. In the last case, a common process of conservation of forage is silage. Silage supplies the feeding in times of scarcity preserving the quality and palpability at low cost (Garcés et al., 2004). Incorporating additives such as molasses to silage is optional, although it is a way to ensure a good conservation and enhance high quality of any ensiled feed resource (Kayouli & Lee 2000). The conservation method includes a process of acidification that blocks the proteolytic action of plant enzymes to inhibit microbial growth (Gouet, 1995). Ensiling success will depend on the level of lactic microflora of lactic microflora and the richness of the substrate in the fermentable carbohydrates (Lowrie and Wells, 1991).

The productivity of domestic livestock needs improvement through utilization of high quality feed to overcome the current undernutrition issue. As an easy solution, feed grains are imported to supply the nutritional demand for milking cow’s total mixed ration. The imported

raw materials take 50-60% of production costs in the dairy sector (León 2009, Castro 2012, González 2013) and this is not sustainable. Since high quality feeding ingredients are limited and expensive, it is necessary to enhance utilization of less expensive existing resources (Ulloa, 2004). This approach will reduce the current high dependency on the expensive imported feed (soy, corn, etc.). Banana byproducts or banana waste have great potential as a raw material for livestock feeding in the banana producing countries.

Although there is a high amount of byproduct, there are also limiting factors. The banana's individual banana parts constitute unbalanced feeding because they are highly fibrous in the leaves, stems and bunch. The second limiting factor is about the availability restricted to the banana-harvesting period, and the last factor ~~. Another one~~ is the high moisture content of the banana. It is necessary to take in consideration these limiting factors before making a banana byproduct silage to avoid spoiling.

Table 1. Nutritional Value of Banana fruit in 100 gr

Components	Amount
Water (g)	58-80
Fiber (g)	0.3-3.4
Sugar (g)	15.1-22.4
Fat (g)	0.4
Proteins (g)	1.1-2.7
Calories (Kcal)	77-116
Ascorbic Acid (mg)	0-31
Carotenes (mg)	0.04-0.66
Thiamine (mg)	0.02-0.06
Riboflavin (mg)	0.02-0.08
Niacin (mg)	0.04-0.08
Folic Acid (Ug)	10
Pyridoxine (mg)	0.5
Vitamin A (IU)	190
Calcium (mg)	22
Iron (mg)	0.4-1.6
Phosphorus (mg)	29
Sodium (mg)	1
Tannins (mg)	122.6-241.4
Potassium (mg)	370

Source: SEA, 2007

Nutritional Value of Banana leaves and pseudostem

The pseudostem is the part of the banana plant that looks like a trunk. The pseudostems haves ~~s~~ a digestibility on ruminants of ~~a~~ 75% and the leaves have ~~a~~ 65%, a significant difference of 10% favorable to the pseudostem (Kimambo et al. 1991). The digestible energy of the different parts of the plant figures between 2.3 to 3 Mcals of digestible energy/kg of DM, which is quite acceptable to integrate a diet in dairy farms. As the pseudostem is not really a stem, the content of lignin in the cell wall and of polyphenols is lower than in a solid stemmed plant, and this is reflected in a greater ruminal degradability (Boschini, Russo, Chacon et al. 2015).

The leaves contain a high amount of polyphenols, close to 8% of the DM, a greater valuevalue greater than the one detected in the pseudostem. However, the amount of condensed tannins is low (Nogueira et al 2012). The leaves have been observed to have anthelmintics properties, associated with the amount of terpenoids and flavonoids. This ability has been observed in cattle, goats and sheep (Oliveira et al. 2010).

In dairy cows production, it is recommended to include banana leaves in the total diet up to a 15% on a dry basis, without affecting digestibility and production. The pseudostem can be included in the diet up to 25% on a dry basis. Given the high content of potassium, higher inclusion levels increases the speed of the food´s pace through the digestive tract, decreasing the total diet digestibility and consequently a gradual decrease in milk production (El-Ghani 1999).

Silage making process

The principles of ensiling byproducts do not differ from the conventional silage. One of the most critical steps in ensiling is to keep the anaerobic conditions by ensuring airtight sealing. Table 2 shows the chemical composition banana has. Banana leaves can be ensiled without any additives or with fish waste, cassava leaves, poultry litter and dried pomace to balance the low protein content. Another critical factor for a production of high quality silage is to lower the pH of banana waste through sufficient amount of lactic acid. If banana waste material is low in sugar, molasses can be added. The declined pH suppresses the proliferation of undesirable microorganisms in the silage. The optimum moisture content for ensiling ranged from 40 to 60%, however, depending on silo type, the moisture content in ensiling material maycan vary. However, tight packing is much easier within the optimum moisture range. The moisture content out of the range can cause spoilage by the pathogenic microorganisms such as clostridia. A spoiled silage always reduce the intake of the animals. The high moisture content in the bananas waste needs some additives, which can absorb moisture and boost protein content.

As the conventional silage, the length of banana waste needs chopping to make the particle size around two cm. Chopping the bananas waste can be done manually or with a stationary forage chopper. Rapid filling and sealing silo are also critical as previously addressed to remove air. Fermentation make the silage stable with low pH. The pH is an important index showing the acidity of the silage and keep the silage contamination by clostridia.

Common types of Silos

Silo in plastic bags

It should be sealed and tied for more security. The bags should be stacked in a pyramidal shape, on a platform that protects the bottom part and cover the bags. It is recommended that for a permanent silo sites its base is hard and impenetrable (Garcia, 2017).

Silo with walls

The most common models have to, three or four walls. The ideal version, silo is covered with a polyethylene cover and protected with a roof. The most pragmatic and economical method is to build two parallel walls, supported by one end at right angles to an existing wall. In general, silos with walls are less demanding regarding the DM content of the forage, since drainage systems for effluent can be incorporated, along with an inclined plane at the bottom of the silo (García, 2017).

Feeding Value of Banana Silage

According to De la Cruz and Gutierrez (2006) the use of banana silage (banana – rachis) in the proportion of 50:50 and 75:25 allows a daily weight gain of more than 1 kg per day in Cebu cattle during 120 day trial. In addition, of the silage, a ratio of 1.1 kg/head/day of soybean meal or pasta plus ~~a~~ 50 g of a premix of common salt and minerals was given to the cattle. The results of banana silage were better than the elephant grass weight gain (0.670 kg).

Faubula and Ponce (2016) concluded that the treatment inoculated with Saccharomyces cerevisiae is the most adequate for animal feed, since it presented a higher percentage of protein (6.91%) and inorganic matter (10.53%) with respect of the control. The microorganisms they tested were, bacteria: Lactobacillus plantarum, Bacillus subtilis; yeast: Saccharomyces cerevisiae; mushrooms: Trichoderma harzianum. The ratio of the silage consisted of 69.3% of green banana, 14.7% of molasses, 16% of water and 2% of the different microorganism.

Toala (2018) elaborated a banana peel silage using efficient microorganisms: molasses, Starlite (humic acids), Microcompostic (decomposing bacteria) and Humiling 25 plus (humic acids). He concluded that the greatest feed of consumption in bovines was with the treatment with molasses and Starlite with 10% and 9.5% using Tukey´s range test. With regard to physical organoleptic factors, the molasses and Starlite presented better characteristics at the level of shell texture in decomposition, a yellowish brown color and a pleasant sweet vinegar smell. The formula with molasses was 3L of water, 3 lb of molasses, and 66 lb of banana peel. The formula with Starlite was 3L of water, 3 lb of molasses, 250 cc of Starlite, and 66 lb of banana peel.

Foulkes and Preston (1977) found out that by using a ratio of 4:1 of stem and leaf to simulate the natural proportions of the forage component (after harvesting the fruit), the digestibility of the forage was 70.2%, and the voluntary consumption index was 2.06 ± 0.03 kg DM/100 kg live weight/day (Espejo et al 1978). The purpose of this experiment was to obtain more information about the digestibility's and voluntary intakes of different proportions of leaf and stem, and compare the results with those of the whole mature plant without fruit.

Potential of Banana Silage

Research indicates some potential of banana silage as following (*et al.,* 1994; Bouqué and Fiems, 1988; Hadjipanayiotou, 1993, 1994).

- Banana waste is available throughout all year
- Expand feed resource availability in banana producing countries
- Provide a recovery period for pasture
- Provide energy dense feed during the dry season
- Secure alternative and economical feeding resource
- Provide an environmental solution for the banana waste pollution

Conclusion

Farmers need an approach for lowering feed cost and recycling of banana waste can be one of the solutions since the banana waste is abundant year-around. Recycling banana waste as a nutritious silage requires some adjustments in the contents of moisture, minerals, and

protein. Therefore, obtaining additives for achieving lactic fermentation should be made considering seasonal availability. Banana byproduct silage will be a promising alternative feed for livestock, lowering feed costs.

Table 2.

Chemical composition of banana waste silage

	Green 3 to 5 days after picking	**Ensiled green**	**Ripe**	**Ensiled ripe**
Physical composition		% DM		
Banana peelings	20		18	
Banana pulp (pseudostem)	80		82	
Chemical composition				
	21.2	29.0	21.7	23.5
Crude fibre	3.7	5.3	3.8	6.1
Crude protein	6.4	3.8	5.3	8.1
Soluble sugars†	1.8	0	73.6	17.3
Starch	72.3	70.9	3.4	6.8
Ash	4.6	3.8	5.2	5.7
pH		4.2		3.8
Lactic acid (g/% DM)		5.3		10.1
Volatile acidity (g CH_3 COOH/100 g DM)		1.8		3.0
Ethanol		0.2		2.3
Losses as percentage of ensiled dry matter		13.5		33.9

.SOURCE: Le Dividich, Sève and Geoffroy, 1976.

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