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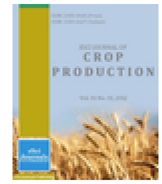

NUTRITIONAL QUALITY AND COST OF PINEAPPLE AND KING GRASS FORAGE BLENDS FOR THE SAN CARLOS REGION OF COSTA RICA

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A B S T R A C T

There is an increasing interest in nontraditional feeds for livestock as more livestock are being raised within tropical climates. This study was conducted in May of 2010 in the San Carlos region of Costa Rica to evaluate new and novel feeds, such as pineapple (*Ananascomosus*) and king grass (*Pennisetumpurpureum*Schumach) forage blends, as an alternative to the traditional feeds offered. The study was designed to provide a nutritional and cost assessment of two new feeds, ensiled pineapple waste and ensiled king grass, blended with soybean (*Glycine max*) meal, citrus *(Citrus sinensis*) pulp and rice (*Oryza sativa*) hulls to achieve three different levels of crude protein with a moisture content of 68%. The overarching objectives were to find alternative feeds for cattle that could be produced sustainably and economically. In conclusion, it is likely more advantageous to include pineapple waste as part of a feeding system because of its relatively lower ingredient cost.

Keywords: Feed cost, forage, king grass, pineapple.

INTRODUCTION

Costa Rica is a tropical country where the climate conditions are divided into three slopes. The Caribbean slope influences the North and Atlantic regions and is characterized by no definite seasons with intermittent rainfalls during the dry months, and high rainfall during the wet months (Solano & Villalobos, 2001). The second sloped area is the Central Intermountain region and is influenced by the Central Intermountain Valley and South region. Finally, the Pacific slope is influenced by the Pacific North, Central, and South region, and has a definite dry and wet season (Solano & Villalobos, 2001).

The San Carlos area is located in the North region, which is influenced by Caribbean slope weather, where the rainfall average oscillates between 3600 mm to 8000 mm per year, with minimum temperature of 17°C and maximum of 24°C (Solano & Villalobos, 2001). This climate allows for good forage growth in pastures with favorable sunshine, rainfall and evapotranspiration conditions from May through September. However, unfavorable weather is present from October through April leading to the potential of over-grazing, which could negatively affect forage yield within the pastures. Thus, it is important to find ways to store forage during the months when unfavorable weather seasons exist, especially for warm season species (Vendramini*et al*., 2010). One of the overall goals for producers is to find alternative feed sources in Costa Rica to allow lower cost, and sustainable sources of feed ingredients for cattle.

Increasing milk yields is a goal that is a constant challenge for dairy producers in tropical climates due to lower forage quality and high temperatures (Guggenberger&Zech, 1999; Ibrahim *et al*., 2000). In addition, there is a dependence on importation and expensive supplements of proper feedstock and constraints that weather has on pasture growth during the year. The improvement in pasture, forage technology and the availability of by-products from crops like pineapple (*Ananassativus*), banana (*Musaspp.*) or orange, (*Citrus sinensis*) have been supporting the development of intensive dairy farms system in the tropical and subtropical zones (Cowan, 1999).

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However, the poor drying conditions due to weather in San Carlos limits the capacity of storage of dry by-products or hay that can be handled. As a solution for limited forage potential, silage and haylage are alternatives to conserving wet dairy feed in areas where difficult weather conditions exist as reported by Vendramini*et al*.(2010), working in similar climates in sub-tropical areas of Florida, USA. In addition, the silage technology has been developing in Costa Rica in order to help with harvesting and storage of the excess growth of forage on the farms. By-products from industrial foods companies are now being utilized to feed cows during the unfavorable weather season in order to move waste away from the facilities quickly and also to benefit the producer.

The by-products from the pineapple crop in Costa Rica are options for a relatively low cost supplemental feed that can be incorporated into cattle rations and reduce the negative impact of pineapple waste in the environment simultaneously. Pineapple production in Costa Rica has been increasing in recent years, where total production is 48.5 ton/ha (SIIM, 2010). This economic activity generates large amount of pineapple waste, which represents 65% of total fruit production (Araya, 1998). However, the inadequate management of pineapple waste has caused environmental pollution. The unusable parts of the pineapple fruit include, pineapple tops, leaves, core, and skin, which are currently being discarded as waste (Kellems*et al.*, 1979). Most Costa Rican dairy farmers have been using skin and pulp of pineapple waste to feed directly to their animals with successful results in production and increase of body condition of animals; however, by-products of pineapple are not always available due to the seasonal harvest cycle, because pineapple productivity is influenced by climate conditions (Malézieux& Bartholomew, 2003).

One alternative to take advantage of cheap pineapple waste is storage as silage and incorporation into feed rations. Producing silage offers an option to preserve the pineapple waste, including the leaves as previously researched by Shiroma& Nakamura (1975), who investigated the potential possibilities. The older leaves are used in fewer amounts to produce the silage because they are now being used more and more for composting to create organic fertilizer; but these by-products could offer a good alternative as forage supplement to feed dairy cow if utilized for forage. Kellems*et al*. (1979) reported that the pineapple leaves (PL) (fresh forage) contain 14.48% of dry matter (DM), 6.41% of crude protein (CP) and 4.48 kcal/g of gross energy with an estimated digestibility energy of 3.31 kcal/g and 730 kg/ha of starch (Shiroma& Nakamura, 1975). In addition, Herrera, Jones & Rojas-Bourillon (2009) studied the fermatation and quality parameters of microsilages of pineapple straw (leaves, shoots, and stems) and determined that is an alternative for ruminant animal supplementation due to its nutritional profile.

An additional important forage resource option that has been successful in Costa Rica is the king grass (KG) (*Pennisetumpurpureum*Schumach) which could potentially help to meet forage demands of cattle during the poor forage production season (Araya &Boschini, 2005) and has medium levels of CP at 8.5% (Chacon-Hernandez & Vargas-Rodriguez, 2009). This research allowed us to determine the nutritional and cost impacts of pineapple and king grass silage blends in San Carlos, Costa Rica. The overarching objectives were to find alternative feeds for cattle that could be produced sustainably and economically with the intentions that the second phase of this research would review the acceptance of these feed combinations when offered to dairy cattle.

MATERIALS AND METHODS

In early March of 2010 in the San Carlos region of Costa Rica, several different feedstuffs were collected and mixed in order to create silage blends with high nutritional values to meet cattle nutrition requirements. The six blends formulated consisted of three with pineapple leaves as the main feedstuff and three with king grass as the main feedstuff. Three different pineapple silage blends were formulated, namely PL1 which is PL Blend 1 – High CP, PL2 which is PL Blend 2 – Low CP, and PL3 which is PL Blend 3 – Medium CP. Three king grass silage blends were formulated namely KG4 which is KG Blend 4 – High CP, KG5 which is KG Blend 5 – Low CP, and KG6 which is KG Blend 6 – Medium CP. Pineapple leaves, which consisted of both pineapple crowns and green leaves from the full plant, and the king grass forage, were collected and mixed with, soybean meal, by-product of the industrial process of tropical fruits which consisted of post-production orange and pineapple pulp and stump, and rice (*Oryza sativa*) hulls (Table 1 and Table 2). The soybean meal was used as a direct source of crude protein and the rice hulls were included to decrease the moisture provided by the fruit by-products. After the formulas were finished the main feedstuffs were sent through a farm chopper twice in order to obtain a particle size from 1-3 cm. All the forage samples were tested for moisture content in the field using the vortex dryer method. All six blends were co-ensiled for 60 days. The blends were created in order to find the optimum CP blend for animal nutrition. Additionally, each blend was determined by the CP percent with all intentions to have a high, medium and low CP blend.

The feedstuffs were individually weighed using a hanging scale and placed in a large drum. Once all the ingredients for the blend were placed in the drum it was mixed thoroughly with a pitchfork and shovel. Following the blending within the drum the mixed feedstuffs were then dumped on a large tarp in which five people mixed the silage by hand and made sure there were no clumps. Once the silage was determined to be thoroughly blended the large batch of 36.28 kg was divided into 4 replications of 9.07 kg each. These 9.07 kg batches were placed within a 3 ml trash compactor bag and then placed inside a Rubbermaid Tupperware container. The blend was then compacted by the weight of a 70 kg person for several minutes in order to ensure compaction. Once compaction was determined to be sufficient an industrial dry vacuum was used to suck out all the air from the bag and the bag was quickly zip tied. Once the oxygen had been removed from the bag and zip tied it was then flipped and bagged again at which point it would have the oxygen removed once more and zip tied. This procedure was repeated a third time in order to minimize the risk of aerobic exposure and rodents chewing through the bags. This method was done for all ensiled research bags. The bags were then safely placed in a small barn and covered to minimize exposure to any pests. The bags were left to ensile for 60 days.

Cost of Production: Relatively high milk prices in Costa Rica have been advantageous to dairy farmers. However, the cost of milk production has been increasing due to high feed costs and dependence on imported corn and soybean feedstuffs to support milk production. Furthermore, variability in forage production to support grazing systems causes management challenges for dairy farmers and other livestock producers in tropical regions. Livestock producers have been seeking new feed options in order to increase farm profits. To determine the quality and economic impact of the pineapple and king grass silage on the dairy profitability, all 6 total blends, consisting of PL1, PL2, PL3, KG4, KG5, and KG6 were evaluated.

The cost of production for mix PL1, PL2, PL3, KG4, KG5, and KG6 were estimated using the prices and quantities of each of the feed ingredients in each mix. The equation used to determine the blend cost was

$$\frac{\sum_1^N \left(FSA_j \times FSP_j\right)}{FSA_j}$$

where, FSA_j= amount of feedstuff *j* (in kilograms), and FSP_j= price of feedstuff *j* (in dollars per kilogram) for *j* = 1 to N, where N is the total number of feed ingredients in the silage mix. The feedstuff prices were the current prices in Costa Rica. Table 4 shows the amount by each feedstuff used in the blends. Table 5 shows the price of each feedstuff. To determine the blend price, the amount by each feedstuff used in the blend was multiplied by each feedstuff prices. The result of those multiplications were added and divided by the total blend amount in order to obtain the blend cost per kilogram.

RESULTS AND DISCUSSION

Table 1 displays the forage analysis profile for the PL and KG silage blends, PL1, PL2, PL3, KG4, KG5, and KG6.

Pineapple silage: Table 2 shows the quantity and nutrition of the feed resources used to formulate the pineapple silage blends. The nutritional values results of the actual developed blends with pineapple leaves as main feedstuff are shown in Table 1. The DM of PL1, PL2, and PL3 were 28.53%, 22.85%, and 22.95%, respectively. The CP of pineapple leaves silage for PL1, PL2, and PL3 were 20.53%, 12.65%, and 16.9% for silage blends PL1, PL2, and PL3, respectively. The CP levels in PL1, PL2, and PL3 were much higher than previously reported by Rani and Nand (2004) who report a CP of 4.8% after 30 days of ensiling and Van Soest (1994) who mentioned 4.6% CP in pineapple bran. Pineapple silage mixed with soybean meal and rice hull was a maximum 20.53% of CP in PL1.

King grass silage: Table 3 shows the quantity and nutrition of the feed resources used to formulate the king grass silage blends. The nutritional values results of the actual developed blends with king grass as main feedstuffs are shown in Table 1. Within Table 1, the DM of the king grass silage was 19.1%, 23.45%, and 22.07% in the blends 4-high, 5-low, and 6-medium, respectively. The CP of king grass silage blends was 14.85%, 11.25%, and 11.52% for blends KG4, KG5, and KG6, respectively.

Table 1. Forage analysis profile of pineapple and king grass blends.

	PL Blend 1-High CP (PL1)		PL Blend 2-Low CP (PL2)		PL Blend 3-Med CP (PL3)		KG Blend 4-High CP (KG4)		KG Blend 5-Low CP (KG5)		KG Blend 6-Med CP (KG6)	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Moisture (%)	71.4667	0.7572	77.1500	2.0506	77.0500	0.6364	80.900	0.2828	76.5500	3.2088	77.9500	2.5632
Dry matter (%)	28.5333	0.7572	22.8500	2.0506	22.9500	0.6364	19.100	0.2828	23.4500	3.2000	22.0750	2.5158
pH	4.9333	0.0577	4.600	0.000	4.9500	0.0707	5.100	0.1414	5.1500	0.1291	5.4000	0.7746
As % of dry matter												
Crude protein (CP) (%)	20.5333	2.967	12.6500	2.1920	16.9000	1.5556	14.85	1.9092	11.2500	0.5916	11.525	0.3775
Calcium (%)	0.3033	0.0208	0.3000	0.0000	0.3900	0.0707	0.2300	0.0000	0.1800	0.0082	0.2100	0.0346
Phosphorus (%)	0.3167	0.0153	0.1800	0.0141	0.2500	0.0141	0.2600	0.0000	0.1850	0.0058	0.1975	0.0222
Lactic acid (%)	0.1267	0.0907	0.1250	0.0778	0.1250	0.0354	0.085	0.0354	0.1100	0.0258	0.1000	0.0183
Acetic acid (%)	8.5800	0.3291	7.375	0.4172	8.3905	1.7748	7.3800	0.2404	4.965	0.554	5.5075	2.2196
Lactic/acetic ratio	0.0167	0.0153	0.0200	0.0141	0.0150	0.0071	0.0150	0.0071	0.0225	0.0050	0.0175	0.0050
Propionic acid (%)	1.3667	0.2371	1.3100	0.1131	2.2850	0.1626	1.7800	0.2546	1.3975	0.1826	1.3100	0.2724
Butyric acid (%)	0.0433	0.0058	0.1000	0.0141	0.0900	0.0141	1.9300	0.9334	0.4050	0.2923	0.8025	0.5214
Iso-Butyric acid (%)	0.0967	0.0058	0.0600	0.0000	0.0900	0.0000	0.1900	0.1156	0.0700	0.0408	0.0975	0.0359
Total acids (%)	10.1967	0.1930	8.9700	0.4384	10.985	1.5768	11.3750	1.5486	6.9450	0.8372	7.8175	2.0304
Amm-N % of total N	14.3333	6.3509	13.5000	3.5355	18.0000	4.2426	31.5000	14.8492	19.7500	5.1235	25.0000	8.7178
IVTD 48hr, % of DM	51.0000	1.7321	44.5000	0.7071	49.5000	2.1213	45.5000	2.1213	44.2500	1.8930	41.0000	4.0825
Ammonia (%)	2.8267	1.0205	1.6550	0.0919	2.9850	0.4596	4.5350	1.5486	2.2200	0.5271	2.8350	0.9236
VFA Score	1.2545		0.3613		2.3100		0.8475		1.8643		1.7305	

Table 2. Quantity and quality nutrition of feed resources used to formulate the pineapple silage blends

	Pineapple leaves blends														
	PL Blend 1-High CP (PL1)					PL Blend 2-Low CP (PL2)					PL Blend 3-Med CP (PL3)				
	PL	**RH**	**SM**	**B-P**	**FB**	**PL**	**RH**	**SM**	**B-P**	**FB**	**PL**	**RH**	**SM**	**B-P**	**FB**
COMP %	67.01	5.15	17.53	10.31	100.00	68.75	2.50	16.25	12.50	100.00	62.50	5.00	20.00	12.50	100.00
DM %	9.10	15.64	4.50	1.20	31.00	7.70	11.96	1.80	1.20	28.00	7.00	14.72	3.60	1.20	33.00
CP %	8.69	2.43	48.00	4.74	12.00	8.69	2.43	48.00	4.74	9.00	8.69	2.43	48.00	4.74	11.00
NDF %	60.34	75.75	-	63.84	-	60.34	75.75	-	63.84	-	60.34	75.75	-	63.84	-
ADF %	34.71	56.57	-	40.87	-	34.71	56.57	-	40.87	-	34.71	56.57	-	40.87	-
Lignin %	10.96	16.61	-	6.22	-	10.96	16.61	-	6.22	-	10.96	16.61	-	6.22	-

percent of each feed resource used in the blends (COMP), percent dry matter (DM), percent crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), pineapple leave (PL), rice hulls (RH), soybean meal (SM), by-product (B-P) is from the industrial process of tropical fruits which consisted of post-production orange and pineapple pulp and stump, fresh blend (FB).

Table 3. Quantity and quality nutrition of feed resources used to formulate the king grass silage blends.

	King grass silage blends														
	KG Blend 4-High CP (KG4)					KG Blend 5-Low CP (KG5)					KG Blend 6-Med CP (KG6)				
	KG	RH	SM	B-P	FB	KG	RH	SM	B-P	FB	KG	RH	SM	B-P	FB
COMP %	69.77	12.79	5.81	11.63	100.0	68.75	16.25	2.50	12.50	100.0	62.50	20.00	5.00	12.50	100.
DM %	8.40	10.12	4.50	1.20	28.00	7.70	11.96	1.80	1.20	28.00	7.00	14.72	3.60	1.20	33.00
CP %	5.79	2.43	48.00	4.74	14.00	5.79	2.43	48.00	4.74	9.00	5.79	2.43	48.00	4.74	11.00
NDF %	70.96	75.75	-	63.84	-	70.96	75.75	-	63.84	-	70.96	75.75	-	63.84	-
ADF %	45.38	56.57	-	40.87	-	45.38	56.57	-	40.87	-	45.38	56.57	-	40.87	-
Lignin %	5.07	16.61	-	6.22	-	10.96	16.61	-	6.22	-	10.96	16.61	-	6.22	-

percent of each feed resource used in the blends (COMP), percent dry matter (DM), percent crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), king grass (KG), rice hulls (RH), soybean meal (SM), by-product (B-P) is from the industrial process of tropical fruits which consisted of post-production orange and pineapple pulp and stump, fresh blend (FB).

Table 4. Quantity of feed ingredients used in the different blends (as fed).

	Pineapple			King grass		
	PL Blend 1- High CP (PL1)	PL Blend 2- Low CP (PL2)	PL Blend 3-Med CP (PL3)	KG Blend 4-High CP (KG4)	KG Blend 5-Low CP (KG5)	KG Blend 6-Med CP (KG6)
Soybean meal	7.73	5.91	7.27	2.27	0.91	1.82
Rice hulls	2.27	0.91	1.82	5.00	5.91	7.27
Concentrate	0.00	0.00	0.00	0.00	0.00	0.00
Citrus Pulp	4.55	4.55	4.55	0.00	0.00	0.00
Pineapple Leaves	29.55	25.00	22.73	4.55	4.55	4.55
King grass	0.00	0.00	0.00	27.27	25.00	22.73
Total	44.09	36.36	36.36	39.09	36.36	36.36

Table 6. Cost price of feed ingredients in blends and blend cost per kilogram (as fed).

	Pineapple			King grass		
Feedstuff	PL Blend 1- High CP (PL1)	PL Blend 2- Low CP (PL2)	PL Blend 3-Med CP (PL3)	KG Blend 4-High CP (KG4)	KG Blend 5-Low CP (KG5)	KG Blend 6-Med CP (KG6)
Soybean meal	$4.17	$3.19	$3.93	$1.23	$0.49	$0.98
Rice hulls	$0.70	$0.28	$0.56	$1.55	$1.83	$2.25
Concentrate	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Citrus Pulp	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09
Pineapple Leaves	$0.30	$0.25	$0.23	$0.00	$0.00	$0.00
King grass	$0.00	$0.00	$0.00	$13.64	$12.50	$11.37
Total	**$5.26**	**$3.81**	**$4.81**	**$16.50**	**$14.91**	**$14.69**
Blend cost/kg	**$0.12**	**$0.10**	**$0.13**	**$0.42**	**$0.41**	**$0.40**

Table 5. Feed ingredient prices per kilogram, from Costa Rica (as fed).

Feedstuff prices ($/kg)		
Soybean meal	$	0.54
Rice hulls	$	0.31
Concentrate	$	0.40
Citrus Pulp	$	0.02
Pineapple Leaves	$	0.01
King grass	$	0.50

The digestibility (IVTD) of the dry matter for the pineapple silage mixes was higher than the digestibility of the king grass mixes. Higher digestibility of the pineapple silage mixes over the king grass silage mixes may promote increased intakes by cattle. The calcium, phosphorus, and volatile fatty acid profile for PL1, PL2, Pl3, KG4, KG5, and KG6 are within reasonable ranges of acceptability for cattle diets (Van Soest, 1994).

***Cost of production for silage blends*:** The cost of production for each of the silage blends was calculated as described above. Table 6 shows the blend costs per kilogram for PL1, PL2, PL3, KG4, KG5, and KG6. The cost for the pineapple silage blends (PL1, PL2, and PL3) is much lower than that of king grass (KG4, KG5, KG6) with pineapple blends ranging in price per kg from $0.10/kg to $0.13/kg while king grass blends ranged in price from $0.40/kg to $0.42/kg. While practically significant differences in cost of blends exist between the pineapple and king grass silage blends, it is important to note that the costs between the different CP levels within pineapple blends or king grass vary very little. Practically, PL1, PL2, and PL3 are of nearly the same cost, varying by only $0.03/kg between the high and low CP blends. Similarly, KG4, KG5, and KG6 vary only by $0.02/kg in cost between the high and low CP blends.

Simply comparing costs of production may be useful in determining possible cost reductions by replacing other feedstuffs. But, careful assessments to determine proper total rations must be completed. It should be recognized that while a blend may be lower cost, if it results in lower milk yields than other feedstuffs, the profit may be lower – even though costs were reduced.

CONCLUSION

In conclusion, this analysis provided a helpful insight on what changes should be made in silage blends, and how this could be a potentially resourceful feed source for Costa Rican cattle. All silage blends investigated were found to be within acceptable nutritional profiles for tropical cattle production. Costs of pineapple blends investigated were much lower than those of king grass because pineapple is easily accessible and a relatively low cost feed ingredient. Total costs of the high protein blends with pineapple versus king grass as main feedstuffs varied by $0.30/kg, a practically important difference for cattle producers in Costa Rica to recognize.

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