Research Article

Ensiling Techniques for Whole-Plant Sunflowers (*Helianthus annuus*) and their Nutritive Values for Ruminants in Vietnam

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Abstract | The study aimed to evaluate the biomass yield, chemical composition and ensiling techniques of whole-plant sunflower Aguara 6. In Exp. 1, whole sunflower plant was harvested at the seeding period (SP) to measure biomass yield, chemical composition and energy values. Results showed that, fresh biomass yield was 62 tonnes/ha, in which, heads consisting of 46.8% with the highest, leave accounting for 35.5% and stems consisting of 17.7% as fresh matter with the lowest proportion. The dry matter (DM) content of the whole plant was 17.5% DM, in which 13.5% CP, 45.8% NDF, 44% ADF and 20.7% Lignin; and DE and ME values for ruminants were 3,436 and 2,818 kcal/kg DM, respectively. In Exp. 2, eight treatments included: Control (CTL) – without any additives; Salt 0.5% added to CTL (SCTL); Cassava byproduct added to CTL at 5, 10 and 15% (CB5, CB10 and CB15, respectively); Molasses added to CTL at 2.5, 5.0 and 7.5% (M2.5, M5.0 and M7.5, respectively). Samples were collected at day 0, 7, 14 and 21 for pH and ammonia, and day 0 and 21 for chemical analysis. Results indicated that after 21 days of ensiling, the pH value of silage in 8 treatments were lower than 4.5. There was no effect of additives and their level inclusions on ensiled sunflowers nutritive values. Change in organic matter was found with 0.7-2.3% unit in all treatments. In general, whole Aguara 6 sunflower can be ensiled and has a potential for ruminants.

Keywords | Sunflower, Biomass yield, Nutritive values, Additives, Ensiling.

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INTRODUCTION

Sunflowers *(Helianthus annuus)* are native to Central and North America, but have been grown around the world (Heiser, 1955; Soare and Chiurciu, 2018). It is grown with the main objective of obtaining sunflower oil. Since the early 20th century, sunflower by-products such as postharvest stems, heads and by-products after oil pressing have been used as fodder for livestock. Sunflower plants have the characteristics of fast growth and high yield of fresh matter. In Cuba, sunflower yielded about 45-75 tons/ha of fresh matter in 60-70 days and in Brazil up to 90 tons/ha (Heuzé et al., 2015). Harvesting time of sunflower for ruminant depends on yield of fresh matter and protein value in it.

In Viet Nam, the research results on Mexican sunflower (*Tithonia diversifolia*) indicated that sunflower could be used as a good silage for pigs (Nhan et al., 2011) and goats (Hong and Preston, 2013) or as forage for goats (Sao et al., 2010). However, sunflower was first widely grown and used as a feed resource for dairy cows in 2010 at TH Truemilk, Nghe An province. According to Cuong (2016), the variety Aguara 6 was introduced to Viet Nam during 2013 to

2016, and the fresh matter yield of Aguara 6 was 15-20% higher than that of maize whole-plant. The CP content of sunflower (13%) was higher than that of other forages such as Elephant grass (*Pennisetum purpureum*) (9.7%) (Heuzé et al., 2015; Heuzé et al., 2020).

Usually, sunflower plants are harvested for animal feed when the plant is in bloom and often used for silage. Whole-plant sunflower silage usually contains higher CP (11,4%), EE (17,4%) and minerals (3,5%) when compared to maize silage (5,7% CP, 4,2% EE and 2,5% minerals) (Mello et al. 2004). The advantages of sunflower in comparison with the maize and sorghum were the higher tolerance to drought, lower temperatures in the germination period (until 5°C), shorter vegetative cycle, favouring more than one cultivation in summer with other culture and desired quality of the ensiled product. Neumann et al. (2009) reported that the lower content of DM (20 - 25%) and the high content of EE (10 - 18%) had been indicated as the main restrictions for sunflower silage, due to higher storage losses.

On the other hand, the use of additives such as cassava byproduct (CB) and molasses (M) to enhance natural fermentation for silage making was mentioned by many authors (Ba et al., 2005). The addition of rice bran or cassava root meal in cassava foliage silage at levels of 5 or 10% produced good quality silage that could be stored for at least five months (Ly and Ngoan, 2007).

This study therefore, aimed at identifying the potential use of sunflower Aguara 6 whole-plant as ruminant feed through chemical composition assessment and ensiling technique applications.

MATERIALS AND METHODS

The study was carried out at the University Research Centre (URC) in Huong Tra district, Thua Thien Hue province during 2019-2020.

Experiment 1. Determination of biomass yield and chemical composition

Sunflower Aguara 6 plants were planted with a density of 30,000 plants/ha in 1,300m^2 devided equally into 5 plots during Summer-Autumn 2019 in Thua Thien Hue province, Central Viet Nam. Monthly average temperature and rainfall ranged 26.4-28.5°C and 120-320 mm in Summer, respectively; and 20.3-23.9°C and 600-1,500 mm in Autumn, respectively.

Samples were taken at seeding period (50% of flower seeding, 85 days old) to determine biomass field of whole-plant and plant components (leaves, stems and heads). In each plot, whole-plants were cut within an area of 1 m^2 as 5 replicates.

Experiment 2. Ensiling technique

Experimental design

The experiment was arranged with 8 treatments and 4 replicates: Control (CTL) - no additives were used; Salt added 0.5% to CTL (SCTL); added 5% cassava byproducts (CB) to CTL (CB5); 10% CB to CTL (CB10); 15% CB to CTL (CB15); added 2.5% molasses (M) to CTL (M2.5); 5% M to CTL (M5); and 7.5% M to CTL (M7.5).

Whole-plant sunflower in the Exp. 1 were harvested at seeding stage, chopped, mixed carefully and withered in the sun drying for one day. Then they were carefully mixed with salt or additives (CB and M) following above mentioned proportions. For each treatment, 1 kg of the mixture sample was randomly taken and put in a plastic bag (size 40 × 60 cm). There were 40 bags (5 replicates x 8 treatments) in total. The bags were then vaccummed and sealed to ensure anaerobic conditions. All bags were stored in Styrofoam containers to avoid direct sunlight.

Sampling

Silage samples were taken at days of 0, 7, 14, and 21 for pH and ammonia analyses. In order to determine pH and ammonia, samples were chopped to less than 1 cm in size, weighed 15 g and added distilled water into a 250 ml plastic bottle with a double-layer cap to ensure that water did not flow out when shaking. Pour 140 ml of distilled water (deionized water) into the sample bottle and shake vigorously and evenly (using a sample shaker) and place in the refrigerator, then shaked once every 6 hours. After 24 hours, take it out and put it in the shaker, shake it for 1 hour; Continue to take samples and extract the water, a subsample of each replicate was stored for further analysis of ammonia and then use the pH meter to determine the value of each sample.

The silage samples were taken at days of 0, 7, 14 and 21, dried at 60°C, then finely ground, preserved and analysed for chemical composition.

Chemical analysis

Analyse of feed samples and silage samples was conducted at the Lab of the Faculty of Animal Sciences and Veterinary Medicine, University of Agriculture and Forestry, Hue University. Analytical parameters and methods: including dry matter, crude protein, ether extract and total ash were analysed according to routine methods (AOAC, 1990). The fibre components of NDF, ADF and Lignin were analysed on the Ankom system (A200). Ammonia in silage was analyzed using the technique described by Chaney and Marbach (1962) and a detailed processing was described by Nguyen et al. (2019).

Data analysis

The data were managed and calculated on Microsoft Excel software. Comparison of changes in chemical composition of sunflower after incubation was processed according to the model: one-way ANOVA, using SPSS software (version 24.0). When the P value of the F test is less than 0.05, the LSD test is used to check for difference. Statistical analysis model:

$Y_{ij} = \mu + T_i + e_{ij}$

Where, Yij = Random variable, μ = Overall mean value; Ti = Effect of treatment, eij = Random error.

RESULTS AND DISCUSSIONS

Biomass yield and chemical composition

The yield of sunflowers cut at seeding stage and the chemical composition of the plants at the seeding stage are presented in Tables 1 and 2.

Table 1: Biomass yield and proportion of parts of sunflower whole plant at seeding stage.

Biomass (kg fresh/ m^2)	Biomass (ton fresh / ha)	Proportion (% in fresh matter)		
		Stems	Leaves	Heads (Flower)
6.20	62.0	17.7	35.5	46.8

Table 2: Chemical composition of sunflower whole-plant at seeding stage (% as DM).

Item	Value
Dry matter	17.5
Crude protein	13.5
Ether extract	5.91
NDF	45.8
ADF	44.0
Crude fibre	21.7
Lignin	20.7
Ash	11.4
Caculated DE* (kcal/kg DM)	3,436
Calculated ME* (kcal/kg DM)	2,818

* Calculated followed NRC 2016: DE (kcal/ kg DM) = 100(-4.4 + 1.1 x GE – 0.024 x CF)/4.184; ME (kcal/kg DM) = 0.82 x DE (NRC 2016) and GE (kcal/kg DM) = 4,143 + 56 x EE + 15% x CP – 44 x Ash. In which, GE in MJ/kg DM, and CF, EE, CP in % DM

Sunflower (*Helianthus annuus* L.) was primarily an oil crop but the plant itself and its crop residues (heads and leftover stalks) have been a popular roughage for livestock since the early 20th century. Sunflower is a fast-growing crop with high biomass yield, so it can be used as an alternative forage. Sunflower could be a valuable option of forage under drought conditions or where there was a shortage of roughage (Garcia, 2006; Goncalves et al., 1999).

In this study, biomass yield of sunlower whole plant was 62 tons of fresh/ha in 85 days and the biomass yield of heads accounted for 46.8% of total biomass, was highest in comparion with leaf and stem. Biomass yield of sunflower varies depending on different growing condition, For example, in Cuba, fresh matter yields of sunflower were 45-75 tons/ha in 60-70 days in dry conditions, and up to 90 tons/ha in Brazil (Goncalves et al., 1999). In Romania, biomass yield of sunflower plants planted with different densities, different soil compositions, and different seasons ranged from 56.6-90.1 tons of fresh/ha (Ion et al., 2015). Estrada and Gozales (2010) reported that, the biomass yield of sunflowers grown on saline soils in Mexico ranged from 30-100 tons of fresh/ha. Therefore, the results on biomass yield of sunflower whole-plant in this recent study are comparable with above reports.

In this study, sunflower whole-plant was harvested at 50% flowers seeding. It was late harvest as compared with Tan and Tumer (1996), who recommended the harvest time at stages between 25% flowers blooming and the final flowering stage. However, Myers et al. (1993) reported that, half the flower area filled with immature seeds can be a signal for harvest. The best harvest time for ensiling sunflower was highly variable, depending on climatic conditions and sunflower genotypes (Toruk et al., 2010; Goncalves et al., 1999).

Heuzé et al. (2015) reported that NDF, ADF and lignin contents of sunflower were 39.6%, 35.9% and 9.7%, respectively. Those values are all lower than the current research results, especially the lignin content. This difference may be due to the time of harvest or may be due to climate (temperate versus tropical climate). Crude protein value in this study was 13.5%, which is consistent with finding by Heuzé et al. (2015) and Myers et al. (1993) that CP level declined, and lignin content greatly increased after flowering stage.

pH value and chemical composition of ensiled sunflower

pH value: Results of pH values in all treatments throught the ensiling periods are presented in Table 3 and Figure.1.

pH value is one of the important criteria for assessing the quality of the silage product. The pH value of the silage is affected by many factors and was reported in range 3.7 to 4.0 in maize silage and 4.3 to 5 in legume silage (Limin et al., 2018).

Table 3: Effect of additives and times on pH value during ensiling.

Treatment	Ensiling day				SEM	*p*-value
	0	**7**	**14**	**21**		
CTL	5.28^{ab1}	4.67^{a2}	4.79^{a2}	4.24^{a2}	0.048	<.001
SCTL	5.37^{ab1}	4.56^{ab2}	4.49^{b2}	4.47^{ab2}	0.049	<.001
CB5	5.33^{ab1}	4.44^{bc2}	4.38^{bc2}	4.24^{bc2}	0.065	<.001
CB10	5.47^{a1}	4.32^{d2}	4.12^{d2}	4.23^{bc2}	0.049	<.001
CB15	5.30^{ab1}	4.26^{d2}	4.14^{d2}	4.27^{bc2}	0.049	<.001
M2.5	4.95^{c1}	4.33^{cd2}	4.22^{cd2}	4.17^{c2}	0.042	<.001
M5	5.19^{abc1}	4.33^{cd2}	4.24^{cd2}	4.19^{c2}	0.061	<.001
M7.5	5.05^{bc1}	4.29^{bcd2}	4.30^{bcd2}	4.17^{c2}	0.036	<.001
SEM	0.068	0.026	0.046	0.051		
p-value	<.000	<.000	<.000	<.000		

^{abcd}: Means in the same column without common letter are different at p<0.05

^{12}: Means in the same row without common letter are different at p<0.05

Table 4: Effect of additives on dry matter content during ensiling (%).

Treatment	Ensiling day				SEM	*p*-value
	0	**7**	**14**	**21**		
CTL	20.30^{1}	16.26^{b2}	21.47^{a1}	16.07^{ab2}	1.474	0.049
SCTL	17.62	17.51^{ab}	13.92^{b}	15.14^{b}	1.260	0.154
CB5	18.33	18.46^{ab}	16.50^{ab}	18.19^{a}	0.580	0.108
CB10	18.89	18.43^{ab}	18.69^{a}	18.27^{a}	0.509	0.832
CB15	18.32	18.33^{ab}	19.40^{a}	18.36^{a}	0.509	0.91
M2.5	19.38^{1}	18.85^{a12}	15.59^{ab12}	18.14^{a2}	1.261	0.033
M5	21.67^{1}	17.52^{ab12}	14.17^{b2}	18.29^{a12}	0.832	0.014
M7.5	18.90	18.19^{ab}	19.00^{a}	18.66^{a}	0.673	0.832
SEM	1.031	0.509	1.527	0.817		
p-value	0.205	0.042	0.017	0.049		

^{ab}: Means in the same column without common letter are different at p<0.05

^{12}: Means in the same row without common letter are different at p<0.05

Table 5: Effect of additives and times on organic matter content during ensiling (% as DM).

Treatment	Ensiling day				SEM	*p*-value
	0	**7**	**14**	**21**		
CTL	88.55^{d}	87.25^{c}	85.65^{c}	87.46^{d}	0.702	0.232
SCTL	88.05^{d1}	87.25^{c1}	85.65^{c2}	85.82^{e2}	0.318	<.001
CB5	91.72^{b1}	91.51^{b1}	90.732^{b2}	90.99^{b2}	0.113	<.001
CB10	93.46^{a1}	92.98^{a1}	92.32^{a2}	92.16^{a2}	0.138	<.001
CB15	93.98^{a1}	93.57^{a12}	92.89^{a2}	93.01^{a2}	0.139	0.015
M2.5	91.19^{bc1}	90.17^{b2}	89.59^{b2}	90.27^{bc2}	0.222	0.001
M5	91.72^{b1}	90.29^{b2}	89.62^{b2}	90.37^{bc2}	0.191	<.001
M7.5	90.47^{c1}	89.98^{b2}	89.62^{b2}	89.67^{c2}	0.199	0.038
SEM	0.208	0.493	0.261	0.202		
p-value	<.000	<.000	<.000	<.000		

^{abc}: Means in the same column without common letter are different at p<0.05

^{12}: Means in the same row without common letter are different at p<0.05

Figure 1 shows that, initially, the pH values of the silages were from 4.9 to 5.5 and rapidly decreased after 7 days of ensiling to 4.3 - 4.7 and reached stable levels of 4.2 - 4.8 during 7 - 21 days. The pH value of the CTL treatment after 14 days of ensiling was 4.8, which was higher than all other treatments (pH<4.5) (P<0.05) and the recommended value; After 21 days of silage, the molasses added treatments had a lower pH values than those of the CTL and SCTL treatments (pH<0.05), however the pH values in all treatments were smaller than 4.5.

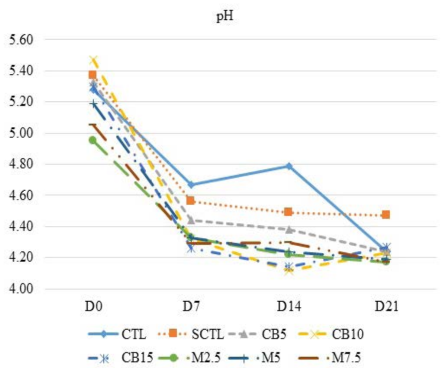

Figure 1: pH value of ensiled whole sunflower plant durig ensiling process.

Thus, the pH value decreased during the first 14 days of ensiling and became quite stable during the next week. The addition of cassava byproducts and molasses resulted in a decrease in pH and remained stable at 4.2 - 4.3 after 21 days of ensiling. Molasses have been reported to be an effective silage additive regarding to enhancing lactic fermentation resulting in reducing silage pH and starch from cassava also is an available substrate for development of lactic acid bacteria (Yitkarek and Tamir, 2014). Silages with molasses had the lowest pH while the control silages without additive tended to have the highest pH. In general, the pH values of the ensiled materials were in the range of 5.0 to 5.5, which was higher than traditional silages made from grass or maize (McDonald et al., 1991).

Dry matter content during ensiling

Data in Table 4 shows that the DM contents of all cassava byproduct added treatments, SCTL and M7.5 were stable throughout the silage period, while DM contents of CTL, M2.5 and M5 treatments were declined after 21 days of ensiling (P<0.05). There was no significant difference on DM content between all treatments at starting day (P>0.05), but after 21 days, DM of SCTL was lower than all other tested treatments (P<0.05). The decrease in DM content in the pre- and post-fermentation periods may be due to the initial aerobic exchange that produces water, CO_2, ammonia and heat production (Mc Allister and Hristov 2000). This is followed by evaporation and loss of water, which reduces the dry matter content. However, Nguyen et al. (2005) reported no difference in dry matter content of Orchard grass before and after ensiling. Similarly, Gerlach et al. (2018) and Köhler et al. (2019) also reported no difference in DM content of corn and grass silages. In the initial aerobic exchange stage, aerobic microorganisms continue to work with the remaining oxygen in the incubator. As a result, carbohydrate and protein compounds are converted to water, CO_2, heat and free ammonia (Mc Allister and Hristov, 2000). This process only stops when the amount of O_2 in the incubator is used up. As the annealing temperature increases, the loss of organic matter increases. Ree (1982) reported that 1.7% of the dry matter was lost with an increase of 10°C of the incubator. The author also revealed that the temperature of the annealing blocks often increased by 12°C compared to the initial incubation time. The dry matter content depends on the initial sun exposure of sunflower plants, in this experiment the sunflowers were exposed to about 80% humidity. Although the humidity level was high, the quality of silage was not damaged through the storage time.

Organic matter

Effects of different additives on organic matter content during ensiling process presented in Table 5.

The results in Table 5 show that, in all treatments, the OM content of the silage in day 21 (the final day) decreased by about 0.7-2.3% compared to day 0 (the beginning day) (P<0.05), with the exception of the CTL treatment. As the result of additives added, all cassava and molasses treatments had higher OM content than the CTL and SCTL treatments at all 4 measurement days.

Crude protein content

Table 6 shows that the crude protein of the initial incubation was at around 8.5 - 13.7%. After 21 days of fermentation, the highest crude protein values were observed in CTL treatments (ranged from 13.4-13.5%), followed by treatments added molasses (from 11.7-12.4 %) and the lowest values were recorded in treatments added cassava products (roughly from 8.5-10.5%) (P<0.05). Interestingly, CP values after 21 days were significantly (P<0.05) different between three treatments added cassava products, in that the higher level of cassava added (15%), the lower CP value was recorded.

Crude protein content represented an important nutritional value for animals. The primary goal of the silage block is to preserve the feed and maintain the nutritional value. Especially if in the incubation block after 21 days, the protein value is maintained, showing good quality of the incubator. During the bulk incubation, proteolysis and lipolysis increase non-protein nitrogen which can lead to a change in the protein content of the incubator (Mc Don

Table 6: Effect of additives and times on crude protein during ensiling (% as DM).

Treatment	Ensiling day				SEM	*p*-value
	0	7	14	21		
CTL	13.72^{a}	12.49^{a}	14.15^{a}	13.52^{a}	0.423	0.088
SCTL	13.27^{ab1}	12.61^{a12}	13.29^{a12}	13.48^{a2}	0.415	0.011
CB5	9.74^{c}	10.81^{ab}	11.21^{b}	10.59^{c}	0.344	0.06
CB10	9.43^{cd}	11.05^{a}	8.98^{c}	9.40^{d}	0.724	0.243
CB15	8.48^{d}	9.09^{b}	8.56^{c}	8.53^{e}	0.721	0.66
M2.5	12.73^{b1}	12.59^{a2}	12.44^{ab12}	12.45^{b12}	0.383	0.029
M5	12.18^{b1}	12.59^{a2}	12.32^{ab12}	11.77^{b2}	0.187	0.021
M7.5	12.09^{b1}	11.75^{a1}	12.97^{ab2}	12.46^{b12}	0.185	0.003
SEM	0.202	0.399	0.412	0.152		
p-value	<.000	<.000	<.000	<.000		

abc: Means in the same column without common letter are different at $p<0.05$

1234: Means in the same row without common letter are different at $p<0.05$

Table 7: Effect of additives and times on ammonia content during ensiling (% as total N).

Treatment	Ensiling day				SEM	*p*-value
	0	7	14	21		
CTL	3.66^{a1}	6.61^{ab2}	7.49^{3}	8.71^{ab3}	0.485	<.001
SCTL	3.35^{b1}	5.61^{abc2}	7.53^{3}	8.98^{a3}	0.472	<.001
CB5	3.06^{c1}	4.73^{bc2}	6.28^{2}	6.64^{ab2}	0.663	<.001
CB10	3.01^{c1}	6.90^{a2}	6.38^{2}	6.96^{ab2}	0.390	<.001
CB15	3.86^{d1}	6.54^{ab2}	7.65^{2}	7.07^{ab2}	0.391	<.001
M2.5	3.38^{b1}	5.77^{abc2}	5.35^{2}	7.14^{ab2}	0.643	<.001
M5	3.38^{b1}	5.07^{abc2}	7.13^{2}	7.28^{ab2}	0.721	<.001
M7.5	3.33^{b1}	4.40^{c2}	5.43^{2}	5.91^{b2}	0.459	<.001
SEM	0.048	0.413	0.613	0.619		
p-value	<.000	0.002	0.064	0.035		

abc: Means in the same column without common letter are different at $p<0.05$

123: Means in the same row without common letter are different at $p<0.05$

Table 8: Effect of additives and times on NDF content during ensiling (%).

Treatment	Ensiling day				SEM	*p*-value
	0	7	14	21		
CTL	45.73^{1}	45.71^{a1}	46.08^{a1}	43.14^{abc2}	0.610	0.018
SCTL	46.69	43.25^{a}	45.44^{ab}	41.30^{bc}	1.891	0.244
CB5	42.74	41.81^{ab}	43.84^{abc}	41.86^{bc}	0.890	0.372
CB10	43.53	41.82^{ab}	42.26^{bc}	41.49^{bc}	0.798	0.332
CB15	43.09	40.58^{b}	40.62^{c}	41.13^{bc}	0.799	0.139
M2.5	42.48	45.61^{a}	42.70^{bc}	44.04^{ab}	0.791	0.653
M5	46.65	45.61^{a}	46.23^{a}	45.88^{a}	1.081	0.774
M7.5	41.92	41.25^{ab}	42.15^{c}	40.38^{c}	0.466	0.079
SEM	1.351	1.088	0.687	0.728		
p-value	0.093	0.019	<.000	<.000		

abc: Means in the same column without common letter are different at $p<0.05$

12: Means in the same row without common letter are different at $p<0.05$

ald et al., 1991). The content of non-protein nitrogen in the substrate plants determines the degree of proteolysis in the incubator.

Ammonia content

Effects of additives on ammonia concentration of ensilages during ensiling process are indicated in Table 7 and Figure 2.

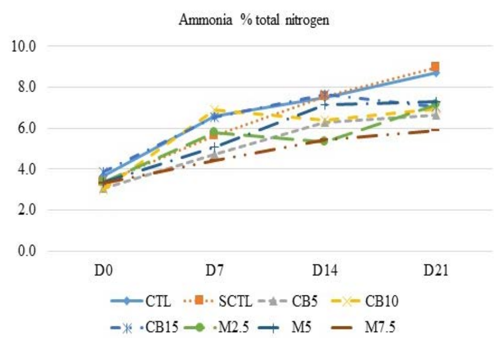

Figure 2: Ammonia value of ensiled sunflower during ensiling process.

The ammonia contents of all treatments increased through the silage time (P<0.05). At the beginning ammonia ranged from 3.01 to 3.86 % of total nitrogen, it increased between 5.91% to 8.98% after 21 days. Ammonia content of SCTL treatment was higher than that of the M7.5 treatment (P<0.05) after 21 days of silage. Ba et al. (2005) reported that the ammonia content of total N increased from about 9% in the fresh foliage to about 11% after ensiling. The increase in ammonia-N was indicative of some breakdown of the protein, which would be facilitated by the relative high pH with 5.0 to 5.6.

Neutral Detergent Fibre content

The role of NDF is to provide fibre as an essential substrate for ruminants through fermentation of microorganisms. The NDF content reflects the nutritional quality of the compost over the substrates. Data in Table 8 shows that, NDF of CTL treatment was significant (P<0.05) difference between day 0 and day 21, whereas significant (P>0.05) differences were not showed in other treatments The result of NDF value was consistent with the hemicellulose content (by calculated the NDF-ADF content) of sunflower at 1.8% (Table 2). Some studies have reported that the silage often reduced the NDF content (Gerlach et al., 2018; Köhler et al., 2019), the result of the structural carbohydrates being hydrolysed by enzymes in the ensilage. However, Köhler et al. (2019) showed that the decrease in NDF content was due to the reduction of hemicellulose, meaning that the ADF content did not decrease after incubation. This could be due to the chemical structure of the sunflower, the time of harvest as well as the microbial activity of the silage. In the day 0, the control and salt added control treatment tended to contain higher NDF content than other treatments (P<0.1). In the mean time of silage at days of 7, 14 and 21, there was a difference in NDF content between treatments. However, the was no clearly effect of additives on NDF content.

In general, the disadvantage of sunflower silage was the fibrous stalk that causes a high fibre content which could be two to three times as much as maize silage. The increased fibre content of sunflowers was caused by high levels of lignin, which is the indigestible portion of the plant. Because the increased fibre content of sunflower silage is offset somewhat by the higher oil content, the total digestible nutrients (TDN) of sunflower silage is only slightly lower than maize silage.

CONCLUSIONS AND RECOMMENDATIONS

The biomass yield of the sunflower Agura-6 whole-plant grown in Thua Thien Hue province was at 62 tons of fresh/ha at 85 days old. Sunflower whole-plant contained 17.5% dry matter and 13.5% crude protein, but high lignin content (20.7%). Calculated values of DE and ME for ruminants were 3,436 and 2,818 kcal/kg DM.

Additives such as cassava byproduct and molasses in different proportions did not clearly affect the nutritional characteristics of the silage. However, changes in the composition of volatile fatty acids and lactic acid in the silage should be determined to have full assessment of the quality of the silage.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

NOVELTY STATEMENT

To our knowledge, this is the first study to evaluate the biomass yield and potential use as ruminant feed of the sunflower Aguara-6 in Vietnam. In the current study, the local additives such as cassava byproduct and molasses did not clearly effect on the chemical composition of ensiling products.

AUTHORS CONTRIBUTION

All authors shared equally in experimental design and conducting the experiment. NHQ, NHV and LDN drafted and revised the final manuscript.

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