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Effect of feeding *Pennisetum giganteum* silage to sheep compared to *Zea mays* silage

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Abstract

The potential of the livestock sector in agriculture is great. The essential basis of ruminant feed is fodder. In the two distinct seasons in Madagascar, the rainy season has a better qualitative and quantitative fodder yield and the dry season whose fodder supply does not cover the animals' needs.

Fodder conservation during the period of abundance is necessary to prevent the period of deficit. Silage in pit silos is expensive for small herds of animals. An improvement of the micro soil manufacturing technique is envisaged. Thus, the elaboration of micro-silo in welded tarpaulin is realized.

The comparison of the effect of silage of *Zea mays* and *Pennisetum giganteum* fed to sheep is carried out. The determination of the analytical values of green and ensiled forages is carried out as well as the weight monitoring of sheep.

The chemical compositions of the two forages did not differ significantly except for the lignin content (6.7% DM) of the green *Pennisetum, which was* higher than that of the green *Zea mays (5.5% DM)*, which was also observed for the ensiled values. However, for the protein content, the opposite is true: 8.3% DM (*Pennisetum)* compared to 9.3% DM (*Zea mays*). The energy and PDI values of the two silage species and the rations are equivalent. The *Zea mays* ration is more ingested than the *Pennisetum* one as proven by the weight gain (4.1kg vs 3.3kg).

The advantage of *Pennisetum* fodder lies in its high biomass and its tolerance to climatic changes, always green throughout the year compared to *Zea mays*. They can be fed to ruminants in both green and silage form and do not compete with human food.

Keywords: Forage conservation, micro-silo, welded tarpaulin, *Zea mays*, *Pennisetum giganteum* and sheep

Introduction

The potential of the livestock sector in the agricultural sector is great. Thus, 71% of the Malagasy population practice rural activities (PDRASAN, 2010) [8] and 70% of the total surface area of grazing land is dedicated to large and small ruminants, i.e. about 34 million hectares (Rasambainarivo and Ranaivoarivelo, 2006) [9]. Feeding is the permanent factor ensuring satisfactory performance of livestock for their health and reproduction.

The essential basis of ruminant feeding is fodder. As Madagascar is made up of two distinct seasons, the rainy season, which has a better qualitative and quantitative fodder yield, and the dry season, whose fodder supply does not cover the animals' needs.

Forage conservation during the period of abundance to prevent the period of deficit is necessary. Various types of forage can be ensiled. *Zea mays* silage is the most commonly used. *Zea mays* is a seasonal plant and when making silage, the seeds are cut when they are in the milky phase and not yet mature enough to be used for human food. Therefore, the production of *Zea mays* silage is in competition with human food.

In general, silage is commonly made in pit silos, which is expensive and used by large herds.

Within the framework of the project Ecological intensification pathways for the future of crop livestock integration in African agriculture (Eco Africa), the improvement of micro-silo manufacturing for farms with a small number of animals is being studied. As a result of previous experimentation, the development of welded tarpaulin micro-silo has been carried out.

According to recent research, Juncao or *Pennisetum giganteum* is now the most popular crop. *Pennisetum giganteum*, is a tall perennial grass, reaching up to 5m in height with a relatively long inflorescence and powerful stem. Its root system is strong and fibrous, capable of descending rapidly to a great depth of soil of 2m to extract water and mineral elements (Xhanxi, 2010) [11]. This plant is very drought resistant and remains green even during the dry season (Feifan, Macanauwai and Kaloumaira, 2019) [2].

In this context, the production of *Pennisetum giganteum* and *Zea mays* silage in welded tarpaulin micro-silo was carried out. Thus, the effect of these silages fed to sheep was compared. Nutrient values of *Pennisetum giganteum* and green and silage *Zea mays* were determined. The weight evolution of the sheep was monitored.

Materials and method

The silage was made in the following steps: manufacture of micro-silos, cutting and transporting the forage, chopping (2 to 5 cm) and placing in the silo by vigorously packing the forage. Good packing reduces air to a minimum, a very important condition for good silage (Berthiaume and Baillargeon, 2013) [1].

It is also essential to ensure that forages are not soiled with soil or plant waste and that they can retain the leafy parts

(Zapata and Bonault, 2011) [10]. Silage quality depends on the harvesting conditions of the plant at early heading for grasses: *Pennisetum giganteum* and *Zea mays*. They can maintain a feed value as close as possible to that of green forage (Paragon *et al*. 2004) [4]. After two and a half months of ensilages, the animal test was carried out. In the meantime, SPIR predictions of these green and ensiled forages were performed in the laboratory. Organoleptic tests on these silages were carried out.

The animal tests were carried out on sheep fed *Zea mays* and *Pennisetum giganteum* silage in welded tarpaulin micro-silos.

12 local breed lambs, about 14 months old and with an average weight of 18.45±1.45 kg, were divided into 3 batches of 4. The first batch served as a control, the second was fed *Pennisetum g.* silage and the last was fed *Zea mays* silage. Each individual was placed in 1.4 m x 2.4 m boxes. The weight evolution was monitored. Thus, the distribution of the sheep rations is shown in table 1.

Table 1: Rationing of sheep fed silage in a welded tarp micro-silo

Ration	Witnesses	Batch *Pennisetum g.*	Batch *Zea mays*
Cynodon	2,29	1,62	1,69
Pennisetum giganteum silage		0,56	
Zea mays silage			0,50
Rice bran	0,52	0,58	0,50
Peanut cake	0,01	0,01	0,01

Results and discussion

The organoleptic tests of the two silages were carried out just after opening. The different fractions of the plant, such as the stems and leaves, are clearly recognisable, as are the ears and stalks of *Zea mays.* The silage is generally brown in colour. The smell is fruity and slightly alcoholic. Mould is almost non-existent. The silage is successful. As the bag is welded, there are no more holes from the seams observed during the previous experiment to let air in.

After the analysis step, the analytical results are shown in Table 2.

Table 2: Chemical value of forages stored in welded tarps

% of DM	*Pennisetum giganteum*		*Zea mays*	
	Green	Sikworm	Green	Sikworm
DM	28,3	29,0	28,5	28,4
CP	8,3	8,3	9,1	9,3
CF	30,0	31,2	28,8	29,7
MM	9,1	10,0	6,8	7,3
NDF	67,8	65,4	65,3	64,3
ADF	36,6	34,1	35,0	33,5
ADL	6,7	6,5	5,5	5,6

DM: Dry Matter; CP: Crude Protein; CF: Crude Fiber; MM: Mineral Matter; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin

Comparison of the chemical compositions of *Pennisetum giganteum* and green and ensiled *Zea mays* shows that there are no significant differences between the values of each parameter except for lignin (ADL) (Figure 1) and mineral matter (MM) (Figure 2).

The lignin content (6.7% DM) of green *Pennisetum giganteum* is significantly higher than that of green *Zea mays (5.5% DM).* This superiority is valid for silage values.

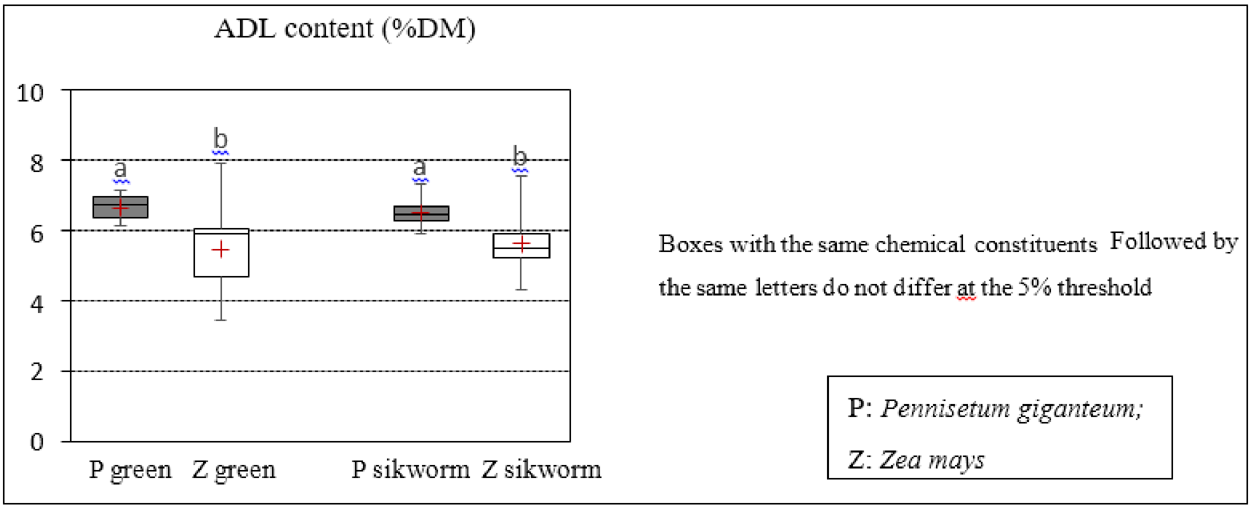

Fig 1: ADL content of forages used in welded tarpaulins

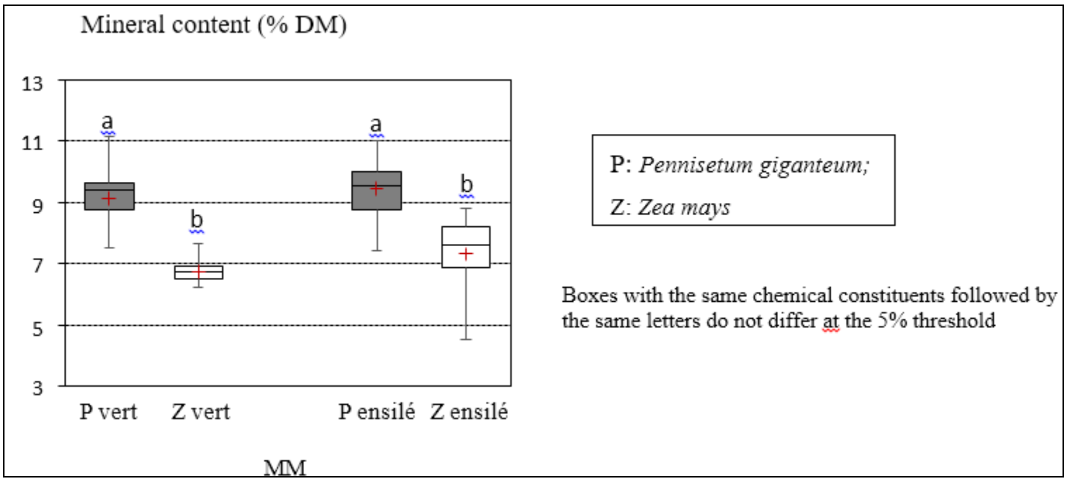

Fig 2: Mineral content of forages used in welded tarpaulins

The protein content of ensiled *Zea mays is* increasing but that of Pennisetum giganteum is stable (figure 3).

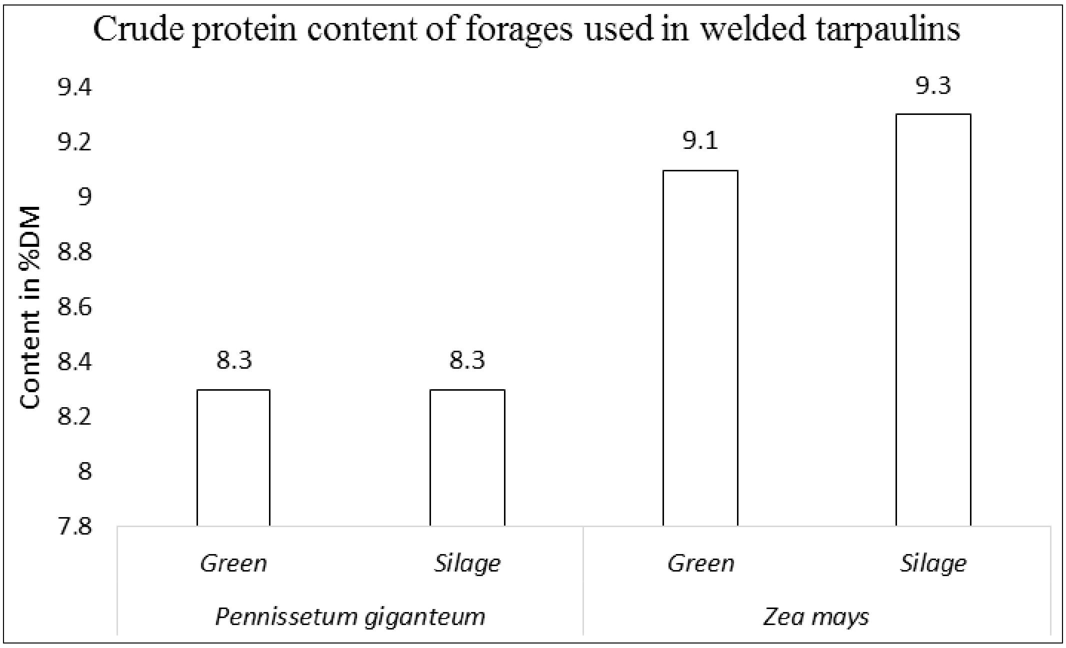

Fig 3: Crude Protein content of forages used in welded tarpaulins

The protein content of *Pennisetum giganteum* is lower than that of *Zea mays* in both green and silage condition.

A non-significant decrease in parietal constituents is observed. It may be due by the partial decrease of hemicellulose and crude cellulose. In agreement with this statement, Peyrat and al. (2014) [5] pointed out that hemicellulose may undergo partial hydrolysis to starch and crude cellulose to volatile fatty acids (VFA).

The energy and PDI values of the two ensiled species are almost identical. This is quite normal because of the similarity in their chemical compositions.

Pennisetum giganteum silage has an average value of 0.94 UFL/kg and 0.73 UFV/kg, similar to 0.93 UFL/kg and 0.71 UFV for *Zea mays*.

Referring to the study of Peyrat *et al*, 2015, they indicated that the VFU, FU content of the *Zea mays* silage used are 0.8/kg DM; 0.91/kg DM respectively which are comparable to the value of this trial.

Also, *Pennisetum giganteum* silage has a value of 86.52g/kg DM in EIDP and 57.12 g/kg DM in NIDP, close to 86.54 g/kg DM in EIDP and 59.01 g/kg DM in NIDP of *Zea mays* silage. In contrast to net energy and IDP, the bulk value of *Pennisetum giganteum* silage was significantly higher (p-value <0.01) than that of *Zea mays* silage (1.32 EMU versus 1.12 EMU).

However the value in PDIE and PDIN of Peyrat *et al*, 2016 is low compared to that of this study. This difference could be explained by the low amount of PB. It should be noted that the MAT content of this study is higher than the results of these authors (92 g/kg DM versus 72g/kg).

The EMU value of *Pennisetum giganteum* silage is significantly higher than that of maize silage. This means that maize silage is more analytically palatable than *Pennisetum giganteum* silage.

The calculated nutrient value of *Pennisetum giganteum* and *Zea mays* silage is shown in Figure 4.

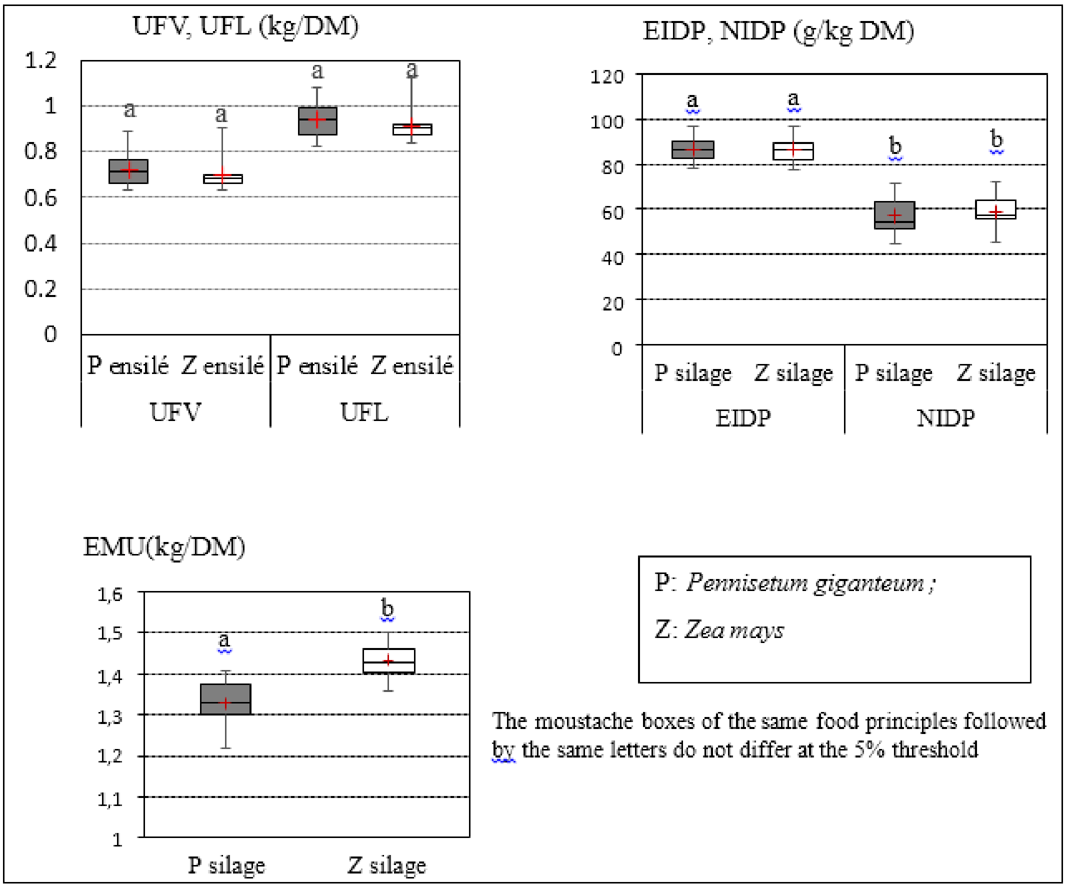

Fig 4: Nutrient value and bulk value of *Pennisetum giganteum and Zea mays* silage

The feed value of the raw materials used and the different types of rations is also calculated and is presented in Table 3.

Table 3: Nutrient value of rations used

Raw Materials		content in g/kg DM			
	CP	**CF**	**UFV**	**EIDP**	**NIDP**
Cynodon dactylon green	96	310	0,67	85	61
Zea mays silage	92	276	0,69	86	57
Pennissetum gigateum silage	89	279	0,72	86	59
rice bran	121	64	1,06	84	93
Peanut cake	401	74	1,21	382	231
Rationing 0-4 weeks					
RATION Control	90,54	175,78	0,59	77,48	59,08
RATION *Zea mays*	95,43	170,15	0,62	82,21	62,08
RATION *Pennisetum giganteum*	92,68	162,80	0,60	80,06	60,81
Rationing 4-8 weeks					
RATION Control	111,45	233,50	0,74	95,26	72,85
RATION *Zea mays*	109,59	223,06	0,76	93,21	72,29
RATION *Pennisetum giganteum*	107,13	213,89	0,75	91,19	71,53

From the resolution of the nutritive value, the zootechnical performance of sheep is determined by the ingestibility of rations.

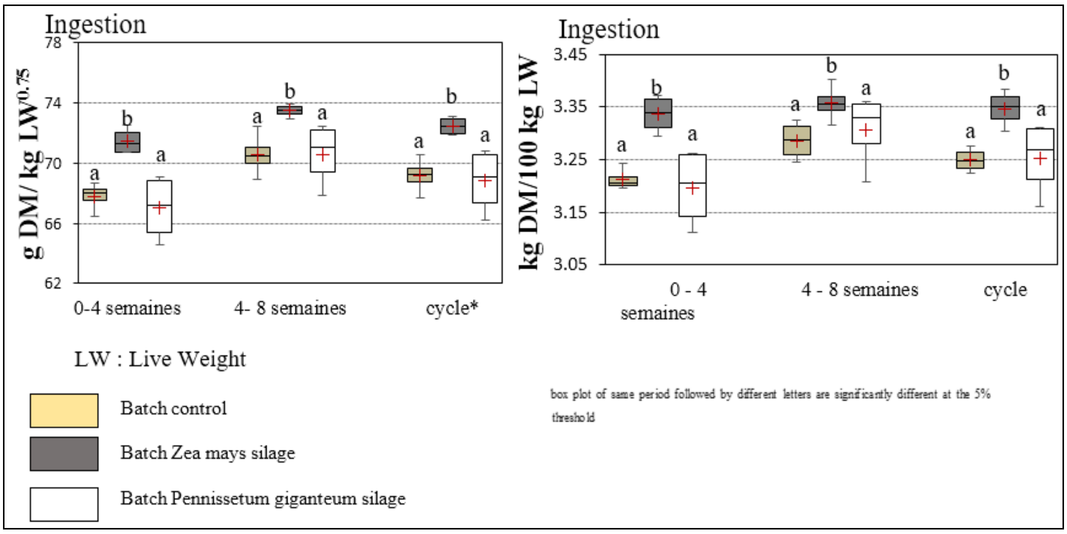

Fig 5: Ingestibility of the 3 types of rations

It is reported both in g DM per kg metabolic weight (g/kg $LW^{0.75}$) and in kg DM per 100 kg live weight (kg/100kg LW). DM intake seems to be influenced by the types of ration, because after performing ANOVA, a significant increase in the amount of DM intake of the *Zea mays* lot (72 ± 0.63 g/kg $LW^{0.75}$) was observed compared to the *Pennisetum giganteum* lot (69 ± 1.17 g/kg $LW^{0.75}$) and the control lot (68 ± 2.18 g/kg $LW^{0.75}$). This significance was observed for the value in metabolic weight (p-value=0*.012*) but also for the evaluation in % of live weight (p-value= *0.02*).

Similarly for both expressions, the Ingestibility is increased with the age of the animals. The values for the first 4 weeks are lower than those for the last 4 weeks.

During the whole experiment, the Ingestibility of the *Zea mays* batch varied from 68 to 72 g/ kg LW 0.75.

The amount of DM ingested by the *Pennisetum giganteum* batch was significantly lower than that of the *Zea mays* batch. This could be explained by the analytical bulk value of the *Pennisetum giganteum* silage being lower than that of the *Zea mays* silage. This could induce a decrease in the intake of the basic ration that was given *ad libitum*, hence a decrease in the total amount of DM ingested.

For your information, the great advantage of *Pennisetum giganteum* fodder is that its biomass is high compared to that of *Zea mays*. Moreover, it does not compete with human food. However, it has a high bulk value, so for a better use of this forage, it should be combined with low bulk value forages.

The weight evolution of sheep tested with *Pennisetum giganteum* compared to those fed *Zea mays* silage in the welded tarpaulin bags is shown in figure 6.

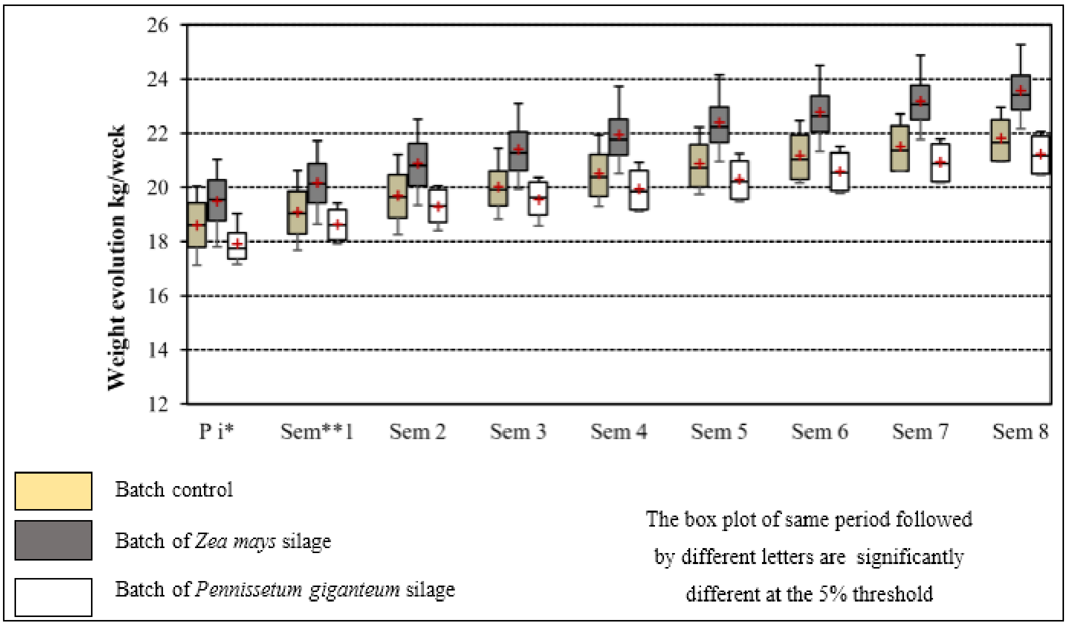

Fig 6: Weight change of sheep fed *Pennisetum giganteum* and *Zea mays* silage

At the beginning of the trial, the weights of the animals in each batch (Control lot=18.6±1.29 kg; *Zea mays* lot=19.49±1.37 kg; *Pennisetum giganteum* lot=17.9±0.82 kg) were almost identical. The weights of the different lots did not differ significantly (p-value = 0.22). However, a noticeable variation (pvalue = 0.04) starts to be seen at the beginning of the 3rd week. The *Zea mays* lot shows an expressive superiority over the Control and *Pennisetum giganteum* lots. This superiority is valid until the end of the trial. At this period the *Zea mays* silage fed lot has a weight value of 23,58 ± 1.03 kg against 21,8 ± 1 kg for the Control lot and 21,22 ± 0.84 kg for the *Pennisetum giganteum*

The trend in weight development of all lots is more pronounced in the first 4 weeks to the last 4 weeks. During the 8 weeks of testing, they increased respectively by 17% for the Control batch, 30% for *Zea mays* batch and 18% for the *Pennisetum giganteum* batch.

The ADG value is presented in figures 7. Over the whole trial, the minimum and maximum ADG value has a difference of 16 g. Indeed a significant difference (p-value = 0.01) is observed for the different types of lot. It is noted that the *Zea mays* lot has a high ADG compared to the other lots, with a value of 73 ± 4.85 g, followed by the *Pennisetum giganteum* lot (59 ± 5.9 g) and lot T (57 ± 8.05 g).

In contrast to DM intake, the average daily gain value is low in the last 4 weeks compared to the beginning of the trial until week 4éme

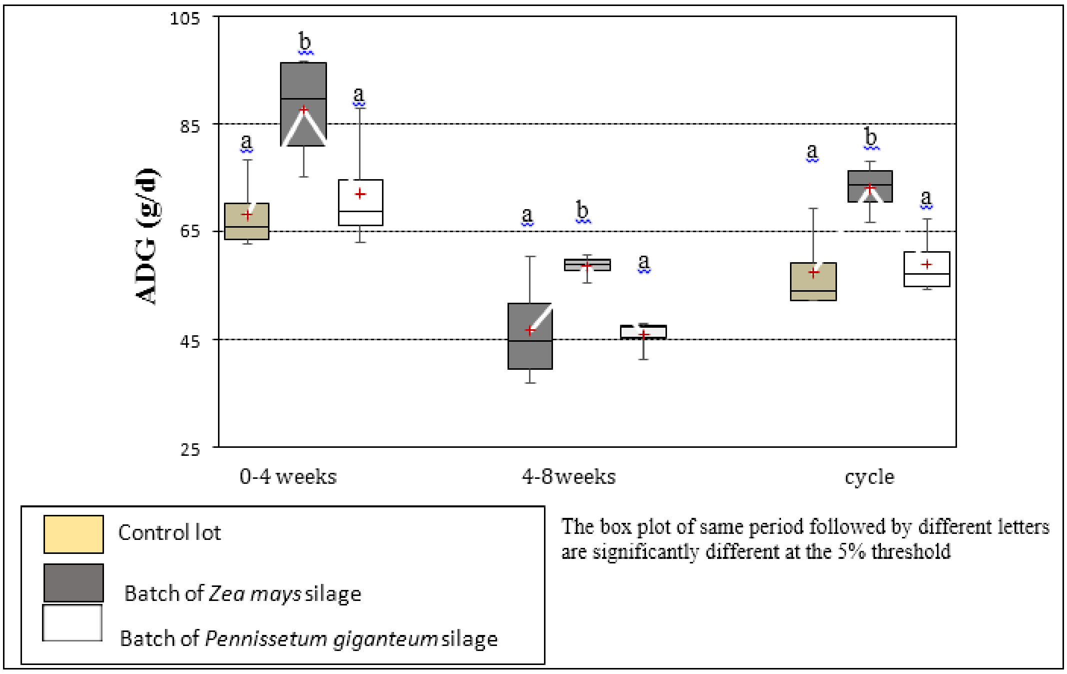

Fig 7: Average daily gain (ADG)

In fact, the weight gains of the sheep during the experiment are proportional to the protein content of their feed.

The weight gain of animals fed *Pennisetum giganteum* is lower than those fed *Zea mays* because their need is not satisfied and even though the refusal decreases as they are fed *Pennisetum giganteum*. By being fed *Pennisetum giganteum*, the sheep adapt well to it and their growth will no longer be affected, the consumption index of which is shown in figure 9.

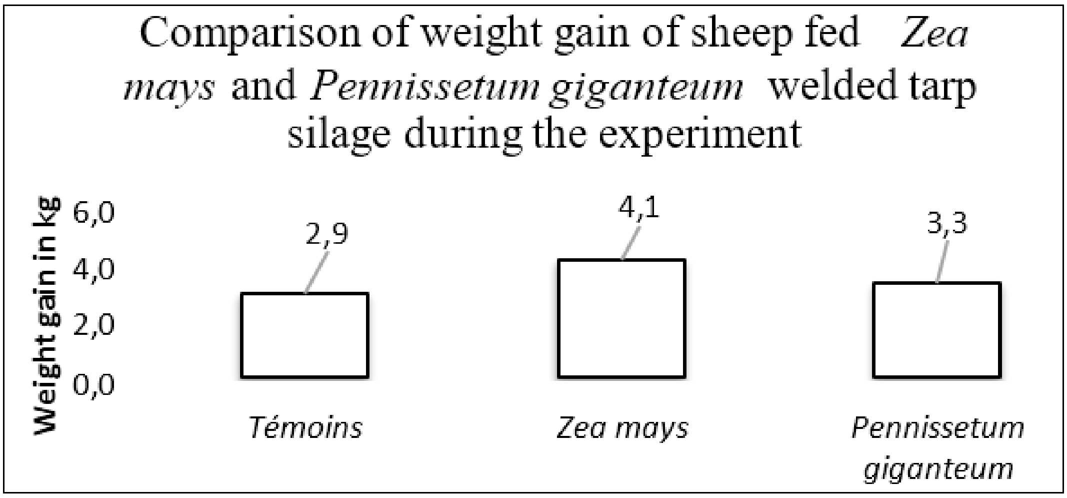

Fig 9: Consumption Index (CI)

All the batches did not show a significant difference on the consumption index. In compensation, the *Zea mays* batch had a numerically low CI. This generally means that the use of *Zea mays* silage resulted in better feed conversion in the lambs' diet. In agreement with this result, Khaing *et al.*, (2015) claimed that substitution of *Pennisetum purpureum* with *Zea mays* silage induced a considerable decrease in CI. This author studied in his trial the substitution of 0%, 25%, 50%, 75%, 100% *Pennisetum purpureum* by *Zea mays* silage. He stated that replacing 25% of *Pennisetum purpureum* with *Zea mays* silage induced a 23% decrease in CI (7.6 vs. 6).

Conclusion

For farmers with only a few herds (2 to 4), silo silage is expensive, which is why the development and improvement of micro-silo production is essential. Indeed, this improvement of technique shows a success. Good silage with a brown colour and caramel tobacco smell is obtained.

The welding of the tarpaulins does not allow air to penetrate. The results are therefore the most acceptable. The moulds are less in relation to the quantity of silage produced.

Pennisetum giganteum and *Zea mays* silages made in welded tarpaulin micro-silos are suitable. The nutritional value of *Pennisetum giganteum* silages is lower than that of *Zea mays*. This results in a proportional weight gain for the sheep. The feed made of *Pennisetum giganteum* silage must be supplemented with other protein-rich raw materials. However, the great advantage of *Pennisetum giganteum* fodder lies in its high biomass and also in its tolerance to climatic changes, always green throughout the year compared to *Zea mays*. They can be fed to ruminants in both green and silage form. Moreover, they do not compete with human food. In order to solve this forage shortage in the dry season, the number of silos must be adapted to the size of the herd and to the feeding schedule of the ruminants.

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