Meta-analysis of sorghum silages maturity stage produced in Brazil

J. Rossetto[1,2], J.P. Velho[3], D.R.M. Alessio[4], A. Faccenda[1], E.D. Sartori[1], K.C. Welter[1,5]

[1]Federal University of Santa Maria, undergraduate student in Animal Science, Palmeira das Missões, Rio Grande do Sul, Brazi;. [2]FAPERGS scholarship student; [3]Federal University of Santa Maria, Department of Animal Science and Biological Sciences, Palmeira das Missões, Rio Grande do Sul, Brazil. Email: velhojp@ufsm.br; [4]Santa Catarina State University, Graduate Education Program in Animal Science, Lages, Santa Catarina, Brazil. CAPES scholarship student; [5]PIBIC/CNPq/UFSM scholarship student

Introduction The maturity stage in which forage plants are harvested for silage is one of the factors that interfere on the fermentation and, therefore on the nutritional value of silage. Concerning the importance of this factor on the sorghum silage production, several researchers have been studying it using different hybrids in different edaphoclimatic conditions in order to set the appropriate time for harvesting to maximize the production of silages in terms of quantity and quality. Thus, the chemical composition of sorghum silages produced in different stages of maturity in experiments carried out in Brazil were evaluated in a meta-analytical research.

Materials and Methods To compose the database (DB), we have looked for public domain scientific papers published between January, 1989 and December, 2010, covering the last 22 years of researches about sorghum silage in Brazil. So, the database was built of 82 works with 604 treatments, which totalized 797 silos. The list of selected papers can be requested for the authors of this paper. In this meta-analytical study, it have been selected experiments which presented parameters relating to the chemical composition of sorghum silage (SS), concerning the maturity stage of the grain at the harvesting time. The considered stages of maturity were MI:Milky; MI-PA:Milky-Pasty; PA:Pasty; PA-DO: Pasty-Dough and DO:Dough, so the DB was composed by 191 treatments coming from 28 works, comprising 581 silos. The development of the work was based on the methodologies idealized by Normand (1999) and Lovatto et al. (2007). Statistical analyses were performed through mixed models according to Littell et al. (2006), considering the work as a random effect and the maturity stages as a fixed effect. The dry matter (DM) content was assumed as a co-variable item, considering the difference between each maturity stage (Table 1). It was used Tukey-Kramer test to compare means when necessary.

Results and Discussions When sorghum plants are harvested with the grain completely at the milky stage, they generate low dry matter silage content (Table 1), which is different ($P<0.01$) from all other maturity stages. Probably, in the milky stage every plant remains green and as soon as it evolutes its maturity stage, it begins to get senescent, contributing to the DM increase. When the photoassimilates of the grain start to get pasty consistency (milky-pasty), there are no differences ($P>0.05$) between the other maturity stages. During the maturity grain evolution occurs deposition of the backup nutrients (starch) in the panicle. However, this action is not enough to dilute the cell wall contents of produced silages. Silage stored with low DM levels (21.86%) may increase effluent losses, causing deleterious effects on the environment. There was no change on crude protein (CP) content ($P>0.05$) and ammonia nitrogen content ($N\text{-}NH_3$) since the nitrogen content is reduced in sorghum and, as we were dealing with silage experiments, we have concluded that silage first steps (chopping, compaction and sealing) have probably been well applied. The $N\text{-}NH_3$ content showed that proteolysis occurred in acceptable levels. Despite the technological evolution that has been happening in Brazil, nowadays the determination of soluble sugars and organic acids is done in few experiments. So, it was not possible to consider

the results of soluble carbohydrates in this study. However, the results of lactic and acetic acids allowed us to assume that the bacteria proliferation was optimized by soluble sugars, which have probably limited proteolysis. During the stages in which the grain is partial or totally milky, there was more lactic acid production ($P<0.02$), but it did not cause differences in pH. The fibrous carbohydrate and lignin contents did not change ($P>0.05$) in all maturity stages. Considering that sorghum silage is primarily an energy source, especially for rumen microorganisms, it is essential that researches look for ways to reduce fiber content, since it decreases the concentration of energy and may limit voluntary intake.

Conclusions The different stages of sorghum grain maturity modify the dry matter content of silage, as well as the production of lactic acid, but they do not modify the proportions of fibrous carbohydrates, lignin and pH value.

References

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Table 1. Dry matter content of silage sorghum produced under experimental conditions in Brazil between 1989 and 2010 and average chemical values according to dry matter as co-variable

Parameter	N	Maturity Stages[1]					P=
		MI	MI-PA	PA	PA-DO	DO	
DM (%)	172	21.86a	26.73b	30.62b	29.82b	34.49b	<0.001
CP (%DM)	191	7.31	8.72	7.23	7.32	6.96	0.5355
N-NH_3 (%TN)	121	5.84	9.33	6.44	1.92	5.29	0.4590
NDF (%DM)	182	59.72	57.07	57.28	57.82	58.78	0.6490
ADF (%DM)	175	35.35	34.25	33.71	35.57	33.82	0.6771
Hemicellulose (%DM)	144	22.42	22.94	21.84	21.12	22.53	0.9641
Cellulose (%DM)	136	24.27	30.82	23.82	24.48	24.55	0.1530
ADL (%DM)	159	5.29	5.18	5.20	5.76	5.46	0.9217
pH	127	3.74	3.89	3.84	3.88	3.78	0.6204
Lactic acid (%DM)	72	9.93a	10.46a	6.83b	--	6.91b	0.0172
Acetic acid (%DM)	64	1.71	1.77	1.35	--	1.17	0.0523
Propionic acid (%DM)	18	0.35	--	0.42	--	0.38	0.7304
Butiric acid (%DM)	40	0.07	0.06	0.12	--	0.07	0.5631

[1] Evaluated Maturity stages: MI = Milky; MI-PA= Milky-Pasty; PA= Pasty; PA-DO= Pasty-Dough; DO= Dough;