IMPACT OF MATURITY STAGES FROM DIFFERENT SORGHUM VARIETIES ON FERMENTATION CHARACTERISTICS AND LEACHATE LOSSES

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Introduction

Apart from tropical regions, sorghum becomes more and more important in many temperate areas (Bolsen et al. 2003). Besides draught stress, pests like western corn rootworm (*Diabrotica virgifera*) menace maize more often. Concerning yield and quality safety of home grown forage, alternative crops will become more important for cattle nutrition in the future. There is only little experience regarding sorghum cultivars and their nutritive value for cattle in Central Europe. Apart from that, sorghum varieties with different properties (biomass [bm], silage [si], grain [gr]) are existing. However, it´s not clear which type of sorghum varieties is the optimal choice for cattle farmers. The European Innovation Parntership (EIP) funds projects focusing on agricultural productivity and sustainability. The project "Nutritive value and fermentation of whole plant silages from different sorghum varieties in cattle feeding" is part of an EIP project and was started in 2016 by different partners to get answers regarding plant production, forage conservation and animal nutrition.

Materials and Methods

Six different sorghum cultivars (i Aristos^{bm}, ii ES Harmattan^{si}, iii RGT Vegga^{si}, iv Nutrigrain$^{si/gr}$, v RGT Primsilo^{gr}, vi RGT Ggaby^{gr},) were cultivated in Hafendorf (R 15°18'40.7"; H 47°27'19.3") and compared with maize silage (cultivar Angelo) in three years (2016 to 2018). Crop management (cultivation, fertilisation, maintenance) was executed with regard to recommendations of good practice. Sorghum harvest was carried out at three different maturity stages (grain ripeness: i early = soft dough, ii middle = dough, iii late = physiological maturity). Yield of total green mass and also of separated panicles (heads) and residual plants (stems and leaves) was measured from each sorghum cultivar. Samples of separated plant material were collected and prepared for chemical analysis (oven drying 48 h, 50°C). Material of chopped whole plants was compacted into plastic barrels (60 litre) and sealed hermetically via cover plates. All barrels were quickly transported to Gumpenstein (R 14°06'13.0"; H 47°29'36.9") for storage. Approximately 70 kg dry matter (DM) of sorghum silage were needed for different experiments (fermentation, leachate production, in vivo and in vitro digestibility, in situ degradability). After four months, barrels were weighed and opened to get samples of silage and leachate. Chemical analyses (DM, nutrients, fiber components, minerals, pH, NH_3-N, volatile organic compounds [VOC]) were carried out at AREC Raumberg-Gumpenstein via standardised wet chemical methods (VDLUFA 1976).

Results

Sorghum varieties showed lower DM content (194.9 to 332.8 g/kg FM) than maize silage (334.3 g/kg). DM content was significantly affected by factors cultivar ($P<0.01$), maturity ($P<0.01$) and year ($P<0.05$). Due to low DM content (below 280 g/kg DM) at early and middle grain maturity, leachate was produced (up to -12.4% of total FM) during fermentation, predominantly in silage sorghum varieties. Cultivar Aristos contained a spongy marrow inside the stems and therefore, leachate was bonded very effectively under low DM conditions in early maturity. Except for variety Aristos (64.6 g/kg DM), all sorghum cultivars contained higher crude protein content (XP) than maize silage (67.3 g/kg DM) – NutriGrain had the highest XP content (85.0 g/kg DM). Content of non-fiber carbohydrates (NFC) showed a high variance (237 to 425 g/kg DM). Compared to maize (425 g/kg DM), silage type of sorghum had markedly lower NFC content (below 300 g/kg DM), grain types had a NFC content between 303 and 368 g/kg DM. Content of structured carbohydrates (NDF, ADF, ADL) was reverse to NFC. Maize silage showed lowest NDF content (424 g/kg DM), cultivars of silage type 515 to 589 g and biomass type Aristos 606 g NDF/kg DM – RGT Ggaby was the sorghum cultivar lowest in NDF (452 g/kg DM).

In early grain ripeness, natural acidification of some sorghum cultivars was suboptimal, because of pH above recommendation level (DLG 2012). On average, a higher total VOC content was observed in silage sorghum varieties compared to biomass and grain type or maize. Acetic acid production was nearly optimal in every variety – content was between 10 and 23 g/kg DM. No problems with *clostridia tyrobutyricum* occurred in whole plant sorghum silages as average content of butyric acid was less than 1.0 g/kg DM. Only one sample of cultivar Primsilo contained 18.2 g/kg DM butyric acid in 2018. That´s the reason why the cultivar average raised up to 9.2 g/kg DM. Vendramini et al. (2018) found similar fermentation characteristics in sweet sorghum silage. In general, content and especially percentage of ethanol in total VOC was high in sorghum silages (average 32.8%) with a strong influence of the year (22.7% in 2018, 45.9% in 2016). Other fermentation parameters (pH, VOC, NH_3) were also most affected by weather conditions (factor year). Biomass and silage type showed proteolysis above 8% ammonia content of total nitrogen. The increase of grain maturity caused decreasing content of some VOC and ammonia in sorghum silages (table 1).

Table 1: DM content, fermentation parameters and leachate production of silage from various sorghum cultivars at different grain maturities in comparison with maize silage

	parameter	Dry matter		pH		lactic acid		acetic acid		propionic acid		butyric acid		ethanol		ammonia (NH_3)		leachate (FM-loss)	
	statistics	avg	sd	avg	sd	avg	sd	avg	sd	avg	sd	avg	sd	avg	sd	avg	sd	avg	sd
cultivar	maturity	g/kg FM				g/kg DM		g/kg DM		g/kg DM		g/kg DM		g/kg DM		% of N_{total}		% of FM	
Aristos[bm]	early	249	35	4.8	1.5	31	29	15	13	0.8	0.3	0.6	0.3	20	17	10	5.1	0	-
	middle	281	24	4.2	0.3	24	17	21	8	0.7	0.1	0.5	0.3	34	15	9	4.7	0	-
	late	290	31	4.1	0.1	24	10	20	5	0.6	0.1	0.2	0.1	40	14	10	3.9	0	-
Harmattan[si]	early	195	28	4.3	0.8	36	33	19	7	1.0	0.3	1.7	2.1	21	7	10	4.2	4.4	4.7
	middle	225	24	3.9	0.1	45	13	20	4	0.9	0.1	0.2	0.2	18	9	11	4.3	0.5	0.8
	late	229	15	4.1	0.1	41	19	21	5	0.9	0.2	0.1	0.1	28	19	9	2.9	0.3	0.7
Vegga[si]	early	212	10	3.9	0.2	51	31	23	6	1.3	0.2	0.8	0.6	29	24	9	4.0	2.9	3.3
	middle	227	25	3.8	0.1	52	16	23	5	0.9	0.2	0.3	0.4	24	13	9	3.7	1.6	1.7
	late	245	18	4.0	0.1	35	8	21	7	0.8	0.3	0.2	0.1	47	28	7	2.3	0.6	1.0
NutriGrain[si/gr]	early	227	2	4.1	0.3	46	37	17	0	0.9	0.5	0.4	0.1	23	13	9	1.5	2.2	1.6
	middle	242	4	4.0	0.0	38	3	11	1	1.0	0.2	0.1	0.1	13	2	9	1.5	1.0	0.7
	late	254	16	4.2	0.1	30	1	13	4	0.8	0.4	0.1	0.0	13	0	7	1.3	0.5	0.7
Primsilo[gr]	early	298	5	4.5	0.4	19	23	10	8	1.2	0.6	9.2	12.8	15	5	7	5.3	0	-
	middle	319	17	4.0	0.1	35	3	13	7	0.6	0.0	0.2	0.1	10	1	6	4.0	0	-
	late	328	33	4.1	0.1	29	3	12	5	0.6	0.3	0.1	0.1	20	12	4	2.3	0	-
Ggaby[gr]	early	275	21	4.5	0.9	25	20	14	7	0.9	0.3	0.8	0.6	20	6	8	3.9	0.1	0.4
	middle	333	63	4.3	0.5	23	15	12	7	0.7	0.1	0.1	0.2	13	5	8	4.6	0	-
	late	305	29	4.3	0.2	25	9	12	7	0.7	0.1	0.1	0.0	12	2	6	1.4	0	-
Maize-silage Angelo (reference)	middle	334	22	4.0	0.2	29	15	15	6	1.0	0.6	0.2	0.1	16	5	9	4.1	0	-

statistics: avg = average, sd = standard deviation; sorghum type: bm - biomass, si - silage, gr - grain

Conclusions

In comparison with maize silage, fermentation characteristics of most tested sorghum varieties were similar. However, cultivars of silage type were tending to have lower DM content and higher production of leachate. These silage sorghum cultivars showed loss of leachate especially at early and middle grain maturity. Biomass sorghum had low content of valuable nutrients (XP, NFC). Therefore, this type will be dropped from the list of alternative crops for cattle farmers. Concerning nutrient composition, fermentation quality and leachate losses, cultivars of grain sorghum type could be an alternative to maize silage, especially in temperate regions with draught stress in summer.

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