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Article

Effects of sorghum silage in lactating buffalo cow diet: biochemical profile, milk yield and quality

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Abstract: The influence of replacing corn silage with sorghum silage in the diet of dairy buffalo cows on metabolic status and on milk yield, chemical characteristics and fatty acid profile was studied. Forty dairy buffalo cows were included in the trial and divided into two homogeneous groups (SS, sorghum and CC, corn). Blood was collected at the end of the trial (120 days), individual milk yield was registered daily. Samples of milk were monthly collected and analyzed for fat, protein and lactose. Moreover, fatty acid profiles of silages and milk were determined. Buffalo cows fed sorghum silage showed an average milk yield higher than group CS (kg/d 10.120 vs 9.270; $P<0.05$), probably due to the lower lignin content of sorghum silage (31 vs 47 g/kg dry matter, respectively for SS and CS diets) and by consequence to its energy value, higher than expected. The percentage of linoleic acid was significantly higher in milk of group CS (C18:2: 1.27% vs 2.05%; $P<0.01$) due to the higher content of these acids in corn than in sorghum silage. The omega 6/omega 3 ratio was significantly lower in milk from buffalo cows fed sorghum than corn silage (7.8 vs 12.9; $P<0.01$). Serum biochemistry showed no negative effects of the corn replacing with sorghum.

Keywords: Sorghum silage; Corn silage; Buffalo cows; Milk; Serum biochemistry

1. Introduction

The breeding of Bufala Mediterranea Italiana (Bubalus bubalis) represents an important sector for the Italian economy, in particular for the production of mozzarella cheese with a growing trend that has reached 50 million pounds in 2018, 31% of which coming from export.

Corn silage (Zea mays L.) is the main forage utilized in the diets of dairy buffaloes, but several concerns related to its use have been raised in the last years. In particular, the cost of irrigation represents a limit to corn cultivation. Furthermore, corn presents a contamination risk by mycotoxins, produced by fungal organisms. In particular, the genera Fusarium (47%) and Aspergillus (34%) can be found in the corn silage. The molds of the genus Fusarium are able to produce 20 different mycotoxins, including zearalenone and fumonisin, while molds of the Aspergillus genus produce aflatoxins [1]. Indeed, the effects of micotoxins counteracted with feed additives.

These concerns have given growing interest to the possible substitution of corn silage with other silages, such as sorghum silage (*Sorghum vulgare* L.). Sorghum is able to tolerate drought better than corn and it can be attributed to the root system, characterized by primary roots able to provide water and nutrients from the soil, and secondary roots finer and branch approximately more than double as roots from corn plants, able to penetrate

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very deep into the soil. In addition, leaves represent a small area per plant, and this can limit the transpiration, thus, in dry and warm conditions sorghum can bend more efficiently compared to corn [2]. For all these reasons, and since sorghum was showed to make silage nearly equal to corn silage [3], several authors investigated about its possible use in ruminant diet and, in particular, about the effects of a partial or total replacement of corn silage.

Moreover, as consumer requirements concerning food quality have largely improved in recent years and since animal diet has been widely demonstrated to affect food nutritional characteristics, research has to investigate also this aspect, assessing any possible change of food nutritional value occurring by modifying animal diet ingredients. As suggested by Cattani et al. [1] in dairy cows this is particularly important when dealing with the fatty acid profile, mainly the concentration of omega-3 polyunsaturated fatty acids, which have been associated with a decrease in the risk of heart disease and with conjugated linoleic acids (CLA) which are recognized as having antioxidative and anticarcinogenic properties in animal models [4, 5] and in human [6]. Aim of present trial was to study the influence of replacing corn silage with sorghum silage in the diet of dairy buffalo cows bred in South Italy, on animal health and milk yield, chemical characteristics and fatty acid profile.

2. Materials and Methods

2.1 Animals and diets

The trial was performed according to the Animal Welfare and Good Clinical Practice (Directive 2010/63/EU) and was approved by the local Bioethics Committee (protocol number: PG/0016571). The trial was carried out at a dairy buffalo farm in Cassino, province of Frosinone (Center-South Italy), located on an irrigated area (41°26'27''N, 13°50'00''E, 40 m a.s.l.) with 1100 mm average annual rainfall mainly concentrated in autumn-winter and monthly average temperatures ranging from 7.3 C° (January) to 23.3 C° (August). The farm host 150 Italian Mediterranean buffalo cows in open yards that allowed 15 m2 with a feeding trough space of around 1.0 m/head. For the sorghum (Sorghum vulgare) the forage hybrid seeds BMR 333 (Brown Mid Rib) and for the corn (*Zea mais* L.), as farm use, the cultivar Kamil (class FAO 400) were utilized. Both the forages were sown in a soil that previously hosted alfalfa (Medicago sativa), fertilized with bibasic ammonia phosphate (2 q/ha) plus urea (2 q/ha) at sowing time, and ammonia nitrate (2 q/ha) at covering, for a total nitrogen of 150 kg/hectare. Eight irrigations (5000 m3/ha) for the corn and one for the sorghum was effected. The crops, seeded in May 2017, were harvested in September (soft dough and kernel dent phases of maturity, for sorghum and corn respectively) chopped and ensiled in two bunker silos for about 40 d. After silos opening, 3 representative samples of each forage were monthly taken, pooled and analysed for fermentation parameters, according to Calabrò et al. [7]. Other 3 representative samples of each forage were monthly taken, pooled, dried at 60°C for 48 h, milled (1.1 mm screen) and analyzed for the chemical composition [8]. In addition, the fibrous carbohydrates were fractioned according to Van Soest et al. [9] and the net energy for lactation (NEl, MJ/kg DM) content was estimated as suggested by Sauvant and Nozière [10]. Samples of alfalfa hay and concentrate were analysed as well.

Immediately after calving, forty multiparous dairy buffalo cows (LW: kg 650 ± 13) were equally divided into two homogeneous groups (SS and CC) on the basis of parity (3 to 5 calving) and previous milk yield (kg 2180 ± 142 in 270 days). They were allocated in ten separate open yards (5 per group; 4 animals/each) that allowed 15 m2 with a feeding trough space of around 1.0 m/head and with free access to water. In order to meet their nutritive requirements, two isoenergy and isoprotein diets (Table 1) were formulated using alfalfa hay, concentrate and sorghum (diet SS) or corn silage (diet CS) and administered, once daily, as total mixed ration (TMR), prepared by a total mixer wagon. The amount of TMR distributed in the mangers of each group as well as orts were measured daily.

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Table 1 Diets ingredients (kg of DM), crude protein (g/kg DM) and energy (NEl, MJ/kg DM).

Ingredients	SS	CS
Corn silage	-	5.325
Sorghum silage	5.000	-
Alfalfa hay	3.670	3.450
Concentrate*	6.500	6.225
Crude protein	152.0	150.0
NEl, MJ/kg DM	6.335	6.335

SS, sorghum silage diet;

CS, corn silage diet.

*Concentrate ingredients (% DM): wheat bran 34.0, faba bean 30.0,

pea seeds 12.0, cotton meal 8.8, corn meal 7.5, dried beet pulp 6.0, CaCO3 1.6, vit-min 1.1

2.2 Milk analyses

Individual milk yield was daily registered and monthly (from 30 days until 120 days in milk) samples, representative of the two daily milking, were collected and analyzed for fat, protein and lactose (MilkoScan™ 133B, Foss Matic, Hilleroed, Denmark). Moreover, milk and silages fatty acid profiles were determined. Fat from silages were extracted by a chloroform/methanol solution (2/1 v/v) as reported by Folch et al. [11], while milk lipids were extracted using the method described by Hara & Radin [12]. In both cases, extracted lipids were evaporated in a stream of nitrogen, then recovered with 5 mL of hexane and stored in amber glass vials with screw caps at a temperature of -20 °C until the subsequent derivatization operation. The samples extracted were esterified by treating a volume of extract containing 75 mg of fat with 500 µL of saturated solution of potassium hydroxide in methanol in teflon-coated screw cap tubes for 20 minutes at room temperature in according with Basic transmethylation: IDF-FIL method 182 (1999). The tubes were centrifuged (2000×g) for 10 minutes and the volume of the upper phase containing the methyl esters of fatty acids (FAME) was removed and analyzed on the same day. The FAMEs were analyzed in a Gaschromatograph model FOCUS (Thermo Scientific Co. Waltham, MA USA 02451) equipped with a capillary column in fused silica SP-2380 (100 m × 0.25 mm id × 0.2 mm film thickness: Supelco, Inc., Bellefonte, PA, USA) using the AS 3000 II autosampler. The carrier gas, helium, was set at the constant pressure of 180 kPa, splitting flow of 50 ml/min, injection volume of 1 µl. Column parameters: the initial temperature of the column was maintained at 170 ° C for 15 minutes; then with an increase of 5 ° C/min it was brought up to 240 ° C and kept constant for 35 min. The total execution time was 64 minutes. The data were collected automatically, using the Chrom-Card for Windows program (Thermo Scientific Co. Waltham, MA USA 02451), the fatty acids were identified by comparing the retention times of the commercial standards containing 37 methyl esters of fatty acids (Sigma -Aldrich, Inc St. Louis, MO USA 63103). The retention times of the CLA isomers were controlled by the elution of commercial standards (Larodan AB-SE-171 65 Solna Sweden) of these fatty acids. The area of each individual fatty acid identified in the sample was quantified by percentage calculation on the total area of the eluted peaks, as described by Tudisco et al. [13].

2.3 Blood analyses

Health status of animals was monitored monthly based on clinical signs of disease always by the same veterinary practitioner. At the end of the experiment (120 days), blood samples were obtained from the coccygeal vein at 07:00 am before feeding. All blood samples were collected into 10 ml vacutainer tubes (Becton Dickinson, Franklin Lakes, NJ, USA) and allowed to clot and kept at 4°C until separation of serum. Clotted blood was centrifuged at 1600 x g at 4°C for 20 minutes. The separated serum samples were stored at -80°C until analysis to avoid loss of bioactivity and contamination and were thawed on ice for approximately 2 h before use. Blood chemistry analyses were performed by an automatic biochemical analyser AMS Autolab (Analyzer Medical System, Rome, Italy) using reagents from Spinreact (Girona, Spain) to determine: blood urea nitrogen (BUN), creatinine (CREA), glucose (GLU), aspartate amino transferase (AST), cholesterol (CHO) and triglycerides (TRI); reagents from Catachem (Bridgeport-Connecticut- USA) to determine β-hydroxybutyric acid (B-HBA), reagents from Randox (Ireland) for non-esterified fatty acids (NEFA), and from Diacron International s.r.l. (Grosseto, Italy) to assess reactive oxygen metabolites (d-ROMs) and the biological antioxidant potential (BAP).

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2.4 Statistical analysis

Data of milk yield and quality were analysed using the MIXED procedure of the JMP® (Version 9 SW, SAS Institute Inc., Cary, NC, USA, 1989–2019), according to the model:

$$yijk = m + Gi + Pj + G \times Pij + eijk$$

where yijk = single observation; m = general mean; Gi = group effect (i = C and S); Mj = month of milking effect (j = I,...IV); Gi x Mj = interaction group x month; eijk = error. The differences among means were tested by Tukey test and the differences were considered statistically significant at $p < 0.05$.

Data of blood samples were analysed with one-way ANOVA using the JMP® (Version 9 SW, SAS Institute Inc., Cary, NC, USA, 1989–2019) considering only the group effect according to the following model:

$$yik = m + Gi + eij$$

where yij = single observation; m = general mean; Gi = group effect (i = CS and SS); eij = error. The differences among means were tested by Tukey test and the differences were considered statistically significant at $p < 0.05$.

3. Results

3.1 Silages

Sorghum silage (SS) showed lower dry matter (DM: 26.2% vs 28.5%) and protein content (CP: 80.2 vs 83.0 g/kg DM) than corn silage (CS). Concerning fibrous fractions, NDF were higher in sorghum silage while ADL in corn silage (569.3 vs 551.2 g/kg DM and 31.0 vs 47.0 g/kg, for SS and CS, respectively). The net energy for lactation of silages were similar (5.125 vs 5.267 MJ/kg DM, for sorghum and corn silage, respectively) both lower than that of alfalfa hay (Table 2).

Table 2 Feeds chemical composition (g/kg DM) and nutritive value.

Chemical characteristics	SS	CS	H	C*
DM (%)	26.2±0.4	28.5±0.3	-	-
Crude protein	80.2±1.3	83.0±1.6	161.0±1.6	203.0
Ether extract	32.2±0.7	33.0±0.6	20.0±0.4	55.1
NDF	569.3±32.2	551.2±34.1	439.0±15.7	232.4
ADF	360.1±19.8	361.3±21.6	313.0±10.8	92.3
ADL	31.0±0.9	47.0±1.1	52.0±0.8	24.2
NEl MJ/kg DM	5.125±0.3	5.267±0.2	5.480±0.2	7.829

NDF, neutral detergent fibre;

ADF: acid detergent fibre;

ADL: acid detergent lignin.

*Concentrate ingredients (% DM): wheat bran 34.0, faba bean 30.0, pea seeds 12.0, cotton meal 8.8, corn meal 7.5, dried beet pulp 6.0, $CaCO_3$ 1.6, vit-min

The fermentations were adequate for both the silages (Table 3) as suggested by pH values, negligible proportion of propionic and butyric acids, much higher production of lactic than acetic acid and N-NH_3 values lower than 7 g/kg total N [14].

Concerning silages fatty acid profile, the percentage of stearic (C18:0) and myristic acid (C14:0) were similar between the silages. Corn silage showed higher content of linoleic acid (C18:2: 21.0% vs 35.8%, for SS and CS silage respectively) and sorghum silage higher contents of palmitic (C:16: 20.80% vs 17.0, for SS and CS silage, respectively) oleic (C18:1: 26.6% vs 24.4%, for SS and CS silage respectively) and alfa-linolenic acid (C18:3: 13.6% vs 5.8%, for SS and CS silage respectively).

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Table 3 Silages fermentative parameters and FA profile (% total FA).

Fermentative parameters	SS	CS
pH	4.15±0.2	4.03±0.3
Lactic acid (g/kg DM)	42.3±1.6	46.0±1.9
Acetic acid (g/kg DM)	13.1±0.5	15.0±0.3
Propionic acid (g/kg DM)	0.5±0.01	0.5±0.02
Butyric acid (g/kg DM)	0.3±0.002	0.2±0.002
N-NH3 (g/kg total N)	4.20±0.4	5.30±0.3
Fatty acid profile		
C14:0	0.40±0.03	0.30±0.03
C14:1	0.02±0.001	0.02±0.002
C16:0	20.8±2.01	17.0±2.13
C16:1	0.31±0.02	0.20±0.03
C18:0	2.4±0.03	2.3±0.03
C18:1 *cis 9*	26.6±0.9	24.4±0.8
C18:1 *cis 11*	1.12±0.02	0.81±0.02
C18:2 *cis 9 cis 12*	21.0±0.8	35.8±1.2
C18:3 *cis 9 cis 12, cis15*	13.6±1.10	5.8±0.5
C20:0	1.31±0.1	0.4±0.06
C20:1 *cis 11*	0.3±0.01	0.2±0.01
C20:2	0.02±0.01	0.02±0.01
C22:0	0.98±0.01	0.42±0.01
C24:0	1.02±0.04	0.72±0.03

SS, sorghum silage;

CS, corn silage.

3.2 Animals and milk

No refusals were detected for both groups; dry matter intake (DMI) was similar between the groups (Table 3). Buffalo cows fed sorghum silage showed an average milk yield significantly higher than group CS (kg/d 10.120 vs 9.270; P<0.05) and the differences were observed also for the sampling effect, as well as the interaction between group and sampling. Milk chemical composition was not significantly different between the treatments.

Table 4 Daily dry matter intake (DMI, kg DM/head/day), milk yield (kg/head/day) and chemical composition (%).

Milk chemical composition	SS	CS	Group effect	Sampling effect	G x S	SEM
DMI	15.17	15.00	NS	NS	NS	2.1
Yield	10.120	9.270	*	*	*	1.5
Fat	8.52	8.38	NS	NS	NS	0.21
Protein	4.70	4.68	NS	NS	NS	0.16
Lactose	5.01	5.02	NS	NS	NS	0.12

SS, sorghum silage;
CS, corn silage
*, P <0.05;
NS, Not Significant;
SEM, standard error of mean.

Most of milk fatty acids were unaffected by treatment (Table 4), even if group CS showed significantly higher percentage of linoleic acid (C18:2 cis 9cis12: 1.27% vs 2.05%; P<0.01, for SS and CS group respectively) total PUFA (2.32% vs 3.23%; P<0.01, for SS and CS group respectively) and PUFA omega 6 (1.56% vs 2.45%; P<0.01, for SS

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and CS group respectively). The omega 6/omega 3 ratio was significantly lower in milk from SS than CS group (7.8 vs 12.9; P<0.01, for SS and CS group respectively).

Table 5 Milk fatty acid profile (% total fatty acids).

Milk fatty acids profile	SS	CS	Group effect	Sampling effect	G x S	SEM
C4:0	4.00	3.72	NS	NS	NS	0.97
C6:0	1.80	1.77	NS	NS	NS	0.38
C8:0	0.88	0.89	NS	NS	NS	0.20
C10:0	1.92	1.98	NS	NS	NS	0.56
C11:0	0.14	0.15	NS	NS	NS	0.02
C12:0	2.67	2.65	NS	NS	NS	0.53
C14:0	11.0	11.1	NS	NS	NS	1.53
C14:1 *cis* 9	0.24	0.28	NS	NS	NS	0.05
C15:0	0.78	0.74	NS	NS	NS	0.03
C15:1	0.18	0.17	NS	NS	NS	0.01
C16:0	31.40	32.00	NS	NS	NS	2.84
C16:1 *cis* 9	1.42	1.43	NS	NS	NS	0.20
C17:0	0.74	0.75	NS	NS	NS	0.05
C17:1	0.27	0.25	NS	NS	NS	0.02
C18:0	13.20	13.33	NS	NS	NS	0.62
C18:1 *cis* 9	3.09	3.08	NS	NS	NS	0.53
C18:1*trans* 11	21.15	21.95	NS	NS	NS	0.90
C18:2 *trans* 9 *trans* 12 *omega* 6	0.15	0.24	NS	NS	NS	0.11
C18:2 *cis* 9 *cis* 12 *omega* 6	1.27	2.05	**	**	**	0.87
C20:0	0.50	0.48	NS	NS	NS	0.04
C18:3 *omega* 3	0.20	0.19	NS	NS	NS	0.09
C22:0	0.21	0.24	NS	NS	NS	0.14
C24:0	0.22	0.19	NS	NS	NS	0.04
C22:6 *omega* 6	0.14	0.16	NS	NS	NS	0.02
cis-9 *trans*-11 CLA	0.50	0.53	NS	NS	NS	0.18
trans-10 *cis*-12 CLA	0.06	0.06	NS	NS	NS	0.01
SFA	69.46	69.99	NS	NS	NS	3.51
MUFA	26.35	27.16	NS	NS	NS	2.19
PUFA	2.32	3.23	**	**	**	0.54
∑ CLA	0.56	0.59	NS	NS	NS	0.12
PUFA *omega* 6	1.56	2.45	**	**	**	1.06
PUFA *omega* 3	0.20	0.19	NS	NS	NS	0.032
omega 6/*omega* 3	7.8	12.9	**	**	**	1.02

SS, sorghum silage;

CS, corn silage;

SFA, saturated fatty acids;

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MUFA, monounsaturated fatty acids;

PUFA, polyunsaturated fatty acids;

CLAs, conjugated linoleic acids.

**, P<0.01;

NS, Not Significant;

SEM, standard error of mean.

2.3 Blood

Blood chemistry parameters (Table 6) were in the normal range for the physiologic state of animals and no significant differences were detected between groups. Similarly, results concerning the oxidative status showed no d-ROMs either BAP differences.

Table 6 Blood chemistry parameters.

Blood chemistry	Units	SS	CS	Group effect	SEM
BUN	*mg/dl*	20.87	23.12	NS	2.87
CREA	*mg/dl*	0.831	0.806	NS	0.121
GLU	*mg/dl*	50.18	47.78	NS	8.69
AST	*U/L*	43.45	38.09	NS	6.13
CHO	*mg/dl*	58.56	66.90	NS	13.48
TRI	*mg/dl*	59.88	65.13	NS	9.09
B-HBA	*mg/dl*	9.62	8.06	NS	1.02
NEFA	*mg/dl*	6.73	5.82	NS	0.781
d-ROMs	*UCARR*	3224	3481	NS	1021
BAP	*µmol/L*	38.9	44.6	NS	6.79

SS, sorghum silage; CS, corn silage. NS, Not Significant.

SEM, standard error of mean.

BUN, blood urea nitrogen; CREA, creatinine; GLU, glucose;

AST, aspartate amino transferase; CHO, cholesterol; TRI, triglycerides;

B-HBA, β-hydroxybutyric acid; NEFA, non-esterified fatty acids

d-ROMS, reactive oxygen metabolites;

BAP, biological antioxidant potential.

4. Discussion

The silages protein contents (CP) were higher than those reported for both sorghum and corn silages by Cattani et al. [1], only for corn silage by Getachew et al. [15] and only for sorghum silage by Calabrò et al. [16]. On the contrary, CP content of sorghum silage in the present trial was similar to those found by Getachew et al. [15] and Grant et al. [17]. Sorghum silage showed higher neutral detergent fibre and lower acid detergent lignin (ADL) contents than corn silage, according to Calabrò et al. [16] while Cattani et al. [1] reported also ADL higher for sorghum than corn silage. This difference could be due to the fact that BMR sorghum hybrids, like the one used in the present trial, are characterized by the expression of a BMR gene associated with lower lignin concentration than comparable non-BMR hybrids [15].

Both silages used in this trial could be defined of good quality according to Grant et al. [17]. The fermentative parameters of corn silage were similar to those reported by Morand-Fehr et al. [18], while Hassanat et al. [19] found lower lactic acid proportion (38.6 g/kg DM) and higher NH3-N content (10.1 g/kg DM). Our results

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concerning fermentative parameters of sorghum silage agree with those of Cattani et al. [20] while Grant et al. [17] reported higher concentration of acetic acid.

Dry matter intake was not different between groups, according to Cattani et al. [1], while milk yield was higher milk yield in buffalo cows fed sorghum silage. This result could be attributed to its lower ADL content compared to corn silage; in fact, according to Miron et al. [21], lower lignin content increased NDF digestibility. Moreover, Miron et al. [21] reported significantly higher ($P<0.05$) NDF in vitro digestibility for sorghum than corn silage (60% vs 56%), despite their similar lignin contents (5.9 vs 6.2% DM, respectively for sorghum and corn silage). According to these authors, the higher levels of grain in corn silage can inhibit cellulolytic activity of rumen bacteria, thereby reducing the extent of corn NDF digestibility. In contrast, Barile et al. [22] found no differences in milk yield in buffalo cows fed with sorghum silage vs corn silage diets. Several studies aimed to completely replace corn with sorghum silage in dairy cow's diet have been conducted with contrasting results. Indeed, milk yields were unaffected by treatment according to Miron et al. [21] and Khosravi et al. [23], while Colombini et al. [3] and Cattani et al. [1] reported higher milk yield when cows received the diet based on corn silage. This negative results for sorghum silage could be attributed to the variety of forage, in fact, Grant et al. [17] found negative influence of replacing corn with sorghum silage sorghum only when dairy cows were fed diet based on non-BMR sorghum while milk yield was unaffected when BMR was used. These authors reported also higher NDF digestibility for BMR than non-BMR sorghum silage. In the present trial, milk chemical characteristics were unaffected by treatment, according to Grant et al. [17]. Conversely, Miron et al. [21] and Cattani et al. [1] found that sorghum silage based diet increased fat percentage compared to the corn silage diet. These authors attributed the effect to the greater intake of NDF when cows received the sorghum silage diet.

Replacing corn silage with sorghum silage in the diet of buffalo cows had no effect on milk saturated and monounsaturated fatty acids, whereas total polyunsaturated and particularly linoleic acid were greater with corn diet. Higher proportion of linoleic acid we have found also in corn silage than in sorghum silage, which instead showed higher percentage of alfa-linolenic acids. Cattani et al. [1] found either linoleic and alfa-linolenic acids higher in milk when cows were fed corn compared to sorghum silage; on the contrary Khosravi et al. [23] reported higher proportions of alfa-linolenic acid in milk of dairy cows fed sorghum silage diet. Both linoleic and alfa-linolenic acids are recognised as main precursors of milk CLA [13, 27] which in present trial was unaffected by the treatment in contrast with Cattani et al. [1] which reported higher total CLA when cows were fed sorghum silage. According to the results of these authors, also in the present trial replacing corn with sorghum silage determined improvements on the nutritional value of milk, particularly, a significant reduction of omega 6/omega 3 ratio was seen. These 2 classes of fatty acids have different physiological functions (pro- and anti-inflammatory activity for omega 6 and omega 3, respectively): lowering their ratio is considered optimal for human health [29].

Importantly, serum biochemistry showed that the experimental diet had no negative effects either at organ levels nor in terms of energy metabolism. All markers of health status showed no differences between groups, thus showing that the experimental diet did not affect cow metabolism even during the first part of the experiment. Also, the oxidative status did not change suggesting that the tested diet ensured a physiological ROS production.

The concentrations of biochemical parameters in the serum of the animals were within the typical ranges reported for cattle [30] and the effects of experimental diet were similar (Table 5). Absence of difference in blood parameters among the experimental cows was probably due to the similar diet nutritive values and DMI. The BUN is a well-known marker of protein status of an animal as well as of rumen performance [31], thus, these two aspects were not influenced by the sorghum diet. Blood glucose and NEFA are important markers of energy metabolism in dairy cows [32] and serum fatty acids negatively correlate with energy balance in dairy cows [33]. In our study, concentrations of NEFA, BHBA, GLU, CHO and TRI in the two groups were within normal ranges [34], therefore, the lack of any differences between the diets was probably due to similar intakes and digestibility, and suggest that sorghum can be safely used. Such hypothesis is also confirmed by the results concerning the oxidative state of animals. The absence of differences in dROMs levels between groups shows that the SS diet did not increase oxidative stress and the antioxidant barrier (BAP) exerted the same protection of the CS diet against free radicals.

5. Conclusions

In conclusion, the present trial suggests that the complete replacing of corn silage with sorghum silage in the diet for dairy buffalo cows resulted in significantly higher milk yield without negative effects on animal health, milk protein and fat concentrations. In addition, from a dietetic point of view, milk of buffalo cows fed sorghum silage seems to be more favourable. Indeed, even if the differences were only due to the decrease of linoleic acid, they determined significantly lower omega 6/omega 3 ratio recognised as having beneficial effects on human health.

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