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Evaluation of rehydrated corn grain silage with okara or soybean inclusion in the performance of lactating cows

Avaliação da silagem de grãos de milho reidratados com inclusão de okara ou soja no desempenho de vacas em lactação

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Highlights:

Corn silage reduces intake by 10.1% and 12.1% with okara and soybean inclusion, respectively, compared to the control.

Corn grain silages with okara or soybean do not change milk production.

Soybean inclusion in the corn grain silage increases the CLA content in cow milk.

The use of okara or soybean in corn silage is subject to economic analysis.

Abstract

This study aimed to evaluate dry matter intake, nutrient digestibility, milk production and composition, and feed efficiency of cows fed corn grain silages with okara or raw soybean inclusion. Six Holstein cows were distributed in a double Latin square and arranged in the following treatments: concentrate formulated based on corn grain silage with 30% okara inclusion; concentrate of corn grain silage with 20% raw soybean inclusion, and concentrate based on dry corn grains. Statistical analysis was performed using Bayesian inference. Diets formulated with silages reduced dry matter intake compared to the diet of concentrate based on dry grains. High digestibility of DM, OM, NFC, and EE was observed for diets with silage inclusion. Milk presented an increase in CLA for the diet of corn grain silage diet with soybean inclusion. Rehydrated grain corn silage with soybean or okara inclusion reduced dry matter intake and increased nutrient digestibility, maintaining the same milk production, which demonstrates the higher efficiency of these diets.

Key words: Fatty acids. Conjugated dienes. Feed efficiency. Agricultural by-product. Milk production.

Resumo

Objetivou-se avaliar a ingestão de matéria seca, digestibilidade dos nutrientes, produção e composição do leite e a eficiência alimentar de vacas alimentadas com silagens de grãos de milho com adição de okara ou de soja crua. Foram utilizadas 6 vacas da raça Holandesa, distribuídas em um duplo quadrado latino, nos seguintes tratamentos: concentrado formulado à base de silagem de grãos de milho com

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adição de 30% de okara; concentrado com silagem de grãos de milho com adição de 20% de soja crua e concentrado à base de grãos secos de milho. A análise estatística foi realizada por meio de Inferência Bayesiana. As dietas formuladas com as silagens diminuíram o consumo de matéria seca em relação à dieta com concentrado à base de grãos secos. Foi verificada maior digestibilidade da MS, MO, CNF e EE para as dietas com a inclusão das silagens. Houve aumento do CLA no leite para a dieta com silagem de grãos de milho com adição de soja. A ensilagem de grãos de milho reidratados com adição de soja ou okara diminui o consumo de matéria seca, aumenta a digestibilidade dos nutrientes, mantendo a mesma produção de leite, o que demonstra superioridade na eficiência destas dietas.
Palavras-chave: Ácidos graxos. Dienos conjugados. Eficiência alimentar. Subproduto da agroindústria. Produção de leite.

Introduction

Starch degradability in the rumen depends on several factors, such as corn grain texture, processing, intake level, and ruminal kinetics (Donkin, 2014). Processing as corn grain silage acts positively on the digestibility of starch granules, as it leads to the breakdown of the protein matrix that involves the starch granules (Hoffman et al., 2011). In the feeding of dairy cows, some studies have not reported a difference in milk production and composition, but overall, grain silage is more efficient due to better use of nutrients in the total diet (Canizares et al., 2011; Panichi et al., 2012).

Composition and nutritional quality of corn grain silage can be changed considerably with the inclusion of different foods at the time of ensiling (Jobim, Calixto, Bumbieris, & Oliveira, 2010). However, its use must be strategic, depending on each case. Soybean grain with a 20% inclusion in the corn grain silage has shown positive results in terms of nutritional quality, fermentation in the silo, and animal response (Calixto, Jobim, Osmari, & Tres, 2017).

In addition to soybean inclusion in the corn grain silage, other products can be used at the time of ensilage, such as okara, a by-product of soybean processing to obtain aqueous extract and tofu. To obtain okara, soybean grains are washed, macerated, ground, heated at 100 °C for five minutes, and then passed through a filtration process that separates the aqueous extract from okara. This by-product has the good nutritional quality and low acquisition cost, with protein content from 240 to 375 g kg^{-1}, lipids from 93 to 223 g kg^{-1}, and crude fiber from 140 to 550 g kg^{-1}, based on the dry matter (Mateos-Aparicio, Mateos-Peinado, Jiménez-Escrig, & Rupérez, 2010; Diaz-Vargas et al., 2016). However, its high moisture content makes it difficult to be dried, but it is a promising food for silage with dry corn grains.

The objective was to evaluate dry matter intake, diet digestibility, milk composition and production, and feed efficiency of cows fed rehydrated corn grain silages with okara or soybean grain inclusion.

Material and Methods

The performance of dairy cows was evaluated in an experiment conducted in the Sector of Milk Cattle at the Experimental Farm Iguatemi, with chemical analyses conducted at the Laboratory of Food Analysis and Animal Nutrition, belonging to the State University of Maringá, in the Northwest region of Paraná, Brazil.

The following treatments were evaluated: concentrate formulated with corn grain silage with 30% okara inclusion (SGCO), concentrate formulated with corn grain silage with 20% raw soybean inclusion (SGCS), and concentrate based on dry corn grains (DG). Whole-plant corn silage was used as a roughage in a proportion of 60% of the diet.

Corn silage with okara inclusion was produced by grinding dry corn grains and, subsequently, okara (a by-product of the aqueous soybean extract) was included in an amount of 30% of dry matter. The ensilage process was carried out by a homogeneous mixing.

Dry corn silage with 20% soybean inclusion in the natural material was produced by grinding the grains in 10-mm mesh sieves. Water was added aiming at a moisture content of 35%, allowing an adequate fermentation in the silo, which was ensiled after homogeneous mixing.

The *Lactobacillus plantarum* MA 18/5U and *Propionibacterium acidipropionici* MA 26/4U (Lallemand Animal Nutrition) based microbial inoculant was applied on both silages using a knapsack sprayer, aiming at uniform distribution.

Plastic barrels with a capacity of about 200 kg were used as experimental silos. The silos were stored in a covered area and remained sealed for 104 days. Part of the dry corn grain used for silage production was stored for later concentrate formulation, considered as the control treatment. Table 1 shows the fermentation products of corn grain silages with soybean and corn grains with okara.

Table 1
Fermentation products of the evaluated corn grain silages

	Grain silage with okara	Grain silage with soybean
Lactic acid (g kg^{-1})	69.1	41.2
Acetic Acid (g kg^{-1})	8.0	3.4
Butyric acid (g kg^{-1})	0.2	0.00
2,3-butanediol (g kg^{-1})	0.8	0.3
Ethanol (g kg^{-1})	2.5	6.0
Propionic acid (g kg^{-1})	0.2	0.1
1,2-propanediol (g kg^{-1})	1.4	0.00
Formic acid (g kg^{-1})	0.2	0.2
pH	3.90	4.02

Six Holstein cows with an average body weight of 596 ± 44 kg and an average lactation time of 110 ± 37 days were grouped in two simultaneous 3 × 3 Latin squares to evaluate the performance and digestibility. The experimental periods lasted 21 days each, with the first 14 days for the adaptation to the diets and 7 days for collections. The animals fed experimental diets, formulated to be isoproteic and isoenergetic (Table 2).

The animals were managed in individual tie stalls, with an individual feeding trough and a drinking trough for two stalls. Food was provided ad libitum, twice a day, with leftovers of 10% of that provided. The control of food supply and leftovers was carried out daily, as well as individual milk production. The daily temperature variation is shown in Figure 1.

The in vivo digestibility was evaluated from the fifteenth to the nineteenth day of each experimental period by collecting feces samples directly from the rectum of each cow, in the following distribution: 15th day (6 h), 16th day (9 h), 17th day (12 h), 18th day (15 h), and 19th day (18 h). Samples of food and leftovers were also collected. A composite sample of food, leftovers, and feces was obtained and analyzed aiming at determining the contents of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) (Association of Analytical Chemists [AOAC], 2006), neutral detergent fiber (NDF), and acid detergent fiber (ADF), according to Van Soest, Robertson and Lewis (1991).

Table 2
Chemical and percentage composition of the evaluated experimental diets

Food (g kg^{-1})	SGCO	SGCS	DG
Grain silage with 20% soybean	0.00	218.5	0.00
Grain silage with 30% okara	208.8	0.00	0.00
Corn grain	5.9	0.00	185.1
Soybean meal	160.3	154.2	187.6
Limestone	2.4	4.4	3.9
Sodium bicarbonate	2.5	2.5	3.0
Premix*	20.0	20.3	20.0
Corn silage	600.0	600.0	600.0
Nutrient (g kg^{-1} of food)			
CP	151	158	151
TDN	700	700	700
NDF	385	375	378
ADF	225	220.4	219.9
EE	37	37.9	25.7
Calcium	5.3	6	6
Phosphorus	3.3	3.3	3.9

SGCO = diet with corn grain silage + 30% okara; SGCS = diet with corn grain silage + 20% raw soybean; DG = diet with dry corn grains; CP = crude protein; TDN = total digestible nutrients; NDF = neutral detergent fiber; ADF = acid detergent fiber; EE = ether extract. *Composition: Calcium 145.00 g/kg; Phosphorus 51.00 g/kg; Sulfur 20.00 g/kg; Magnesium 33.00 g/kg; Potassium 28.00 g/kg; Sodium 93.00 g/kg; Cobalt 30.00 mg/kg; Copper 400.00 mg/kg; Chromium 10.00 mg/kg; Iron 2,000.00 mg/kg; Iodine 40.00 mg/kg; Manganese 1,350.00 mg/kg; Selenium 15.00 mg/kg; Zinc 1,700.00 mg/kg; Vitamin A 135,000.00 IU/kg; Vitamin D3 68,000.00 IU/kg; Vitamin E 450.00 IU/kg; Sodium monensin 480.00 mg/kg; Fluorine 510.00 mg/kg.

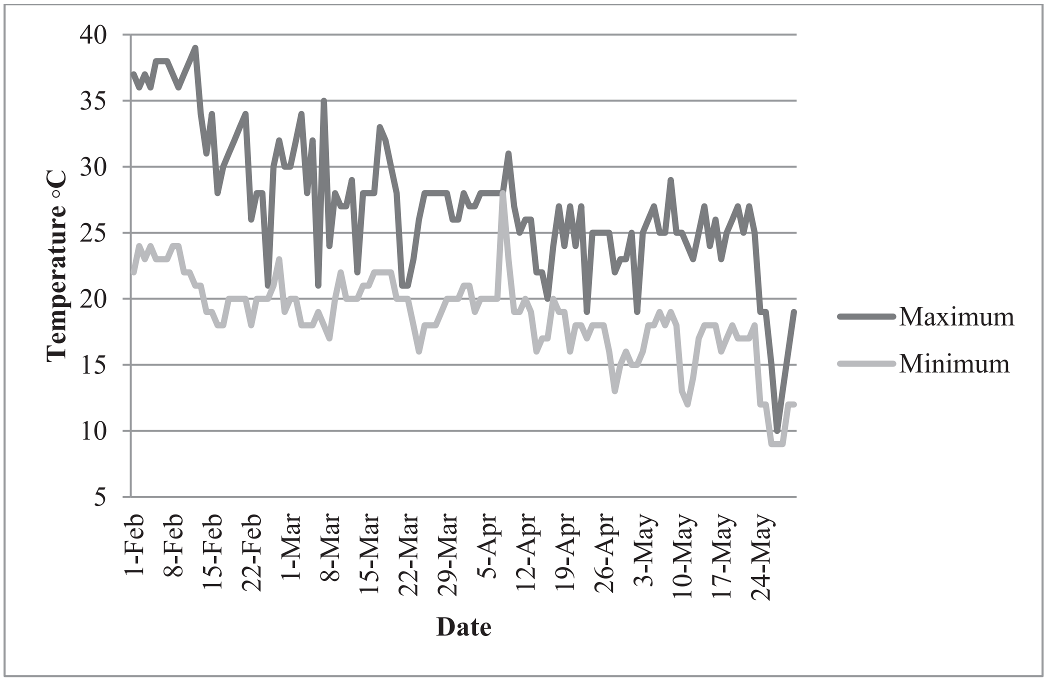

Figure 1. Temperature data during the experiment period.

The internal indicator used to estimate fecal production was the indigestible neutral detergent fiber (NDFi). For this, Holstein cattle were adapted for 14 days before incubation with a diet similar to that used, with a 60% roughage made of whole-plant corn silage. Samples of food, leftovers, and feces were processed through a 2-mm mesh sieve and incubated in the rumen in F57 bags (Ankom Technology, Macedon, NY), with an in situ incubation for 288 hours. The apparent digestibility allowed calculating the percentage of total digestible nutrients (TDN) according to the equation described by Sniffen, O'Conner, Van Soest, Fox and Russel (1992).

The evaluation of milk production considered the data collected in the last five days of each experimental period. Milk production was corrected to 3.5% fat according to Sklan, Kaim, Moallem and Folman (1994). Feed efficiency was calculated from the milk production value corrected to 3.5% fat.

The determination of milk constituents (fat, lactose, protein, casein, total solids, urea nitrogen, and somatic cell count - SCC) was carried out during three days of milk collections with composite samples from morning and afternoon milking. These samples were stored with the Bronopol® preservative and sent for analysis at the Laboratory of the Milk Analysis Program of the Paraná Association of Holstein Cattle Breeders (APCBRH), Curitiba, PR, Brazil.

Fatty acid composition of milk fat was determined using 50 mL of sample, proportionally considering the morning and afternoon milking, based on the individual daily production of each animal. Milk fat was extracted by centrifugation (Murphy, Connolly, & McNeill, 1995) and esterified according to the method 5509 of the International Organization for Standardization [ISO] (1978) with KOH/methanol and n-heptane.

Fatty acid methyl esters were analyzed using an autosampler gas chromatograph (Trace GC Ultra, Thermo Scientific, USA) equipped with flame ionization detector at 235 °C and fused-silica capillary column (100 m in length, 0.25 mm internal diameter, and 0.20 μm, Restek 2560). The gas flow consisted of 1.4 mL/min of H_2 (carrier gas), 30 mL/min of N_2 (auxiliary gas), and 30 and 300 mL/min of H_2 and synthetic air (flame gases), respectively. The initial temperature of the column was set at 65 °C, maintained for 4 minutes, raised to 185 °C at a rate of 16 °C/min, maintained for 12 minutes for up to 235 °C of final temperature raised at a rate of 20 °C/min, and maintained for 14 minutes. The quantification of fatty acids in the sample was performed by comparison with the retention time of fatty acid methyl esters from standard samples (Sigma Aldrich).

Another milk sample was collected with sodium azide preservative and preserved at −20 °C to measure the lipid oxidation using the products formed in the oxidation reaction or conjugated diene hydroperoxides (CD), following the protocol described by Kiokias, Dimakou, Tsaprouni and Oreopoulou (2006).

Blood samples were taken by puncture of the mammary vein on the last day of each experimental period after morning milking to measure the blood parameters glucose, total cholesterol, and triglycerides. Laboratory analyses were performed using commercial kits (Analisa®), with readings on a spectrophotometer.

The response (Y_{ij}) was considered to follow a normal distribution, that is, $Y_{ij} \sim N(\mu_j, \sigma_j^2)$, $i = 1, 2, \ldots, n_j$ for j-th treatment levels. Non-informative distributions were a priori considered for each μ_j and σ_j^2, respectively, $\mu_j \sim N(0, 10^{-6})$ and $\tau_j \sim \text{Gamma}(10^{-3}, 10^{-3})$, $\sigma^2 = 1/\tau$, according to OpenBUGS parameterization through the BRugs package of the software *R* (R Development Core Team [R], 2014). Multiple comparisons were carried out between a posteriori distributions of treatment means. Treatment levels whose credibility intervals for the mean differences that did not include the zero value were considered as different at a 5% significance level. The convergence of the chains was verified using the Heidelberger & Welch (1983) criteria in the coda package of *R*.

Results and Discussion

A concentrate effect was observed on dry matter intake (DMI). The highest DMI (17.59 kg DM) was found for the concentrate with dry corn grains, with the diet showing the lowest nutrient digestibility (Table 3). The reduction in DMI of the diet was 2.13 kg and 1.78 kg DM for SGMCS and SGCO, respectively, compared to the diet dry grain-based concentrate.

Table 3
Bayesian estimates for dry matter intake (DMI), apparent digestibility of nutrients, total digestible nutrients (TDN), and blood parameters of the evaluated diets

Variable	Diet								
	SGCO			SGCS			DG		
	Mean	sd	*σ*	Mean	sd	*σ*	Mean	sd	*σ*
DMI (kg)	15.81^{b}	0.42	0.95	15.46^{b}	0.58	1.34	17.59^{a}	0.29	0.66
DMI (g kg^{-1} $LW^{0.75}$)	129.90^{b}	4.36	9.89	127.60^{b}	6.83	15.83	144.30^{a}	4.14	9.48
DMD (g kg^{-1})	712.0^{ab}	23.9	54.1	748.9^{a}	18.8	43.6	674.8^{b}	23.6	54.1
DOM (g kg^{-1})	731.2^{ab}	23.1	52.3	766.1^{a}	15.6	36.2	694.0^{b}	22.7	52.0
DCP (g kg^{-1})	757.0^{b}	14.6	33.0	803.1^{a}	17.6	40.7	718.9^{b}	32.1	73.4
DNFC (g kg^{-1})	950.2^{a}	7.8	17.6	969.9^{a}	7.9	18.4	916.9^{b}	9.1	20.7
DEE (g kg^{-1})	915.6^{a}	7.8	17.6	922.5^{a}	8.1	18.8	833.3^{b}	20.1	45.9
DNDF (g kg^{-1})	466.6^{a}	64.6	146.4	497.3^{a}	48.4	112.2	428.0^{a}	52.0	119.0
TDN (g kg^{-1})	721.2^{ab}	24.5	55.6	750.4^{a}	15.7	36.4	670.4^{b}	22.8	52.1
Glucose (mg/dL)	73.16^{a}	1.85	4.19	73.87^{a}	4.61	10.69	65.27$_{b}$	2.57	5.88
Cholesterol (mg/dL)	89.73	9.46	21.45	90.48	10.42	24.16	92.74	11.95	27.35
Triglycerides (mg/dL)	13.12	2.61	5.90	11.66	1.76	4.07	12.26	2.39	5.47

SGCO = diet with corn grain silage + 30% okara; SGCS = diet with corn grain silage + 20% raw soybean; DG = diet with dry corn grains; DMD = apparent digestibility of dry matter; DOM = apparent digestibility of organic matter; DCP = apparent digestibility of crude protein; DNFC = apparent digestibility of non-fibrous carbohydrates; DEE = apparent digestibility of ether extract; DNDF = apparent digestibility of neutral detergent fiber. Means followed by different letters in the rows differ from each other by Bayesian comparisons ($p<5\%$). sd and σ: standard deviation of the estimated a posteriori mean and population, respectively.

Intake reduction was also found by Bradford and Allen (2007) for ensiled grains. The decrease in DMI for silage can be attributed to a more fermentable starch in the rumen, which increases VFA production, especially the propionate proportion (Allen, Bradford, & Oba, 2009). Propionate is oxidized in the liver when it is present at a rate higher than that which could be converted into glucose, generating ATP, which has the function of sending satiety signals to the brain and hence reducing DMI (Bradford & Allen, 2007; Allen et al., 2009).

A concentrate effect was observed on dry matter and organic matter digestibility of the diets (Table 3). The highest values were found for the treatment with corn grain silage + soybean, but similar to the concentrate of corn grain silage + okara. The high nutrient availability can be attributed to the effect of the ensilage of corn grains, which has shown a decrease in the content of prolamin proteins (called zeins in corn) due to the fermentation in the silo. Prolamins are responsible for encapsulating the starch granules, forming a hydrophobic protein matrix. This matrix (protein-starch) has been defined as an impediment to starch digestion in ruminants (Hoffman et al., 2011).

The SGCS diet provided the highest CP digestibility values (803.1 g kg^{-1} DM), possibly due to the higher proteolysis during the fermentation that occurred in the silo for this silage. CP digestibility for the diets based on SGCO (757 g kg^{-1} DM) and DG (718.9 g kg^{-1} DM) was similar.

The highest digestibility of NFC was observed for diets with ensiled grains, with values of 969.9 g kg^{-1} DM for SGCS and 950.2 g kg^{-1} DM for SGCO, higher than the dry corn grain-based concentrate (916.9 g kg^{-1} DM), which shows the high availability of starch in ensiled grains.

The diet showed an effect on the calculated TDN content, with the highest values observed for diets with SGCS (750.4 g kg^{-1} DM) and SGCO (721.2 g kg^{-1} DM). The concentrate formulated with dry grains resulted in lower TDN (670.4 g kg^{-1} DM) due to the low nutrient digestibility. The high TDN found for silages is also related to the high EE content of diets with SGCS and SGCO-based concentrates, providing high availability of energy for animals.

Regarding blood parameters, Table 3 shows an increase in glucose concentration of cows fed silage-based SGCS (73.87 mg/dL) and SGCO concentrates (73.16 mg/dL) compared to those that received dry grains (65.27 mg/dL). Oba and Allen (2003) also found higher levels of plasma glucose for cows fed diets with high rumen fermentation grains. The high starch content increases propionate production in the rumen, which is likely to promote high gluconeogenesis rates. Propionate is the main precursor of glucose in ruminants, followed by amino acids and lipids (Allen et al., 2009).

Concentrates showed no influence on milk production (Table 4), with values of 19.57, 18.13, and 17.78 L for treatments with dry grains, SGCS, and SGCO, respectively. This numerical difference in milk production may be related, among other factors, to the intake, which was lower in diets with ensiled grains.

The decreased DMI observed for silages with okara (129.9 g kg^{-1} $LW^{0.75}$) and soybean inclusion (127.6 g kg^{-1} $LW^{0.75}$) is offset by an increase in digestibility found for DM, OM, NFC, and EE in these silages. The decreased intake and increased digestibility show superior feeding efficiency for treatments with the inclusion of silages. The results of studies in the literature have indicated that grain silage is more efficient due to the better use of nutrients in the total diet (Canizares et al., 2011; Panichi et al., 2012).

The concentrate showed no effect on milk chemical composition (Table 4). Increases in CD concentrations (mmol kg^{-1} of fat) of 45.6 and 25.4% were observed in the milk of animals fed SGCO and SGMS, respectively, compared to the diet with dry corn grains (Table 4). The balance between concentrations of antioxidants and polyunsaturated fatty acids is the main determinant of the onset of oxidation in milk. Thus, the increase in the content of unsaturated fatty acids, which is beneficial to human health, may lead to changes in the oxidative stability of milk (Kalač & Samková, 2010).

Table 4
Bayesian estimates for production and composition of milk from Holstein cows fed diets based on corn grain silage with okara inclusion (SGCO), corn grain silage with soybean grain inclusion (SGCS), or dry grains (DG)

Variable	Diet								
	SGCO			SGCS			DG		
	Mean	sd	σ	Mean	sd	σ	Mean	sd	σ
MP (kg/day)	17.78	3.66	8.29	18.13	3.01	6.96	19.57	2.94	6.73
MPC (kg/day)	17.44	3.10	7.03	17.08	3.31	7.66	18.84	2.31	5.28
FEC	1.10	0.19	0.42	1.13	0.26	0.60	1.07	0.12	0.28
FE	1.12	0.21	0.47	1.20	0.24	0.56	1.11	0.16	0.36
Fat (g kg^{-1})	34.6	4.20	9.60	30.9	4.00	9.20	33.5	2.3	5.3
Protein (g kg^{-1})	35.6	2.9	6.6	34.9	2.8	6.5	34.4	2.3	5.2
Lactose (g kg^{-1})	44.2	0.7	1.6	43.7	1.2	2.9	45.4	4.5	3.4
Casein (g kg^{-1})	28.4	2.60	5.80	28.0	2.4	5.5	27.4	2.0	4.5
Solids (g kg^{-1})	123	6.40	4.50	121	4.60	10.5	123	5.50	12.5
SCC	231.50	137.30	317.00	388.60	305.60	771.50	203.20	125.20	291.10
UNM (mg/dL)	18.55	1.95	4.42	17.43	1.92	4.45	19.61	1.60	3.66
DC	41.73^{a}	5.71	12.93	35.93^{ab}	3.78	8.76	28.66^{b}	2.00	4.53

Means followed by different letters in the rows differ from each other by Bayesian comparisons (p<5%). sd and σ: standard deviation of the estimated a posteriori mean and population, respectively. MP = milk production; MPC = milk production corrected to 3.5% fat; FE = feed efficiency (milk production/dry matter intake); FEC = feed efficiency corrected for a milk production at 3.5% fat (MPC/dry matter intake); SCC = somatic cell count; UNM = urea nitrogen in milk; CD = conjugated diene hydroperoxides (mmol/kg of fat).

The diet showed no effect on milk fat content, but the treatment with SGCS-based concentrate showed a trend to decrease the milk fat content. Some studies (Oba & Allen, 2003) have demonstrated this effect when cows are fed with moist corn grain silage. In the present study, the treatment with SGCS showed higher participation in the corn silage because the proportion of soybean and okara inclusion in the corn grain silage was not the same (20% for soybean and 30% for okara), which may have provided a high starch availability in the rumen due to the effect of ensilage on grains. Changing the proportion of VFA produced in the rumen, with a reduction in the molar proportion of acetate due to an increase in the propionate production rate with high starch availability, may result in an inadequate supply of lipid precursors for the de novo synthesis in the mammary gland, decreasing fat in the milk (Maxin, Glasser, Hurtaud, Peyraud, & Rulquin, 2011).

The proportion of soybean in silage can also favor a decrease in milk fat. The increased linoleic acid content in diets with soybean may cause an increase in CLA production. Two isomers are proposed to cause depression in milk fat, i.e., trans 10 cis 12 is responsible to cause the highest effect cis 9 trans 11-CLA is responsible to cause the lowest effect (Kadegowda, Pierova, & Erdman, 2008). According to Bauman, Perfield, Harvatine and Baugmard (2008), CLA can inhibit the de novo synthesis, resulting in a decrease in the level of saturated fatty acids in milk.

The increase in cis 9 trans 11 CLA was observed in this study for the treatment with SGCS (Table 5). However, studies with soybean grains or soybean oil inclusion have not shown depression in milk fat as long as the inclusion levels are up to 7% in DM (Barletta et al., 2012). Because EE contents in the evaluated diets were low, i.e., 25.7 g kg^{-1} for DG, 37.0 g kg^{-1} for SGCO, and 37.9 g kg^{-1} for SGCS, the trend in the depression in milk fat of cows of the treatment with soybean may have occurred by the interaction between the composition of fatty acids of soybean and the starch with higher availability in the rumen. The increased CLA concentration in milk is beneficial to human health mainly due to its anticarcinogenic properties and the reduction in total cholesterol (Bauman et al., 2008; Holanda, Holanda, & Mendonça, 2011). No effect was observed for the other fatty acids evaluated in milk (Table 5).

Table 5
Bayesian estimates for the fatty acid profile of milk (g 100 g^{-1} of total milk fat) of Holstein cows fed a diet based on corn grain silage with okara inclusion (SGCO), corn grain silage with soybean grain inclusion (SGCS), or dry corn grains (DG)

	SGCO			SGCS			DG		
	Mean	sd	*s*	Mean	sd	*s*	Mean	sd	*s*
C4:0	0.25	0.04	0.09	0.24	0.02	0.05	0.23	0.04	0.09
C6:0	0.63	0.10	0.22	0.62	0.08	0.18	0.63	0.08	0.18
C8:0	0.52	0.06	0.14	0.56	0.04	0.09	0.60	0.06	0.13
C10:0	3.20	0.44	1.00	3.08	0.22	0.50	3.03	0.27	0.61
C11:0	0.02	0.01	0.03	0.05	0.02	0.05	0.02	0.01	0.03
C12:0	4.07	0.69	1.56	4.21	0.55	1.25	4.42	0.41	0.92
C13:0	0.39	0.08	0.18	0.34	0.04	0.10	0.30	0.03	0.07
C14:0	2.74	0.50	1.13	2.27	0.53	1.20	1.76	0.21	0.47
C15:0	2.14	0.41	0.94	2.59	0.25	0.58	2.20	0.19	0.43
C16:0	29.34	1.27	2.88	29.63	0.75	1.68	31.24	1.47	3.30
C17:0	0.90	0.09	0.20	1.01	0.06	0.14	1.05	0.06	0.13
C18:0	16.05	0.81	1.84	16.14	0.82	1.85	16.14	0.76	1.72
C20:0	0.17	0.04	0.09	0.18	0.02	0.05	0.17	0.03	0.06
C23:0	0.28	0.05	0.10	0.24	0.04	0.10	0.20	0.02	0.05
C16:1	2.67	0.25	0.58	2.82	0.19	0.43	2.85	0.30	0.68
C17:1	0.47	0.13	0.28	0.37	0.02	0.05	0.33	0.05	0.11
C18:1n9c	28.72	1.48	3.37	28.55	1.53	3.45	29.40	1.54	3.46
C22:1n9	0.16	0.04	0.09	0.13	0.02	0.06	0.10	0.03	0.06
C18:2n6t	0.40	0.03	0.06	0.46	0.05	0.11	0.35	0.05	0.11
C18:2n6c	0.62	0.05	0.11	0.61	0.07	0.15	0.59	0.08	0.19
c9,t11- CLA	0.37[ab]	0.06	0.13	0.44[a]	0.05	0.119	0.31[b]	0.03	0.07
C20:2	0.97	0.14	0.33	0.84	0.11	0.25	0.79	0.07	0.15
C18:3n6	4.84	0.62	1.40	5.10	0.53	1.19	4.60	0.63	1.41
C18:3n3	0.31	0.04	0.08	0.30	0.06	0.14	0.25	0.03	0.06
C20:3n6	0.03	0.01	0.03	0.03	0.01	0.02	0.02	0.01	0.03
C20:3n3	0.03	0.01	0.03	0.02	0.01	0.03	0.01	0.01	0.03
C20:4n6	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02
C20:5n3	0.04	0.01	0.03	0.04	0.01	0.03	0.03	0.01	0.03

continue

continuation

C22:6n3	0.03	0.02	0.04	0.05	0.01	0.03	0.02	0.02	0.04
AGS	60.69	1.64	3.74	61.17	1.29	2.91	62.00	1.50	3.38
AGM	32.03	1.39	3.17	31.87	1.45	3.28	32.69	1.31	2.94
AGP	7.67	0.79	1.79	7.89	0.42	0.95	6.99	0.52	1.16
omega 6	5.91	0.63	1.43	6.21	0.45	1.02	5.57	0.56	1.25
omega 3	0.42	0.05	0.11	0.41	0.07	0.15	0.32	0.04	0.08
n6:n3	14.73	2.44	5.56	17.08	4.11	9.29	18.51	4.08	3.86

Means followed by different letters in the row indicate different treatment means by Bayesian comparisons ($p<5\%$). sd and σ: standard deviation of the estimated a posteriori mean and population, respectively.

Conclusions

Ensilage of rehydrated corn grains with soybean or okara inclusion decreases dry matter intake and increases nutrient digestibility.

The use of the combination of corn with soybean grain or with okara can be used in the diet of dairy cows without altering milk production and composition.

Corn grain silage with soybean increases CLA contents in milk.

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