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Feed intake, nutrient digestibility, milk production and composition in dairy cows fed silage of wet brewers grain

Consumo, digestibilidade dos nutrientes, produção e composição do leite de vacas alimentadas com silagens do resíduo úmido de cervejaria

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Abstract

The aim of this study was to evaluate the supply of wet brewers grain silage with and without nutrient additives in ensiling (wheat bran, soybeans hulls and ground corn), and the effect of additives on the intake and digestibility of dry matter and nutrients as well as the efficiency, production and milk composition of Holstein cows. Four multiparous Holstein cows were used, with an average milk production of 25 liters per day. The cows were randomly assigned, via the Latin Square design (4x4), to one of four experimental diets. The experimental period was 21 days. The results obtained in the experiment were evaluated by analysis of variance, Fisher's F test and Tukey's test at 5 % probability. The experimental diets consisted of wet brewers grain silage alone, and this silage with the addition of wheat bran, soybean hulls or ground corn. The diets did not affect the initial body weight of the animals. Diets containing wheat bran and ground corn provided a higher intake of dry matter (21.78 and 21.50 kg day^{-1}) and organic matter (20.42 and 20.22 kg day^{-1}) compared to the wet brewers grain silage alone and the diet containing soybean hulls. The results observed for dry matter (636.96 and 632.96 g kg^{-1}), organic matter (659.16 and 654.35 g kg^{-1} DM), crude protein (712.84 and 717.79 g kg^{-1} DM) and neutral detergent fiber (598.99 and 538.90 g kg^{-1} DM) when cows were fed diets containing soybean hulls and ground corn, respectively, were higher than other diets. The different diets did not change daily milk production, milk production corrected for 3.5 % fat or milk composition. The milk urea nitrogen from cows fed ground corn diets was a lower concentration (17.67 mg dL^{-1}), however, it was still above the suitable range (10 to 14 mg dL^{-1}). Providing wet brewers grain silage with soybeans hulls or ground corn to Holstein cows increased the digestibility of dry matter and nutrients. However, the use of silages with

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wheat bran, soybean hulls or ground corn did not alter the efficiency, production or milk composition of cows fed with these silages.
Key words: Nutrient additives. Agro-industrial by-products. Ground corn. Soybean hulls. Milk urea nitrogen. Wheat bran.

Resumo

Objetivou-se avaliar a inclusão do farelo de trigo (FT), casca do grão de soja (CGS) ou milho moído (MM) na ensilagem do resíduo úmido de cervejaria (RUC), e seus efeitos sobre o consumo e a digestibilidade da matéria seca e dos nutrientes, bem como, sobre a eficiência, produção e composição do leite de vacas da raça Holandês. Foram utilizadas quatro vacas da raça Holandês, multíparas, com produção média de 28 litros/dia, distribuídas no delineamento em quadrado latino (4x4), com quatro períodos experimentais de 21 dias e quatro silagens. As vacas foram alimentadas com dietas compostas por feno de Tifton 85, silagens do RUC e ração concentrada. Os tratamentos consistiram de silagem do RUC (SRUC), silagem do RUC com FT (SRFT), CGS (SRCGS) ou MM (SRMM). As dietas não interferiram no peso corporal dos animais. As inclusões do FT ou MM, na ensilagem do RUC, proporcionaram maiores consumos de matéria seca e matéria orgânica das dietas SRFT e SRMM. As maiores digestibilidades da matéria seca, orgânica, fibra em detergente neutro e proteína bruta foram observadas nas dietas SRCGS e SRMM. A produção diária, a produção corrigida para 3,5 % de gordura e a composição do leite não foram alteradas pelas dietas. Para o nitrogênio ureico no leite a dieta SRMM apresentou menor concentração, acima da variação considerada adequada. A inclusão da CGS ou MM, na ensilagem do RUC, aumenta a digestibilidade da matéria seca e dos nutrientes, no entanto, o uso de aditivos nutrientes com alto teor de matéria seca não altera a produção, a eficiência ou a composição do leite de vacas da raça Holandês.
Palavras-chave: Digestibilidade. Nitrogênio ureico no leite. Produção de leite. Qualidade do leite. Resíduo de cerveja. Subprodutos agroindustriais.

Introduction

The seasonality of forage production is one of the challenges for dairy cattle farms, and leads to increased feeding costs in the production system. Thus, the substitution of ingredients commonly used for alternative food sources is of great importance because it enables production costs to be minimised, without neglecting nutritional requirements of the animals.

An alternative food source is the wet brewer grain (WBG), which appears feasible due to its nutritional value, availability and low cost in various regions of Brazil. In addition, its use mitigates environmental pollution that this waste can cause if disposed of improperly in the environment.

The WBG is obtained in the brewing process. This residue is characterised by having approximately 28.4 % crude protein, 47.1 % neutral detergent fiber and 5.2 % ether extract (NRC, 2001), as well as a high moisture content of about 80 % (BROCHIER; CARVALHO, 2009). Although the WBG contains appropriate nutritional qualities, its storage is hampered by high moisture, making it difficult to use efficiently.

The problems associated with high moisture WBG can be minimised with the use of nutrient additives with high dry matter (DM) content in silage. These additives prevent the formation of effluents, which may carry nitrogenous compounds, sugars, organic acids and minerals (MCDONALD; WHITTENBURY, 1973; ALVES et al., 2011), which decreases the nutritional losses.

The use of high DM food as nutrient additives, due its bromatological characteristics, has a few effects on silage, including increasing the DM content, and changing the fermentation pattern and nutritional value. For example, wheat bran reduces the silage fiber content (ZANINE et al., 2006), ground corn increases the concentration of soluble carbohydrates, which are essential substrates for the development of microorganisms in silage (JOBIM et al., 2007), and soybean hulls provide highly degradable structural carbohydrates (ZAMBOM et al., 2001).

Studies by Belibasakis and Tsirgogianni (1996), Chiou et al. (1998) and Geron et al. (2010) reviewed the use of WBG in dairy cows and found no alterations in DM intake. According to these authors, the use of this residue in the diet can improve milk production due to its higher level of non-degradable protein in the rumen, which contributes to the increased availability of amino acids for metabolism. In addition, the availability of food sources that have low rumen-degradable protein is scarce in the animal feed market.

The aim of this study was to evaluate diets of WBG silage with and without nutrient additives in ensiling (wheat bran, soybean hulls and ground corn), and their effect on the intake and digestibility of DM and nutrients as well as the efficiency, production and milk composition of Holstein cows.

Materials and Methods

The study was carried out at the Experimental Station Prof. Dr. Antonio Carlos dos Santos Pessoa, the State University of Western Paraná (UNIOESTE) Campus Marechal Cândido Rondon, Paraná - PR and the State University of Maringa (UEM), PR, under Protocol 06411 of the Ethics Committee at Trial Animal and Practical Classes - CEAAP / UNIOESTE. The processing of samples and the laboratory tests were performed at the Animal Nutrition Laboratory of UNIOESTE and Animal Food and Nutrition Analyses Laboratory of UEM.

The WBG used in the experiment was acquired in a brewing industry, located in the city of Toledo, Western PR region, and transported to the Experimental Station. About 20 % of nutrient additives with a high content of DM (wheat bran, soybean hulls and ground corn), relative to the total ensiled WBG, were added in order to attain the DM considered suitable (30 % to 35 % DM) for silage fermentation (McDonald et al., 1991). A cement mixer equipped with a fixed engine and a capacity of approximately 400 liters was used for the homogenisation of the WBG with nutrient additives.

After homogenisation, the WBG ensiled with and without additives was placed in experimental silos (cement shackles of 1.20 m wide x 1.0 m high) with a capacity of approximately 1000 kg of silage. These silos were packed, sealed with polyethylene canvas and after 30 days opened at the beginning of the experiment. The bromatological composition of the ingredients used in the diets is shown in Table 1.

Table 1. Bromatological composition of the food used in the formulation of diets.

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Nutrients	Foods[1]						
	SWBG	SWBWB	SWBSH	SWBGC	HT85	SM	GC
Dry matter (g kg^{-1})	241.25	304.59	333.95	391.92	908.58	890.30	894.10
Mineral matter (g kg^{-1} DM)	54.90	63.82	45.70	42.17	66.13	61.86	12.27
Organic matter (g kg^{-1} DM)	945.10	936.18	954.30	957.83	933.87	938.14	987.73
Crude protein (g kg^{-1} DM)	265.20	216.00	195.60	194.29	86.53	517.62	87.81
Ether extract (g kg^{-1} DM)	72.46	56.61	55.20	61.84	14.03	16.20	46.76

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Neutral detergent fiber (g kg^{-1} DM)	758.00	704.43	747.21	635.76	802.89	146.79	137.90
Acid detergent fiber (g kg^{-1} DM)	265.52	212.61	239.13	190.89	396.01	93.13	59.09
Hemicellulose (g kg^{-1} DM)	492.48	491.82	508.08	444.87	406.88	53.66	78.81
Cellulose (g kg^{-1} DM)	148.55	87.99	141.95	88.54	274.84	79.33	44.41
NDIP[2] (g kg^{-1} CP)	89.93	59.17	70.65	70.04	474.98	67.64	15.49
ADIP[3] (g kg^{-1} CP)	34.92	38.10	22.75	33.38	94.76	7.11	2.39
Total carbohydrates[4] (g kg^{-1} DM)	607.46	663.60	703.51	701.70	833.31	397.55	853.16

[1]SWBG: silage of wet brewers grain alone; SWBWB: silage of wet brewers grain with wheat bran; SWBSH: silage of wet brewers grain with soybean hulls; SWBGC: silage of wet brewers grain with ground corn; HT85: hay Tifton 85; SM: soybean meal; GC: ground corn. [2]NDIP: Neutral detergent insoluble protein. [3]ADIP: Acid detergent insoluble protein. [4]Estimated according to equation Sniffen et al. (1992).

Four multiparous Holstein cows were used, with body weights of 618 ± 23 kg and 100 ± 20 days in milk with an average production of 25 liters day^{-1}. The cows were randomly assigned in the Latin square design (4x4) to one of four experimental diets. The experimental period was 21 days each, with 14 days for adaptation and seven days for data collection, totaling 84 days.

The experimental diets consisted of WBG silage alone (SWBG), and SWBG with the addition of wheat bran (SWBWB), soybean hulls (SWBSH) or ground corn (SWBGC). Diets were formulated according to the established requirements by the NRC (2001), to meet the requirements of lactating cows with a body weight of 600 kg and milk production of 25 kg milk day^{-1}. The diets were composed of 40 % Tifton 85 hay, 20 % residue silage (SWBG, SWBWB, SWBSH, SWBG or SWBGC) and 40 % of concentrate (ground corn, soybean meal and mineral-vitamin supplement) (Table 2).

Table 2. Ingredients and bromatological composition of diets.

	Diets containing different wet brewers grain based silages[1]			
	SWBG	**SWBWB**	**SWBSH**	**SWBGC**
Ingredients				
Hay Tifton 85 (g kg^{-1} DM)	400.00	400.00	400.00	400.00
Silage of wet brewers grain (g kg^{-1} DM)	200.00	200.00	200.00	200.00
Soybean meal (g kg^{-1} DM)	94.17	109.50	133.50	137.00
Ground corn (g kg^{-1} DM)	289.84	274.50	250.50	247.00
Mineral-vitamin supplement® (g kg^{-1} DM)	16.00	16.00	16.00	16.00
Bromatological composition				
Dry matter (g kg^{-1})	770.51	792.01	788.89	799.47
Mineral matter (g kg^{-1} DM)	62.82	63.86	62.13	59.53
Organic matter (g kg^{-1} DM)	937.18	936.14	937.87	940.47
Crude protein (g kg^{-1} DM)	161.85	163.77	164.83	166.07
Ether extract (g kg^{-1} DM)	35.18	31.71	30.53	31.75
Neutral detergent fiber (g kg^{-1} DM)	526.55	517.44	524.74	502.48
Acid detergent fiber (g kg^{-1} DM)	237.40	228.28	233.46	223.94
Total carbohydrate (g kg^{-1} DM)	740.15	740.66	742.51	742.65

[1]SWBG: silage of wet brewers grain alone; SWBWB: silage of wet brewers grain with wheat bran; SWBSH: silage of wet brewers grain with soybean hulls; SWBGC: silage of wet brewers grain with ground corn.

Cows remained housed in indoor facilities equipped with individual drinkers and feeders and received feed twice a day, at 07h00 and at 15h00. Cows were milked at 06h00 and at 18h00. The animals had access to rest paddocks without forage supply, from 12h00 to 14h00 and after 21h00.

The control of DM intake was adjusted weekly to obtain 10 % leftover food. The intake of DM and nutrients was determined by the difference between the supplied and the leftover food. During the period of data collection, from the 15th to the 21st day of each trial period, the animals' weights were recorded and both the samples of provided diets and the leftover food were stored in a freezer for further analysis.

Faecal samples were collected directly from the rectum from the 15th to 20th day of each trial period, to determine the digestibility of DM and nutrients, at 0800, 1000, 1200, 1400, 1600 and 1800 hours every day.

The faecal excretion estimates were obtained using indigestible neutral detergent fiber (iNDF) as the internal marker, as proposed by Cochran et al. (1986). The iNDF was estimated by in situ incubation: after 288 hours, samples of diets provided, leftover food and faeces were placed in F57 filters (ANKOM® Technology Corporation), and subsequently analysed.

Samples of silage, diets provided, the leftovers and faeces were collected and frozen for later analysis. To carry out the bromatological analysis the samples were thawed and submitted to drying in a forced air ventilation oven for 72 hours at 55 °C, and processed in a *Willey* mill equipped with a sieve with a 1 mm mesh size, making proportionately one sample per animal per period.

Subsequently, samples of diets, leftover food and faeces were analysed for DM, mineral matter (MM), crude protein (CP), and ether extract (EE), according methodology from Silva and Queiroz (2006), and neutral detergent fiber (NDF) and acid detergent fiber (ADF), according to Van Soest et al. (1991). The total carbohydrates (TC) and total digestible nutrients (TDN) were estimated according to the equation described by Sniffen et al. (1992).

Neutral detergent insoluble nitrogen (NDIN) and acid detergent insoluble nitrogen (ADIN) were determined according to the methodology described by Licitra et al. (1996).

Cows were mechanically milked and production per animal was measured twice daily by glass collector milking, in the morning and afternoon of the 15th to the 21st day. The 3.5 % fat corrected milk (FCM) was estimated, according Sklan et al. (1992), by the following equation: FCM = [(0.1625 x + 0.432% milk fat) x milk production in kg day^{-1}].

On the 15th and 16th days of each trial period, milk samples were collected from each cow, packed in polyethylene bottles containing Bronopol® preservative (2-bromo-2-nitropopano-1, 3-diol) and sent for physicochemical analysis, somatic cell counts and milk urea nitrogen measurements in the Laboratory of the Program of Analysis of Paraná's Dairy Cattle (PARLPR), belonging to the Paranaense Association of Holsten Cattle Breeders (APCBRH). The milk samples were analysed for fat, protein, lactose, and total solids in the Bentley 2000 (Bentley Instruments®), via the optical and infrared systems. Somatic cell counts (SCC) were performed by flow cytometry, in Somacount 500 (Bentley Instruments®) equipment. For analysis of milk urea nitrogen the Chemspec 150 (Bentley Instruments®) was used, via the Berthelot method.

The cows' blood samples were obtained on the 21st day of each period, 04h00 after delivery of the morning feeding, via jugular venipuncture. Serum was obtained by blood centrifugation at 3500 rpm for 15 min and was stored in Eppendorf® tubes. The urea concentration was determined using commercial kits from Gold Analyzes Diagnostic Ltda®, and the urea nitrogen value was obtained by multiplying the urea value by 0.466, corresponding to the content of nitrogen in the urea.

The data obtained in the experiment were submitted for variance analysis and Fisher's F test (PIMENTEL GOMES; GARCIA, 2002; PIMENTEL GOMES, 2009). When a significant effect was found on the studied variables, the averages of the treatments were compared by the Tukey's test at 5 % probability.

Results and Discussion

The use of different silages of WBG for feeding lactating cows did not change (P>0.05) the animals' body weights. The diets constituted with the SWBWB and SWBGC provided higher (P<0.05) intakes of DM and organic matter in relation to cows fed diets containing SWBSH and SWBG (Table 3).

Table 3. Body weight, and intake of dry matter and nutrients for dairy cows fed with different wet brewers grain-based silages.

Variables	Diets containing different wet brewers grain-based silages[1]				CV %	P Value
	SWBG	SWBWB	SWBSH	SWBGC		
Body weight (BW) (kg)	620.25	607.50	618.00	611.25		0.120
	Intake (kg day^{-1})					
Dry matter	20.03^{b}	21.78^{a}	20.39^{b}	21.50^{a}	0.91	0.000
Dry matter (% BW)	3.23^{b}	3.59^{a}	3.30^{b}	3.53^{a}	1.25	0.000
Organic matter	18.75^{c}	20.42^{a}	19.16^{b}	20.22^{a}	0.83	0.000
Crude protein	3.42^{c}	3.65^{ab}	3.60^{b}	3.81^{a}	2.08	0.002
Ether extract	0.76^{a}	0.74^{a}	0.66^{b}	0.71^{ab}	3.39	0.006
Neutral detergent fiber	10.25^{a}	10.11^{a}	10.35^{a}	9.21^{b}	1.97	0.001
Neutral detergent fiber (% BW)	1.68^{b}	1.81^{a}	1.71^{b}	1.74^{ab}	1.90	0.006
Acid detergent fiber	4.56^{b}	4.79^{a}	4.68^{ab}	4.68^{ab}	0.67	0.044
Total carbohydrate	14.58^{d}	16.03^{a}	14.90^{c}	15.70^{b}	0.85	0.000

Means followed by the same letter on the line do not differ by Tukey test at 5 % probability. [1]SWBG: silage of wet brewers grain alone; SWBWB: silage of wet brewers grain with wheat bran; SWBSH: silage of wet brewers grain with soybean hulls; SWBGC: silage of wet brewers grain with ground corn.

The use of nutrient additives with high DM content (Table 1) was advantageous for the conservation and quality of silage, since this addition increased the percent of DM and improved the standard fermentation of the silage, minimising losses of DM.

The WBG silage with additives provided diets with approximately 790 g kg^{-1} DM (Table 2). The high DM content of the Tifton 85 hay used also contributed to the DM of the diets as well as the observed results of consumption.

According to Lahr et al. (1983), DM intake is changed by the diets' DM and fiber concentrations. These authors observed reductions in DM intake along with a linear decrease in DM content of the diet, and concluded that diets with levels below 650 g kg^{-1} DM tend to reduce DM intake of dairy cows.

It was previously observed that with up to 30 % of WBG included in the diets, slight variations are observed in DM intake, from 1 % to 4 % (BELIBASAKIS; TSIRGOGIANNI, 1996; CHIOU et al., 1998). However, there is no information regarding the use of residue silage with additive nutrients containing a high DM content.

West et al. (1994) evaluated the use of WBG in the diets (corn silage, alfalfa silage and concentrate) of Jersey cows producing approximately 14.5 liters of milk day^{-1}. These authors found that the inclusion of 0 %, 15 % and 30 % of WBG in the diets with

DM of 54.6 %; 43.3 % and 35.5 %, respectively, did not cause variations in consumption. However, the higher moisture content diets of 15 % and 30 % WBG, while not statistically significant, did tend to reduce consumption.

Chiou et al. (1998), in a study of cows producing about 20 liters of milk day^{-1}, did not find any effect from inclusion of 10 % WBG residue in diets consisting of alfalfa hay, corn silage and concentrate when compared with a control diet. Likewise, no effects were observed in DM intake or nutrients in Holstein cows with an average production of 28 liters day^{-1}, according to Geron et al. (2010), who evaluated the inclusion of 0 %, 5 %, 10 % and 15 % of WBG in diets composed of corn silage, ryegrass and commercial concentrated feed, and containing about 66 % DM.

The use of nutrient additives with a high content of DM (wheat bran, soybean and grain corn hulls) in making silage based in WBG influenced ($P<0.05$) consumption of CP, EE, NDF, ADF and TC. This variation in consumption of nutrients is likely due to differences in DM intake, and physical and bromatological characteristics of each additive used in the ensiling of WBG.

The NDF and ADF contents in the SWBG and SWBSH diets (Table 2) may have reduced consumption because, according to Mertens (1992), food intake is dependent on physical factors such as the distension of the digestive system caused by dietary fiber which results in a filling effect thereby reducing consumption. The slower fermentation and longer time NDF remains in the rumen compared to non-fiber carbohydrates are correlated with a reduction in the intake of DM and other non-fibrous nutrients (ROBINSON; MCQUEEN, 1997).

The contents of NDF of diets provided the increase in consumption of this nutrient, reaching values greater than the 1.2 % of body weight suggested by Mertens (1992). But even though diets had higher NDF, this did not limit the DM intake as the cows met the minimum requirement of DM intake as recommended by the NRC (2001) for their category.

The inclusion of nutrient additives with high DM in the WBG silage promoted differences ($P<0.05$) in digestibility of DM and nutrients (Table 4), due to the characteristics observed in the bromatological composition of each additive.

Table 4. Digestibility of dry matter and nutrients, and total digestible nutrients in diets of dairy cows fed with different wet brewers grain-based silages.

Digestibility	Diets containing different wet brewers grain-based silages[1]				CV %	P Value
	SWBG	SWBWB	SWBSH	SWBGC		
Dry matter (g kg^{-1})	551.90[b]	560.14[b]	636.96[a]	632.96[a]	1.73	0.000
Organic matter (g kg^{-1})	577.21[b]	586.58[b]	659.16[a]	654.35[a]	1.62	0.000
Crude protein (g kg^{-1})	660.17[b]	671.18[b]	712.84[a]	717.79[a]	1.82	0.001
Ether extract (g kg^{-1} DM)	860.98	854.96	871.02	869.36	1.08	0.149
Neutral detergent fiber (g kg^{-1} DM)	502.62[bc]	453.49[c]	598.99[a]	538.90[b]	4.28	0.000
Acid detergent fiber (g kg^{-1} DM)	465.37[ab]	386.84[b]	492.13[a]	459.79[ab]	7.46	0.021
Total carbohydrates (g kg^{-1} DM)	543.06[b]	554.94[b]	636.79[a]	629.29[a]	2.06	0.000
Non-fibrous carbohydrates (g kg^{-1} DM)	635.41[b]	689.43[a]	718.12[a]	697.14[a]	3.45	0.040
Total digestible nutrients (g kg^{-1} DM)	578.72[b]	589.99[b]	660.76[a]	646.75[a]	1.53	0.000

Means followed by the same letter on the line do not differ by Tukey test at 5% probability. [1]SWBG: silage of wet brewers grain alone; SWBWB: silage of wet brewers grain with wheat bran; SWBSH: silage of wet brewers grain with soybean hulls; SWBGC: silage of wet brewers grain with ground corn.

The use of WBG silage containing additive nutrients with a high content of DM in the feeding of lactating cows ($P<0.05$) promoted changes in nutrient digestibility (Table 4). It was observed that diets with SWBSH and SWBGC had higher ($P<0.05$) digestibility for DM, OM, CP, NDF and TC compared to the SWBG and SWBWB diets. It is likely that the SWBSH diet enabled better digestibility due to NDF characteristics, because according to Belyea et al. (1989) and Zambom et al. (2001) in vitro digestibility of the DM and the cell wall of soybean hulls is approximately 95 %, indicating the best fiber quality.

According to Lima et al. (2009), although the energy value of soybean hulls is less than corn, several experiments have shown that the performance of animals did not change when these foods were interchanged. The use of Tifton 85 hay (908.58 g kg^{-1} DM and 802.89 g kg^{-1} NDF DM), which is commonly used in dairy cow diets and naturally has a lower digestibility than corn silage, may have influenced the results of DM digestibility (551.90 to 636.96 g kg^{-1}) for all of the studied diets. These digestibility values are low compared to those from other studies that evaluated the use of WBG, such as Rogers et al. (1986). Those authors analysed the inclusion of 22 % or 40 % of WBG and dehydrated brewers waste in diets composed of corn silage and corn starch for lactating cows and found no change in the digestibility of DM, which averaged 690 g kg^{-1}.

According to a study conducted by Geron et al. (2010), the inclusion of up to 15 % brewers grain in diets composed of corn silage, silage rye grass and concentrated feed, which were provided to Holstein cows, resulted in a mean digestibility value of approximately 770 g kg^{-1} DM . According to the authors, those results were influenced by the variation in the percentage composition of roughage in the rations.

In this study, the results observed concerning the digestibility of nutrients showed that the quality of roughage used in the diet is crucial for both the digestibility of DM, and for the energy amount in the diet.

Diets containing SWBSH and SWBGC had higher digestibility of CP ($P<0.05$) compared to the SWBG and SWBWB diets, due the higher concentrations of protein and soybean meal in concentrated feed diets (Table 2). According to Armentano et al. (1986), soybean meal has a higher digestible nitrogen fraction compared to WBG, and provides greater degradable protein intake for rumen microbes. Whereas in WBG, approximately 50 % of protein may be in the form of rumen undegradable protein (CLARK et al., 1987; GERON et al., 2007). The low digestibility of CP in WBG is due to processing in the brewing industry, which removes or ferments most soluble proteins, albumin and globulins (GILAVERTE et al., 2011).

Diets containing SWBSH and SWBGC provide higher digestibility of nutrients resulting in higher TDN values for these diets (Table 4), indicating increased availability of digestible energy. The SWBSH diet, despite the lower consumption observed due to the higher concentration of fiber, showed higher digestibility of nutrients. This was possibly due to the soybean hull nutritional quality and also to a lower pass ratio, which implies a greater length of stay in the rumen, therefore favoring rumen fermentation and fiber digestibility (GROVUM; WILLIAMS, 1973).

Dairy cows fed diets containing SWBG and SWBWB showed the highest NDF levels, which probably reduced the TDN value of these diets, in addition to causing a possibly slow and incomplete digestion of NDF in the gastrointestinal tract. (Van Soest, 1994). The results obtained for TDN in the SWBG and SWBWB diets were approximately seven percentage units lower than the SWBSH and SWBGC diets.

The daily milk production (kg day^{-1}) and 3.5 % fat corrected milk, were not affected ($P> 0.05$) by the different diets (Table 5), even with the observation that the TDN values of the SWBG and SWBWB diets did not meet the requirements recommended by the NRC (2001) for cows producing 25 liters of milk daily.

Polan et al. (1985), Belibasakis and Tsirgogianni (1996) and Chiou et al. (1998) observed higher milk production with the use of brewers residue, and concluded that this was due to a higher rumen undegraded protein intake (RUP) which contributed to the increased availability of amino acids, essential to metabolism of milk production.

However, Geron et al. (2010) evaluated the inclusion of brewers grain silage (up to 15 %) in the diets of lactating cows with corn silage, ryegrass silage and concentrate, and found no differences in milk production. According to the authors, even with the higher levels of RUP in the feed, these levels did not sufficiently supply the amino acids considered essential to the synthesis of milk production, such as methionine and lysine.

In this study, no differences ($P>0.05$) were observed in the milk composition of Holstein cows fed with different WBG based silages, regarding fat, protein, lactose, total solids and somatic cell count (Table 5).

The values obtained for fat (31.55 to 35.30 g kg^{-1}) and milk protein (32.51 to 32.88 g kg^{-1}) in the analysed diets were consistent with the minimum necessary stated in Normative Instruction 62 (BRASIL, 2011), which are 30 g kg^{-1} for fat and 29 g kg^{-1} for protein. Similarly, Polan et al. (1985), West et al. (1994), Kazemi et al. (2009) and Geron et al. (2010) did not observe effects on fat and milk protein with the addition of brewer grains in diets for lactating cows. According to Jenkins and McGuire (2006), the milk protein percentage may have little response to changes in dietary composition, as the lactose content is rarely modified and fat is the most sensitive component of the diet manipulation.

There were no differences ($P>0.05$) in lactose between diets containing different WBG based silages, due to the small variability of this component in milk and its participation as a regulator of milk production. According to Park and Jacobson (1996), the lactose concentration is balanced by the release of water in the blood and by mixing with other components found in the alveoli of the mammary gland; thus, lactose synthesis controls the amount of milk produced.

The SWBGC diet had a lower concentration ($P<0.05$) of milk urea nitrogen (MUN) compared to the other experimental diets (table 5). However, for the other diets there was no change ($P>0.05$) in MUN compared to WBG alone, with an average MUN concentration of 20.04 mg dL^{-1}. According to Wittwer et al. (2000), over-degradable and soluble protein in the rumen, or its imbalance with the energy content, promote excessive formation and absorption of rumen ammonia, increasing urea in milk. The addition of ground corn in the ensiling of WBG resulted in higher concentrations of soluble carbohydrates, promoting greater synchronisation of nutrients in the rumen and decreasing excess ammonia.

The levels of MUN obtained in the cows fed with the different diets containing WBG based silages were above 10 to 14 mg dL^{-1}, which is the range considered appropriate by Moore and Vargas (1996), Jobim and Santos (2000), Campos (2002) and Aquino et al. (2007). This demonstrates the excessive intake of protein in the diet and an energy deficit or lack of synchronisation of degradable and non-degradable fractions in the rumen (SANTOS et al., 1984). This is because there is a direct relationship between blood concentrations of urea nitrogen with dietary protein intake, as well as the energy: protein ratio (CLAYPOOL et al., 1980; CONTRERAS, 2000). The higher dietary protein intake promotes a higher nitrogen concentration in milk. Thus, the MUN is an important indirect method to determine the efficiency of nitrogen use by ruminants, as well as to characterise the nutritional balance of diets (DEPETERS; FERGUSON, 1992; DEPETER; CANT, 1992).

Table 5. Milk production and composition from cows fed with different wet brewers grain-based silages.

Parameters	Diets containing different wet brewers grain-based silages[1]				CV %	P Value
	SWBG	SWBWB	SWBSH	SWBGC		
Milk production (MP) (kg day^{-1})	26.69	27.21	28.48	29.44	6.94	0.277
MP corrected to 3.5% (kg day^{-1})	26.89	27.30	26.97	28.82	7.28	0.532
Efficiency MP (kg milk kg^{-1} DMI)	1.32	1.24	1.39	1.37	6.45	0.205
Fat (g kg^{-1})	35.30	35.19	31.55	33.75	4.91	0.060
Fat (kg day^{-1})	0.95	0.96	0.90	0.99	8.04	0.493
Protein (g kg^{-1})	32.85	32.56	32.51	32.88	2.31	NS
Protein (kg day^{-1})	0.88	0.89	0.93	0.97	5.42	0.128
Lactose (g kg^{-1})	44.73	46.14	45.45	45.03	2.63	0.425
Lactose (kg day^{-1})	1.19	1.26	1.29	1.32	6.62	0.243
Total solids (g kg^{-1})	122.56	124.29	119.50	121.44	2.52	0.268
Total solids (kg day^{-1})	3.27	3.38	3.40	3.56	6.37	0.266
Somatic cell count (log_{10} CFU[2] mL^{-1})	2.11	2.14	2.18	2.29	10.82	NS
Milk urea nitrogen (mg dL^{-1})	20.52[a]	20.21[a]	19.40[a]	17.67[b]	3.46	0.004

Means followed by the same letter on the line do not differ by Tukey test at 5 % probability. NS: not significant. [1]SWBG: silage of wet brewers grain alone; SWBWB: silage of wet brewers grain with wheat bran; SWBSH: silage of wet brewers grain with soybean hulls; SWBGC: silage of wet brewers grain with ground corn. [2]CFU: Colony Forming Unit.

Conclusion

Diets containing silage of WBG with soybean hulls or ground corn, fed to Holstein dairy cows, increases the digestibility of DM and nutrients. However, the use of wheat bran, soybean hulls or ground corn in the ensilage of WBG does not alter the production, efficiency or milk composition of cows fed with these silages.

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References

ALVES, S. P.; CABRITA, A. R. J.; JERÓNIMO, E.; BESSA, R. J. B.; FONSECA, A. J. M. Effect of ensiling and silage additives on fatty acid composition of ryegrass and corn experimental silages. *Journal of Animal Science*, Champaign, v. 89, n. 8, p. 2537-2545, 2011.

AQUINO, A. A.; BOTARO, B. G.; IKEDA, F. S.; RODRIGUES, P. H. M.; MARTINS, M. F.; SANTOS, M. V. Efeito de níveis crescentes de ureia na dieta de vacas em lactação sobre a produção e a composição físico química do leite. *Revista Brasileira de Zootecnia*, Viçosa, v. 36, n. 4, p. 881-887, 2007.

ARMENTANO, L. E.; HERRINGTON, T. A.; POLAN, C. E.; MOE, A. J.; HERBEIN, J. H.; UMSTADT, P. Ruminal degradation of dried brewers grains, wet brewers grains, and soybean meal. *Journal of Dairy Science*, Madison, v. 69, n. 8, p. 2124-2133, 1986.

BAKER, L. D.; FERGUSON, J. D.; CHALUPA, W. Responses in urea and true protein of milk to different protein feeding schemes for dairy cows. *Journal of Dairy Science*, Madison, v. 78, n. 11, p. 2424-2434, 1995.

BELIBASAKIS, N. G.; TSIRGOGIANNI, D. Effects of wet brewers grains on milk yield, milk composition and blood components of dairy cows in hot weather. *Animal Feed Science and Technology*, Amsterdam, v. 57, n. 3, p. 175-181, 1996.

BELYEA, R. L.; STEVENS, B. J.; RESTREPO, R. J.; CLUBB, A. P. Variation in composition of by-products feeds. *Journal of Dairy Science*, Madison, v. 72, n. 9, p. 2339-2345, 1989.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Instrução Normativa nº 62, de 29 de dezembro de 2011. Aprova o regulamento técnico de produção, identidade e qualidade do leite tipo A, o regulamento técnico de identidade e qualidade de leite cru refrigerado, o regulamento técnico de identidade e qualidade de leite pasteurizado e o regulamento técnico da coleta de leite cru refrigerado e seu transporte a granel, em conformidade com os anexos desta instrução normativa. *Diário Oficial [da] República Federativa do Brasil,* Brasília, 31 dez. 2011. Seção 1, p. 6.

BROCHIER, M.A.; CARVALHO, S. Efeito de diferentes proporções de resíduo úmido de cervejaria sobre as características da carcaça de cordeiros terminados em confinamento. *Arquivos Brasileiros de Medicina Veterinária e Zootecnia,* Belo Horizonte, v. 61, n. 1, p. 190-195, 2009.

CAMPOS, R. Alguns indicadores metabólicos no leite para avaliar a relação nutrição: fertilidade. In: CONGRESSO BRASILEIRO DE MEDICINA VETERINÁRIA, 29., 2002, Gramado, RS. *Anais*... Porto Alegre: UFRGS, 2002. p. 40-48.

CHIOU, P. W. S.; CHEN, C. R.; CHEN, K. J. Wet brewers' grains or bean curd pomance as partial replacement of soybean meal for lactating cows. *Animal Feed Science and Technology*, Amsterdam, v. 74, n. 2, p. 123-134, 1998.

CLARK, J. H.; MURPHY, M. R.; CROOKER, B. A. Supplying the protein needs of dairy cattle from byproducts feeds. *Journal of Dairy Science*, Madison, v. 70, n. 5, p. 1092-1109, 1987.

CLAYPOOL, D. W.; PANGBORN, M. C.; ADAMS, H. P. Effects on dietary on high-producing dairy cows in early lactation. *Journal of Dairy Science*, Madison, v. 63, n. 5, p. 6833-837, 1980.

COCHRAN, R. C.; ADAMS, D. C.; WALLACE, J. D.; GALYEAN, M.L. Predicting digestibility diets with internal markers: Evaluation of four potential markers. *Journal of Animal Science,* Champaign, v. 63, n. 5, p. 1476-1483, 1986.

CONTRERAS, P. Indicadores do metabolismo proteico utilizados nos perfis metabólitos dos rebanhos In: GONZÁLEZ, F. H. D.; BARCELLOS, J. O.; OSPINA, H.; RIBEIRO, L. A. O. (Ed.). *Perfil metabólico em ruminantes*: seu uso em nutrição e doenças nutricionais. Porto Alegre: Gráfica UFRGS, 2000. p. 23-30.

DePETERS, E. J.; CANT, J. P. Nutritional factors influencing the nitrogen composition of bovine milk: a review. *Journal of Dairy Science*, Madison, v. 75, n. 8, p. 2043-2070, 1992.

DePETERS, E. J.; FERGUNSON, J. D. Nonprotein nitrogen and protein distribution in the milk of cows. *Journal of Dairy Science*, Madison, v. 75, n. 11, p. 3192-3209, 1992.

GERON, L. J. V.; ZEOULA, L. M.; ERKEL, J. A.; PRADO, I. N.; BUBLITZ, E.; PRADO, O. P. P. Consumo, digestibilidade dos nutrientes, produção e composição do leite de vacas alimentadas com resíduo de cervejaria fermentado. *Acta Scientiarum. Animal Sciences,* Maringá, v. 32, n. 1, p. 69-76, 2010.

GERON, L. J. V.; ZEOULA, L. M.; BRANCO, A. F.; ERKEL, J. A.; PRADO, O. P. P.; JACOBI, G. Caracterização, fracionamento proteico, degradabilidade ruminal e digestibilidade *in vitro* da matéria seca e proteína bruta do resíduo de cervejaria úmido e fermentado. *Acta Scientiarum. Animal Sciences,* Maringá, v. 29, n. 3, p. 291-299, 2007.

GILAVERTE, S.; SUSIN, I.; PIRES, A. V.; FERREIRA, E. M.; MENDES, C. Q.; GENTIL, R. S.; BIEHL, V. M.; RODRIGUES, G. H. Digestibilidade da dieta, parâmetros ruminais e desempenho de ovinos Santa Inês alimentados com polpa cítrica peletizada e resíduo úmido de cervejaria. *Revista Brasileira de Zootecnia,* Viçosa, v. 40, n. 3, p. 639-647, 2011.

GROVUM, W. L.; WILLIAMS, V. J. Rate of passage of digesta in sheep. *British Journal of Nutrition,* v. 30, n. 2, p. 313-329, 1973.

JENKINS, T. C.; McGUIRE, M. A. Major advances in nutrition: impact on milk composition. *Journal of Dairy Science,* Savoy, v. 89, n. 4, p. 1302-1310, 2006.

JOBIM, C. C.; SANTOS, G. T. Influência da qualidade de forragens conservadas sobre a qualidade do leite de vacas. In: WORKSHOP SOBRE PRODUÇÃO E QUALIDADE DO LEITE, 2., 2000, Maringá. *Anais*... Maringá: Universidade Estadual de Maringá, 2000. p. 1-9.

JOBIM, C. C.; NUSSIO, L. G.; REIS, R. A.; SCHIMIDT, P. Avanços metodológicos na avaliação da qualidade da forragem conservada. *Revista Brasileira de Zootecnia,* Viçosa, v. 36, p. 101-119, 2007. Suplemento Especial.

KAZEMI, M.; TAHMASBI, A. M.; VALIZADEH, R.; DANESH MESGARAN, M.; NASERIAN, A. A. Effect of ensiled barley distillers` grains for Holstein dairy cows. *Journal of Animal Veterinary Advances,* Mashhad, v. 8, n. 4, p. 807-813, 2009.

LAHR, D. A.; OTTERBY, D. E.; JOHNSON, D. G.; LINN, J. G.; LUNDQUIST, R. G. Effects of moisture content of complete diets on feed intake and milk production by cows. *Journal of Dairy Science*, Madison, v. 66, n. 9, p. 1891-1900, 1983.

LICITRA, G.; HERNANDEZ, T. M.; VAN SOEST, P. J. Standardization of procedures for nitrogen fractionation of ruminant feeds. *Animal Feed Science and Technology*, Amsterdam, v. 57, n. 4, p. 347-358, 1996.

LIMA, M. L. M.; FERNANDES, J. J. R.; CARVALHO, E. R.; SANTOS, S. C.; ROCHA, F. M.; LIMA, D. A. Substituição do milho triturado por casca de soja em dietas para vacas mestiças em lactação. *Ciência Animal Brasileira,* Goiânia, v. 10, n. 4, p. 1037-1043, 2009.

McDONALD, P.; HENDERSON, A. R.; HERON, S. J. E. *The biochemistry of silage.* 2th ed. Marlow: Chalcombe Publications, 1991. 340 p.

MCDONALD, P. R.; WHITTENBURY, R. The Ensilage Process. In: BUTLER, G. W.; BAILEY, R. W. (Ed.). *Chemistry and Biochemistry of Herbage.* London an New York: Academic Press, 1973, p. 33-60.

MERTENS, D. R. Análise de fibra e sua utilização na avaliação de alimentos e formulações de rações. In: SIMPÓSIO INTERNACIONAL DE RUMINANTES, Lavras, 1992. *Anais*… Lavras: SBZESAL, 1992. p. 188-219.

MOORE, D.A.; VARGAS, G. BUN and MUN: urea nitrogen testing in dairy cattle. *Compendium on Continuing Education for the Practicing Veterinary,* Princeton, v. 18, n. 6, p. 712-721, 1996.

NATIONAL RESEARCH COUNCIL - NRC. Nutrient requirements of dairy cattle. Washington, D.C.: National Academic Press, 2001. 381 p.

PARK, C. F.; JACOBSON, N. L. Glândula mamária e lactação. In: SWENSON, M. J.; REECE, W. O. *Dukes:* fisiologia dos animais domésticos. Rio de Janeiro: Guanabara Koogan, 1996. p. 645-659.

PIMENTEL GOMES, F.; GARCIA, C. H. *Estatística aplicada a experimentos agronômicos e florestais:* exposição com exemplos e orientações para uso de aplicativos. 11. ed. Piracicaba: FEALQ, 2002. 309 p.

PIMENTEL GOMES, F. P. *Curso de estatística experimental*. 15. ed. Piracicaba: FEALQ, 2009. 451 p.

POLAN, C. E.; HERRINGTON, W. A.; WARK, W. A. Milk production response to diets supplemented with dried grains, wet brewers grains, or soybean meal. *Journal of Dairy Science,* Savoy, v. 68, n. 8, p. 2016-2026, 1985.

ROBINSON, P. H.; McQUEEN, R. E. Influence of level of concentrate allocation and fermentability of forage fiber on chewing behavior and production of dairy cows. *Journal of Dairy Science,* Savoy, v. 80, n. 4, p. 681-691, 1997.

ROGERS, J. A.; CONRAD, H. R.; DEHORITY, B. A. Microbial numbers, rumen fermentation and nitrogen utilization of steers fed wet or dried brewers´ grains. *Journal of Dairy Science,* Savoy, v. 69, n. 3, p. 745-753, 1986.

SANTOS, K. A.; STERN, M. D.; SATTER, L. D. Protein degradation in the rumen and amino acid absorption in the small intestin of lactating dairy cattle fed various proteins sources. *Journal of Animal Science*, Champaign, v. 58, n. 1, p. 244-255, 1984.

SILVA, D. J.; QUEIROZ, A. C. *Análise de alimentos*: métodos químicos e biológicos. 3. ed. Viçosa, MG: UFV, 2006. 235 p.

SKLAN, D.; ASHKENNAZI, R.; BRAUN, A.; DEVORIN, A.; TABORI, K. Fatty acids, calcium soaps of fatty acids, and cottonseeds fed to high yielding cows. *Journal of Dairy Science*, Madison, v. 75, n. 9, p. 2463-2472, 1992.

SNIFFEN, C. J.; O'CONNOR, J. D.; VAN SOEST, P. J.; FOX, D. G.; RUSSEL, J. B. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. *Journal of Animal Science,* Savoy, v. 70, n. 10, p. 3562-3577, 1992.

VAN SOEST, P. J. *Nutritional ecology of ruminant*. Ithaca: Cornell University Press, 1994. 476 p.

VAN SOEST, P. J.; ROBERTSON, J. B.; LEWIS, B. A. Methods for dietary fiber, neutral detergent fiber, and non starch polysaccharides in relation to nutrition. *Journal of Dairy Science,* Savoy, v. 74, n. 10, p. 3583-3597, 1991.

WEST, J. W.; ELY, L. O.; MARTIN, S. A. Wet brewers grains for lactating dairy cows during hot, humid weather. *Journal of Dairy Science,* Savoy, v. 77, n. 1, p. 196-204, 1994.

WITTWER, F. Diagnósticos dos desequilíbrios metabólicos de energia em rebanhos bovinos In: GONZÁLEZ, F. H. D.; BARCELLOS, J. O.; OSPINA, H.; RIBEIRO, L. A. O. (Ed.). *Perfil metabólico em ruminantes*: seu uso em nutrição e doenças nutricionais. Porto Alegre: Gráfica UFRGS, 2000. p. 9-22.

ZAMBOM, M.A.; SANTOS, G.T.; MODESTO, E.C.; ALCALDE, C. R.; GONÇALVES, G. D.; SILVA, D. C.; SILVA, K. T.; FAUSTINO, J. O. Valor nutricional da casca do grão de soja, farelo de soja, milho moído e farelo de trigo para bovinos. *Acta Scientiarum,* Maringá, v. 23, n. 4, p. 937-943, 2001.

ZANINE, A. M.; SANTOS, E. D.; FERREIRA, D. J.; PEREIRA. O. G.; ALMEIDA, J. C. C. Efeito do farelo de trigo sobre as perdas, recuperação da matéria seca e composição bromatológica da silagem de capim Mombaça. *Brazilian Journal of Veterinary Research and Animal Science,* São Paulo, v. 53, n. 6, p. 803-809, 2006.