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Crude glycerin as an alternative energy feedstuff for dairy cows

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ABSTRACT

The intent of this study was to demonstrate the potential of biodiesel derived crude glycerin as a good alternative for an energy feedstuff in dairy cow diets. Eight multiparous Jersey cows with 85 ± 20 days in milk were used. The following treatments were evaluated: 0, 40, 80, and 120 g crude glycerin (containing 814.4 g glycerol/kg) dietary inclusion/kg dry matter. The experimental diets contained equal protein and energy levels. A replicated Latin square experimental design was applied. Crude glycerin intake did not influence average daily milk yield, energy corrected milk yield, or crude fat, lactose, and total milk solids average daily yield and concentration. Milk protein concentration was higher when 120 g crude glycerin was included in the diet when compared with the control group (37.2 vs. 36.1 g/kg, respectively, $P<0.05$). Crude glycerin intake also increased average daily crude protein yield at the dietary inclusion levels of 80 g/kg (0.77 vs. 0.71 kg by the control group, $P<0.05$). None of the evaluated treatments influenced dry matter or organic matter intake. Dry matter, organic matter, and neutral detergent fiber digestibility, and serum concentrations of non-esterified fatty acids and urea were not influenced by crude glycerin intake. Glycemia showed a quadratic response to crude glycerin intake ($P<0.05$), and was lower at the intermediate levels of dietary inclusion (40 and 80 g/kg). Crude glycerin is a good alternative energy feedstuff for dairy cows at a dietary inclusion levels of up to 120 g/kg dry matter in partial substitution of ground corn in dairy cow rations, and may even improve milk protein concentration.

1. Introduction

The inclusion of 20 mL of biodiesel/L fossil fuel diesel is mandatory in Brazil, since 2008 (ACT n. 11.097, as of January 13, 2005). In 2010, Resolution CNPE n. 6/2009 allowed the inclusion of up to 50 mL/L. This has resulted in 2011 in the production of more than 2.64 billion liters of biodiesel in Brazil, whereas between March and December, 2005, only 736,100 L were

Abbreviations: CGL, crude glycerin; CP, crude protein; DM, dry matter; DMD, dry matter digestibility; DMI, dry matter intake; ECM, energy corrected milk; EE, ether extract; aNDFom, neutral detergent fiber with a heat stable amylase and expressed exclusive of residual ash; NDFD, neutral detergent fiber digestibility; NEl, net energy of lactation; OM, organic matter; OMD, organic matter digestibility; OMI, organic matter intake; RDP, rumen degradable protein; VFA, volatile fatty acids.

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produced (ANP, 2012). This huge increase in the production of biodiesel is not restricted to Brazil. The estimated global biodiesel production for 2019 is of about 41 billion liters (OECD-FAO, 2010).

Although this growth in productions creates to some problems, it may also create opportunities. It estimated that each liter of biodiesel produced generates about 100 mL crude glycerin (CGL) (Dasari et al., 2005), which contains variable glycerol content.

A large surplus of CGL has been recently produced, and a nobler destiny than routine burning and disposal in rivers and industrial dump, need to be found in order to reduce environmental pollution and improve the economic return of the biodiesel producers. However, complex and costly processes are required to obtain the degree of purity required for the traditional applications of glycerin in food, drug, cosmetic and tobacco industries cosmetics, drugs, and cleaning products (Pachauri and He, 2006), because it contains, several impurities including residual methanol, NaOH, carry-over fat/oil, some esters, and low amounts of sulfur compounds, proteins, and minerals (Celik et al., 2008).

Glycerol, the main component of CGL, has high energy content, which is approximately the same as that of corn starch (Donkin and Doane, 2007), and can potentially be used for animal feeding.

In general CGL was used as a supplement, increasing energy intake, in beef cattle diets, and nutrient utilization was not reported for those studies (Schröder and Südekum, 1999; Mach et al., 2009; Wang et al., 2009; Lage et al., 2010). Therefore, further studies are required to evaluate the use of CGL as an alternative energy feedstuff to replace corn grain, the main energy feedstuff in dairy diets.

The objective of the present study was to demonstrate that CGL derived from a biodiesel production plant may be an interesting alternative energy feedstuff for dairy cows in the middle third of lactation fed iso-energy and iso-protein diets, thereby upgrading its status as residue to important by-product. In addition, the specific aim was to determine maximal CGL dietary inclusion level, up to which no negative effects on production and feed utilization are observed.

2. Materials and methods

2.1. Animals and location

The field experiment was carried out between September and December, 2009, at the Dairy Cattle System sector (SISPEL) of the experimental farm Terras Baixas (ETB) of the Temperate Climate Agriculture Research Center of Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), located at the municipality of Capão do Leão (31° 52′ 20″ south latitude and 52° 21′ 24″ west longitude, mean altitude of seven meters above sea level), Rio Grande do Sul, Brazil. Milk component analyses were carried out at the Milk Quality Laboratory (LABLEITE) located at that experimental station. Chemical analyses were performed at the Animal Nutrition Laboratory and the biochemical analyses in the Veterinary Clinical Analyses Laboratory, both belonging to Universidade Federal do Rio Grande do Sul (UFRGS). The work was carried out in accordance with EU Directive 2010/63/EU.

Eight purebred Jersey cows, of 2–8 parities, with average body weight of 421 ± 39 kg and 85 ± 20 days of lactation, were selected from the SISPEL herd. Average daily milk yield before the beginning of the experiment was 20.5 ± 2.7 kg. Cows were individually housed in free stall, and were separated by an electrical fence. All pens were equipped with a drinker, dispensing drinkable water, and sand litter.

2.2. Treatments

The following treatments were evaluated: Control – no CGL inclusion in the diet; G4 – 40 g CGL/kg of dietary dry matter (DM); G8 – 80 g CGL/kg dietary DM; G12 – 120 g CGL/kg dietary DM. CGL inclusion levels are described on dry matter basis.

The CGL tested contained 814.4 g glycerol/kg DM, 860.1 g of DM/kg, 1.1 g crude protein (CP)/kg of DM, 14.29 MJ of gross energy (GE)/kg of DM and less than 50 ppm of methanol. Glycerol was considered as completely digestible during diet calculation. Metabolizable energy (ME) was estimated as: $ME = (1.01 \times DE - 0.45)$, and net energy of lactation (NEl) was estimated as: $NEl = (0.703 \times ME) - 0.19$. In both equations, units are expressed as calories/kg, according to the NRC (2001). Energy content, NEl, was then transformed in MJ/kg DM, and CGL NEl was estimated as 8.20 MJ/kg of DM.

Metabolizable energy (ME) of the other feedstuffs was also estimated based on their chemical composition, also according to the NRC (2001). When feedstuffs contained less than 30 g ether extract (EE)/kg of DM, $ME = DE^{*}1.01–0.45$, when EE/kg was higher than 30 g/kg of DM, $ME = DE^{*}1.01 - 0.45 + 0.0046^{*}(EE - 3)$. The same equation that was used to estimate the NEl of CGL was used to estimate the NEl of the other feedstuffs with less than 30 g of EE/kg of DM. For feedstuffs with more than 30 g of EE/kg of DM, the following equation (NRC, 2001) was applied: $NEl = (0.703^{*}ME) - 0.19 + ((0.097^{*}ME + 0.19)/97)^{*}(EE - 3)$. Feedstuff digestible energy (DE) values were obtained from the NRC tables (2001), as they were used only to supply equal energy density to the experimental diets. As mentioned before, because the models were built using as unit calories/kg, results were transformed in MJ/kg.

The experimental diets were formulated with the aid of the software program Spartan® (Michigan State University). The diets contained equal energy and protein levels and were formulated to supply the requirements of cows producing 20 kg of milk/day containing 48 g of fat/kg, according to the NRC (2001).

The NEl estimated based on the chemical composition of the CGL was very similar to the energy density obtained with ground corn. Therefore, CGL entered in diet composition almost exclusively in replacement of corn grain.