Effect of Safflower Seeds on Production Performance of Finishing Cattle

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Abstract: With the increasing price of soybean meal, grain sorghum and maize, it is necessary to use alternative grains for feeding finishing cattle. Safflower seeds can be set as an alternative for feeding cattle, but need to know how to be used as an ingredient. The objective was to evaluate the effect of safflower seeds on productive performance in finishing cattle. In a completely randomize design, 36 male bovine (*Bos Taurus* vs. *Bos indicus*) (356.24 ± 17.21 kg BW) distributed in three treatments with 12 replications, staying in cages and fed individual *ad libitum* for 90 d plus 15 d of adaptation. Safflower seeds were included at three levels of 0% (SF0), 15% (SF15) and 30% (SF30) of a high grains (65%) diet. Average daily gain (ADG), dry matter intake (DMI) and feed conversion (FC). No differences were obtained for ADG with increased ($P<0.05$) DMI of animals fed safflower seeds. SF0 and SF15 had the same FC with increased ($P<0.05$) DMD. SF15 had greater ($P<0.05$) ruminal pH at 20-d and 60-d. SF15 treatment increased ($P<0.05$) ratio of butyric acid; however, increased ruminal ammonia N concentrations ($P<0.05$) were observed with the treatment SF30 and SF15 compared to SF0. At15-d, SF0 had greater ($P<0.05$) ruminal cellulolytic bacteria (10^{10}/mL) concentration compared to SF15 and SF30 treatments. It could be concluded that addition of safflower seeds at 15% of the diets of finishing cattle improved feed intake and dry matter digestibility with positive effects on ruminal fermentation.

Keywords: cattle, finishing, grains, safflower seeds.

1. Introduction

New feeding strategies including feed additives (Elghandour *et al*., 2014, 2015; Salem *et al*., 2014a,b), and feed treatments (Abdel-Aziz *et al*., 2015; Salem *et al*., 2015; Valdes *et al*., 2015) should be used to improve animal performance. Whole safflower seeds with high oil content have several characteristics as a desirable supplement for beef cows due to the high lipid concentration and a moderate concentration of protein with easy storage and handling. Moreover, with the increasing price of soybean meal, sorghum and corn grains, it is necessary to find alternative grain feeds for finishing cattle in feedlots. The safflower seeds can be established as an alternative for feeding cattle. Safflower seeds contain a high percent of fat, especially linoleic and oleic acids which may be fat dietary supplementation (Kott *et al*., 2010). Safflower seeds could be used to replace traditional protein supplements with a concomitantly lipid source. Supplementation of beef cattle with safflower seeds or feeding diets containing sunflower seeds or oils has variable effects on rumen fermentation and productive performance (Schólljegerdes *et al*., 2004; Atkinson *et al*., 2006; Kott *et al*., 2010).

Dietary supplementation with lipids, such as oilseeds of safflower seeds may be a method to cover more adequately meet nutritional demands associated with growth, lactation, and postpartum reproduction in young beef cows (Bottger *et al*., 2002). The high oil concentration of safflower seeds makes it an attractive energy-dense feed for animals with high energy requirements, such finishing feedlot cattle. Moreover, feeding cattle on supplemental have many benefits where dietary fat can exert on reproduction and on the quality of ruminant-derived food products (Schólljegerdes *et al*., 2004).

Oilseeds can increase the concentrations of conjugated linolenic acid (CLA) in meat (Kott *et al*., 2010) and milk (Bell *et al*., 2006), which may give more health advantages to human consumers of these food products (Schólljegerdes *et al*., 2004).

Therefore, our objective was to evaluate some productive variables, and ruminal fermentation patterns in ale cows fed safflower seeds at different levels.

2. Materials and methods

2.1. Animals, treatments and management

Thirty sex male cows (*Bos Taurus* vs *Bos indicus*) with average weight of 356.24 ± 17.21 kg in a completely randomize design were distributed in three treatments with 12 repetitions each were fed individually *ad libitum* for 90 d plus 15 day of adaptation, on isocaloric and isonitrogenous diets of high grains. The treatments consisted of three levels of safflower seeds inclusion: 0% (SF0), 15% (SF15) and 30% (SF30) of the diet. Feed intake was measured daily throughout the experiment, recording the feed amount offered and rejected; voluntary intake was obtained by the difference between the two values.

2.2. Body weight changes

Animals were weighed at the beginning of the experiment and every 15 d, before morning feeding at 08:00 h. The average daily gain (ADG) was calculated as the difference between the final weight and initial weight divided by the days of the period.

Feed efficiency was calculated as the amount of feed consumed in kg required for one kg of body weight in kg.

2.3. Total feces collection and apparent dry matter digestibility

Three samplings were performed at 20, 40 and 60d of the experiment. Five lambs from each treatment were randomly selected for each animal and the total production of feces was collected for three consecutive days. From the collected composite faeces sample, a subsample of 10% was taken to determine the amount of dry matter.

2.4. Ruminal fermentation activity

On the days0, 15, 30, 45 and 60 of the study, samples of ruminal fluid were withdrawn from each animal using a stomach tube before the morning feeding. Samples (50 mL/ animal) were immediately filtered using four layers of cheesecloth. Strained rumen liquor was stored in glass bottles (45-mL) with a few drops of toluene and paraffin oil to cover the surface and stored at -18 °C for total volatile fatty acids and ammonia-N analyses.

Ruminal pH was measured immediately after collecting rumen fluid with an Orion model 710A brand potentiometer calibrated at pH 4.0 and 7.0.

2.5. Chemical analysis

Conventional analysis of feed and fecal samples was carried out according to AOAC (1997) for dry matter (DM; #934.01), ash (#942.05), N (#954.01) and ether extract (EE; #920.39). The neutral detergent fiber (NDF; Van Soest *et al*., 1991), acid detergent fiber (ADF) and lignin (AOAC, 1997; #973.18) analyses used an ANKOM200 Fiber Analyzer unit (ANKOM Technology Corporation, Macedon, NY, USA). The NDF was assayed without use of an alpha amylase but with sodium sulfite. Both NDF and ADF are expressed without residual ash. Urinary N was analyzed according to AOAC (1997; #954.01).

The McCullough technique (1967) was used for determination of ammonia N concentration. After rumen fluid was collected, 4 mL was acidified with 1 mL of metaphosphoric acid (25% solution in water), then the sample was centrifuged at 14000 rpm for 5 min and the supernatant transferred to 1.5 mL glass vials. For determination of ammonia N concentration, 20 µL were taken, where 1.0 ml phenol and 1.0 mL of sodium hypochlorite basified with sodium hydroxide were added and placed in 18 × 130 mm sample tubes. The tubes were incubated at 39 °C for 30 min where 5.0 mL of distilled water was added to dilute the sample. Ammonia nitrogen concentration was measured at 630 nm absorbance in a Perkin Elmer UV-VIS Lambda model 40 with blank contained 1.0 mL of phenol, 1.0 mL of sodium hypochlorite and 5.0 mL of distilled water. The final concentration of ammonia N was compared with a previously calibrated standard curve of nine molar concentrations of ammonia N.

Concentration of VFA was determined once rumen fluid acidified with metaphosphoric acid at ratio of 4: 1 sample: metaphosphoric acid. The sample was centrifuged at 14000 rpm for 15 min where 1.5 mL of the supernatant was collected. Concentration VFA in the samples was determined by gas chromatography on a Perkin Elmer chromatograph, Model Clarus 500 Elite FFAP with a capillary column. The carrier gas used was hydrogen at flow rate of 15 mL/min. Sample of 1 µl was injected with injector with temperature 200°C, detector 250°C and an oven temperature of 140°C. The total run time was 7 min.

For determination of cellulolytic rumen bacteria Concentration, liquid anaerobic culture medium (Cobos and Yokoyama, 1995) was prepared and used in culture tubes (13 × 100 mm) at a rate of 4.5 mL medium per tube. Tubes were remained for 72 h of incubation at 38 °C to observe any possible development of bacteria and contaminates in the media. After checking the sterility of the medium, two sets of tubes with 0.5 mL per replicate for each treatment of ruminal fluid were inoculated. Dilutions were 10-1 to 10-10 and after inoculation the tubes were incubated at 38 °C for 10 days. At the end of incubation, readings were made and the positive tubes were those with a marked degradation of Whatman No. 541. To determine bacterial concentrations number, the most probable number technique was used with two series of dilutions (Harrigan and McCance, 1979). Cellulolytic bacteria concentration was determined at 15, 30, 45 and 60 days of the experiment.

2.6. Statistical analysis

Data were analyzed using the GLM procedure of SAS (SAS 2002, North Carolina, USA) using the following model.

$$Y_{ijk} = \mu + T_i + A_j + E_{ijk}$$

where Y_{ijk} expressed every observation of the *j*th animal in the *i*th treatment, μ expressed the general mean, T_i expressed the treatment effect, A_j expressed the animal effect and E_{ijk} expressed the experimental error. Unless stated otherwise, significance was declared when P<0.05.

3. Results and discussion

3.1. Production variables

No differences were obtained for ADG due to feeding safflower seeds. Inclusion of safflower seeds increased (P<0.05) DMI of animals compared to control. However, no difference was observed between SF15 and SF30. Both of SF0 and SF15 had the same FC with no different DMD, and both had higher (P<0.05) FC and DMD compared to SF30 (Table 2). However the inclusion of safflower seeds on diets improved DMI, no effects were observed for the ADG. This may be related with the oil content of safflower seeds. Palmquist (1994) explained that high oil content of oilseeds may affect negatively on utilization and efficiency of feeds throughout the negative effects on ruminal digestion and decreased intestinal absorption. This phenomena can explained the better performance for animals fed on 15% safflower seeds (i.e., SF15) than those fed on 30% safflower seeds (i.e., SF30). Kott *et al*. (2010) evaluated the effects of safflower seed on Rambouillet ram lambs performance, and carcass characteristics. They noted that final BW, DMI, ADG and FC did not differ between lambs fed safflower seeds or control with no safflower seeds. Moreover, Mir *et al*. (2000) reported that DMI was decreased when lambs were supplemented with safflower oil. In another study, greater ADG was obtained when lambs were fed diets containing safflower seeds (Kott *et al*., 2003).

In addition, Bottger *et al*. (2002) fed Primiparous Angus × Gelbvieh rotationally crossed beef cows on diets had two types of safflower seeds high in linoleic or oleic acid *versus* control, and reported that OM, DM and forage intake did not differ among supplemental treatments. Moreover, they noted unaffected cow's BW or BW changes.

Scholljegerdes *et al*. (2004) evaluated the site and extent of nutrient disappearance in Angus × Gelbvieh heifers fed supplemental cracked safflower seeds *versus* corn-based diet (control). They reported that the true ruminal OM and ruminal NDF disappearances (percentage of intake) were greater for control than those fed safflower seeds. Moreover, they reported greater NDF intake by cattle fed safflower seeds. In 2006, Atkinson *et al*. studied ruminal

fermentation characteristics and site and extent of nutrient digestion in sheep fed on high concentrate diet supplemented with high-linoleate (77%) safflower oil at 0, 3, 6, and 9% of DM. They noted that OM intake was increased linearly, without affecting NDF and N intake, and apparent ruminal digestibilities of OM, NDF, and N by safflower oil in the diets. Dschaak *et al*. (2011) found that total tract digestibilities of DM, OM, CP, NDF, and ADF were not influenced by safflower seeds inclusion in the diets of Holstein cows.

3.2. Ruminal fermentation

No effects were observed (P>0.05) due to inclusion of safflower seeds in ruminal pH during the first 15 days (i.e., 15-d) and the third 15 days (i.e., 45-d). However, SF15 had greater (P<0.05) ruminal pH during the second 15 days (i.e., 20-d) and the forth 15 days (i.e., 60-d) (Table 3). Ruminal pH values for all treatments ranged between 6.16 and 6.47, which were within the range considered acceptable for fiber digestion (Ørskov and Ryle, 1990). Atkinson *et al*. (2006) reported that increased dietary safflower oil on diets of sheep did not affect ruminal pH. However, Greater ruminal pH was obtained for animals fed safflower seeds rich in linoleate than fed safflower seeds rich in Oleate without any differences between animals fed control and safflower-based diets (Scholljegerdes *et al*., 2004).

Almost no effects (P>0.05) were observed in the individual ruminal VFA acetic and propionic acids. However, increased (P<0.05) ratio of butyric acid was observed with SF15 treatment compared to the other treatments (Table 4). However, it was expected that the molar proportion of propionate in the rumen will be increased based on the fact that supplemental safflower oil can increased availability of glycerol from ruminal lipolysis, which is rapidly converted to propionate in the rumen (Chalupa *et al*., 1986). Scholljegerdes *et al*. (2004) noted that ruminal total VFA did not differ between animals fed diets contained safflower seeds or corn-based diet. They also reported that ruminal molar proportions of acetate did not differ between treatments. However, ruminal molar proportions of butyrate were lower for the diets supplemented with safflower seeds compared to greater propionate for cattle fed safflower seeds than Control. These results are in a good agreement with our results where butyric acid was lowered for diet contained 30% safflower seeds. They explained the higher proportion of butyrate for Control than safflower seeds fed animals based on the lack of differences observed for acetate because butyrate has the potential to be formed from acetate (Van Soest, 1994). However, fatty acid composition of feeds does not influence VFA production (Palmquist, 1991). In another study, total ruminal VFA concentrations were

not affected by increased dietary safflower oil. However, a linear decrease in molar proportion of acetate along with a linear increase in molar proportion of propionate was observed with increased dietary safflower oil (Atkinson *et al*., 2006).

Increased ruminal ammonia N concentrations (P<0.05) were observed with the treatment SF30 followed by SF15 compared to SF0 treatment. However, during the first 15 days SF15 had increased (P>0.05) ammonia N *versus* SF30; without significant difference. Throughout the experiment, no differences were observed (P>0.05) between SF30 and SF15 treatments (Table 5). Ruminal ammonia N were ranged between 21.1 to 36.5 mg/dL which were above the range (0.60 to 1.59 m*M* ammonia N) considered by Satter and Slyter (1974) to be sufficient for microbial N production. However, Scholljegerdes *et al*. (2004) noted that ruminal ammonia concentrations did not differ due to safflower seeds inclusion in the diets of animals. In addition, Atkinson *et al*. (2006) noted that increasing dietary safflower oil did not affect ruminal ammonia N.

Table 1. ingredients and chemical composition of experimental diets (DM basis).

	Diets[1]		
	SF0	SF15	SF30
Ingredients (g/kg)			
Safflower seeds	0	150	300
Corn stover	300	300	300
Soybean meal	144	67	0
Rolled sorghum grains	535	462	378.5
Molasses	6	6	8
Urea	5	5	3.5
Minerals	10	10	10
Chemical composition (g/kg)			
Crude protein	140.0	140.0	138.7
Digestible energy	2.9	3.0	2.9
net energy	0.96	1.05	0.89
Total digestible energy[2]	623.6	653.9	600.0
Crude fiber	141.6	138.3	157.0
Acid detergent fiber	91.9	103.0	113.5
Neutral detergent fiber	180.4	193.4	225.2
Phosphorus	3.6	3.8	4.1
Calcium	1.9	1.8	2.0

[1]Diets: Safflower seeds was included in the diets at levels of 0% (SF0), 15% (SF15), and 30% (SF30).
[2]Calculated according to NRC (2001).

Table 2. Effect of including safflower seeds at different levels on production variables in finishing cattle.

	Diets[1]			
Variables	SF0	SF15	SF30	SEM
ADG (g/d)	1615	1671	1639	246.0
DMI (kg/d)	12.17[b]	12.59[a]	11.98[a]	1.561
FC (gain:feed)	7.53[a]	7.53[a]	7.30[b]	0.473
DMD (%)	69.54[a]	69.41[a]	63.87[b]	2.655

[1]Diets: Safflower seeds was included in the diets at levels of 0% (SF0), 15% (SF15), and 30% (SF30).
[a,b] Means in a row with different letters are significantly different (P<0.05); ADG = Daily weight gain; DMI = Dry matter intake; FC = Feed conversion, DMD = dry matter digestibility.

Table 3. Effect of including safflower seeds at different levels on ruminal pH in finishing cattle.

	Diets[1]			
	SF0	SF15	SF30	SEM
15-d	6.28	6.25	6.17	0.13
30-d	6.32[b]	6.27[a]	6.41[b]	0.12
45-d	6.25	6.25	6.16	0.11
60-d	6.21[a]	6.26[a]	6.47[b]	0.12

[1]Diets: Safflower seeds were included in the diets at levels of 0% (SF0), 15% (SF15), and 30% (SF30).
[a,b] Means in a row with different letters are significantly different (P<0.05)

Table 4. Effect of including safflower seeds at different levels on ruminal individual fatty acids (%) in finishing cattle.

	Diets[1]			
	SF0	SF15	SF30	SEM
Acetic acid				
15-d	57.9	55.8	52.1	3.14
30-d	54.9	57.1	54.0	2.94
45-d	53.3	59.5	57.3	3.21
60-d	54.6	55.6	55.4	3.04
Propionic acid				
15-d	21.2	25.7	25.1	2.58
30-d	22.6	23.5	22.7	3.07
45-d	25.3	27.2	22.0	2.98
60-d	24.0	24.1	27.7	2.88
Butyric acid				
15-d	8.7	9.4	7.8	1.43
30-d	8.3[ab]	10.2[a]	7.6[b]	1.19
45-d	8.2	8.5	8.5	1.54
60-d	9.8	8.9	10.5	1.76

[1]Diets: Safflower seeds were included in the diets at levels of 0% (SF0), 15% (SF15), and 30% (SF30).
[a,b] Means in a row with different letters are significantly different (P<0.05)

Table 5. Effect of including safflower seeds at different levels on ruminal ammonia N (mg/dL) in finishing cattle.

	Diets[1]			
	SF0	SF15	SF30	SEM
15-d	21.1[b]	31.9[a]	30.0[a]	3.14
30-d	23.9[b]	29.2[ab]	31.9[a]	3.23
45-d	23.9[b]	35.2[a]	36.5[a]	3.01
60-d	25.1[b]	34.1[a]	36.1[a]	3.47

[1]Diets: Safflower seeds were included in the diets at levels of 0% (SF0), 15% (SF15), and 30% (SF30).
[a,b] Means in a row with different letters are significantly different (P<0.05)

Table 6. Effect of including safflower seeds at different levels on ruminal total cellulolytic bacteria (10[10]/mL) concentration in finishing cattle.

	Diets[1]			
	SF0	SF15	SF30	SEM
15-d	4.15[a]	2.97[b]	3.11[b]	0.466
30-d	3.39	3.79	3.49	0.656
45-d	3.56	3.70	3.57	0.516
60-d	2.43	2.21	2.61	0.356

[1]Diets: Safflower seeds were included in the diets at levels of 0% (SF0), 15% (SF15), and 30% (SF30).
[a,b] Means in a row with different letters are significantly different (P<0.05)

Only during the first 15 days (i.e., 15-d), SF0 had greater (P<0.05) ruminal cellulolytic bacteria (10^{10}/mL) concentration compared to SF15 and SF30. However, no significant effects (P>0.05) were observed for the rest of the experimental periods (Table 6). During the first period of the study, inclusion of safflower seeds in the diets decreased number of cellulolytic bacteria. It is well known hat polyunsaturated fatty acids may exert a toxic effect on ruminal cellulolytic bacteria (Nagaraja *et al.*, 1997) and protozoa (Doreau and Ferlay, 1995). However, during the other periods, no effects were observed on the number of cellulolytic bacteria; this may be due to adaptaion to the new feed ingredient included (i.e., safflower seeds). Dschaak *et al.* (2011) reported that inclusion of safflower seeds in the diets of cows not affected cellulolytic activities in the rumen, resulting in no effects on fiber digestion. Scholljegerdes *et al.* (2004) noted that microbial protein did not differ among treatments when safflower seeds were included in the diets of Angus × Gelbvieh heifers.

4. Conclusion

From obtained result, it could be concluded that safflower seeds can be included at 15% of the diets of finishing cattle as a replacement of conventional grains to improve feed intake and dry matter digestibility with some positive effects on ruminal fermentation and animal performance. More studies are required to study the effect of inclusion of safflower seeds in the quality of beef cattle on carcass quality and meat fatty acids profile.

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