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Condensed beet molasses solubles for fattening bulls

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ABSTRACT

The purpose of the experiment was to evaluate the effect of long-term feeding of bulls with a diet containing condensed beet molasses solubles (CBS) supplemented with MgO (10 g/kg CBS) on growth, blood and rumen content indices. The experiment was conducted on 48 crossbred bulls from an initial weight of 148 kg to a slaughter live-weight of 400 kg. Approximately 40% of the concentrate in the experimantal diet was replaced with CBS. Average body gains were 852 and 804 g/d in the control and experimental groups, respectively, but did not differ significantly. Long-term feeding with a CBS-containing diet did not disturb rumen and tissue metabolism and had no effect on carcass composition and chemical composition of the *longissimus dorsi* muscle.

KEY WORDS: condensed molasses solubles, rumen metabolism, blood minerals, bulls growth

INTRODUCTION

Molasses solubles are industrial by-products coming from the fermentation of sugar beets or sugar cane molasses for the microbial production of alcohol, glutamic acid, citric acid and other products. These by-products have been used in animal feeding mainly as a source of nitrogen and energy. The fresh product is comprised of about 7% dry matter (DM), which is unstable and can not be stored. After condensation to 60-70% it becomes durable, resembles molasses and has been successfully used, as such, in sheep feeding (Karalasos and Swan, 1977; Leontowicz et al., 1984a), fattening bulls (Krzemiński et al., 1984; Potter et al., 1985; Würzner et al., 1985; Paseto and Falaschini, 1986), heifers (Troccon and Demarquilly, 1989) and dairy cows (Randel and Vallejo, 1982).

Sugar beet molasses solubles (CBS) contain an average of 30% crude protein, 40% nitrogen-free extractives and 30% ash on a DM basis (Lewicki, 1978; Kulasek et al., 1984a; Kemenade et al., 1988). The main nitrogen compounds of

CBS are betaine and glutamic acid (Lewicki, 1978; Kemenade et al., 1988; Troccon and Demarquilly, 1989). In ruminants, most of the betaine is degraded by microorganisms in the forestomachs, but a part escapes rumen degradation and, after absorption, may be a source of methyl groups in tissue metabolism (Weigand, 1985).

Leontowicz et al. (1984b) calculated from the digestibility coefficient in sheep, that CBS had 10.0 MJ metabolic energy per kg DM, whereas the same value for vinasse depotassified found in the literature is 9.67 (INRA, 1988).

When CBS are used in animal feeding they cause potassium loading because they contain about 10% K on a DM basis (Lewicki, 1978; Potter et al., 1985; Kemenade et al., 1988). It has been reported that a high K level in the diet may disturb mineral metabolism; the absorption of magnesium is especially inhibited in ruminants (Martens and Rayssiguier, 1980; Kulasek et al., 1984b) This is the main reason why CBS are usually depotassified (Lewicki, 1978; Troccon and Demarquilly, 1989), but the process is money and labour consuming.

The main purpose of this experiment was to evaluate the long-term feeding of bulls with a diet in which the concentrate was comprised of about 40% on a DM basis of non-depotassified condensed beet molasses solubles (CBS). Growth as well as rumen and blood indices were also estimated. To diminish the unfavourable effects of elevated amounts of potassium on mineral metabolism, CBS were supplemented with magnesium oxide.

MATERIAL AND METHODS

The experiment was conducted on 48 crossbred bulls (HF x local Polish Black-and-White and Red-and-White breeds) from 148 ± 12 kg at the beginning of the experiment to a slaughter live-weight of 400 kg. The animals were divided by the analogue method into two groups of 24. The bulls were fed corn silage, hay and concentrate (control diet – C). In the experimental diet (E) about 40% of the concentrate was replaced with CBS, i.e. 1 kg of CBS for 0.61 kg of concentrate on a DM basis. CBS were supplemented with 10 g of magnesium oxide per kg of CBS. The daily diets were increased proportionately to inreases in body weight, i.e. after each 100 kg. Corn silage and concentrate with or without CBS were offered in the morning feeding, whereas hay was given in the afternoon.

At 144, 206, 318 and 410 days of the experiment, rumen content and blood samples were collected twice daily from the same animals in each group before the morning feeding and two hours after corn silage and concentrate were offered. Blood was collected from the jugular vein and rumen contents were obtained through an esophageal tube. In the rumen liquid samples, ammonia was determined with phenol reagent, whereas L (+) lactic acid was measured by Boehringer test and volatile fatty acids by gas chromatography according to

Ziołecki and Kwiatkowska (1973). Glucose (Fermognost test), L (+) lactic acid (Boehringer test), and urea (with urease and phenol reagent) (Kulasek, 1972) were determined in the blood plasma. Additionally, sodium and potassium (SMA-6, Technicon Instr.), as well as, magnesium and calcium (ASA) were determined in the rumen fluid and blood plasma.

The animals were slaughtered when the lighter bull from each analog pair reaches 400 kg live weight. This stage was reached after approximately 420 days of the experiment. The carcasses of 10 bulls, chosen at random from each group, were dissected and chemical analysis of the *longissimus dorsi* muscle was also done.

The results were statistically evaluted by the one way analysis of variance and Duncan multiple range test (Statgraf 2.1.).

RESULTS

The chemical and nutritional compositions of the feeds are presented in Tables 1 and 2, respectively. CBS comprised about 20% the daily DM intake. Bulls in the experimental group fed the diet with CBS consumed more nitrogen than animals in the control group (Table 2) and moreover, more than 200 g of their nitrogen compounds was betaine originating from CBS. Daily body gains did not differ significantly between groups, but the dressing percentage was somewhat lower ($P<0.05$) in the experimental group (Table 3). In this experiment, we did not find significant differences in carcass composition or chemical composition of the *longissimus dorsi* muscle. Replacing part of the concentrate with CBS decreased concentrate intake per kg body gains in the experimental group by 37% as compared with the control group ($P<0.01$) (Table 3).

TABLE 1

Proximate analysis of feeds for bulls

Feed	Dry matter, %	In dry matter, %				
		crude protein	crude fibre	fat	N-free extractives	ash
Corn silage	23.35	8.38	32.09	5.81	49.04	4.68
Meadow hay	87.50	15.03	30.33	3.36	45.05	6.23
Concentrate*	87.52	22.62	8.91	2.61	59.61	6.25
CBS**	63.00	30.00	—	—	39.80	30.20

* concentrate composition, %: wheat - 20, barley - 28, oat - 20, groundnut meal - 14, linseed meal - 15, limestone - 0.8, fodder phosphate - 0.7, salt - 1.0, mineral mixture - 0.5.

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TABLE 2

Diet composition for bulls from 250 to 350 kg of live-weight

Items	Group control	Group experimental
Composition of daily diets, DM %:		
Corn silage	49.1	47.9
Hay	21.7	15.8
Concentrate*	29.2	16.9
CBS	—	19.1
MgO	—	0.3
Intake:		
Dry matter, kg/d	8.1	8.3
Crude protein (N x 6.25), g/d	1130	1319
Metabolizable energy, MJ/d**	84.6	82.4
Crude fibre, g/kg DM	248	216

* see Table 1 for composition

** calculated according to van Es regression coefficients for calculation of ME values for cattle (1978) and digestibility coefficients for sheep (Leontowicz et al., 1984b)

TABLE 3

Live-weight gains, concentrate intake kg/kg gain (n = 24) and carcass evaluation (n = 10)

Items	Group control	Group experimental
Number of animals	24	24
Initial weight, kg	149 ± 26	148 ± 27
Daily gains, g	852 ± 26	804 ± 72
Concentrate intake, kg/kg gain	2.94 ± 0.37[A]	1.84 ± 0.34[B]
Dressing percentage	56.28 ± 1.21[a]	54.87 ± 1.73[b]
Right half carcass, kg	117.56 ± 5.63	114.54 ± 7.65
Composition of right half of carcass, kg:		
lean	75.27 ± 5.05	73.72 ± 6.31
fat	20.18 ± 2.59	18.01 ± 2.17
bone	21.91 ± 1.63	22.72 ± 1.81
Chemical composition of *m. longissimus dorsi*:		
pH	5.53 ± 0.07	5.58 ± 0.05
water, %	74.78 ± 1.09	74.93 ± 1.75
crude protein (Nx6.25), %	20.18 ± 0.77	20.12 ± 0.45
fat, %	4.05 ± 0.52	4.19 ± 1.04

a, b — $P<0.05$; A, B — $P<0.01$

TABLE 4

Concentration of ammonia, L(+) lactic acid, VFA and minerals in rumen fluid (mmol/l). An average from 7 bulls in each group and 4 sampling during the experiment ± SD

Items	Sampling*	Group	
		control	experimental
Ammonia,	0	3.7 ± 1.2	4.2 ± 1.1
	2	12.0 ± 2.7[A]	14.9 ± 3.0[B]
L(+) lactic acid	0	1.3 ± 0.6[A]	2.4 ± 0.9[B]
	2	2.2 ± 0.9	4.1 ± 1.8[B]
Total VFA	0	41.0 ± 6.4[a]	50.4 ± 14.3[b]
	2	72.1 ± 16.1[A]	83.4 ± 14.5[B]
Acetic acid	0	32.7 ± 5.4	39.0 ± 10.2[b]
	2	51.3 ± 12.8[a]	57.0 ± 9.7[b]
Propionic acid	0	4.8 ± 1.2[a]	5.8 ± 2.2[b]
	2	12.1 ± 1.9[A]	14.2 ± 3.6[B]
n-Butyric acid	0	2.9 ± 1.0[A]	3.9 ± 1.9[B]
	2	7.3 ± 1.8[A]	9.1 ± 2.5[B]
Sodium	0	117.5 ± 2.7	103.5 ± 13.8
	2	89.5 ± 10.4	71.0 ± 10.9
Potassium	0	15.4 ± 2.9[A]	27.2 ± 10.4[B]
	2	27.4 ± 4.2[A]	48.0 ± 10.6[B]
K/Na	0	0.13 ± 0.01	0.26 ± 0.09
ratio	2	0.30 ± 0.15[a]	0.69 ± 0.19[b]
Calcium	0	3.35 ± 1.33	3.50 ± 1.27
	2	4.12 ± 1.00	6.33 ± 1.43
Magnesium	0	0.71 ± 0.53	0.76 ± 0.43
	2	2.36 ± 0.89	2.22 ± 0.68

a, b – $P<0.05$; A, B – $P<0.01$;

* time of sampling: 0 - before morning feeding, 2 - 2 h after morning feeding at 144, 206, 318 and 410 d of the experiment

After feeding, the rumen liquid of both groups contained lower concentration of sodium and higher concentrations of potassium, magnesium and calcium as compared to values before the morning feeding (Table 4). The potassium concentration was significantly higher in experimental animals, both before and after feeding ($P<0.01$). There were no differences between the groups regarding the concentrations of the remaining analyzed minerals; however, 2 h after feeding the K/Na ratio of the experimental group was about 2 times higher ($P<0.05$) than that of the control group (Table 4).

No significant differences were found in the average plasma concentrations (mmol/l) of glucose (2.81–C, 2.85–E), urea (3.16–C, 3.32–E) and minerals: sodium (141–C, 141–E), potassium (4.15–C, 4.38–E) and calcium (2.66–C, 2.73–E). However, the magnesium concentration in both of the groups was near the lower limit of physiological ranges (Mc Dowell, 1992).

TABLE 5

Concentration of glucose, urea and minerals in plasma (mmol/l) of bulls. An average from 7 bulls in each group and 4 sampling during the experiment ± SD

Items	Sampling*	Group	
		control	experimental
Glucose	0	3.05 ± 0.62	3.01 ± 0.63
	2	2.58 ± 0.52	2.68 ± 0.61
Urea	0	2.96 ± 0.64	2.80 ± 0.92
	2	3.36 ± 0.57	3.84 ± 1.09
Sodium	0	138.0 ± 5.6	138.0 ± 5.2
	2	144.0 ± 5.5	143.5 ± 5.5
Potassim	0	4.20 ± 0.40	4.45 ± 0.31
	2	4.10 ± 0.43	4.30 ± 0.33
Calcium	0	2.74 ± 0.50	3.11 ± 0.56
	2	2.57 ± 0.52	2.34 ± 0.64
Magnesium	0	0.84 ± 0.14	0.94 ± 0.19
	2	0.97 ± 0.16	0.85 ± 0.12

* time of samping: 0 – before morning feeding, 2 – 2 h after morning feeding

DISCUSSION

Replacement of about 40% of concentrate with CBS did not significantly change body gains of fattening bulls (Table 4). Krzemiński et al. (1984) reported increased body gains for bulls in the experimental group, i.e. 0.26 kg/d, by offering the same diet to the control and experimental groups, but supplementing the experimental group diet with 1.67 kg of CBS. Troccon and Demarquilly (1989) fed heifers a diet based on corn silage where concentrate was substituted with depotassified or non-depotassified vinasse in a DM proportion of 0.85: 1.09-1.18, respectively. Similar body gains were observed in all groups. On the other hand, Potter et al. (1985) fed bulls diets containing 0, 5, 10 and 15% CBS without magnesium supplementation and observed that even the smallest dose of CBS decreased body gains.

It appears that in the present study, the experimental group diet was deficient in regards to calculated metabolizable energy (Table 1). The digestibility coefficients of CBS used in this study were taken from another of our experiments with sheep (Leontowicz et al., 1984b). Most probably, this lower energy supply to the experimental group caused slightly lower body gains and lower dressing percentage ($P < 0.05$). A slight decline ($P > 0.05$) in fat deposition in the carcasses of the experimental group (Table 3) also confirmed that their diet was deficient in energy. These results suggest that the energy value of CBS for sheep, i.e. 10 MJ of metabolizable energy (UFV – 1.13/kg organic matter - OM) per kg 1 DM is lower for cattle; it is necessary, therefore, to conduct digestibility experiments on cattle to determine the real digestibility coefficients for CBS and calculate its energy value for cattle. Troccon and Demarquilly (1989) calculated the energy value of vinasse from 0.87 to 1.05 UFV per kg of OM.

Condensed non-depotassified beet molasses solubles contain about 10% potassium, therefore animals from the experimental group were additionally over-loaded with potassium – from 90 to 160 g/d from the beginning towards the end of the trial, respectively. This amount of potassium may depress the absorption of magnesium (Martens and Rayssiguier, 1980; Kulasek et al., 1984b). It seems that in the presented experiment, supplementation of CBS with MgO maintained the retention of magnesium at similar levels in each group. This presumption is based on the results from our previous balance experiment on sheep (Kulasek et al., 1984b) and is partially supported by the fact that the plasma magnesium concentration did not differ between the two groups.

A higher concentration ($P<0.05$) of lactic acid and volatile fatty acids was observed in the rumen contents of experimental animals (Table 4). This revealed that CBS stimulated fermentation processes in the forestomachs through their action on cellulolytic microorganisms, which are considered to produce the major amount of acetic acid. During the entire experiment, the concentration of this acid in the group fed with CBS was higher than in the control – not only after but also before feeding.

Despite this, the experimental animals consumed an average of 200 g/d more crude protein than the controls; their rumen ammonia level was slightly higher 2 h after feeding. This was probably due to the higher development of rumen microorganisms and the lower rate of betaine degradability in the forestomachs of the experimental animals.

CONCLUSIONS

1. Long-term feeding of condensed non-depotassified beet molasses solubles, supplemented with magnesium, at a rate of about 20% of the diet on a DM basis (concentrate was substituted by CBS in a DM proportion of 1:1.65, respectively) during a fattening period of bulls did not effect the metabolism negatively, either in the rumen or tissues, and had no effect on body gains, carcass composition and chemical composition of the *longissimus dorsi* muscle.

2. Condensed beet molasses solubles accelerated rumen fermentation and incerased concentrations of volatile fatty acids and lactic acid in the rumen.

3. Non-depotassified condensed beet molasses solubles supplemented with magnesium oxide at a rate of 10 g per kg of CBS may be used as a partial concentrate replacer in diets for fattening buls.

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STRESZCZENIE

Wywar melasowy w żywieniu bydła opasowego

Doświadczenie przeprowadzono w ciągu 420 dni na 48 buhajkach mieszańcach podzielonych na 2 grupy. Zwierzęta grupy kontrolnej (C) karmiono dawką zawierającą kiszonkę z kukurydzy, siano i mieszankę treściwą (49:22:29). W grupie doświadczalnej (E) około 40% mieszanki treściwej zastąpiono zagęszczonym wywarem melasowym (CBS) z dodatkiem magnezu. Oznaczono przyrosty masy ciała, wykorzystanie paszy oraz skład tuszy na podstawie dysekcji 10 opasów z każdej grupy, a także niektóre wskaźniki treści żwacza i krwi.

W grupie doświadczalnej intensywniejsza była fermentacja w żwaczu, istotnie wzrosło stężenie LKT i kwasu mlekowego.

Przyrosty masy ciała wynosiły średnio 852 i 804 g/d, odpowiednio w grupie C i E, lecz różnice nie były istotne.

Uzyskane wyniki wskazują, że długotrwałe stosowanie w żywieniu opasów dawek pokarmowych zawierających CBS nie zaburza metabolizmu w żwaczu i w tkankach. Nie stwierdzono także istotnych różnic w przyrostach masy ciała, składzie tuszy oraz analizie chemicznej mięśnia najdłuższego grzbietu. Na podstawie uzyskanych wyników stwierdzono, że CBS uzupełniony MgO (10 g MgO/kg CBS) można stosować jako częściowy zamiennik paszy treściwej w żywieniu bydła opasowego.