

EFFECTS OF ACCOMPANYING USE OF HEAT TREATED CORN GRAIN AND WHOLE SOYBEANS IN CONCENTRATES ON WEANED CALVES PERFORMANCES^{**}

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Abstract: The objective of this experiment was to evaluate the effects of simultaneous using heat-treated corn grain as basic energy source and heat-treated whole soybeans as protein source, in diet for calves 60-120 days old. The main predicted effects were improved energy and nutrients utilization efficiency and production performances of calves at this age. Thirty-six weaned Holstein calves were used, there were three treatments using different concentrates, formulated as: concentrate with micronized corn grain and extruded whole soybeans (KTT); concentrate with non-treated corn grain and soybean meal (KTN); concentrate with non-treated corn grain and extruded whole soybeans (KS). The marked effects of simultaneous use of heat-treated corn grain and whole soybeans were determined for feed efficiency (feed conversion ratio, FCR was 6,2% higher for calves on KTT than on KTN and 4,3% higher than on KS treatment). Efficiency of energy utilization (MJ ME/kg of gain) was better for calves on diet with KTT concentrate (5.8 % and 5.3% lower efficiency of metabolic energy utilization for KTN and KS treatment respectively). Consumed crude protein was better utilized for growth by calves on KTT diets, than other two treatments (10.8 % more CP/kg of growth for KTN, and 7.5% more for KS).

Key words: calf, nutrition, micronizing, corn, extruding, soybeans

Introduction

Previous processing in the form of heat treatment of feeds (energy and protein sources) is the most significant factor of influence on efficiency of feed utilization (*Stojanović et al. 2004., Sretenović et al. 1996., Grubić et al. 1990.*)

Starch is the most significant energy compound of cereal grains. Average starch content in corn grain dry matter (DM) is about 72% (Herrera-Saldana et al. 1990). Heat, steam and pressure interaction in different heat treatments of cereal grains causes destruction of endosperm structure and protein matrix by which starch granules are surrounded in the grain endosperm and gelatinization of usual semi-crystal structure of starch granules is caused (Stojanović et al. 2005., Kotarski et al. 1992). That way starch is becoming more accessible for the ruminal microorganisms and rate of its degradation in the rumen is increased (Huntington, 1997). Using heat treated cereal grains in calf's rations increases utilization efficiency of consumed protein, because the rate of ruminal microbial protein synthesis is increased, as also a duodenal flow of non-ammonia nitrogen, losses in ammonia and urea nitrogen are reduced and N retention is increased (Cooper et al. 2002., Theurer et al 2002., Barajas and Zinn 1998).

Using heat treated soybeans in nutrition of calves rely to their nutritional value and favorable effects on animal production and quality of products. High level of high-quality protein (with increased content of undegradable protein) and high quantity of fat are typical for heat treated soybeans, and due to that, there are positive effects on nitrogen balance and animal performances (Cummins et al. 1982).

The objective of this experiment was to determine the significance and effects of simultaneous use of micronized corn grain as main energy source and extruded soybeans as main protein source, in concentrate for weaned calves (60-120 days old) on productive performances and energy utilization efficiency.

Materials and methods

Experiment was conducted with thirty-six weaned Holstein calves. There were three treatments, with equal distribution of birth date and sex. Calves were housed in group pens with straw bedding and outlet. Three isoenergetic and isoprotein (18% CP) concentrates were formulated: concentrate with micronized corn grain and extruded whole soybeans (KTT); concentrate with non-treated corn grain and soybean meal (KTN); concentrate with non-treated corn grain and extruded whole soybeans (KS).

Average temperature during micronization of corn grain was 116 °C, and average moisture content of corn grain was 12.14%. Corn grain was rolled after micronization. Difference in density was used for determining heat treatment efficiency. These values were 0.71 and 0.47 kg/l respectively for raw and micronized corn grain. Extrusion of soybeans is done on 140 °C.

Each group of calves was fed a different mixture. Calves also consumed high-quality alfalfa hay. Diet consumption was *ad libitum*.

Tabela 1. Sastav smeša koncentrata za telad i njihova hranljiva vrednost, %
Table 1. Composition and nutritional values of concentrates, %

Hranivo/Feed	KTT	KTN	KS
Kukuruz (mikroniziran)/Corn micronised	59,0	-	-
Kukuruz (prekrupa)/Corn grnd.	-	62,0	59,5
Punom. soja (ekstrud.)/Soybean whl.extrd.	22,0	-	21,0
Sojina sačma-44%/soybean meal	-	19,0	-
Suncokretova sačma-33%/sunflower meal	15,0	15,0	15,5
Minazel	0,5	0,5	0,5
Stočna kreda/Limestone	1,0	1,0	1,0
Di-Ca-fosfat/CalciumDiPhosphate	1,0	1,0	1,0
Stočna so/Salt NaCl	0,5	0,5	0,5
Vitam. Miner. predsmesha/Vit.Miner.Premix	1,0	1,0	1,0
Suva materija/Dry Matter, %	91,35	89,73	90,27
Sirovi protein/Crude Protein, %	17,83	18,36	18,18
Sirove masti/Ether extract, %	7,50	3,74	6,24
Sirova celuloza/Crude Fiber, %	6,33	4,32	7,81
B.E.M./N.F.E., %	54,87	57,93	53,06
Sirovi pepeo/Ash, %	4,82	5,38	4,98
ME, MJ/kg	11,92	11,50	11,78

To determine feed intake quantities of offered concentrate and hay were measured every day, as a quantities of unconsumed concentrate and hay were measured twice a week. Body weights were recorded at 60, 90 and 120 days of age. Statistical analysis was done by ANOVA (Statistica, V 6.0)

Results and discussion

Body weights and gains

Average body weights (BW) of calves (Table 2) were similar during the experimental period. There were no statistical differences ($p < 0.05$) between treatments for BW.

Tabela 2. Prosečne TM i dnevni prirasti teladi u ogledu.**Table 2. Average BW and daily gains of calves.**

Uzrast, dani / Age, days	Tretmani / Treats		
	KTT	KTN	KS
	Prosečne TM/Average BW, kg		
60.	65,5	62,5	64,6
90.	91,5	89,8	86,3
120.	123,2	121,0	121,6
	Prosečan dnevni prirast g/dan / Average daily gain g/day		
60-90.	866,7	907,2	720,6
90-120.	1057,2	1041,7	1177,2
60-120.	962,0	974,5	948,9

The average daily gains were also similar: 962, 974.5 and 948.9 g for calves fed with KTT, KTN and KS concentrates. There were no statistical differences ($p < 0.05$). These agree with results of other previous studies (*Owens et al. 1997.*, *Abdelgadir and Morril 1995.*, *Albro et al. 1993.*, *Zinn 1993*).

Dry matter intake

Relations between experimental groups for average daily dry matter intake (Table 3) were similar to relations in daily intake of concentrate, because of the similar hay intake for all treatments. During the whole experimental period, the highest average daily feed intake was recorded for group fed a KTN concentrate. Consumption was 8.4 % higher relative to KTT treat, and 3.6 % higher relative to KS treat. For calves consumed KS concentrate, 4.6 % higher feed intake was recorded, relative to calves fed KTT concentrate.

Decreased feed intake (5.5-9.0 %) was also concluded in some studies (*Owens et al. 1997.*, *Barajas and Zinn, 1998.*, *Zinn 1993*). This was a result of increased feed efficiency for calves fed concentrates with heat treated corn grain.

Using extruded whole soybeans instead of soybean meal in concentrates did not have effect on dry matter intake (*Griffin et al. 1993*); decreased daily feed intake (5.5 %) (*McEwen, 1994*); increased daily feed intake (*Maiga et al. 1994*). According to *Casper et al. (1994)* and *Grubić (1991)* increase of ruminally undegradable protein content in diets, results in increased daily DM intake.

Tabela 3. Prosečno konzumiranje koncentrata, sena, SM obroka, i efikasnost iskorišćavanja hrane**Table 3. Average concentrate, hay, DM consumption, and feed efficiency.**

Uzrast, dani / Age, days	Tretmani / Treats		
	KTT	KTN	KS
	Konzumiranje koncentrata g/dan / Concentrate intake, g/day		
60-90.	1965,1	2260,9	1783,9
90-120.	2855,2	3217,4	3448,6
60-120.	2410,2	2739,2	2616,3
	Konzumiranje sena g/dan / Hay intake g/day		
60-90.	492,9	443,1	460,2
90-120.	548,1	513,6	488,5
60-120.	520,5	478,4	474,4
	Konzumiranje SM, g/dan /DM intake, g/day		
60-90.	2204,3	2396,6	1992,5
90-120.	3063,3	3313,4	3518,7
60-120.	2633,8	2855,0	2755,6
	SM hrane kg/kg prirasta / Feed efficiency, kg DM /kg gain		
60-90.	2,54	2,65	2,78
90-120.	2,97	3,21	2,99
60-120.	2,76	2,93	2,88

Dry matter utilization efficiency

The highest utilization efficiency of consumed diet DM was for calves on KTT concentrate (Table 3). The poorest feed conversion ratio had calves on KTN concentrate (they needed 6.2 % more dietary DM per 1 kg of gain than calves on KTT concentrate). Calves fed KS concentrate expressed medium feed efficiency, for the same gain they needed 4.3% more and 1.7% less dietary DM respectively, relative to KTT and KTN treatments.

Positive effect of using heat treated corn grain (10-20% increasing in feed efficiency) reported in their studies *Barajas and Zinn, (1998)*, *Owens et al. (1997)* and *Grubić et al. (1987)*.

Substitution of soybean meal for extruded whole soybeans in feedlot diets results in increasing efficiency of feed utilization followed by decreasing of daily feed intake. This is connected with higher energy concentration in diets, decreased methane production, and higher metabolic efficiency of fat retention (*Albro et al.1993*). *Swartz et al. (1991)* reported increasing level of undegradable protein in Holstein calves diets results in higher feed utilization efficiency.

Energy and protein utilization efficiency

The most effective utilization of metabolic energy expressed calves on KTT concentrate. Calves on rest two treatments had almost equal efficiency of ME utilization. Calves at KS and KTN group needed 5.3% and 5.8% more ME consumption respectively for same gain, relative to calves on KTT concentrate. Calves which consumed concentrate with micronized corn grain, generally showed higher utilization efficiency of dietary ME. Conclusion is that using heat treated corn grain in calf's nutrition increases content of dietary net energy, according to increasing efficiency of nutrients and followed energy utilization. Using extruded whole soybeans had positive effects on energy utilization.

Tabela 4. Utrošak ME (MJ/kg prirasta) i SP g/kg prirasta teladi
Table 4. Efficiency of ME (MJ/kg of gain), and CP utilisation (g/kg of gain)

Uzrast, dani Age, days	Tretman / Treats					
	KTT		KTN		KS	
	ME	SP / CP	ME	SP / CP	ME	SP / CP
60-90.	31,07	498,09	32,34	540,90	33,96	558,66
90-120.	36,85	582,48	39,50	656,08	37,59	602,74
60-120.	33,96	540,29	35,92	598,49	35,77	580,70

Barajas and Zinn (1998) report 13% increasing of maintenance net energy (NEm) and 15% of gain net energy (NEg) content for steam rolled corn grain relative to dry rolled. In feedlot diets, using high-pressure steam rolled corn and wheat grains resulted in increased level of metabolic energy: 21% for corn grain, and 13% for wheat grain (*Owens et al. 1997*).

Abdelgadir et al. (1996) in their study find that using of roasted whole soybeans (138 °C) instead of soybean meal, together with roasted corn grain (135 °C) resulted in better efficiency of energy utilization and also better productive performances of Holstein calves.

Calves on KTT concentrate attained the highest efficiency of crude protein utilization, 10.8 % higher than calves on KTN treat, and 7.5% higher than calves which were fed KS concentrate. Calves on KS concentrate had 3.1 % better utilization of crude protein relative to calves on KTN concentrate.

The highest efficiency of crude protein utilization obtained on KTT treatment, may be explained with favorable effect of heat treated corn grain on entire digestibility of N and increased synthesis of microbial protein in rumen and its increased duodenal flow. These are consequences of increased supply of accessible energy and higher rates of ruminal fermentative processes enabled by increasing ruminal starch degradation (*Theurer et al. 2002*). On the other side, the use of extruded whole soybeans in concentrate increases content of ruminally undegradable protein and also contributes to higher and more complete supply of animal requirements in essential amino acids (first of all

lysine), their flow to the duodenum with undegraded protein is more extensive as is an efficiency of their intestinal absorption (*Grubić, 1991., Cummins et al. 1982*).

Conclusion

It can be concluded that simultaneous using of heat treated corn grain and whole soybeans in concentrates for weaned calves has positive effects on dry matter utilization as well as on metabolic energy and crude protein utilization, and does not have significant effect on rate of daily gain, because of its negative impact on daily feed intake. All these effects are more expressive relative to the complete mixture containing non-treated corn grain and soybeans meal, and at lesser extend to concentrate with non-treated corn grain and extruded whole soybeans. In general conclusion it can be emphasized that using heat treated corn grain and extruded whole soybeans results in increasing of the nutritional value of concentrates for weaned calves.

Efekat istovremenog uključivanja termički obrađenog kukuruza i soje u koncentrat, na performanse odlučene teladi

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Rezime

Cilj istraživanja je bio utvrđivanje značaja i uticaja istovremenog uključivanja termički tretiranog zrna kukuruza kao osnovnog izvora energije, i termički obrađenog zrna soje kao izvora proteina u koncentrat za telad uzrasta 60-120 dana, u pogledu povećanja efikasnosti iskorišćavanja energije i hranljivih materija, a koja bi se ogledala u poboljšanju osnovnih proizvodnih pokazatelja teladi u ovom uzrastu. Ogled je izveden sa 36 odlučениh teladi crno-bele rase u tipu holštajna, telad su bila raspoređena u 3 grupe, a u ishrani su korišćene sledeće smeše: smeša sa mikroniziranim kukuruzom, i ekstrudiranom sojom (KTT); smeša sa neobrađenim kukuruzom i sojinom sačmom (KTN); smeša sa neobrađenim kukuruzom i ekstrudiranom sojom (KS). Utvrđen je značajan pozitivan uticaj istovremenog korišćenja termički obrađenog kukuruza i soje u koncentratu za odlučenu telad, na efikasnost iskorišćavanja: konzumirane hrane-manji utrošak SM hrane za kg prirasta teladi KTT grupe, za

6,2% u odnosu na telad KTN grupe, odnosno za 4,3% u odnosu na telad KS grupe; energije iz konzumirane hrane: manji utrošak ME za kg prirasta teladi KTT grupe, za 5,8% u odnosu na telad KTN grupe, i 5,3% u odnosu na KS grupu; konzumiranog sirovog proteina: telad KTN grupe su imala veći utrošak SP po kg ostvarenog prirasta za 10,8%, telad KS grupe za 7,5%, u odnosu na telad na KTT koncentratu.

Ključne reči: telad, ishrana, mikronizacija, kukuruz, ekstrudiranje, soja

References

- ABDELGADIR, I.E.O., MORRILL, J.L., HIGGINS, J.J. (1996). Effect of roasted soybeans and corn on performance and ruminal and blood metabolites of dairy calves. *J.Dairy Sci.* 79: 465-474.
- ABDELGADIR, I.E.O., MORRILL, J.L. (1995). Effect of processing sorghum grain on dairy calf performances. *J.Dairy Sci.* 78: 2040-2046.
- ALBRO, J.D., WEBER, D.W., DELCURTO, T. (1993). Comparison of whole, raw soybeans, extruded soybeans, or soybean meal and barley on digestive characteristics and performance of weaned beef steers consuming mature grass hay. *J.Anim. Sci.* 71: 26-32.
- BARAJAS, R., ZINN, R.A. (1998). The feeding value of dry-rolled and steam flaked corn in finishing diets for feedlot cattle: influence of protein supplementation. *J.Anim.Sci.* 76: 1744-1752.
- CASPER, D.P., SCHINGOETHE, D.J., BROUK, M.J., MAIGA, H.A. (1994). Nonstructural carbohydrate and undegradable protein sources in the diet: growth responses of dairy heifers. *J.Dairy Sci.* 77: 2595-2604.
- COOPER, R.J., MILTON, T.C., KLOPFENSTEIN, T.J., SCOTT, T.L. (2002). Effect of corn processing on starch digestion and bacterial crude protein flow in finishing cattle. *J.Anim.Sci.* 80: 797-805.
- CUMMINS, K.A., NOCEK, J.E., POLAN, C.E. (1982). Growth and nitrogen balance of calves fed rations of varying nitrogen degradability and physical form. *J.Dairy Sci.* 65:773-783.
- GRIFFIN, C.D., BUNTING, L.D., STICKER, L.S., VORA, B. (1993). Assesment of protein quality in heat-treated soybean products using the growth responses of lambs and calves and a nylon bag-rooster assay. *J. Anim. Sci.* 1993. 71: 1924-1931.
- GRUBIĆ, G. (1991). Uticaj razgradivosti proteina obroka na proizvodne performanse i neke fiziološke konstante u mladim goveda. *Zbornik radova Poljoprivrednog fakulteta.* God.36, sv. 598. pp.9-25.

- GRUBIĆ, G., ZEREMSKI, D., PAVLIČEVIĆ, A. (1990). Vrednost termički obrađenih žitarica u ishrani životinja. *Krmiva*. Vol.32. Br.78. Str. 129-137. Zagreb.
- GRUBIĆ, G. (1987). Hranidbena vrednost termički obrađenog zrna kukuruza u ishrani teladi. *Magistarski Rad. Poljoprivredni fakultet Zemun*.
- HERRERA-SALDANA, R.E., HUBER, J.T., POORE, M.H. (1990). Dry matter, crude protein, and starch degradability of five cereal grains. *J. Dairy Sci.* 73:2386-2393.
- HUNTINGTON, G. (1997). Starch utilization by ruminants: from basic to the bunk. *J. Anim. Sci.* 75:852-867.
- KOTARSKI, S.F., WANISKA, R.D., THURN, K.K. (1992). Starch hydrolysis by the ruminal microflora. *J. Nutr.* 122:178.
- MAIGA, H.A., SCHINGOETHE, D.J., LUDENS, F.C., TUCKER, W.L., CASPER, D.P. (1994). Response of calves to diets that varied in amounts of ruminally degradable carbohydrate and protein. *J. Dairy Sci.* 77: 278-283.
- McEWEN, P.L. (1994). Performance of holstein bull calves fed a whole corn diet with roasted soybeans as a protein source. *Ontario beef research update*. University of Guelph.
http://bru.aps.uoguelph.ca/Articles94/a-performance_of_holstein_bull_cal.htm
- OWENS, F. N., SECRIST, S. D., HILL, W.J., GILL, R.D. (1997). The effect of grain source and grain processing on performance of feedlot cattle: A Review. *J. Anim. Sci.* 75: 868-879.
- SRETENOVIĆ LJ., JOVANOVIĆ, R., GRUBIĆ, G., ADAMOVIĆ, M., STOICEVIĆ, LJ. (1996). Termički obrađena soja i žitarice u obrocima teladi. Budva, VI Simpozijum: Tehnologija stočne hrane.
- STOJANOVIĆ, B., GRUBIĆ, G., ADAMOVIĆ, O., ĐORĐEVIĆ, N. (2005). Efekti korišćenja termički obrađenih žitarica u ishrani podmlatka goveda. XIX Savetovanje agronoma, veterinara i tehnologa. *Zbornik naučnih radova*, Vol. 11. No. 3-4. Beograd.
- STOJANOVIĆ, B., GRUBIĆ, G., ADAMOVIĆ, O. (2004). Korišćenje termički obrađenih žitarica i soje u ishrani teladi. *Biotechnology in Animal Husbandry* 20 (5-6), p. 211-220.
- SWARTZ, L.A., HEINRICHS, A.J., VARGA, G.A., MULLER, L.D. (1991). Effects of varying dietary undegradable protein on dry matter intake, growth, and carcass composition of holstein calves. *J. Dairy Sci.* 74: 3884-3890.
- THEURER, C.B., HUNTINGTON, G.B., HUBER, J.T., SWINGLE, R.S., MOORE, J.A. (2002). Net absorption and utilization of nitrogenous compounds across ruminal, intestinal, and hepatic tissues of growing beef steers fed dry-rolled or steam-flaked sorghum grain. *J. Anim. Sci.* 80: 525-532.

ZINN, R.A. (1993). Influence of processing on the feeding value of barley for feedlot cattle. *J. Anim. Sci.* 71:3.