THE EFFECT OF A SOAPY BY-PRODUCT OF THE COTTONSEED INDUSTRY AND SODIUM HYDROXIDE ON MILK PRODUCTION WHEN ADDED TO COTTONSEED HULLS

by

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ABSTRACT

In a double switch-back feeding trial, 12 lactating dairy cows were fed 120 percent of the NRC requirements for maintenance and production of a dairy ration containing 50 percent high-energy concentrate, 25 percent alfalfa hay cubes and 25 percent pelleted cottonseed hulls (CSH). Four different treatments of the CSH were studied: (a) control, no additives; (b) addition of 3.25 percent of a soapy by-product (SBP) of the cottonseed oil industry; (c) addition of 3 percent sodium hydroxide (NaOH); and (d) addition of 3.25 percent SBP plus 3 percent NaOH.

No differences due to the diet were detected in feed intake, milk production, milk constituents or body weight gains. Mean molar percentages of rumen volatile fatty acids were not affected, except for propionate (treatment d lower than the others) and for butyrate (control higher than treatment c). Mean percentages of milk fatty acids were not significantly affected except for $C_{12:1}$, where the control was lower than treatment c.

The data obtained suggests that under the levels and circumstances of this experiment, addition of SBP and/or treatment with NaOH had no toxic effects or nutritional benefits on CSH utilization by lactating dairy cows.

INTRODUCTION

Cottonseed hulls (CSH) are obtained as a major by-product of the cottonseed oil industry, and are available in sufficient amounts to be used as an ingredient in rations for livestock in large areas of the United States, especially in the south.

For every ton of cottonseeds crushed and processed, approximately 500 lb of hulls are produced. According to the U. S. Department of Agriculture (45), in 1974 U. S. total CSH production was estimated to be 1,072 tons, there being approximately 100 thousand tons of CSH produced in the state of Arizona.

Due to the low volume density and high transportation costs, CSH generally can be only consumed in areas where they are produced. Morrison (28) stated that when properly fed, CSH were generally equal in value to fair quality grass hay, and were worth more per ton than corn or sorghum stover, straw or poor hay. Hale (17) commented that CSH could be added to the ration without further processing, and it was generally believed that cattle were easier to maintain on high concentrate rations, if the ration contains a low level of CSH. He also indicated that fattening rations containing CSH were less dusty and of less density, when compared to rations with alfalfa hay as the only roughage. Inclusion of four to five percent CSH in a high concentrate ration significantly increased feed intake.

In another experiment, Hale, Theurer, Lambeth and Taylor (19) determined that the feeding value of CSH was greatly influenced by the content of lint in the hulls. Lint is completely composed of highly digested carbohydrates. The lint content of the hulls was influenced principally by the type or variety of the cotton plant, and by the number of times that the hulls are passed through the delinter.

Several studies have been made searching for a more economical roughage than alfalfa hay for standard dairy rations. The limiting factor in any forage substitution program is the high energy requirements of the high producing, lactating cow. The total amount of energy ingested by the cow is greatly determined by the energy density of the ration.

Methods for removing or altering the lignin content of low energy feedstuffs have been available since the last century, but have generally not been utilized to upgrade feeds. This restraint has been mainly because of economic considerations influenced by the availability of alternative feedstuffs of higher quality. According to Donefer (7), of the various chemicals employed or studied to improve the feeding value of low quality roughages, sodium hydroxide (NaOH) appears to be the most effective and economical.

The objective of this study was to evaluate the effects of NaOH treatment, addition of a soapy by-product (SBP) of the cottonseed industry, and the combination of both on the feeding value of pelleted CSH. The CSH made up 25 percent of a complete ration for high producing lactating cows.

LITERATURE REVIEW

Utilization of Cottonseed Hulls by Ruminants

Fattening cattle with nothing but CSH and cottonseed meal was a successful and common operation in the south during the 1880s (28).

The first reports dealing with digestibility of CSH were made by Harrington (20) and Emery and Kilgore (11), both in 1891. Harrington, in an experiment conducted in Texas, found that five steers digested 41.6, 5.7, 78.0, 30.4 and 41.2 percent respectively for dry matter, protein, ether extract, nitrogen-free extract and fiber in CSH. Emery and Kilgore (11) at North Carolina Agricultural Experimental Station, fed one jersey cow with CSH and obtained coefficients of digestion of 35.9 for dry matter, 24.6 for protein, 80.6 for ether extract, 40.3 for nitrogen-free extract and 27.1 for crude fiber. It appears in these two experiments that the diets evaluated consisted only of CSH.

Several other experiments were conducted using CSH as a major ingredient. In 1947, Schneider (39), using results from the agricultural experimental stations of North Carolina and Texas, calculated the total digestible nutrients (TDN) for this by-product, obtaining values of 45.2 percent for cattle and 52.8 percent for sheep. Digestible protein averaged -0.6 percent.

In 1949, Forbes and Garrigus (13), in a digestion trial with five wether lambs, compared two rations of similar nutrient analysis. The first ration, similar to the standard cornbelt lamb-fattening ration, was composed of 55.5 percent yellow corn and 44.5 percent good quality alfalfa hay, the second contained 50.6 percent yellow corn, 29.9 percent CSH with 10 percent molasses, 15 percent cottonseed meal and 4 percent alfalfa leaf meal. Basically, alfalfa hay was substituted with CSH and supplement. When compared to the first ration, the second one was digested 91 percent as well for dry matter, 82 percent as well for protein, 117 percent as well for fat, 92 percent as well for nitrogen-free extract and 93 percent as well for energy. Later, Garrigus (14) in 1951, in a similar experiment with feeder lambs, substituted alfalfa hay in the standard cornbelt lamb-fattening ration (55.6 percent U.S. No. 2 yellow shelled corn and 44.4 percent U.S. No. 1 alfalfa hay), with supplemented CSH. The results indicated that the ration with supplemented CSH, composed of 50.6 percent corn, 26.9 percent CSH, 3.0 percent black strap molasses, 15.5 percent cottonseed meal and 4.0 percent alfalfa leaf meal, was almost as good as the standard ration, and that 100 pounds of the supplemented CSH will replace about 80 pounds of U.S. No. 1 alfalfa hay in producing gains in lambs fattened in dry lots.

Tillman, Sirny and MacVicar (43) improved the digestibility by sheep of all ration components, especially crude fiber, by adding alfalfa ash to a ration containing approximately 60 percent CSH. All the minerals were supplied by the CSH except calcium, phosphorus, sodium, chlorine and sulphur, suggesting to the authors that the improvement in performance was due to one or more inorganic elements that were either low or not contained in the hulls, but were supplied in sufficient amounts by the alfalfa ash.

Hale, Lambeth, Theurer and Ray (18) fed three levels of CSH in high roughage complete rations for beef steers in order to determine the TDN content of this low quality roughage. The estimated TDN value of 44 percent on a dry matter basis, was somewhat lower than older values [43.3 percent TDN on a 90 percent dry matter basis by Morrison (28)], suggesting to the researchers that it was probably due to the lower lint content of the present day CSH.

It is generally recognized that roughages have a lower feeding value in high concentrate rations than in high roughage rations. Hale (17) indicated that in growing rations containing a low level of grain, the energy value of CSH is about 70 percent that of alfalfa hay, and in high concentrate rations, its energy value is only 25 to 30 percent of the value of the alfalfa hay. Digestibility of CSH is thus reduced markedly when included in high concentrate fattening rations.

Several studies comparing different levels of CSH with other roughages have been conducted in digestion trials (either meat or milk production). McCoy, Olson and Reed (26), using a 30 percent roughage ration fed to lactating cows, obtained significantly higher milk production for two rations, one with CSH as the roughage and the other with a combination of alfalfa hay and orchard grass, over a ration containing corn cobs. Sargent, Olson and McCoy (38) in another experiment with lactating dairy cows found that a 30 percent CSH complete feed depressed the yield of milk fat, increased milk production and retained a normal level of other milk constituents, as compared with an isocaloric and isonitrogenous 50 percent corn silage complete feed. The same authors (37) in a similar experiment found that digestibility of a corn silage complete feed was greater than a CSH complete feed, even though average daily milk production during the digestion trial was greater for the latter.

Calhoun and Shelton (4) indicated that CSH appeared equal to ground alfalfa hay and peanut hulls when fed to feeder lambs as ten percent of the ration. Olson and

McCoy (35), studying two levels of CSH found that a complete feed containing 40 percent CSH was more efficient in converting dry matter to fat corrected milk, than a complete ration with only 30 percent CSH. Hunt, Cummings and Lusk (21) found no difference in milk production and fat content, when CSH was included in complete rations at levels of 25, 35 or 45 percent. They did report feed refusal and diarrhea problems.

In two trials, each involving 12 lactating dairy cows, Brown, Whiting, Daboll, Turner and Schuh (3) studied the effect of substituting both pelleted and non-pelleted CSH for 10, 30 or 50 percent of the alfalfa hay of a ration containing 50 percent alfalfa hay cubes and 50 percent concentrate. No significant differences due to the diet were detected in total milk production and milk constituents, and although milk yield decreased slightly when non-pelleted CSH were fed, they conversely increased with the feeding of the hulls in the pelleted form. Digestibilities of protein, acid detergent fiber and combustible energy, but not fat, were progressively depressed as CSH increased in the diet.

Sherrod and Summers (40) made two attempts to increase the feeding value of CSH by treatment with NaOH. In 1974, they studied CSH under four treatments: 1) control, 2) 5 percent NaOH (roughage dry matter basis) at 50 percent moisture and stored in polyethylene bags, 3) soaked in a 0.5 percent NaOH solution for three hours, drained, rinsed and dried, and 4) ground to 1 mm, treated with 5 percent NaOH at 50 percent moisture and stored in screw-cap jars. Fibrous components increased and soluble portions decreased. In vitro digestibility of cell wall components was improved by all NaOH treatments. Digestibility studies were conducted with sheep fed 50 percent roughage rations. Digestibilities for cell wall components and soluble portions for treatments 1, 2 and 3 were respectively 26.1, 68.0; 32.3, 76.9; 29.9, 71.9. In 1975, the same researchers (42) treated CSH with 5 percent NaOH at 50 percent moisture. Fibrous components decreased and cell soluble materials increased, but the in vitro digestibility was only slightly increased above the control (29.5 versus 24.8). The results indicate that NaOH treatment also may be species specific, thus improving very little digestibility of CSH as compared to the effects on other forages.

Sodium Hydroxide Treatment of Low Quality Roughages

Three studies, in a period of over 40 years, demonstrated that delignification procedures could be used to convert low quality forages to feedstuffs of higher energy availability. Kellner and Kohler [as cited by Woodman and Evans (49)], in 1900 boiled rye straw under pressure in a solution containing NaOH and several other alkali salts. They increased the digestibility of the straw from less than 50 percent to 88 and 96 percent for organic matter and crude fiber respectively. This discovery was extensively used in Germany during the War of 1914-18 for increasing the feeding value of straw for cattle.

In 1921, Beckman (1) described a process that became widely used for upgrading the feeding value of straw. It consisted of soaking chopped straw in a 1.5 percent NaOH solution, at a ratio of 8 parts solution to 1 part straw, for a minimum of four hours at atmospheric temperature and pressure. The result was then drained and washed free from alkali with running water. This mild treated straw was fed wet and resulted in a two-fold increase in digestibility. However, the washing of the straw did cause a loss by leaching of 20 to 30 percent of the dry matter. The manufacture of this fodder cellulose was carried out under exactly the same conditions as were used in the making of paper from straw.

Years later, between 1942 and 1946, Woodman and Evans (49) used a cellulose prepared from wheat straw. The straw was boiled in a 6 percent NaOH solution for seven hours, under a pressure of 70 lb/sq in., after which the remaining cellulose was washed free from alkali and dried. This treated straw was then fed to sheep as 38 percent of the ration, obtaining a 74 percent dry matter digestion coefficient and a calculated starch equivalent (net energy) of 68, compared with 67 for oats.

Smith, Goering and Gordon (41) evaluated six chemicals in their ability to increase the in vitro cell wall digestibility of feces from cattle, fed either alfalfa hay or sudan silage. The data obtained indicate that sodium hydroxide, sodium peroxide, calcium hydroxide and calcium hypochlorite are of the same effectiveness, and that NaOH was by far the most economical. The other two studied were sodium chlorite and acetyl peroxide. Similar results were obtained by Chandra and Jackson (5), when they compared the ability of different levels of six chemicals to increase the dry matter digestibility of five roughages in nylon bags. The chemicals studied were sodium sulfite, sodium sulfide, sodium carbonate, hydrogen peroxide, sodium hydroxide and bleaching powder. All were dissolved in small quantities of water and sprayed on the roughage. No washing was done after treatment. NaOH was the most effective reagent, obtaining a steady linear increase in digestibility, up to the 10 percent level (10 grs of NaOH per 100 grs of straw). In ground corn cobs, at this level, rumen dry matter digestibility increased by more than 100 percent and lignin content was reduced by 26 percent.

In another experiment by Yu, Thomas and Emery (50), similar results were obtained. Four different kinds of chemicals (six chlorine compounds; one alkali and two combinations of alkali and chlorine; enzymes; and electron irradiation), were evaluated in their ability to improve the in vitro cell wall digestion of wheat straw, oat straw and alfalfa residue. NaOH treatment was found to be the most feasible method of improving the nutritive value of these low quality roughages.

Guggolz, Kohler and Klopfenstein (16), studying grass straw digestibility by an enzymatic method, observed that steam treatment of the straw for three minutes at 28 kg/cm^2 increased its digestibility by an average of more than 50 percent; and that by adding 3 percent NaOH to the steam treatment, the digestibility was more than doubled. However, Klopfenstein et al. (22) found that the use of NaOH in combination with pressure in treating corn cobs was of little nutritional value. They studied two treatments: one consisted of adding 3 percent NaOH under pressure (17.5 kg/cm^2 steam pressure for 50 seconds), and in the other, 3 percent NaOH was incorporated following pressure treatment.

The data and conclusions of the reports described indicate a high degree of variation concerning the optimum level or amount of NaOH necessary to improve the nutritional value of low quality roughages. The level ranged from 3 percent to 12 percent, all on dry matter basis.

Donefer, Adaleye and Jones (8), while evaluating the effect of varying both the volume and concentration of NaOH, on in vitro cellulose digestion of oat straw, concluded that the optimum level was 8 grs of NaOH and 60 ml of solution per 100 grs of straw. They also found that this optimum level minimized the quantity of alkali used, with an anticipated improvement in the digestibility of the straw. Ololade and Mowat (30) obtained similar results when they determined the effect of time (0, 1 or 24 hrs), temperature (60, 80, 100 or 130 C) and NaOH concentration on in vitro dry matter digestibility and chemical composition of barley straw. At all temperatures and times, digestibility increased linearly with NaOH concentrations up to the 6 percent level. Above the 8 percent level of NaOH, little or no further increase in digestibility occurred. The same experiment was later repeated by Ololade, Mowat and Winch (33), utilizing alfalfa stem, barley straw and corn stover. The results showed the 8 percent level of NaOH as the upper limit for increasing the in vitro dry matter digestibility. They also found that the response of the roughages to the treatment with NaOH varied with the type of roughage. At the 8 percent level, at 23 C for 24 hrs, in vitro dry matter digestibility increased by 8.5, 39.6 and 21.5 percent for alfalfa stem, barley straw and corn stover respectively. The conclusions of this experiment agree with Summers and Sherrod (42), who also obtained species specific response to NaOH treatment.

Ololade, Mowat and Smith (32) studied a ration consisting of barley straw and whole grain at a ratio of 50:50, treated with four levels (0, 2, 3 and 4 percent on a dry matter basis) of NaOH. The mixture was then steam processed for 30 minutes at atmospheric pressure. NaOH treatment significantly increased the digestibility up to the 3 percent level, while only a slight increase occurred beyond that level.

Ololade and Mowat (31) studied whole plant barley treated and reconstituted with NaOH at levels of 0, 2, 3 and 4 percent of dry matter and obtained increased digestibilities at all levels. Gharib et al. (15), while studying poplar bark, obtained a slightly different result. They concluded that concentrations of 9 and 12 g of NaOH per 100 g of bark were necessary to reduce hemicellulose and lignin content of this ground poplar bark. In addition the effect was obtained in one day (versus 20 days), and was not greatly influenced by temperature (25, 50 or 75 C). A different method of applying NaOH to forages was utilized by Craig and Ralston (6). They found that soaking straw in a one percent NaOH solution was markedly superior in increasing digestibility to treating straw with NaOH at the 8 percent level on a dry matter basis. Neither one of the two treated straws were washed free from alkali.

The effect on rumen fluid of treating the feeds with NaOH was studied by Ololade, Mowat, Yao and Smith (34). They found that levels up to 4 percent of the alkali had no significant effect on the molar concentrations of the rumen volatile fatty acids acetic, isovaleric or valeric. Only propionic increased significantly with increasing levels of NaOH. Ololade and Mowat (31), with levels from 0 to 4 percent NaOH, showed that NaOH treatment increased rumen fluid molar proportions of propionate and decreased isovalerate. Acetic tended to decrease and butyric to increase.

Chandra and Jackson (5) commented that unreacted alkali at higher levels of treatment and/or high sodium intake might upset the rumen fermentation and thus prevent the potential digestibility of the feed (obtained by an in vitro digestion technique) from being realized. Quintero [as cited by Rounds et al. (36)] remarked that prolonged intake by animals of crop residues treated with NaOH increases the sodium content of the urine and eventually may result in a sodium buildup in the soil to which the feces are applied. Rounds et al. (36), in growing rations for lambs, found that treating and ensiling ground corn cobs with 3 percent NaOH plus 1 percent $Ca(OH)_2$, increased average daily gain and feed efficiency over cobs treated with 4 percent NaOH. They commented that the improvement in performance may be the result of decreasing the amount of sodium fed to the lambs. It also appears that $Ca(OH)_2$ complements NaOH [Quintero, as cited by Rounds et al. (36)].

Koers, Klopfenstein and Woods (23) determined the effects of adding NaOH at 4 percent of dry matter to corn cobs at ensiling time, and the neutralization of the sodium ions with chloride ions from HCL and NH_4CL. Increased gain for the lambs fed the 33 and 66 percent neutralized levels was significant. A significant reduction in gain occurred at the 100 percent neutralization level.

Soapy By-product Description

The soapy by-product[1] (SBP) used in this experiment was recovered following caustic refining of cottonseed oil dissolved in N-hexane.

1. Personal communication from Ranchers Cotton Oil, Fresno, California.

EXPERIMENTAL PROCEDURE

Twelve Holstein cows, near the peak of lactation, were selected from the university dairy herd and randomly assigned to one of four groups in a double switch-back feeding trial (24).

Four different experimental rations were studied. Rationcomposition and analysis of ration ingredients are shown in Table 1. A basic ration consisting of 50 percent concentrate, 25 percent alfalfa hay cubes and 25 percent of variously treated pelleted CSH was used to compare effect of treatment of CSH by either SBP or NaOH. Treatment of the CSH were as follows:

1. Control, no additives.
2. 3.25 Percent SBP.
3. 3.00 Percent NaOH.
4. 3.25 Percent SBP plus 3.00 percent NaOH.

The NaOH was added to the CSH as a concentrated solution (50 percent NaOH in H_2O) by spraying with a metering pump prior to pelleting. No further process of drying or steaming was performed. The SBP was added in a similar manner.

Table 1. Composition of concentrate mixture, alfalfa cubes and cottonseed hulls containing a "soapy by-product" (SBP) of the cottonseed industry and/or sodium hydroxide.[a]

	Dry Matter (%)	Crude Protein (%)	Ether Extract (%)	Acid Detergent Fiber (%)	Combustible Energy (Kcal/gm)
Concentrate mixture[b]	88.97	16.49	6.60	16.87	4.21
Alfalfa hay cubes	90.93	19.30	3.00	30.61	4.09
CSH--Control	90.47	4.98	.98	67.97	4.16
CSH--3.25% SBP	91.13	5.29	3.85	66.82	4.19
CSH--3.00% NaOH	90.62	5.33	1.57	66.46	4.06
CSH--3.25% SBP + 3.00% NaOH	90.43	4.24	3.76	66.97	4.04

[a]All experimental cows received a ration consisting of 50 percent concentrate mixture and 25 percent alfalfa hay cubes. The remaining 25 percent of the ration was made up of one of the CSH experimental mixtures.

[b]Loose mixture containing: 22.5 percent whole cottonseed, 22.5 percent rolled barley, 22.5 percent rolled corn, 5 percent molasses and 27.5 percent pelleted supplement (United Producers and Consumers Cooperative, Phoenix, Arizona).

The experiment consisted of three 4-week periods with one week changeover intervals. Cows were penned by treatment and group fed twice daily 120 percent of the National Research Council's standards for maintenance and production (29). All three ration components were placed in the manger at the same time but were not blended. As there was no weight-back, there was no problem maintaining the desired ratio of component intake.

Milk samples collected during four consecutive milkings at the end of each week were composited and analyzed immediately for each cow. Milk fat was determined by the standard Babcock method, protein by the Orange G method of Udy (44), and solids-non-fat (SNF) by Watson (48). Weights of the four milkings were averaged to determine daily production.

Milk samples from the last week of each period only were frozen at -14 C until analyzed by gas-liquid chromatography for the component fatty acids of the milk fat. Fatty acids extracted from the milk fat of the last week of each period were analyzed utilizing the method described by Brown, Stull and Stott (2), except that a Perkin-Elmer Model 800 dual-flame gas chromatograph was utilized. The method of Metcalfe, Schmitz and Pelka (27) was used to prepare the fatty acids' esters for analysis.

Body weight changes were calculated by difference between starting and finishing weights (average of three consecutive daily weighings) during each period. Fecal samples were collected by rectal removal twice daily (1100 and 2300) on three consecutive days at the end of each experimental period and were composited for each animal. Dried composite feces (dried at < 50 C), roughage, and concentrate samples were analyzed for percent ether extract, fiber (47), and lignin (10). Apparent digestibility was estimated by the lignin ratio technique (25). Percent protein was determined by the standard kjeldahl method and combustible energy by an adiabatic oxygen bomb carolimeter (Parr Instrument Co., Moline, Illinois).

Rumen fluid samples were taken by rumen tube on the last morning of each period. Samples were strained through two layers of cheesecloth, preserved by the addition of one part saturated mercuric chloride solution to ten parts rumen fluid, and stored at -14 C until analyzed for volatile fatty acids (VFA) by the method of Erwin, Marco and Emery (12).

Variance was analyzed (24) and means for the treatments were compared by Duncan's Multiple Range Test (9).

RESULTS AND DISCUSSION

All rations were consumed without rejection or apparent digestive or physiological disturbance in spite of the high level of feed offered (120 percent of the NRC standard). Visual observations indicated that there was little preferential consumption of ration components. The animals may have showed a slight preference for the concentrate with the CSH being consumed last. This was not considered serious or significant especially in light of the fact that all rations components were completely consumed. These results are supported by others (3, 26, 35, 37) who obtained similar results but contrast to Hunt et al. (21), who reported problems of feed refusal and diarrhea in lactating dairy cows fed complete rations containing 25 to 45 percent CSH.

Pelleting of the CSH may have partially enhanced the high feed consumption and improved nutritional value even though neither was born out in a previous study by Brown and Whiting et al. (3). In fact, other desirable characteristics of the CSH (17, 19) such as decreasing ration density and dustiness and imparting a desirable physical property may be lost due to the pelleting process.

As previously pointed out (3), pelleting the CSH will compress them to less than 40 percent of the bulk of non-pelleted hulls and it is presumed that the improvement in handling, lowering of transportation costs and possible enhancement of consumption and nutritional value far offset any adverse effects that may also take place. It should be pointed out that while other low energy by-product feeds are ground before pelleting this is not the case with CSH.

As shown in Table 2 there were no significant effects ($p > 0.05$) in total milk production or composition. Body weight changes also were not affected. Obviously the low amounts of SBP or NaOH did not help or hinder milk production or body weight changes. This is understandable in view of the fact that only .81 percent and .75 percent of the total ration was SBP and NaOH respectively. Even though previous work (17) has shown the addition of fat to fattening rations to be beneficial, a measureable response to a non-toxic, non-hormonal type substance added in such low amounts would be unexpected. The fact that the SBP was not harmful was of course significant. It was expected that if NaOH were to give a measureable response to milk production it would undoubtedly be from having influenced digestibility and thus affecting available energy. Obviously, this did not occur.

Table 2. Mean yield and composition of milk, and body weight changes of cows fed pelleted cottonseed hulls containing a "soapy by-product" (SBP) of the cottonseed industry and/or sodium hydroxide.

	Control	3.25% SBP	3.00% NaOH	3.25% SBP plus 3.00% NaOH	F Value	SE
Milk production (kg/day)	30.00	31.62	30.14	29.69	1.61	.96
Fat (%)	2.85	2.95	3.12	3.26	3.69	.14
Protein (%)	2.58	2.51	2.54	2.56	2.04	.03
Solids-not-fat (%)	8.53	8.59	8.48	8.54	1.41	.05
Body weights (kg)	710	703	708	711	1.45	4.20
Body weight gain (kg/day)	.43	.16	-.15	.38	1.70	.29

While milk fat was not significantly influenced by SBP or NaOH there did appear to be a slight trend towards an increase in fat as SBP and NaOH were added to the diet. The diet containing both SBP and NaOH did produce milk with the highest fat content.

Mean digestibilities of ration components are shown in Table 3. There were no significant effects on digestibility of protein, fat, acid detergent fiber or combustible energy caused by the addition of SBP and/or NaOH to the CSH pellet. The lack of effect by the SBP was not unexpected; however, previous work by Sherrod and Summers (40) had shown that NaOH treatment of CSH would significantly increase in vitro digestibility of cell wall components as well as the soluble portions of the cells. In a later trial by the same authors (42) this improvement was not nearly as great.

Total concentration of rumen VFA are shown in Table 4 with mean molar concentrations being indicated in Table 5. There were no significant differences in total concentrations of any of the acids caused by SBP or NaOH. The molar concentration of propionate was significantly depressed as SBP and NaOH were added to the diet with the greatest depression occurring when both were added to the same diet. It is of significance to note that while milk fat was not significantly changed by any of the diets there was a trend towards increased fat percentage as SBP and NaOH were added

Table 3. Mean percent digestibility of rations from cows fed pelleted cottonseed hulls containing a "soapy by-product" (SBP) of the cottonseed industry and/or sodium hydroxide.

	Control	3.25% SBP	3.00% NaOH	3.25% SBP plus 3.00% NaOH	F Value	SE
Protein	62.86	64.49	66.28	63.20	.67	2.67
Fat	85.86	85.51	86.87	82.16	.36	4.84
Acid Detergent Fiber	22.55	29.17	32.58	28.98	1.57	4.72
Combustible Energy	53.23	56.15	59.25	57.31	.58	4.67

Table 4. Mean concentration of volatile fatty acids in rumen fluid of cows fed cottonseed hulls containing a "soapy by-product" (SBP) of the cottonseed industry and/or sodium hydroxide.

Volatile Fatty Acid	Control	3.25% SBP	3.00% NaOH	3.25% SBP plus 3.00% NaOH	F Value	SE
	(uM/ml)					
Acetate	36.70	57.42	49.01	47.43	2.03	7.77
Propionate	24.14	31.33	26.14	22.18	1.50	6.16
Isobutyrate	1.17	.61	2.92	1.80	3.93	.71
Butyrate	15.26	18.32	13.85	16.21	.27	3.72
Isovalerate	1.16	1.27	1.14	1.44	.51	1.50
Valerate	.84	1.32	1.28	1.52	.26	.78
Total VFA	79.27	110.27	94.34	90.58	.98	18.26

Table 5. Mean molar percentages of volatile fatty acids of rumen fluid of cows fed cottonseed hulls containing a "soapy by-product" (SBP) of the cottonseed industry and/or sodium hydroxide.

Volatile Fatty Acid	Control	3.25% SBP	3.00% NaOH	3.25% SBP plus 3.00% NaOH	F Value	SE
	(Molar %)					
Acetate	46.30	52.08	51.95	52.35	4.18	2.06
Propionate	30.45^{a}	28.41^{a}	27.70^{a}	24.49^{b}	6.58	1.49
Isobutyrate	1.48	.55	3.10	1.99	3.57	.80
Butyrate	19.25^{a}	16.61	14.68^{b}	17.90	5.01	1.25
Isovalerate	1.46	1.15	1.21	1.59	2.31	1.07
Valerate	1.06	1.20	1.36	1.68	.53	.51

a, b Values within a group of means with different superscripts indicate a significant difference ($p < 0.05$).

to the diet. This when coupled with the significant depression of molar percent propionate gives further credulence to the review of Van Soest (46) where it was shown that a negative correlation exists between milk fat percentage and propionate percentage in the rumen. Molar percent butyrate was significantly lowered by the diet where only NaOH was added to the CSH pellet. This phenomena is not readily explained. Ololade and Mowat (31) and Ololade, Mowat, Yao and Smith (34) in two experiments had in fact found that increasing levels of NaOH increased rumen fluid molar concentrations of propionate in the first experiment and butyrate in the second.

Analysis of the milk fatty acids are presented in Table 6. No significant differences due to treatment effects were found in any of the acids except $C_{12:1}$. In this single incidence the control diet produced milk fat containing a significantly lower $C_{12:1}$ than the other three diets. No explanation for why this occurred is offered and in view of the low amount of total acid involved, its biological significance is questionable anyway.

The results of this experiment have indicated that the addition of 3.25 percent SBP to pelleted CSH in no way adversely affects the utilization of CSH by lactating dairy cows. The addition of NaOH at the 3 percent level to the pelleted CSH did not produce any adverse or beneficial effects for the lactating cow.

Table 6. Mean percentages of fatty acids of milk from cows fed pelleted cottonseed hulls containing a "soapy by-product" (SBP) of the cottonseed industry and/or sodium hydroxide.

Milk Fatty Acid	Control	3.25% SBP	3.00% NaOH	3.25% SBP plus 3.00% NaOH	F Value	SE
	(%)					
6:0	2.78	4.37	2.39	4.49	1.42	1.28
8:0	3.10	4.96	2.89	5.24	1.56	1.39
10:0	6.72	6.39	4.20	7.74	.80	2.35
10:1	.23	.33	.12	.29	1.94	.09
12:0	5.25	6.63	5.74	6.92	.45	1.64
12:1	.28[a]	.73[b]	.96[b]	.74[b]	16.75	.10
14:0	11.56	11.76	11.60	10.61	.68	.89
14:1	1.15	1.05	1.74	1.33	1.34	.37
15:0	1.74	1.50	2.10	1.48	.66	.51
16:0	30.99	29.65	30.74	28.48	1.00	1.81
16:1	1.55	1.12	2.25	1.47	1.27	.59
16:2	.85	.57	.81	.67	.75	.21
17:0	.49	.48	.48	.47	.01	.16
18:0	9.93	9.11	10.05	10.22	.31	1.25
18:1	20.08	17.98	20.49	16.92	.62	3.03
18:2	3.16	3.17	3.29	2.78	.10	1.01
18:3	.14	.20	.15	.15	.36	.07

[a,b] Values within a group of means with different superscripts indicate a significant difference ($p < 0.05$).

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