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Title Digestibility of By-Product Feeds by Sheep

Abstract approved Redacted for Privacy
Dr. David C. Church, Major Professor

Two digestibility trials using sheep were conducted to determine the digestibility coefficients of a commercially processed NaOH-treated annual ryegrass straw cube. Comparisons were made with loose, chopped ryegrass straw and a ryegrass straw cube processed with molasses as a binder.

The NaOH cubed straw was produced by spraying a solution of 30% NaOH evenly over the straw and processing through a cuber. The resulting product averages 4% NaOH by weight. This treatment resulted in significant ($P < .05$) increase in the digestibility of dry matter, acid detergent fiber, and nitrogen-free-extract when calculated by difference using chopped alfalfa. A trend toward increased digestible protein and digestible energy was shown. Cubing with molasses did not improve ($P < .05$) the digestibility of ryegrass straw when calculated by difference. Digestibility of loose ryegrass straw was significantly ($P < .05$) improved by the NaOH treatment with regard to dry matter, crude protein, and acid detergent fiber when calculated "directly" using urea and molasses.

The TDN (Total Digestible Nutrients) for the NaOH-treated ryegrass straw cubes was 46.3% when calculated by difference and 44.4%

when figured "directly". The TDN values for the molasses cubes by difference, plain straw by difference and plain straw "directly" were 39.7%, 41.3%, and 44.7% respectively.

The conclusion was made that this type of NaOH-treatment of rye-grass straw resulted in significant improvement in its digestibility when fed to sheep.

A third digestibility trial was run to determine digestibility and nutrient composition of a dried bakery product (DBP). This product is produced from non-saleable bakery products which are mixed, dried, and ground. DBP is primarily fed to dairy cows when used in the Northwest. Digestibility was calculated by difference using "typical" dairy ration components. Nutrient composition (%) of the DBP for crude protein (CP), ether extract (EE), ash, acid detergent fiber (ADF), nitrogen-free-extract (NFE), organic matter (OG), calcium, and phosphorous were, respectively, 10.4, 8.5, 3.8, 1.8, 75.5, 96.2, .036, and .088. The gross energy was 4.29 Kcal/g. The digestibility of these components when fed at 20% and 40% of the diet, respectively, was (%) DM, 94.5, 93.4; CP, 82.4, 80.1; EE, 84.7, 84.4; OG, 64.5, 88.9; ADF, 99.7, 89.7; NFE, 97.7, 94.3; and GE, 95.8, 90.6. The digestibility coefficients were not significantly ($P < .05$) different when fed at the two levels, but a trend was noted of lowered digestibility when fed at the higher level. TDN values at the 20% and 40% levels were 93.1% and 88.0%, respectively. It was apparent that the possibility exists that the DBP could be increasing the digestibility of other ration components.

DIGESTIBILITY OF BY-PRODUCT FEEDS BY SHEEP

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INTRODUCTION

There have been many papers published concerning the improvement of low quality roughages which have been used as feedstuffs for ruminant animals. Treatments have been varied and included the use of ammonia (Waiss _et al._, 1972; Garrett _et al._, 1974), soaking or spraying hydroxides with or without subsequent neutralization, rinsing, or steam pressure treatment (Guggolz _et al._, 1971; Fernandez _et al._, 1972, 1974; Anderson _et al._, 1973a, b; Garrett, 1974; Manisor, 1975; and others), sodium bicarbonate (Godden, 1920; Bolduan _et al._, 1974), sodium chlorite (Goering _et al._, 1973 and YuYu _et al._, 1975), fermentation (Han, 1975; Holzer _et al._, 1975, 1976), electron irradiation (YuYu _et al._, 1975), sodium hypochlorite (YuYu _et al._, 1975), gaseous chlorine (YuYu _et al._, 1975), gamma irradiation (Pritchard _et al._, 1962; Huffman _et al._, 1971; and McManus _et al._, 1972), and cellulases (Thomas _et al._, 1968). Varying degrees of improvement, ranging from negative to highly positive results have been reported, primarily with regard to _in vitro_ or _in vivo_ digestion.

The research reported herein was done using a commercially processed NaOH-treated annual ryegrass straw cube. Comparisons have been made with loose, chopped ryegrass straw and a ryegrass straw cube processed with molasses as a binder (produced by the same feed mill). The purpose of the research was to evaluate improvements in digestibility of straw by these processes. Several papers published by Piatkowaki and coworkers (1975, 1976) discuss a cubed, treated cereal straw which was made into a complete ration. Cubes treated in this way might be very feasible for use, especially in the Willamette Valley with its abundant supply of ryegrass straw. They appear to be well accepted by the animals. Such straw cubes could be included in the feeding regimen of cattle or sheep which are fed on a maintenance level. The data presented here should help the producer in a more educated use of such an unfamilar feed as these NaOH treated straw cubes.

For several years now a bakery by-product, dried bakery product (DBP), has been used in dairy rations in this area. There has been little previous research done on this feed. This second experiment was to provide data on the digestibility of the dried bakery product when associated with ration components similar to those used in dairy feeds.

LITERATURE REVIEW

Alkali Treatment of Straw

The implications of a usable process for ryegrass straw improvement can be seen more clearly when the literature available on previous processing methods and use of treated straw is reviewed. Literature concerning the application of alkali to straw residues has been published since 1902 (Godden, 1920) although Beckmann's article in 1921 is often referred to as the original article on alkali treatment of crop residues.

Drawbacks to the Beckmann method have been noted almost since its inception. Lampila (1963) noted that, although alkali treatment of straw has become popular in Norway, some of the practices have limited its economical use. The drawbacks mentioned were large amounts of water for washing, loss of nutrients with washing, cost of alkali and the low protein level of the product. Others have mentioned the additional expense of large quantities of wash water and labor and eliminated the rinsing step (Donefer et al., 1969; Oloade et al., 1970; Chandra and Jackson, 1971; Singh and Jackson, 1971; Fernandez and Greenhalgh, 1972; Fernandez, 1974; and Norong Hutanuqatr et al., 1974). Acid neutralization was used to lower the alkalinity by all but Chandra (1971) and Singh (1972). Other investigators have used steam and pressure treatments to lower the pH of the products (Godden, 1920; Oloade et al., 1970; Guggolz et al., 1971; and Maeng et al., 1971).

The need to neutralize excess alkali has been questioned due to the additional expense involved. Tarkow (1969) noted that washing of treated fiber was probably not necessary for ruminant animals. The necessity for neutralizing treated roughages with acid has not been established experimentally (Chandra and Jackson, 1971). Washing has been shown to not be necessary with levels of alkali up to 6% since residual alkali was a function of time after treatment (Chandra and Jackson, 1971). These authors also demonstrated that when 10 g of NaOH were used to treat 100 g of wheat straw only 3.4 g of alkali were removed by washing 30 minutes later. Levels of NaOH treatment near 12% were shown to decrease microbial degradation of fiber in vitro by by Norong Hutanuqatr (1974). It would be worthwhile here to note that both bovine and ovine rumen fluid, although well buffered, do not tolerate alkaline pH changes as well as acid changes (Turner and Hodgetts, 1955; Bloomfield et al., 1966). Bolduan (1974) found that when urea was used with treated straw that was neutralized, there were significant increases in rumen pH over that for rye fodder without urea.

The ability of alkali treatment to increase voluntary intake of straw is well documented (Singh et al., 1971; Fernandez et al., 1972; and Meissner et al., 1973). The effect of residual alkali on intake was shown by Singh and Jackson (1971). Consumption of straw increased with treatments of 3.3% NaOH which did not include rinsing. Levels of 6.7% and 10% caused a drop in intake.

Increased level of consumption will reduce digestibility of nutrient components with most feeds (Robertson and Van Soest, 1975). While avoiding the excessively high levels of NaOH in the diet, the lower intakes of treated forage may have the additional effect of maximizing digestibility. When treated barley straw was fed at varying levels with alfalfa silage, Maeng (1971) noted that the straw digestibility increased with decreasing percentage of straw in the diets, assuming that digestibility for the silage did not change. These authors also noted that the full potential of straw digestibility was not obtained at high levels of intake. Suggestions were made that the increased water intake increased rate of passage were responsible for the decrease in digestibility. McAmally, as far back as 1942, noted, when working with the digestion of straw by ruminants, that it took approximately seven days to digest 50% of an untreated straw when placed in a silk bag in the rumen. McAmally also noted that alkali pre-treatment of straw would not avoid wastage of nutrients by too rapid a transmission of straw through the rumen.

It is interesting to note that Singh and Jackson (1971) found that consumption of treated straw was greater when chaffed straw rather than ground straw was used. It is usually assumed that ground straw or roughage would allow greater consumption (Church, 1977). The implications of this are interesting. Was the ground roughage accepting more alkali and therefore less palatable even though higher consumption was physically possible? Returning to the idea that rate of passage would effect digestibility, would the chaffed straw then have a greater digestibility?

Animal health is another concern if unwashed treated straw is to be fed. Singh and Jackson (1971) fed unwashed treated straw to cattle for six months without affecting animal health. The health of wether lambs was not affected by unwashed straw in digestibility trials conducted by Anderson and Ralston (1973b).

As mentioned earlier one disadvantage to treated straws as a practical feed is the low protein content. This deficiency has prompted several investigators to research the possibility of using an NPN (Non-protein Nitrogen) source with the straw. The main problem with this is the absence of readily available carbohydrate in the treated straws. It appears though, as shown by Saxena (1971), that alkali treatment of oat straw released enough energy to stimulate bacterial growth with NPN. Shultz and Ralston (1973) found that urea added to treated straw diets increased weight gains and rumen VFA levels in cattle when compared to biuret. Lampila (1963) came to the conclusion that "organisms of the rumen are relatively efficient at utilizing the nitrogen from urea in the synthesis of cell protein, even when the source of energy consists of fiber polysaccaharides, provided they are in a readily available form." Hogan and Weston (1971) calculated the rate of synthesis of all protein as being equivalent to 2.6 to 3.7 g of nitrogen from urea per 100 g straw organic matter fermented in the rumen. The addition of urea to treated oat straw was shown to have a significant effect on intake by Donefer (1969). There was no significant increase in digestibility in this study but there was a trend towards improvement. It is interesting that in this same study sucrose was added to treated and untreated straw diets, with and without urea, with no effect on digestibilities. Other nitrogen sources have been added to treated straw diets. Fernandez (1974), in studies with two levels of soybean meal fed with treated (16% NaOH with neutralization) and untreated wheat straw, found that the addition of the soybean meal increased digestibility of organic matter. Intakes were not affected by the soybean meal but treatment of the straw gave significant increases in intake. It is apparent that this line of research would be a profitable one to continue.

Treated roughages would rarely be used as the sole ingredient in a ration. This is apparent not only because of the low protein content, as mentioned, but by the animal's inability to consume sufficient quantities of the straw to meet even maintainance energy needs. Investigations into the use of treated straw in complete rations has been conducted by a group of authors whose several publications began in 1975 (Piatkowaki and coworkers). A mixture of 40% finely ground treated cereal straw and 60% concentrates was pressed or pelleted and fed to dairy cows. This mixture was given the name "Teilfertigfuttermittel" or TFM. Digestibilities of TFM with treated straw was higher than with untreated straw. There was a slight increase in milk production of high producing cows fed the treated TFM over the crude straw. They concluded that there was no noticable effect of the TFM on milk production in this trial when additional technological costs of production were taken into account. In 1976, a continuation of these trials found that TFM increased cellulolytic activity of the ruminal fluid and its binding capacity for NH_3. TFM reduced the number of protozoa but did not affect the concentrations of VFA in the rumen. The associative effects of treated straws to other rations components appear to need further research.

The physiological effects of using treated straws has also been researched by other authors. Bolduan (1974) found that the use of treated straws, irrespective of the source of nitrogen, significantly decreased the concentration of NH_3 in rumen fluid in the first one to three hours. The ruminating activity of cows fed straw treated with NaOH was found to decrease at different levels depending on physical treatment (Piatkowski, 1975). Chopped feed decreased ruminating activity by 53%, pellets by 40% and pressed blocks by 62% when treated straw was used.

Dried Bakery Product

Some of the by-product feeds used currently have become rather common place, such as beet pulp, bran, oil seed meals, etc. The use of dried bakery waste as an animal feed is fairly new. Morrison (1959) mentioned that dried bakery products (DBP) could be used to replace part of the grain usually fed but since then very little research has been conducted on the value of DBP as an animal feed. The research that has been done includes work with a variety of animals. Feed consumption, feed efficiency and weight gains of animals fed DBP have been the primary data collected.

Turkeys were found to do well on DBP when used as 10% of the diet (Potter et al., 1971). There was a decrease of feed consumption by 2.7% and an increase in feed efficiency by 2.9% with no change in body weight gains when compared to rations using ground yellow corn. Damron (1965) reported that 10% DBP could be used in the diets of broiler chicks with no adverse effects.

Arrington (1965) mentioned reports where favorable responses to DBP were obtained with rats, rabbits, fattening steers, dairy cattle, and growing and weanling pigs.

Feed efficiency was improved and feed costs were less when 12 and 24% DBP were fed to growing and finishing swine (Kornegay, 1974). A concern with high fat ration components, such as DBP, is that an excess amount of body fat would occur on animals so fed, and thus result in lowered cuttability. Kornegay (1974) found no significant difference in back fat thickness in swine fed 0, 12, 24, and 36% DBP.

Cattle have been fed fattening rations containing DBP with good results. Kirk (1969) used DBP to replace 10 and 20% of dried citrus pulp in fattening rations. Increased rate of gain and feed efficiency resulted from the diets containing the DBP. The product was described as being easy to mix, easy to feed and highly palatable. Baker (1964) has also reported favorably on the use of DBP in fattening rations.

EXPERIMENTAL PROCEDURE

Digestibility trials were conducted using twelve crossbred yearling wethers in trial one and three. Fourteen crossbred yearling wethers and six purebred yearling Suffolk ewes were used in trial two. Lambs were randomly assigned to diets and stalls in standard digestibility trials, except in trial two where the ewes were assigned so as to have no more than two ewes per treatment.

Diets

Trial 1 - A commercially produced NaOH-treated annual ryegrass straw cube (straw was evenly sprayed with a 30% NaOH solution and cubed) was used in combination with alfalfa hay. This cube averages 4% NaOH by weight. All feeds were chopped in a commercial hammermill and mixed in a small batch mixer. Diet 1 - chopped alfalfa; Diet 2 - (40%) chopped alfalfa and (60%) chopped NaOH straw cubes; Diet 3 - chopped alfalfa (40%) and (60%) chopped molasses straw cube. The latter cubes were produced by the same feed mill, except that they were cubed with the addition of molasses, only. Nutrient content of diets is given in Table 1.

Trial 2 - The same commercial cubes were used but from the followings year's straw production. In order to attempt to reduce errors in calculations due to "by difference" errors, urea as the supplementary nitrogen source and molasses as a supplementary energy source were added. Digestibility coefficients for acid detergent fiber and other extract were calculated directly. The remaining components were calculated by difference using calculated values for composition and digestibility of urea and molasses (NAS, 1971), this method was suggested by Swingle and Waymack (1975). From the same feed mill as in Trial 1 an uncubed, chopped ryegrass straw was used. Diet 2 - (100%) chopped alfalfa; Diet 3 - (91%) chopped plain straw, (7%) molasses, and (2%) urea; Diet 1 - (91%) chopped NaOH-treated ryegrass straw cubes, (7%) molasses, and (2%) urea; Diet 4 - (51%) chopped alfalfa, and (49%) chopped plain ryegrass straw. The diets 1, 3 and 4 were balanced to yield approximately 9% CP as fed.

Trial 3 - A commercially produced dried bakery waste product was used. It consists of unsaleable bakery products and other ingredients such as candy, nuts, etc. It is minced, dried, and ground; it is used primarily for dairy rations. The basal diet was formulated with "typical" dairy ration components. Diet 1 - Basal diet, (50%) pelleted alfalfa (3/4" pellets), (25%) rolled barley (Pacific Coast), (25%) dried shredded beet pulp and 2 lbs antibiotic premix was added per ton mix; Diet 2 - (80%) Basal diet, (20%) dried bakery product; Diet 3 - (60%) Basal diet, (40%) dried bakery product. Due to the nature of the diets, a uniform mix was not possible, so each of diets 2 and 3 were mixed daily to ensure even distribution of the bakery product.

Intakes were adjusted to approximately 80% of <u>ad libitum</u> intake in all trials. This amounted to daily intakes of 1200g/day/lamb in Trial 1, 1000g/day/lamb in Trial 2 and 1300g/day/lamb on Diet 1, and 1000g/day/lamb on Diets 2 and 3 in Trial 3. All values given above are on an as fed basis.

Methods of Collection and Feeding

The digestibility trial was conducted in total collection metabolism stalls with a false floor (wire grate) with a screen below to separate feces from urine for collection in separate containers. There was a minimum 14-day adjustment period after the lambs were gradually introduced to the experimental diets. A minimum 10-day preliminary period followed where the lambs were accustomed to the collection stalls. An eight-day collection period was used in Trial 1 and 3 and seven days in Trial 2.

The stalls allowed free access to water and a trace mineralized salt block was provided. A twice daily feeding schedule was used.

Daily fecal and urine collections were made after the evening feeding. Aliquots of 10% of daily excreta were compiled, refrigerated and frozen for later analysis, except urines in Trial 2 and 3 which were not frozen. Urine was acidified with phosphoric acid to a pH of 6-7. Feed weighbacks and spilled feeds in Trial 1 were compiled, dried and subtracted from amount of feed fed. Rations in this trial were well mixed, so sorting was not possible. There were no weighbacks in Trials 2 and 3.

Analytical Methods

Feed and feces were dried for 48 hours at 105°C and then ground twice through a 20 mesh screen in a Wiley mill. Crude protein was determined by micro modification of A.O.A.C. on fecal matter and by the macro Kjeldahl method as given by A.O.A.C. for feed and urine. A micro method of the Van Soest method of fiber determination was used

(Waldren, 1971). Acid detergent fiber was used in calculation of TDN. Ether extraction was with a Golfisch extraction apparatus. Nitrogen-free-extract was calculated by difference. Ash was determined by combustion at 550°F for 7-8 hours. Gross energy was determined by burning samples in a bomb calorimeter.

Calcium was determined with an atomic absorbtion spectrophotometer and phosphorous with Rapid-stat (reg.) kit on the DBP.

The pH of the straws was determined by mixing 10g of ground straw with 100 ml of distilled water. The supernatant was decanted off after 30 minutes and the pH measured immediately.

Approoriate analysis of variance was conducted on all data and comparisons were made using Student-Newman-Keuls' test (Steel and Torrie, 1960).

RESULTS

Treated Ryegrass Straw (Trials 1 and 2)

The chemical composition of diets and their components are given in Table 1. The NaOH cubed straw used in Trial 1 showed a trend to higher ash but lower acid detergent fiber (ADF), lignin, nitrogen-free-extract (NFE), and gross energy (GE) than the molasses cubed straw. The NaOH cubed straw used in Trial 2 showed higher ash, similar ADF and lignin, and lower NFE when compared to loose straw. Godden, as far back as 1942, noted that rinsing NaOH treated roughage resulted in large losses of soluble nutrients from that roughage. It was noted that rinsing treatments needed to be altered to minimize that loss. The pH of the NaOH cubed straw was 12. This shows that a considerable amount of residual NaOH was present in the NaOH cubed straw. The pH of the molasses cubed straw and plain loose straw was near neutral.

The digestibility coefficients of the total diets used in both Trials 1 and 2 are given in Table IIIa. In Trial 1 the digestibility of the straw portions was calculated by difference under the assumption that the digestibility of the alfalfa did not change. Dry matter (DM) digestibility was significantly ($P < .05$) higher in the NaOH cubed straw than the molasses cubed straw. *In vitro* dry matter digestibility reported by Anderson and Ralston (1973a) for ryegrass straw soaked in 2% NaOH was 67.8% compared to 32.1% for untreated straw. These figures are comparable to those found here. Crude protein (CP) digestibility was significantly ($P < .05$) increased by NaOH treatment compared to the molasses cubes but not significantly different ($P < .05$) than the mean for plain straw found in Trial 2. This is different than the depression in nitrogen digestibility with NaOH treatment of rice straw reported by Garrett (1974). The low level of crude protein in the ryegrass straw minimizes the effect of improvement or depression of digestibility of that fraction.

Gross energy digestibility was significantly ($P < .05$) increased by NaOH cubing compared to the molasses cubed straw. Neither value was different ($P < .05$) from the mean digestibility of GE for the plain straw used in Trial 2 although increases of approximately 20% in digestible energy for barley straw soaked (rinsed) or sprayed (neutralized) with NaOH were demonstrated by Fernandez (1972). Increases of 10 percentage units in digestibility of GE of oat straw, when treated with 13.3% NaOH and neutralized, were shown by Donefer (1969).

The digestibility of the ether extract (EE) fraction of the NaOH cubed straw was decreased ($P < .05$) compared to the plain straw, but not when compared to the molasses cubed straw. This effect would have little consequence due to the low level of ether extract in the straws tested.

Organic matter (OG), ADF and NFE digestibility of NaOH cubed straw showed significant ($P < .05$) increases of 12.5, 8.6, and 9.4 percentage units, respectively, when compared to plain straw. Similar increases were seen when the NaOH straw cubes were compared to the molasses straw cubes. Significant increases in the digestibility of the ADF fraction of NaOH treated straws, when not accompanied by washing, has been shown by Lampila (1963) and Anderson and Ralston (1973b).

The digestibility coefficients found for NaOH treated ryegrass straw were similar to those found for NaOH treated wheat straw by Singh and Jackson (1971). These authors found the organic matter digestibility of the untreated wheat straw to be 53%, for wheat straw treated with 1000 liters of 3.3% NaOH solution per ton of straw, digestibility was 63% compared to 53.1% and 62.5%, respectively, in the current study.

Although no direct measurements of water intakes by the sheep were made, it was noted that the water containers for the sheep fed the NaOH cubed straw diets emptied about twice as quickly as those animals fed the untreated and molasses cubed straw diets. Increase in water intake has been noted previously by Anderson and Ralston (1973b) and Fernandez (1974) when NaOH treated straw was fed. Measurements of urine excretions were made and, although statistical analysis was not performed, definite increases in urine volume were seen with the diets containing NaOH cubed straw compared to the untreated and molasses cubed straw diets. Urine volumes are given in Table VI.

Comparisons of the data obtained in Trial 2 with those obtained in Trial 1 showed that the urea-molasses method of determining the digestibility of low quality roughages, as described in the experimental procedure section, resulted in differences ($P < .05$) only in the digestibility of crude protein and ether extract for NaOH cubed straw in each trial. In Trial 2 when the loose straw digestibility coefficients obtained "directly" by the urea-molasses method, using diet 3, were compared to the digestibility coefficients obtained by difference in using diet 4, differences were noted only in the digestibility of ether extract. Similar results were obtained by Swingle and Waymack (1975), using the urea-molasses method to determine the digestibility of grain sorghum stover and wheat straw. These authors also noted that the digestion coefficients for crude protein and ether extract differed considerably between the urea-molasses method and the by difference method using alfalfa hay. The low level of CP and EE in ryegrass straw and other low quality roughages make these differences of little concern in calculating the nutrient value of these feeds.

Final conclusions have been made that, 1) Soluble nutrients are not lost by this type of NaOH treatment of ryegrass straw; 2) The digestibility coefficients of ryegrass straw treated in this way are significantly increased; 3) There were no apparent detrimental effects on animal health, although increases in water consumption and urine output were noted; 4) The use of urea and molasses rather than alfalfa as ration ingredients in digestibility trials with low quality roughages appears to be a plausible method of determining digestibility.

Dried Bakery Product (Trial 3)

Digestibility of DBP was calculated by difference assuming no change in percent digestibility of the basal diet with the addition of DBP. Percent digestibilities, for the mean of four observations, are shown in Table IVa and Table IVb. The assumption was incorrect as illustrated by the digestibility of some acid detergent fiber digestibilities greater than 100%. It was noted that, at least with sheep, at the higher level of intake (40% of diet) digestibility of the DBP was less than at the 20% level. It could therefore be concluded that this product is highly digestible (average 90.5% TDN dry basis) and may improve the digestibility of fibrous portions of the diet if used at a moderate level.

During transition to the experimental diets it was noted that the diet with 40% DBP was not well accepted by the sheep. Consumption was considerably less on that diet than on the basal or 20% DBP diet. Sheep have been shown to have a lower tolerance than cattle to sweet tastes (Goatcher and Church, 1970). Kirk (1969) found, with steers, that DBP was readily accepted. Potter (1971) demonstrated a significant decrease in feed consumption when a diet containing 10% DBP was fed to turkeys. Arrington (1965) noted several reports where DBP reduced feed consumption but, increased feed efficiency with rats and rabbits. Swine fed levels of up to 36% DBP did not show as efficient use of the product as when fed at lower levels (Kornegay, 1974). This is in agreement with the trend found in the current work to decreased digestibility of DBP when fed at the 40% level.

TABLE I. CHEMICAL COMPOSITION OF DIETS AND STRAW COMPONENTS FOR TRIAL 1 AND 2

	Nutrient composition, dry basis								
	DM	OG	CP	EE	Ash	ADF	Lignin	NFE	Gross Energy
	%								K cal/g
Diets Trial 1*									
1 (Alfalfa)	84.9	91.6	14.8	1.6	8.4	31.0	7.0	44.2	3.94
2 (Mol + Alf)	85.7	92.6	8.5	1.4	7.4	36.6	7.2	46.2	3.86
3 (NaOH + Alf)	84.6	90.6	10.6	1.1	9.4	34.5	7.3	44.4	3.93
NaOH Cubed Straw	85.6	87.2	4.7	1.0	12.8	39.5	5.7	41.9	3.57
Mol Cubed Straw	88.4	93.9	4.1	0.8	6.1	44.3	7.4	44.7	4.05
Diets Trial 2*									
1 (NaOH + Urea)	86.4	89.5	9.8	0.6	10.5	41.1	9.6	39.6	3.74
2 (Alfalfa)	90.8	88.9	16.5	1.5	11.1	36.8	8.5	34.1	3.87
3 (Plain + Urea)	89.7	95.2	9.8	0.7	4.8	40.5	8.7	46.4	3.97
4 (Plain + Alf)	91.2	94.0	9.5	1.1	6.0	39.9	8.6	45.1	3.83
Plain Straw	88.0	95.5	3.4	1.0	4.5	44.9	9.4	46.2	3.88
NaOH Straw	76.9	88.9	3.2	1.3	11.1	44.2	9.7	40.2	3.59
Molasses	65.4	88.3	3.0	0.0[a]	11.7	0.0[a]	0.0[a]	85.3	3.48[a]
Urea	100.0	100.0	281.0[a]	0.0[a]	0.0	0.0[a]	0.0[a]	0.0	2.52[a]

* See text for complete description of diets

[a] Book values from NAS (1971)

TABLE II. CHEMICAL COMPOSITION OF DIETS AND COMPONENTS USED IN TRIAL 3

Diet *	Nutrient composition, dry basis									
	DM	OG	CP	EE	Ash	ADF	NFE	Ca	P	GE
	%									K cal/g
1 (Basal mix)	90.8	89.6	11.5	1.2	10.4	27.0	49.9			3.71
2 (20% DBP)	90.4	91.4	10.7	2.5	8.6	22.1	56.1			3.59
3 (40% DBP)	90.8	92.4	10.7	4.2	7.6	18.7	58.8			3.82
Dried Bakery Product	91.3	96.2	10.4	8.5	3.8	1.8	75.5	.036	.088	4.29

* See text for complete description of diets

TABLE IIIa. DIGESTIBILITY OF COMPLETE DIETS USED IN TRIALS 1 AND 2

	Apparent Average Digestibility, %						
	DM	CP	EE	OG	ADF	NFE	GE
Trial 1							
Diet 1	61.4	75.7	37.6	63.9	44.3	74.6	59.8
Diet 2	54.9	60.6	46.2	56.3	42.8	66.6	50.0
Diet 3	62.4	61.4	37.7	63.1	50.3	73.9	58.2
Trial 2							
Diet 1	61.1	60.2	20.8	60.1	51.9	70.6	57.0
Diet 2	58.3	74.9	21.2	62.6	37.8	83.8	60.8
Diet 3	54.4	68.9	19.2	55.7	44.2	65.5	54.6
Diet 4	56.4	67.3	35.2	57.9	41.8	72.3	54.1

TABLE IIIb. DIGESTIBILITY OF ANNUAL RYEGRASS STRAW WHEN TREATED AS SHOWN

	Apparent Average Digestibility, %						
	DM	CP	EE	OG	ADF	NFE	GE
Trial 1							
NaOH Cubed by diff (Diet 3)	64.6[a]	46.2[a]	37.8[b]	62.5[a]	53.7[a]	73.4[a]	57.0[a]
Mol Cubed by diff (Diet 2)	50.7[c]	26.7[bc]	50.6[ab]	51.5[b]	42.1[c]	61.6[c]	43.3[b]
Trial 2							
NaOH Cubed (Diet 1)	57.8[ab]	11.1[c]	20.8[c]	56.7[ab]	51.9[ab]	69.8[ab]	54.5[a]
Plain Chopped by diff (Diet 4)	52.7[bc]	32.3[ab]	55.5[a]	53.1[b]	45.1[bc]	60.9[c]	47.0[ab]
Plain Chopped (Diet 3)	50.8[c]	44.1[ab]	16.7[c]	52.3[b]	44.2[c]	63.7[bc]	50.8[ab]

[abc] Means in same column with the same superscripts were not significantly (P < .05) different.

TABLE IVa. AVERAGE DIGESTIBILITY OF COMPLETE DIETS IN TRIAL 3

LEVEL	Apparent Digestibility of, %						
	DM	CP	EC	OG	ADF	NFE	GE
Diet 1	68.3	72.3	19.4	71.8	42.1	89.0	68.6
Diet 2	72.1	72.4	58.0	76.1	40.5	91.6	71.9
Diet 3	78.3	75.1	73.2	81.2	48.3	93.3	77.8

TABLE IVb. AVERAGE DIGESTIBILITY OF DRIED BAKERY PRODUCT WHEN FED AT TWO LEVELS

LEVEL	Apparent Digestibility of, %						
	DM	CP	EE	OG	ADF	NFE	GE
20%	94.5	82.4	84.7	97.7	99.7	100.5	95.8
40%	93.4	80.1	84.4	94.3	97.7	97.7	90.6

TABLE V. TOTAL DIGESTIBLE NUTRIENTS OF STRAW COMPONENT IN TRIAL 1 AND 2 AND BAKERY WASTE COMPONENTS IN TRIAL 3

	% TDN*	
	a	b
Trial 1		
NaOH Cubed by diff (Diet 3)	55.0	46.3
Mol Cubed by diff (Diet 2)	48.2	39.7
Trial 2		
NaOH Cubed (Diet 1)	52.0	44.4
Plain Chopped by diff (Diet 1)	50.8	41.3
Plain Chopped (Diet 3)	51.2	44.7
Trial 3		
20%	101.2	93.1
40%	99.8	88.0

* a Calculated by Dig. CP + 2.25 Dig. EE + Dig. ADF + Dig NFE = % TDN

b Calculated by Kcal Dig. GE/g/4.41x100 = % TDN

TABLE VI. AVERAGE URINE VOLUMES IN TRIAL 1 AND 2

	Daily Production (mls)
Trial 1	
Diet 1	1,404
Diet 2	1,052
Diet 3	2,395
Trial 2	
Diet 1	2,349
Diet 2	1,233
Diet 3	632
Diet 4	708

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