The Use of Peanut By-products in Stocker Cattle Diets

by

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Abstract

Three production trials were carried out to evaluate the usefulness of peanut skins and hulls in stocker diets. In trials 1 and 2, peanut skins were fed with soybean hulls. Twenty-seven Brangus x Continental steers (BW 261-264kg) were fed three diets containing 0, 20, and 40% peanut skins for 84 days (3 pens/diet; 3 steers/pen). ADG decreased linearly ($P<0.05$) with increasing peanut skins. DMI decreased ($P<0.01$) linearly as well. In trial 3, ADG, DMI, and roughage effectiveness were observed when peanut hulls were fed in loose and pelleted form. Twenty-seven Angus x Continental steers (BW 277 kg) were fed three diets for 106 days (3 pens/diet; 3 steers/pen). All diets contained 1:1 ratios of peanut hulls and corn gluten feed. Hay was restricted in one pelleted diet. ADG of pelleted diets was ($P<0.05$) greater. DMI was greater ($P<0.01$) for pelleted diets. This study indicates pelleted peanut hulls are an effective roughage source.

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INTRODUCTION

Stocker cattle are a viable beef cattle enterprise in the southeastern United States, typically because of the pricing cycle and climate. The area is conducive to producing large quantities of high-quality cool season annual forages. However, in years of drought or other unfavorable conditions this may not be the case. In some production systems the producer may not utilize forages and strictly feed cattle in a dry-lot. In this situation low-cost feedstuffs are typically used. In this region some of the more common low-cost feedstuffs are by-products from soybean, corn, cotton, and peanut processing.

Soybeans and corn are produced throughout the United States making them and their by-products readily available. Their production and further processing yields by-products such as soybean hulls and corn gluten feed, both of which work well in growing diets because of their low starch content, which makes them less prone to cause ruminal problems such as acidosis. Soybean hulls, however, have been known to cause bloat when fed to growing cattle (Rankins, 2004).

Peanut processing yields many by-products which are available for use in cattle diets, however, they are limited to the area where peanuts are grown in the southeastern United States. Peanut skins often are used in cattle diets because of their high energy and protein content, however, peanut skins are difficult to transport and mix in rations due to their low bulk density. There also can be a palatability issue when fed in high concentrations due to their tannin content. Peanut hulls are used in cattle diets and are considered to be a low quality roughage source (Utley and McCormick, 1972; Utley et al., 1973).

Several feed trials have been conducted to evaluate peanut by-products in cattle rations. Utley et al. (1993) substituted peanut skins for soybean hulls in a 15% soybean hull diet at recommended (10.5) and high (15.5) protein levels. The results of their study showed that at the recommended protein level peanut skins can replace half of the soybean hulls (7.5% of the ration) or with an increased protein diet peanut skins can replace all (15%) of the soybean hulls in the diet. These results indicate that with an increase in protein, negative effects brought about by the tannins can be diminished.

Peanut hulls are a suitable roughage source; however, once altered, its effectiveness as a roughage may decline. Utley et al. (1973) compared the efficacy of unground, ground, and pelleted peanut hulls in steer finishing diets. Their research indicated that the best form to meet the animal's fiber requirements was the intact or unground form.

The peanut industry provides many by-products to be used in cattle diets. For the purposes of this paper, peanut skins and peanut hulls will be discussed. Production trials were carried out to evaluate their effectiveness in growing cattle diets. Peanut skins were fed in conjunction with soybean hulls to determine the ratio at which they would most complement one another. Peanut hulls, which are considered a roughage source, were fed in pelleted and loose form, with and without hay, to assess their effectiveness as roughage when fed in conjunction with pelleted corn gluten feed.

REVIEW OF LITERATURE

Stocker Cattle

The southeastern United States has the ability to produce high-quality winter annual forages in most years. There are five common fall stocker programs in Alabama which include: (1) winter grazing light-weight stocker calves (160 kg), (2) winter grazing medium-weight stocker calves (200 kg), (3) winter grazing stocker calves (180 kg) on winter grazing with supplemental feed, (4) grazing stocker calves (180 kg) on stockpiled novel endophyte fescues, and (5) stocker calves (200 kg) fed in dry-lot using a by-product-based diet(Prevatt et al., 2009). In years of drought and other less than optimal conditions, the operator will have to supplement with grain and/or by-products until forages are ready, or in some cases, soley feed a ration in dry-lot. The goal of the stocker operator is to obtain weight gains of 0.68 – 1.13 Kg/day with minimal cost. In order to achieve this, the diet must be adequate in energy and protein (Lusby, 2006). Feed is usually the largest cost in any beef operation (Rankins, 2002).

Alabama stocker cattle also are influenced largely by the cattle and price cycles. The cattle cycle is the period of time between lowest cattle inventory numbers. The general belief is that cattle inventory numbers increase in times of higher cattle prices and decrease in times of lower market prices. The price cycle defines the seasonality of market prices. Though prices change annually, seasonal trends typically stay constant.

The Alabama price cycle for 180-200 kg feeder steers indicates that October typically has the least cost index. The weight reflects the initial weight of most stocker cattle and October is often the purchasing month. The pricing cycle for cattle weighing 320-365 kg reaches its highest price index in August; however, most stocker calves are maintained until forage is depleted which is typically April to May. Though this is not the peak price index for feeder cattle of this weight range the price index is in the upswing (Prevatt et al., 2010).

By-products

By-product feeds are for the most part the result of food and fiber production. With a steady rise in population there also will be an increase in these by-products. In previous years, the solution for disposing of the residuals was incineration, landfill dumping, and land application. Incineration has declined in recent years due to increasing environmental concerns. Thus, with a need to rid the facilities of built up by-products, much of it is disposed of in landfills or for some materials it is land applied. Crop residuals such as cotton gin trash are sometimes land applied to act as a soil amendment. In a study by Fryrear and Koshi (1974) lint yield increased 16% to 36% when 11 metric tons of cotton gin trash were applied per hectare. Land application of gin trash increases water retention and also decreases the bulk density of the soil (Koshi and Fryrear, 1973). The use of gin trash as a soil amendment has the potential to increase yields; however, it can also spread weed seeds and disease to the growing cotton plants (Mayfield, 1991). With the high cost of disposing of by-products in a landfill, by-products have become quite economical for use as livestock feedstuffs (Hill, 2002). Economics will continue to drive the use of by-product feeds, however, the consumer's growing interest in production methods have to be taken into account. There has to be a balance between economics and consumer acceptance of beef products which were fed certain alternative feeds (Rankins, 2004).

Traditional feeds such as grains and oilseed meals are typically used to finish cattle; however, with cattle on forage-based diets such as stocker calves or a cow calf operation, they are not the most economical or efficient. By-products are ideal for forage-based diets because they are typically low in starch, moderate in protein and most importantly low cost (Poore et al., 2002). Supplements are usually necessary to meet the energy and protein requirements of the animal; however, as the fiber increases in the forage and starch increases in the supplement, forage intake as well as digestibility decreases. By-products are typically low in starch but still adequate in energy because of the highly digestible fiber fraction of the feedstuff. This allows for proper intake and utilization of the forage as well as meeting the animal's requirements for energy (Lusby, 2006).

Beef cattle operations are one of the more prominent users of alternative feeds. Cattle work well with by-product feeds because of the rumen's ability to transform these feeds into substrates that can be utilized by the animal (Chase, 1982). There are many sources of by-products that can be feasible depending on proximity of the cattle producer to the facility. Some of the issues to be aware of before implementing by-product feed into a cattle operation include: transportation and storage, moisture content, nutrient profile, contaminants, and availability (Rankins, 2002).

Many by-products have a low bulk density, making them difficult to transport. Transportation accounts for most of the cost associated with feeding by-products. Most commodities will be hauled in a tractor trailer as 21.8 metric ton loads. However, a load of the by-product peanut skins may only weigh 13.6 metric tons, which dramatically decreases hauling capacity, and increases the cost associated with transporting the desired amount. The low bulk density of peanut skins also can be problematic when mixing feed ingredients (Rankins, 2002).

Moisture is also a concern with many by-products. It is a common practice in certain regions for cotton gins to spray gin trash with water to decrease dust, thereby increasing its weight. With this increase in weight due to water, the price on a dry matter basis will increase. Other feedstuffs such as corn gluten feed have the steep water added back, at which point it can go on to be dried or sold as a wet feed. With high moisture feeds it is crucial to calculate cost on a dry matter basis, when compared to a feed that is of low moisture the price may seem to be low until the actual dry matter price is calculated (Rankins, 2002). High moisture feeds are more prone to spoilage if not tightly sealed. This makes them more suitable for large operations, such as dairies or feedlots that go through feeds more quickly (Poore et al., 2002).

Contamination is a concern with many by-products. With excess moisture, stored feed is more prone to fungal growth which can lead to the formation of mycotoxins. For example, feed having an aflatoxin concentration over 20 ppb should not be fed to immature animals such as stockers (FDA, 1989). Handling moldy feed can also lead to respiratory problems. Apart from mycotoxins, by-products often will be accompanied by weed seeds and possibly pesticides if the by-product was derived from row crops such as cotton (Rankins, 2002). Producers utilizing alternative feed sources should be aware of possible contaminants and take extra precautions.

The nutrient profile of the alternative feed may be quite variable, making it important for the producer to collect feed samples for analysis. For example corn gluten feed is quite consistent from one facility; however, there is a lot of variation among facilities. Corn gluten feed is a result of the wet milling of corn to produce starch, oil, and syrup. The feed is high in protein and TDN, but with excess heating during the drying phase digestibility may be decreased (Rankins, 2004).

By-product feeds are typically available year round; however, prices tend to be seasonal due to supply and demand. The supply of most feedstuffs is typically the highest in summer and fall months. At this time feed can be purchased at the most reasonable price, especially if purchased in truck load amounts (22 metric tons). During the winter months feedstuffs are in higher demand, thereby increasing their price. In order to obtain feed at the best price the producer must have proper facilities to accommodate large quantities of feed (Prevatt and Prevatt, 2007).

Soybean hulls

Soybeans are a staple crop in American agriculture (Poore et al., 2002). In the 2009 production year there were over 90 million metric tons of soybeans harvested and over 31.4 million hectares were planted (NASS, 2010a). The primary product of soybean production is soybean oil. Soybean crushing is the mechanical means of obtaining soybean oil and its co-product soybean meal. In the 2009/2010 production year the projected domestic crushing rate was approximately 45.5 million metric tons and the majority of those remaining from the total were exported (United Soybean Board, 2010). With this process, the by-product soybean hull or skin is ground off. Soybean hulls like many by-product feedstuffs are quite small and of low density, making them quite difficult to transport. Crushing yields approximately 8% soybean hulls (Klopfenstein and Owen, 1987), so in 2009/2010 production year there were approximately 3.6 million metric tons of hulls produced.

The traditional use of soybean hulls was as "filler" in soybean meal to maintain 44% CP in the final product. Because of their high fiber content, soybean hulls are considered of low value in monogastric diets. However, this makes them ideal for cattle on forage because they do not decrease fiber digestibility, as most energy supplements do. This also makes soybean hulls a readily available feed source for ruminant diets. The fiber portion of soybean hulls is low in lignin, making them potentially digestible for ruminant animals (Anderson et al., 1988)

The nutritive value of soybean hulls show that they have an approximate crude protein concentration of 12 %, however the TDN level is quite variable. According to Waller (2010) the TDN value is 77%. Soybean hulls are composed primarily of digestible fiber, with a NDF (neutral detergent fiber) value of 60.3%. Corn is high in digestible energy most of which is starch. The starch fraction drastically decreases forage digestibility and intake (Anderson et al., 1988). With soybean hulls being practically devoid of starch this makes them an ideal supplement for cattle on forage. Soybean hulls reflect a lower TDN value than corn but when supplemented to cattle on forage diets this value is equal to that of corn because of soybean hulls' positive impact on forage intake and digestibility. Along with their TDN fraction, soybean hulls also have a greater crude protein content than corn (Rankins, 2004). Soybean hulls also work well in dry-lot situations because of their user-friendly characteristics. For example, soybean hulls are less likely to cause metabolic acidosis and founder. However, with any feed, concentrate or by-product, these problems can arise without proper management. With that being said, if the cattle are allowed free-choice access to moderate quality hay in a self feeding situation with soybean hulls, the risk is significantly less than when feeding concentrates (Poore et al., 2002).

Transportation of intact soybean hulls can be problematic due to their low bulk density. With this in mind many processors will pellet or grind soybean hulls to provide a more shippable product. Anderson et al (1988) researched the effects of grinding and pelleting soybean hulls on nutritive analysis. Their findings indicated that above a grind size of 1.5 mm there is no decrease in digestibility. Soybean hulls also have a good storage life and can be kept in grain bins or commodity barns for 6 months or longer (Poore et al., 2002). Another issue faced when feeding soybean hulls is bloat, however, this is only a problem in growing cattle (Rankins, 2004).

Corn gluten feed

Corn is the most prevalent grain crop in the United States (Poore et al., 2002). In the 2009 growing year, over 330 million metric tons were produced from over 35 million hectares (NASS, 2010b). Approximately 80% of the corn is used directly to feed livestock. Ethanol and human food products are achieved through various processing methods (Poore et al., 2002), which produce by-products resulting in livestock feeds. One of the more prominent alternative feeds of corn production is corn gluten feed. Corn gluten feed is a residual of wet milling of corn to produce cornstarch, oil, and syrup.

The wet milling process is started by first screening the grain to cut out debris and damaged kernels. The clean corn is then placed in a weak sulfurous dioxide steep. This acts to loosen the bran and disrupt the protein matrix of the endosperm which releases the starch granules. Further mechanical processing separates the endosperm from the bran and germ. The endosperm is composed of starch and protein, and through centrifugation goes on to produce purified starch and gluten protein fraction. The gluten protein fraction is dried to make corn gluten meal (Poore et al., 2002). The separated germ is used for oil production, leaving bran as the last component. Corn gluten feed is primarily composed of bran and steep liquor; this product can either be sold wet or dry. Some processors add some of the screening back and pelletize the feed, obviously increasing the ease of transport (Stock et al., 1999).

The bran portion of corn gluten feed is primarily composed of digestible fiber and the steep liquor component contains digestible protein, soluble carbohydrates, and other soluble components. Corn gluten feed has a potential fiber digestibility similar to that of soybean hulls (Cordes et al., 1988).

The nutrient content of corn gluten feed is approximately 22% CP and 80% TDN (Waller, 2010). These numbers will vary depending on the processor and how much screenings and steep liquor are added to the feed. The protein portion is highly degradable in the rumen due to the steeping process that dissolves the protein (Poore et al., 2002). The energy portion is almost as high as that of corn which is around 88% TDN (Waller, 2010); however, the sources of energy are different. With corn the majority of the energy comes from the endosperm or starch component and with corn gluten feed the energy arises from the bran or fiber portion. With that being said, this makes corn gluten feed an ideal supplement for cattle on forage because it will have limited effects on fiber digestibility (Myer and Hersom, 2008). The feed is high in P (0.82%) and low in Ca (0.10%) (Waller, 2010). This makes it advantageous to use the feed with cattle on low P forage; however, supplemental Ca will be needed when P is adequate and Ca is low (Poore et al., 2002). Another potential problem is excessive sulfur in the feed, because of the sulfurous dioxide added to separate the starch component. The sulfur concentration of corn gluten feed typically averages 0.5% after the steep water is added. The dietary sulfur requirement for beef cattle is 0.15 to 0.2% with an upper safe limit of 0.4%. Exceeding this limit can result in a decrease in feed intake, copper deficiency, or in severe cases polioencephalomalacia (Myer and Hersom, 2008). This makes it imperative to have feed sampled especially in known high sulfur areas. In case of high sulfur feed, limit feeding will need to be implemented.

Peanut history

Peanuts were first discovered in South America, before being spread by Spanish explorers. South Carolina grew peanuts commercially in the 1800's, however they were difficult to grow and even more difficult to harvest. Peanuts were used for oil, food, and a cocoa substitute. At the time the cultivars were poor, and people considered the peanut to be food for the poor and livestock which prevented them from being grown readily at the time. It was not until the 1860's that the peanut saw an increase in consumption. This marked the beginning of the Civil War and peanuts were packed away in soldiers pockets and carried with them to war. Soon after, around 1900, with the advent of new labor saving equipment, peanuts came into demand. Shortly after that, the botanist, George Washington Carver, developed more than 300 uses for the peanut and vastly improved cultivars. At this time in the early 1900's he encouraged many southern producers to implement the peanut in their rotation with cotton, which was being plagued by the boll weevil (National Peanut Board, 2010).

Peanuts are grown in areas with a temperate climate and sandy soils. Their production area is centered in the Southeastern United States extending into Central Texas, Eastern New Mexico, and Eastern Oklahoma. In 1939, 24.7% of the acreage planted in the Southeast was used for "hogging-off" (used for swine consumption). The other 75% of the acreage was used to feed cattle after the nuts were harvested (Parham, 1942). Due to vertical integration of swine operations less than 3% of peanut acreage is grown out for pigs; however, peanut hay is still common in the Southeastern United States (Hill, 2002). In 2009, U.S. peanut production was 1.67 billion kg produced from 437,000 hectares, with an average yield of 3823 kg/hectare (NASS, 2010c).

Peanut By-products

The peanut industry supplies many by-products. Peanut hay is available after peanuts are harvested and is composed of the vines and peanuts missed by harvesting equipment. The bulk of peanut by-products arise from peanut processing, which include broken and cull peanuts, peanut meal, peanut skins (testa), and peanut hulls (Hill, 2002).

Peanut Hay

Peanut hay is produced wherever peanuts are produced and is typically utilized as a winter supplement for beef cattle. This hay source is available in the fall where dry conditions typically prevail in the Southeast making for a quality hay crop. Along with optimal harvesting conditions there are large quantities of the residual vine material available at one time that can be baled in a short period of time possibly meeting the cattle producer's annual roughage needs. This is contrary to grass hay production that spans over the spring and summer months and requires large quantities of fertilizer (Hill, 2002). The fertilizer requirements for peanut production are quite insignificant as compared to row crops such as corn. Peanuts, being a legume, do not require supplemental nitrogen as long as the pH is kept within the range of 6-6.5 (Wright et al., 2009). Peanuts have a list of required nutrients; however, in past years nitrogen is typically of most cost because of its link to fuel prices.

The nutrient content of peanut hay is based on many factors. Harvesting equipment, harvest conditions, and storage are the main factors that affect the quality of hay. Harvesting peanuts is carried out by first digging and inverting the peanut plants with harvesting machinery. The material is then allowed to dry for a number of days and then combines run over the rows picking up plants. The peanuts are then separated from the plant materials, collected, and the plant materials are ejected out the back of the combine. At this time, if hay is to be baled and moisture is low enough, a hay baler will follow behind. The amount of peanuts left behind along with the vines varies based on the combine used and the operator. Obviously the fewer peanuts left behind by the combine the better it is for the peanut producer; however, with additional peanuts left to be baled, the higher the hay quality. As with any hay, weather conditions play a crucial role in its quality. The length of time and rainfall after digging can significantly affect the hay. Storage is a key player in assuring hay is kept at its best. It is especially critical with peanut hay because of its coarse viney nature. With that being said it is quite permeable to rain, so if kept in the elements it will deteriorate rapidly (Hill, 2002). The nutrient content is as follows: 13 to 17 % CP, 52 to 57 % TDN, and the ash content is typically around 8% because of the attached dirt (Rankins, 2004).

Cull Peanuts

Cull peanuts are peanuts that for whatever reason are turned down for human consumption and make it into livestock diets. Some of the more common reasons for peanuts being culled are broken shells, abnormal size, or high aflatoxin content (Hill, 2002). Whole peanuts are high in energy because of their high oil content. As long as mycotoxin concentrations are below a tolerable amount they make ideal supplements in beef cattle diets.

Peanut meal

Peanut meal is a by-product of peanut oil production and is available in peanut producing areas. However, peanut meal is usually not priced competitively with soybean meal and cottonseed meal because most of the peanuts produced are kept intact or used for peanut butter (Hill, 2002). The ash, CP, and TDN of solvent-extracted peanut meal is 6.3%, 52.3%, and 77.0% respectively (Waller, 2010). Comparing peanut meal and soybean meal, shows that peanut meal has a higher concentration of niacin, pantothenic acid, riboflavin, and thiamin, but essential amino acids lysine, methionine, and tryptophan are lower in peanut meal (Pond and Manner, 1974). When peanut meal was substituted for soybean meal in growing pig diets at levels up to 50 % there was no alteration in performance (Kornegay et al., 1968). Using peanut meal as a supplement in ruminant diets would not pose a problem because ruminants are less dependent upon dietary amino acids as compared to non-ruminants (Hill, 2002).

Peanut Hulls

After harvesting peanuts, they are then transported to a processing facility where they are dried and stored. At this point they are sent to a sheller, where the shell or hull is separated from the nut. Peanut hulls account for approximately 20% of the dried peanut pod by weight, meaning there is a substantial amount of hull residual left after peanut processing (Hill, 2002). As of April 30, 2010, the farmer stock equivalent peanut production was 1.25 mill metric tons, resulting in 250,000 metric tons of peanut hulls produced in the United States (NASS, 2010c). In past years peanut hulls have been disposed of by incineration outside of the shelling facilities. With environmental concerns in mind, other means of disposal have been sought out. Peanut hulls have been used as fuel for running boilers in manufacturing processes, mulch, bedding in poultry houses, soil conditioners, kitty litter, carriers for chemicals and fertilizers, and most important to this paper, peanut hulls are often used as a roughage source in cattle diets (Hill, 2002).

The nutritive analysis of peanut hulls is as follows: 22% TDN, 8 to 10% CP, 76% NDF, 65% ADF, and 5% ash (Waller, 2010). The nutrient content of the feedstuff varies with different shelling facilities, and comes about with the addition of peanut skins, shriveled nuts, and amount of debris left in the feed (Hill, 2002). Once again with most by-product feeds there is an issue with transported peanut hulls because of their low bulk density. With that being said many processors will grind and pellet the feed. This tremendously increases the hauling capacity; however, it is thought to decrease the usefulness of the feedstuff as a roughage source.

The fiber content of feeds arises from plant cell wall components which are made up primarily of carbohydrates.   The components are hemicellulose, cellulose, lignin and soluble fiber (fructans, pectans, galactans, and beta-glucans). Hemicellulose, cellulose, and lignin are insoluble in NDF. As the percent NDF increases in the diet, dry-matter intake decreases. ADF encompasses the cellulose and lignin. As this value increases there will be a decrease in dry matter digestibility. In order to prevent nutritionally inflicted health issues in ruminants there must be an ample fiber source in the diet. The roughage efficacy is based on the amount of effective fiber or eNDF in a ration. This refers to the percentage of NDF which promotes chewing and salivation, rumination and rumen motility (Parish and Rhinehart, 2008).

As ruminants consume fibrous material with adequate particle size rumination is initiated which prompts the secretion of saliva. Saliva acts as a buffer to increase pH in the rumen above 6 in normal situations. Typically by-product feeds have a high fiber content; however, in most cases the fiber portion is highly digestible with little use as an effective fiber. When feeds high in digestible fiber such as soybean hulls are substituted for high starch feeds a higher pH will result, but rumination will cease because they lack the fiber effectiveness that results in rumen “scratch factor” (Garcia and Kalscheur, 2005). It is thought that without adequate fiber particulate length normal rumen function will cease because of its inability to form a rumen mat. The mat prevents rumen contents from passing too rapidly through the rumen, allowing adequate time for microbial action to take place. Some of the more apparent signs of roughage deficiencies are variation in feces (mucus from small intestine buffering), cessation of cud chewing and salivation, increased respiratory rate, and a decrease in intake and production (Parish and Rhinehart, 2008; Garcia and Kalscheur, 2005). This is common in high grain finishing diets because starch content increases in the diet which promotes starch degrading microorganisms in the rumen and a subsequent decrease in fiber digesting microorganisms. Though the roughage content is typically low in finishing diets, one of its main benefits is to decrease grain intake by causing rumen fill, thereby decreasing ruminal acidification. Ionophores also have been shown to decrease intake and control rumen pH fluctuation (Parish and Rhinehart, 2008).

Effective fiber is known to have positive effects on animal health; however, the exact measurements remain uncertain. Some researchers say that the minimum particle length of 6.35 mm is adequate for chopping dry hay where fiber dominates the diet and nutritional management is high, but in most production systems the particle length should not go below 12.7 mm (Parish and Rhinehart, 2008). Particle length can be determined using the Penn State particle separator (PSPS), which has the ability to make three particle sorts (Heinrichs and Kononoff, 2002). The first sieve collects particles greater than 19 mm. Particles of this length are crucial in forming the rumen mat and possess the greatest ability in stimulating rumination. The second sieve separates particles sizes between 19 and 7.9 mm. These particles have a moderate rate of digestion and flow. Particles collected in the last sieve measure between 7.9 and 1.7 mm and are critical in reticulo-rumen retention (Poppi et al., 1985). The PSPS has made huge strides in an attempt to quantify estimates of particle size. A reduction in particle size can increase dry matter intake, digestibility, and decrease bunk sorting. With particle sizes that surpass 19 mm there may be more bunk sorting and a decrease in dry matter intake; however, there will be an increase in rumination which works to increase buffering from saliva production (Kononoff and Heinrichs, 2007). An exact particle length that works to most efficiently accommodate animal growth and health is not known. There are many numbers available, but all vary with type of ration fed. With that being said, there is no substitute for proper bunk management. It is imperative to monitor cattle, and as a rule of thumb, when cattle are resting approximately 50% of the cattle should be ruminating (Garcia and Kalscheur, 2005).

Utley and others (1973) examined unground, ground, and pelleted peanut hulls as a roughage source in steer finishing diets. In their study, peanut hulls were subjected to one of the three processing methods to determine effectiveness as a roughage source. Peanut hulls that were ground and pelleted were ground through a 3.2 mm screen. The diet was composed of 72.8% ground shelled corn, one of the three peanut hulls at 20%, and 7.2% Tift-50 supplement. The Tift-50 supplement was composed of 8.5% ground shelled corn, 7.5% urea, 70% cottonseed meal, 5.5% ground limestone, 3% defluorinated rock phosphate, 5.5% trace mineralized salt, and 33,000 IU vitamin A per kilogram of supplement. Animals were allowed *ad libitum* access to water and trace mineralized salt. Eighty-one yearling crossbred steers were assigned randomly to 9 lots of 9 steers. Steers were on feed for 133 days and weighed every 28 days to monitor performance. At the end of the trial, steers were harvested and livers examined. The group also conducted a digestibility study. The study was carried out over two years. The results of the feedlot trial were not significantly ($P>0.05$) different among treatments. However, two of the nine steers in the ground peanut hull diet went off feed and were not included in the results. Post-mortem examination of the two steers showed gross rumen hyperkeratosis and liver abscesses. One to three steers in all the other replications of the ground and pelleted diets exhibited extremely poor weight gains. These results indicated that decreasing the particulate length of the peanut hull decreases their effectiveness as a fiber source. Supporting these results all steers in the unground peanut hull diet had uniform weight gains and only one of the 27 had liver abscesses, where 14 of the 25 fed ground hulls and 16 of the 27 fed pelleted hulls had liver abscesses at harvest.

Peanut hulls have a high potential as a roughage source. In years of drought where limited forage and roughage sources prevail, they provide an alternative to hay especially in the southeastern United States where peanut production thrives. In whole form, peanut hulls are quite cumbersome and difficult to transport. Pelleting peanut hulls vastly improves their logistics and storage, given they are readily available in the Southeast this makes them an ideal feedstuff. However, for them to be acceptable they must work as an effective fiber source.

Peanut Skins

Peanut skins are readily available peanut by-products that result from blanching. Peanut blanching is the mechanical separation of the skin (testa) from the kernel. After separation the skins are dried and stored until transport. The annual United States production of peanut skins is estimated to be between 20,000 and 30,000 metric tons (Hill, 2002). At this point they may have a number of uses. They are often used to suppress odors in swine waste pits and in laying hen houses (Newton, 1981; Reynnells et al., 1985), but for the purposes of this paper their use in cattle diets will be discussed. The nutritive value of skins is 65% TDN, 17-18% CP, and 25-30 % ether extract (Waller, 2010). Some of the problems associated with feeding peanuts skins are their low bulk density and tannin content. Peanut skin's low bulk density poses many problems. Where 22 metric tons of a normal feedstuff would be delivered in a tractor trailer load typically there could only be 14 metric tons of peanut skins delivered. Their low bulk density also makes them difficult to mix in a cattle diet (Rankins, 2002).

Tannins are naturally occurring plant polyphenols. The word tannin comes from the process of tanning hides, which is a means of preserving or waterproofing leather by using plant extracts. Haslam (1989) defined tannins as water-soluble polymeric phenolics that precipitate proteins, however, this definition is often too restrictive for this diverse group of plant compounds when nutritional effects are considered (Reed, 1995). Horvath (1981) defined tannins more broadly: “any phenolic compound of sufficiently high molecular weight containing sufficient phenolic hydroxyls and other suitable groups (i.e., carboxyls) to form effectively strong complexes with protein and other macromolecules under particular environmental conditions being studied.” Tannins are divided into two categories: hydrolyzable and condensed tannins (proanthocyanidins). Hydrolyzable tannins are of less prominence in nature and can be found in tree species such as oak, which when fed to ruminants are converted to metabolites by microbial action and can be fatal. Condensed tannins are more prominent in nature and are found in many food items. They are seen in items such as various legumes, fruits, teas, chocolate, etc. They account for the astringent taste in peanut skins and other food in which they abound. Apart from providing an off taste in feedstuffs they also have the ability to form polymers with nutrients making them nutritionally unavailable. One of the most affected nutrients is protein. To further complicate matters they also bind enzymes necessary for proteolytic activity (Goldtein and Swain, 1965; Cannas, 2009). There is often a decrease in intake when condensed tannin containing feeds are used. This is attributed to the bitter taste as well as lower digestion rate of the feed, which results in gut fill. In order to avert detrimental effects on production, condensed tannin content in the diet should not exceed 6 % (Cannas, 2009).

Some ruminants such as deer and goats that typically consume high-tannin diets are less affected by tannins because of the proline-rich protein saliva which deactivate tannins to a large extent. Proline-rich proteins are more convenient for the animal to exploit, because proline is a non-essential amino acid (Cannas, 2009).

When using feedstuffs known to contain condensed tannins it is advantageous to have the feed analyzed to determine tannin content. This is difficult to determine because there are numerous methods for the determination of condensed tannins but none are completely satisfactory for determining nutritional effects. Many of the chemical properties that cause the reactivity with polyphenols differ from the properties that cause nutritionally toxic effects (Reed, 1995). Some of the hindering factors involved in determining tannin content are sample preparation, suitability of standards, and more specific to condensed tannins, often a significant percentage is not extractable or insoluble in aqueous organic solvents (Bates-Smith, 1973; Stafford and Cheng, 1980).

When condensed tannins are fed at levels in the diet which do not exceed 4%, positive effects can be seen. Condensed tannin containing feeds decrease ruminal gas formation and microbial deamination by condensed tannin and plant protein interaction (Jones and Lyttleton, 1971; Waghorn and Jones,1989; Min et al., 2003). At moderate levels in the ration there have been increases in nitrogen retention in cattle and sheep. Some of the reasons for this are increase rumen bypass protein, increased urea recycling, and increased microbial efficiency (Cannas, 2009).

Many strategies have been evaluated to negate the ill effects brought about by tannin containing feeds. Some researchers have included higher than normal protein diets to compensate for protein deficiencies brought about by tannins. Utley and others

(1993) examined the substitution of peanut skins for soybean hulls in steer finishing diets containing recommended and elevated crude protein levels. The recommended protein level diets were of 10.5 % CP with peanut skins substituting at the rate of 0, 7.5, and 15%. The high protein diets were 15.5% CP and had the same substitution rates of peanut skins for soybean hulls. The results of their study indicated that when steers were fed the recommended protein diets with increasing peanut skins average daily gain, dry matter intake, and feed:gain ratios decreased linearly ($P < 0 .01$). When the steers were fed the high protein diets with increasing peanut skins average daily gain and dry matter intake increased linearly ($P < 0.05$). Their results indicated that when animals were fed a 15% soybean hull diet, peanut skins can replace half of the soybean hulls when the diet is at the recommended CP level of 10.5%. When the CP level of the diet is increased to 15.5%, peanut skins can completely replace soybean hulls in a 15% soybean hull diet.

Peanut skins work well to compliment the energy as well as protein requirements of beef cattle, when fed in conjunction with soybean hulls. They also have the potential to decrease the incidence of bloat brought about by feeding soybean hulls to growing cattle. Bloat can be averted by feeding an ionophore or in some cases by incorporating feeds or forages that contain condensed tannins (Rankins, 2004). Legume type forages that contain condensed tannins have been shown to decrease bloat (Min et al., 2003). Peanut skins are known to contain tannins, thus when fed in conjunction with soybean hulls they could possibly decrease this problem. To further their usefulness skins are more cost effective, compared to soybean hulls, peanut skins are typically half the price.

Summary

By-product feeds provide cattle producers with a low cost alternative to many grain products. Using by-products as cattle feed also provides processing facilities an alternative means of disposal. The Southeast provides much of the United States with peanuts. There are ample supplies of peanut by-products here that must be disposed of and much of the residual is used for cattle feeding.

Peanut hulls are comparable to a low quality hay. When fed without alteration, peanut hulls work well to provide normal rumen function and subsequent production. However, as with peanut skins, they have a low bulk density making them difficult to transport. Because of this many processors grind and pellet peanut hulls, but this has been shown to reduce their effectiveness as a roughage source.

Peanuts skins are high in energy and protein making them complimentary to soybean hulls, which are used extensively in the cattle industry. Peanut skins are also known for their tannin content which in some cases can be detrimental to production. However, when fed in conjunction with soybean hulls, peanut skins could potentially prevent bloat that comes about when soybean hulls are used.

The purpose of our research was to evaluate the usefulness of peanut skins and peanut hulls in the cattle feeding industry. In addition to average daily gains and dry-matter intake, roughage efficacy also was examined when peanut hulls were fed in loose and pelleted form.

RESEARCH PROBLEM STATEMENT

Soybean hulls have been used in cattle diets because of their low starch content, and price competiveness. Soybean hulls decrease incidence of ruminal complications; however, when fed to growing cattle there is an increased risk of bloat (Rankins, 2004). Forage legumes also are known to produce bloat. Research trials have proven that when legume forages are fed in conjunction with feeds or forages that contain appreciable tannin concentrations bloat can be reduced (Min et al., 2003). Peanut skins which are of greater protein and energy content than soybean hulls also possess tannins. No steers bloated when diets containing a combination of peanut skins and soybean hulls were fed. Utley et al. (1993) showed that when peanut skins substituted for soybean hulls at recommended protein levels, peanut skins can replace half (7.5%) of a 15% soybean hull ration. If the protein level is elevated to 15.5% then peanut skins can replace all of the soybean hulls.

Effective fiber is crucial to insuring successful cattle feeding (Parish and Rhinehart, 2008). When peanut hulls are fed intact or unground, they are quite difficult to transport due to their low bulk density. Pelleting peanut hulls increases their shipping and mixing potential; however, it is thought that this severely decreases their effectiveness as a roughage source. Utley et al. (1973) showed increased incidence of liver abscesses, decreased feed intakes, and decreased ADG with increasing concentrations of pelleted and ground peanut hulls as the roughage source in a diet.

Average daily gain and dry matter intake data was collected in a multi-year production trial in which peanut skins and peanut hulls were fed. In the first two trials, peanut skins substituted for soybean hulls in increasing amounts. In the third year of the study, pelleted corn gluten feed was fed in conjunction with peanut hulls. Peanut hulls were fed in loose and ground pelleted form with and without hay to examine the effect of peanut hull form on roughage efficacy.

MATERIALS AND METHODS

Three production trials were conducted at the Wiregrass Research and Extension Center in Headland, Alabama. All experimental procedures were reviewed and approved by the Auburn University Institutional Animal Care and Use Committee.

Data Collection

Experiment 1

Twenty-seven Brangus x Continental steers (initial BW 261 kg) were assigned randomly to one of three diets and fed for 84 days (three steers/pen; three pens/diet). Pens were 0.2 hectare dry-lots containing a covered feed bunk 3.1 m in length. On a dry-matter basis, diets were as follows: 1) 100% soyhulls, 2) 80% soyhulls and 20% peanut skins, and 3) 60% soyhulls and 40% peanut skins. Steers had *ad libitum* access to these mixtures and bahiagrass hay. The hay was offered as round bales in a hay ring. In addition, all treatments were allowed free-choice access to trace mineral salt with lasalocid and an insect growth regulator (Rabon ®). The calves were weighed initially and then on 28-day intervals throughout the 84-day trial. Feed and hay intakes were monitored throughout the study.

Experiment 2

Everything was the same as experiment 1 except the average initial BW was 264 Kg.

Experiment 3

Twenty-seven Angus x Continental steers (initial BW 277 Kg) were assigned randomly to one of three diets and fed for 106 days (three steers/pen; three pens/diet). Pens were 0.2 hectare dry-lots containing a covered feed bunk 3.1 m in length. On a dry-matter basis the diets, were as follows: 1) 50% corn gluten feed pellets, 50% peanut hull pellets, and free choice bahiagrass hay, 2) 50% corn gluten feed pellets, 50% loose peanut hulls, and free choice bahiagrass hay, and 3) 50% corn gluten feed pellets, 50% peanut hull pellets, and no hay. Steers had ad libitum access to diets and trace mineral salt with lasalocid and an insect growth regulator (Rabon®). Steers were weighed prior to the study and every 28 days throughout the 106-day trial. Feed intake was measured weekly during the trial.

Lab analysis

All feed samples were ground to pass a 2-mm screen using a Wiley mill. Chemical analyses were duplicated for each sample. All analyses were performed in accordance with procedures described by the Association of Official Analytical Chemists (AOAC, 1995). Dry matter, CP, NDF, and ADF were determined for each sample. The amount of crude protein in each sample was determined using the Kjeldahl method (AOAC, 1995). NDF and ADF for all samples were determined sequentially using the Van Soest method (Van Soest et al., 1991). These procedures were carried out using an ANKOM$^{200/220}$ Fiber analyzer and ANKOM Technology F57 Filter Bags. The concentration of condensed tannins in the peanut skins was determined by a commercial lab using the methods of Terrill et. al. (1991).

Statistical Analysis

All experimental data were analyzed as a completely randomized design using GLM procedures of SAS. Pen was the experimental unit. Following significant F-test, experiment 1 and 2 means were separated using linear and quadratic contrast statements. Following significant F-test in experiment 3 means were separated using least significant difference.

RESULTS

Nutrient composition of soybean hulls and peanut skins used to formulate diets in experiments 1 and 2 are shown in Table 1 as well as the nutrient composition of the bahiagrass hay. Table 2 shows the nutrient composition of the final feed mixture used in experiments 1 and 2. Nutrient composition of corn gluten feed pellets, peanut hull pellets and loose peanut hulls are reported in Table 3. Table 4 shows the nutrient composition of feed mixtures in experiment 3.

Experiment 1

Performance data from Experiment 1 are shown in Table 5. Initial BW was not different ($P>0.05$) across treatments. Final BW and ADG decreased linearly ($P<0.05$) as the amount of peanut skins increased in the diets. Feed intake and total intake decreased linearly ($P<0.01$) as peanut skins increased in the diets. There was a quadratic decrease ($P<0.05$) in hay intake as peanut skins increased in the diets.

Experiment 2

Results of Experiment 2 are shown in Table 6. Initial BW was not different ($P>0.01$) across treatments. Final weight, ADG, feed intake, and total intake decreased linearly ($P<0.01$) as peanut skins increased in the diet. Hay intake increased linearly ($P<0.01$) as peanut skins increased in the diets.

Experiment 3

Results of Experiment 3 are shown in Table 5. Initial BW was not different (P>0.05) across treatments. Final BW was not different (P>0.05) among pelleted peanut hull diets, with and without hay, however the loose peanut hull diet was lower (P>0.05). Average daily gain, feed intake, and total intake were not different (P>0.01) among pelleted peanut hull diets, with and without hay, however, they were greater (P<0.01) than the loose hull diets. Hay intake was greater (P<0.01) for the loose peanut hull diets as compared to the pelleted peanut hull diets with hay.

Table 1. Average nutrient composition of peanut skins, soybean hulls, and bahiagrass hay used in experiments 1 and 2

Nutrient[a]	Peanut skins	Soybean hulls	Bahiagrass hay
DM, %	91.0	91.0	91.0
NDF, %	39.6	56.9	76.0
ADF, %	32.7	42.2	38.0
CP, %	18.3	11.4	11.6
Condensed Tannins, %	4.13	-	-

[a]Dry-matter basis

Table 2. Average nutrient composition of experiment 1 and 2 feed mixtures

	Feed mixture[b]		
Nutrient[a]	100 : 0	80 : 20	60 : 40
DM, %	91.0	91.0	91.0
NDF, %	56.9	53.4	50.0
ADF, %	42.2	40.3	38.5
CP, %	11.4	12.8	14.2
Condensed tannins, %	-	0.8	1.6

[a]Dry-matter basis

[b]% soybean hulls : % peanut skins

Table 3. Nutrient composition of pelleted peanut hulls, loose peanut hulls, corn gluten feed pellets, and bahiagrass hay used in experiment 3

Nutrient[a]	Pelleted peanut hulls	Loose peanut hulls	Corn gluten feed pellets	Bahiagrass hay
DM, %	91.6	87.4	91.7	89.3
NDF, %	70.7	76.2	36.3	72.8
ADF, %	60.6	64.9	9.3	35.4
CP, %	8.9	9.3	16.8	9.4

[a] Dry-matter basis

Table 4. Nutrient composition of corn gluten feed/ peanut hull mixtures

	50 : 50 mixture[b]	
Nutrient[a]	Pelleted	Loose
DM, %	91.6	89.5
NDF, %	53.5	56.2
ADF, %	34.9	37.1
CP, %	12.8	13.0

[a]Dry-matter basis

[b]Diet 1 = 50% pelleted peanut hulls + 50% pelleted corn gluten feed, Diet 2 = 50% loose peanut hulls + 50% pelleted corn gluten feed with bahiagrass hay, Diet 3 = 50% loose peanut hulls + 50% pelleted corn gluten feed without bahiagrass hay

Table 5. Body weights, daily gains and daily intakes for steers fed three mixtures of soybean hulls and peanut skins and offered bahiagrass hay (Experiment 1)

	Soybean hull : Peanut Skin Mixtures			
	100:0	80:20	60:40	SE
Initial wt, Kg	262	260	262	6.2
Final wt, Kg[a]	413	391	384	8.0
ADG, Kg/d[a]	1.79	1.56	1.46	0.052
Feed intake, Kg/d[b]	9.3	8.1	7.5	0.23
Hay intake, Kg/d[c]	1.0	0.6	0.6	0.11
Total intake, Kg/d[b]	10.3	8.7	8.1	0.21

[a]Linear ($P<0.05$)

[b]Linear ($P<0.01$)

[c]Quadratic ($P<0.05$)

Table 6. Body weights, daily gains and daily intakes for steers fed three mixtures of soybean hulls and peanut skins and offered bahiagrass hay (Experiment 2)

	Soybean hull : Peanut Skin Mixtures			
	100:0	80:20	60:40	SE
Initial wt, Kg	258	274	261	7.8
Final wt, Kg[a]	411	396	344	12.6
ADG, Kg/d[a]	1.82	1.45	0.98	0.075
Feed intake, Kg/d[a]	10.1	8.8	6.1	0.23
Hay intake, Kg/d[a]	1.2	1.4	2.4	0.21
Total intake, Kg/d[a]	11.3	9.2	8.5	0.23

[a]Linear ($P<0.01$)

Table 7. Body weights, daily gains and daily intakes for steers fed corn gluten feed with pelleted or loose peanut hulls with or without hay (Experiment 3)

	Diets[a]			
	1	2	3	SE
Initial wt, Kg	285	267	279	6.1
Final wt, Kg	445[b]	355[c]	416[b]	12.2
ADG, Kg/d	1.51[d]	0.83[e]	1.30[d]	0.068
Feed intake, Kg/d	12.8[d]	3.2[e]	11.8[d]	0.76
Hay intake, Kg/d	1.6[e]	4.8[d]	-	0.20
Total intake, Kg/d	14.4[d]	8.0[e]	11.8[d]	0.79

[a] Diet 1 = 50% pelleted peanut hulls and 50% pelleted corn gluten feed with free choice bahiagrass hay, Diet 2 = 50% loose peanut hulls and 50% pelleted corn gluten feed with free choice bahiagrass hay Diet 3 = 50% pelleted peanut hulls and 50% pelleted corn gluten feed without bahiagrass hay

[b,c]Means on the same line with different superscripts differ ($P<0.05$)

[d,e]Means on the same line with different superscripts differ ($P<0.01$)

DISCUSSION

Experiment 1 and 2 revealed that as peanut skins increased in the diet, productivity as well as intake decreased. In experiment 1, DM feed intake decreased 13% with the addition of 20% peanut skins in the feed mixture and decreased 19% when 40% peanut skins were added. Daily BW gains decreased 13% and 18% for 20% and 40% peanut skin diets, respectively. Experiment 2 DM feed intakes decreased 13% with the addition of 20% peanut skins and decreased 40% with the addition of 40% peanut skins in the feed mixture. Daily BW gains decreased 20% and 46% with the addition of 20% peanut skins and 40% peanut skin diets, respectively. Similar results were shown in the study performed by Utley et. al. (1993) when increasing amounts of peanut skins were substituted for soybean hulls in recommended protein (10.5% CP) diets. However, as a part of their study some of the diets were fed at 15.5% CP, which is considered an elevated protein concentration for most growing diets. With this increase in CP, production was accelerated. This indicated that with an increased protein concentration, negative effects brought about by condensed tannins could be minimized as long as the peanut skin levels were kept below 15% of the diet.

Studies have also been conducted evaluating the usefulness of peanut skins in goat and sheep diets. Kendricks et. al. (2009) examined the effects of peanut skins on intake, digestibility, and passage rates in meat goats. Experimental diets were composed of 45% Bermuda grass hay, and 55% concentrate with 0, 10, 20, and 30% of peanut skins substituting for soybean hulls in the concentrate portion of the diet. This made the total concentration of peanut skins in the total goat diet 5.5, 11.0, and 16.5%, respectively. Diets were not formulated to have equal concentration of crude protein. Results of their study indicated that up to 16.5% peanut skins could be added to the total diet without significant decreases in nutrient intake or digestibility. A possible explanation for this greater tolerance of peanut skins in the diets can be attributed to proline-rich protein saliva that is found in high concentration in goats. They also were fed diets containing lower concentrations of peanut skins.

Abdelrahim et. al. (2008) examined the effects of increasing the proportion of peanut skins in sheep diets. The diets were composed of 50% hay and 50% feed. The concentration of peanut skins in the feed mixture was at 0, 20, and 40%, making the concentration of peanut skins in the total sheep diet 0, 10, and 20%, respectively. Intake decreased ($P<0.05$) with the inclusion of 40% peanut skins in the feed mixture. However, with increasing peanut skin concentrations weight gains increased ($P<0.05$). Sheep are thought to have a greater tolerance of condensed tannins than cattle but not to the degree of goats (Cannas, 2009). Peanut skins had similar results on DM intake in sheep as they did in cattle.

Diets in the current study were formulated with peanut skins up to 40% of the feed mixture. When total intake was analyzed in the 20% peanut skin diet, steers consumed 19% peanut skins for experiment 1 and 2. In the 40% peanut skin diets steers consumed 37% and 29% peanut skins as a percent of total intake in experiment 1 and 2 respectively. The 29% peanut skin intake in experiment 2 revealed the decrease in total intake that could be attributed to a decrease in palatability. Cattle do not produce high concentrations of proline-rich protein saliva to the extent that goats do. When compared to the results of Kendricks et. al. (2009) and Abdelrahim et. al. (2008), goats and sheep were allowed a smaller percentage of peanut skins as a percent of the total diet. However, even when studies were compared at similar levels goat and sheep daily BW gains increased with increasing peanut skins. In the current study as peanut skins increased in the diet intake as well as daily BW gains decreased. The performance of sheep and goats on peanut skins indicates that they have a higher tolerance for condensed tannins than do cattle. Though there was a decrease in DM intake with the sheep study with increasing peanut skins, daily BW gains continued to increase. This is potentially a result of increasing protein levels as peanut skins increased in the diet. The results of the current study showed that when peanut skins were kept at levels of 20% of the feed mixture, benefits could be seen. Though ADG and DM intake were not as high for the 20% peanut skin mixture as compared to the 100% soybean hull diet, a decrease in cost per kg of gain could be seen.

The incidence of bloat is often seen when high concentrations of soybean hulls are fed to growing cattle. The causes of bloat are often quite variable and are dependent upon a number of factors. Other than excessive gas production, not much is known about the mechanism that produces bloat when large quantities of soybean hulls are fed to growing cattle. Min et. al. (2003) showed that when condensed tannins were fed in conjunction with wheat forage the incidence of bloat can be reduced. Though soybean hull bloat is different than forage bloat, condensed tannins have the potential to decrease its occurrence in soybean hull diets as well. In the current study there were no cases of bloat with animals fed soybean hulls and peanut skins diets.

Along with decreasing the bloat potential of soybean hulls, peanut skins in this study have proven to offset some of the ration cost when substituted for soybean hulls. Peanut skins are typically 50% the cost of soybean hulls. The current study indicates that they can be incorporated at up to 20% of a soybean hull feed mixture. At this point they have the most benefit in production as well as cost effectiveness.

In the third trial, two steers were excluded from the study due to a broken leg and lightning strike. Peanut hulls in pelleted form had the most success, with greater daily gains and intake as compared to loose peanut hulls. Pelleted peanut hulls were also shown to have the potential as an effective roughage source when hay was excluded from the diet.

This was contrary to the study conducted by Utley et.al., (1973) that fed peanut hulls in three forms: loose, ground, and pelleted. All of their diets were fed in conjunction with corn. Their study indicated that when peanut hulls were fed in any form other than loose, animals would exhibit signs of rumen hyperkeratosis and subsequent liver abscesses. However, as found in the current study steers gained efficiently and were not significantly different than those allowed free-choice access to hay.

A possible explanation for these differing results is the feedstuff that was fed in conjunction with the peanut hulls. In the Utley et. al. (1973) study, steers were fed ground and pelleted peanut hulls with corn and in the current study, steers were fed a mixture of pelleted peanut hulls and pelleted corn gluten feed. Corn is a high starch feedstuff which often decreases rumen pH. This can decrease fiber digestibility and overall rumen function. Corn gluten feed is practically devoid of starch and is less prone to the alteration of rumen pH and subsequent decrease in fiber digestibility. Thus, with a stable rumen pH, normal rumen function will continue and the primary fiber source can be maximized.

The loose form of peanut hulls had the poorest performance and DM intakes. Sorting was a major problem with this diet as the steers would selectively consume the pelleted corn gluten feed over the loose peanut hulls. Their hay intake was significantly greater than steers on pelleted peanut hull diet that had access to hay. This indicated that the loose hull diets lacked the energy as well as palatability to substantiate adequate BW gains and overall performance.

Further investigation is needed to test the roughage potential of pelleted peanut hulls fed in conjunction with low starch feedstuffs as this research is contradictory to previous studies. Cattle were indeed in a dry-lot without access to hay or stock-piled forages. Previous research states that ruminants require a minimum particle length 6.35 mm in order to achieve normal rumen function and escape acidotic conditions (Parish and Rhinehart, 2008). The particle lengths of pelleted peanut hulls in the current study had maximum lengths of 2-mm.

IMPLICATIONS

Experiment 1 and 2 diets revealed that peanut skins are the most beneficial to soybean hull diets when kept at or below 20% of the feed mixture. At this point they have the ability to reduce the cost of the diet as well as potentially decrease the incidence of bloat brought about by feeding large quantities of soybean hulls.

Experiment 3 results suggest that pelleted peanut hulls can be fed along with corn gluten feed pellets without access to a long stem roughage source. Pelleting peanut hulls tremendously increases their usability, as they are more easily transported and fed. Their main use in cattle rations is as a roughage. It is not fully understood why the diet composed of pelleted peanut hulls in the absence of hay escaped ill effects. In the study by Utley and others (1973), diets were fed in conjunction with corn. It is known that corn is a high starch feedstuff that has the potential to acidify the rumen. This occurrence is likely to cause ruminal complications and a decrease in fiber digestibility. In the current study, animals were fed diets containing pelleted corn gluten feed, which is practically devoid of starch. Low starch feeds typically do not alter rumen pH to the extent of high starch feeds, this allow for normal rumen function and continued fiber digestibility. This is just one possible explanation for the success of the diet, if this research can be repeated with similar results, the use of pelleted peanut hulls can be vastly increased as a potential hay replacer when fed in conjunction with low starch feedstuffs.

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