EFFECT OF FEEDING A FATTY ALCOHOL PRODUCT TO DAIRY COWS ON FEED INTAKE, DIGESTIBILITY, MILK PRODUCTION AND MILK COMPOSITION

by

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INTRODUCTION

Animal nutrition is ultimately concerned with the nutrition of man. The continued population expansion places increased emphasis on the need for increased food production. The role of animal production in meeting this need will depend to a large extent on the animal's ability to utilize food materials that are not considered useful as human food. From the strictly nutritional standpoint, man can utilize many of the products fed to animals more efficiently when he consumes them directly. Most animals other than ruminants are in actual competition with man for food nutrients. Ruminants have the unique ability to utilize materials, such as cellulose and nonprotein nitrogen, that cannot be utilized by simple stomached animals. Ruminants therefore offer a means of producing taste appealing and nutritionally valuable meat and milk through the use of materials that are not competitive as human foods. It would seem desirable to search for new materials of this type. Much research information has been gained on the use of nonprotein nitrogen as a protein replacer for ruminants. The search for ruminant energy sources continues.

One potential high energy source of this type for ruminants is fatty alcohols. Fatty alcohols are natural constituents of many feeds and therefore are not an entirely new constituent of ruminant diets. They can be produced from fatty acids which possess the proper chain length and from chemical synthesis. Their high energy content suggests that they can be used like fats in ruminant rations. They have an advantage over natural fat in

their storage and transporting properties because they exist as powders.

Very little information is available on the use of fatty alcohols by ruminants. Preliminary research at Kansas State University showed that a long chain fatty alcohol referred to as NPD 2 enhances grain intake. There is currently much interest in maximizing feed consumption as a means of increasing energy intake. One of the factors most seriously limiting livestock production is energy intake, especially where animals are stressed for maximum production. The practical feeding value of products of this type will depend on the extent and efficiency of utilization, freedom from harmful effects, and cost of production.

The work reported here attempts to provide more information on the feeding of NPD 2 to lactating dairy cows. Effects of NPD 2 on feed consumption, milk production, milk composition, and body weight gain were determined. The digestibility of NPD 2 and the effect of NPD 2 on the digestibility of other ration components were also determined.

REVIEW OF LITERATURE

Natural sources and suitability of fatty alcohols as a livestock feed

Fatty alcohol is the term applied to primary aliphatic alcohols having a carbon chain corresponding to that of natural fatty acids (Kirschenbaur, 1960). Little work has been done on evaluating fatty alcohols in biological systems. In establishing the suitability and safety of a product such as the fatty alcohol NPD 2 for consideration as a livestock feed, it is significant that fatty alcohols are found as natural constituents of plant and animal tissue.

Fatty alcohol content of plants. Fatty alcohols are constituents of forages such as alfalfa, grains such as grain sorghum, and various grasses. Blair, Mitchell and Silker (1953) reported the isolation of a mixture of long-chain free alcohols from the wax of the chlorophyll fraction of alfalfa. Their data indicated that the alcohol fraction was a mixture of n-triacontanol and n-octacosanol, with n-triacontanol predominating. When the wax esters were saponified, the alcohols freed were similar to the free alcohols present in the alfalfa wax.

The fatty alcohol content of grain sorghum, a major component of many concentrate rations, was measured by Dalton and Mitchell (1959). The crude wax was isolated by extracting the grain with Skellysolve B and precipitating the wax with acetone. Upon analysis the wax extraction consisted of approximately 5% paraffins, 49% esters, and 46% free alcohols. The mixture of primary alcohols was similar to those found in alfalfa. The

data indicated the probability of a mixture of n-hexacosanol, n-octacosanol and n-triacontanol. Hsien-Wen Hsu (1955) reported the wax content of sorghum grain bran extracted with absolute alcohol to be 7.86% of the weight of the dry bran.

Warth (1947) reported finding fatty alcohols in various plant materials that are frequently used for livestock feeds. The wax from soybean oil was reported to contain 10% free alcohols. The chain length of the free alcohols ranged from C_{32} to below C_{28}, while the acids in the form of alkyl esters have an average chain length of 22 carbon atoms.

Chibnall (1934) studied the fatty alcohols produced by saponification of the wax fractions of various plant and insect waxes, including some pasture grasses such as cocksfoot grass and the wheat blade. Cocksfoot grass, a plant common in the United States, Canada and Europe, contained alcohols consisting primarily of n-hexacosanol. The wheat blade alcohols contained primarily n-octacosanol.

Hilditch and Williams (1964) stated that the chief higher fatty alcohols present in lipids dealt with in their book are

> cetyl (n-hexadecyl), n-octadecyl, and n-tetradecyl alcohols in the saturated series and oleyl (n-octadec-9-enyl) alcohol in the unsaturated series. Other alcohols, saturated and unsaturated, of the C_{12}, C_{20}, C_{22} and C_{24} series are also occasionally encountered, while in the true (ester) waxes of plants and insects the characteristic alcohols are members of the saturated series of still higher (e.g., C_{26} to C_{36}) carbon content alcohols.

The authors pointed out that any of these natural alcohols could be prepared artificially from the corresponding acids, or the esters of the latter, by several methods.

Straight chain alcohols consisting primarily of carbon chain lengths between C_{20} and C_{22} are found in the oil from the nuts of Simmondsia chinensis (jojoba), a wild desert shrub. Its nuts contain 50% of an oil (Knoepfler and Vix, 1958) which is a liquid wax similar in some respects to sperm whale oil. The oil contains about 14% eicosenol, 33% docosenol, 2% hexacosenol, 14% docosenoic acid, and 30% eicosenoic acid. It was suggested that these acids could serve as intermediates in the preparation of long-chain alcohols. The cultivation of this shrub for its possible industrial potential is discussed. As can be seen, normal ruminant rations include small quantities of free long-chain primary alcohols.

Safety and toxicology. Fatty alcohols, as contained in natural ruminant feeds, are not new to the ruminant digestive system. Fatty alcohols have also been consumed in fairly large amounts, although not digested, by the American Indian as reported by Mirov (1952). The nuts of the jojoba shrub are roasted and eaten as a delicacy. The oil is recovered by boiling the seeds in water and is used for culinary and medicinal purposes. Jojoba oil, upon hydrolysis, contains 50% fatty alcohols. The presence of these in the digestive system of the human being has caused no recorded harm. The shrub is browsed by cattle, goats, sheep and deer, and the seeds are reported to be consumed by rodents. The addition of purified fatty alcohols to the ruminant diet would appear to be a natural, safe way to supplement energy requirements.

Additional assurance is given in this area by the establishment of favorable LD_{50} levels for laboratory animals. A toxicity study of higher synthetic fatty alcohols was conducted by Bulgakov (1966). An LD_{50} level of 23 g/kg was determined for rats. Mice were less sensitive. After administering a dose of 20 and 25 g/kg, no mice died. The product was given to rats at the rate of 2 g/kg (corresponding to 1/10 of the LD_{50} value) daily for 21 days. Cholinesterase activity in the blood decreased. No effect on the content of glycogen in the liver and ascorbic acid in the adrenal glands at the end of the experiment was observed. A corresponding intake of fatty alcohol for a ruminant would be about 15.9 kg per 500 kg body weight per day if the ration contained 6% fatty alcohol.

This high LD_{50} level for rats and an even greater tolerance for mice are consistent with the fact that long-chain fatty alcohols occur normally in some animal tissues. They occur esterified or free or both in small quantities in normal mouse tissue (Blank and Synder, 1970). They occur most frequently and in largest quantities in marine mammals such as the whale and dolphin. Hilditch and Lovern (1929) found that the head oil of the sperm whale contained 74% wax esters of the higher fatty acids, and blubber oil contained about 66%. The jaw oil of a species of dolphin (Gill and Tucker, 1930) contained about 19% of higher fatty alcohols. Fatty alcohols occur in varying small percentages of fat extractions of most plants and animals tested. Warth (1947) stated that many of the ordinary animal and vegetable waxes yield 50 to 55% of wax alcohols, free and combined

(as esters), whereas the fats yield only 1 to 2% of fatty alcohols.

The natural occurrence of a chemical substance in normal tissue would indicate the ability of the animal to synthesize or to metabolize the substance. It would be unlikely to be toxic to the animal.

The possibility of contaminating the environment from the undigested residual percentage of fatty alcohols left in feces is unlikely. Prochazka and Payne (1965) cultured a fatty alcohol (dodecanol) and found it to be biodegradable as measured by bacterial growth and confirmed by gas-liquid chromatography.

Metabolism of fatty alcohols. Wang, Ta-Shen and Wang (1964) reported that the oxidation of fatty alcohols (C_8 to C_{18}) by soil microorganisms was similar to that of the corresponding alkanes. The rate of O_2 consumption was about the same. The n-alkane oxidation was believed to occur by way of the intermediate steps of the corresponding alcohols and fatty acids and finally enter the β-oxidation system. Primary alcohols may be oxidized in the biological system to aldehydes as an intermediate step in conversion to acids as is known to occur in the laboratory. It is a common laboratory procedure (Brewster and McEwen, 1961) to convert primary alcohols to aldehydes by passing the vapor of primary alcohols over copper oxide in a heated tube. The aldehydes may be oxidized further to acids, thus providing two stages in the oxidation of a primary alcohol.

The complete oxidation of an organic compound yields CO_2 as an end product. The energy available from the complete

oxidation of an organic compound depends on the closeness of its oxidation level to that of CO_2. The complete oxidation of an alcohol (Brock, 1970) would release more energy than the complete oxidation of an equal chain length acid. When one mole of ethanol (CH_3CH_2OH) is oxidized to CO_2, 326 Kcal of energy are released, but when one mole of acetic acid (CH_3COOH) is oxidized, only 269 Kcal are released. An alcohol is less oxidized than an acid and therefore has a higher energy content.

Conventional high energy ruminant feed sources

Ethanol as a ruminant energy source. The lower molecular weight alcohol, ethanol, has been studied as a ruminant energy source. Ethanol differs considerably from fatty alcohols in physical properties and energy content. This liquid alcohol has a gross energy content of 7,070 cal/g (Maynard and Loosli, 1969).

Ethanol apparently is only slowly fermented by rumen organisms but is rapidly absorbed in the rumen for metabolism. Lewis, Emery and Everett (1958) reported that ethanol was rapidly absorbed from the rumen of cattle into the general circulation and that the rate of rumen metabolism of ethanol was extremely low. In experiments with cattle receiving purified diets containing ethanol (Orskov, et al., 1967), the ethanol disappeared rapidly from the rumen. Emery et al. (1959) administered 800 ml of 47.5% ethanol through the fistula into the rumen of cows for 14 days. It disappeared from the rumen but was not fermented in in vitro studies. Digestibility of crude protein and organic matter was slightly reduced, but not significantly.

Feeding trials of various types have been conducted to evaluate the effect of dietary ethanol on ruminant production. Studies on the value of adding ethanol to rations for feeder lambs (Pratt and England, 1962), fattening cattle (Richardson et al., 1958), growing beef heifers (Richardson et al., 1958), growing dairy heifers (Bates et al., 1958), and lactating cows (Balch and Campling, 1961) have been inconclusive.

Some beneficial effects have been observed on milk fat percentage from feeding ethanol to ruminants. Orskov and Hemken (1967) fed three lactating dairy cows a high-grain pelleted ration and simultaneously infused ethanol. They observed an increase in the fat content of milk and an altered rumen volatile fatty acid composition. Blood ethanol increased. As the trial progressed, rumen ethanol disappeared more rapidly, indicating an adaptation effect. Pradhan and Hemken (1970) obtained an increase in milk fat content by ethanol infusion of cattle fed a fat depressing ration. They also observed changes in rumen acids in vivo and in vitro. These workers showed that the rumen microorganisms adapted to ethanol in vitro. They reported an incorporation of ethanol-2-^{14} C presumably into iso-valeric acid.

Various workers have evaluated ethanol as a ruminant energy source and its effect on digestibility of nutrients. Chalupa, Evans, and Stillions (1964) stated that ethanol's most likely role in rumen fermentation was as an energy source. They reported a 6% increase in cellulose digestion in vitro when 0.012 ml ethanol (per 100 g rumen DM) was added. Higher ethanol levels either depressed cellulose digestion or had no influence.

The 0.012 ml ethanol addition supplied 64 calories of energy. Subsequent studies showed the same small increase in cellulose digestion from equicaloric amounts of acetaldehyde, acetic acid, starch or glucose additions. Drori and Loosli (1959) found that isocaloric amounts of starch had the same effect on nutrient digestibility and nitrogen retention as did ethanol. Both increased cellulose digestibility in feeding trials where the rations were very low in starch. It was felt that this effect was due to a lack of available energy in the rations.

It seems clear that ethanol can be used by the ruminant as a source of energy. It shows beneficial results at certain levels in energy deficient diets and may have some value in increasing milk fat percentage when cattle are fed fat depressing rations. Since ethanol can only be conveniently fed as a liquid either in drinking water or molasses and since considerable losses due to its volatility occur, its practical value as a feedstuff is somewhat limited.

Natural fats as a ruminant energy source. NPD 2 is a rich source of energy. It has a gross energy content of 10,509 cal/g. This is a higher value than natural fats. However, since this product is in the same general energy category as fats, a brief review of the role of fats in ruminant nutrition and in the nutrition of lactating ruminants in particular is presented. This will establish a basis for comparison of the role of NPD 2 in the nutrition of the lactating ruminant.

Ruminant digestion and absorption of fat occurs in the small intestine as it does in nonruminants. Before entering the

intestine, however, fats are modified by the fermentation processes occurring in the rumen (Garton, 1967) and (Keeney, 1970). There is extensive hydrolysis of triglycerides to free fatty acids and glycerol. The glycerol is fermented rapidly to volatile fatty acids. Ward, Scott and Dawson (1964) report that unsaturated fatty acids are hydrogenated to varying degrees and some of the naturally occurring cis forms of these acids are converted into trans isomers which are well digested. Microbial lipids are also synthesized in the rumen and some contain long-chain fatty acids with an odd number of carbon atoms (C_{15}, C_{17}) and branched chain isomers of these and of fatty acids containing an even number of carbon atoms.

Increased intake of energy from fats results in increased yields of milk as a rule (Vanschoubroek, 1966). However, with the addition of some natural fats this is not always true. Also different fats may increase or decrease fat percentage. It is generally accepted that fats containing a high proportion of saturated, medium-chain length fatty acids, increase the milk fat percentage without necessarily affecting milk yield (Kirchgessner, Friesecke and Koch, 1967). Unsaturated fats as a rule tend to cause a marked depression of milk fat (Van Soest, 1963). Highly unsaturated marine oils, such as cod liver oil and whale oil, usually reduce the fat content of milk, and sometimes there is an accompanying reduction in milk production (Armstrong and Ross, 1968). The addition of animal fat has a tendency to reduce slightly the protein content of SNF (Peters et al., 1961). Some workers (Orth, Kaufmann and Rohr, 1966) also obtained a slight

drop in the protein content by addition of 600 g of vegetable fat to the ration.

There is not complete agreement as to the optimum level of fat required in the ration for dairy cows. Leroy and Bonnet (1947) believe that the daily consumption of digestible fat should be approximately 350 g/1,000 kg of live weight, the type of fat and level of milk production determining the exact amount. Garton (1960) estimated that a cow that would consume 45.4 kg of pasture forage would get as much as 500 g of plant lipids. Morrison (1957) reported work done at Cornell showed that a ration containing 4% fat compared to a 2% ration would give a 4% increase in milk production. Church (1969) stated that the addition of fat to ruminant rations is not nutritionally essential, but addition of 2-5% stabilized animal fat to the diet reduces dustiness, may improve energy utilization by decreasing methane gas losses, and usually is economical. Vanschoubroek (1966) concluded that 400 g of crude fat was sufficient to provide relatively high milk yields, and therefore the concentrate should contain about 2 to 4% fat depending on the basal ration of a 500 to 700 kg dairy cow. The maximum amount of fat was considered to be about 700 g/day for high yielding cows. He also stated that at the 5% level or above the digestibility of nutrients seemed to decrease.

The amount and kind of fat affects the digestibility of fats and other dietary constituents as well. Increasing the chain length has much less effect on depressing the digestibility of fats in ruminants than in nonruminants. Heath et al. (1964)

reported the C_{18} unsaturated fatty acids that are intraruminally hydrogenated to stearic acid are readily assimilated from the small intestine of sheep. This is in contrast with the poor digestibility of stearic acid in the nonruminant animal (Carroll and Richards, 1958). Czerkawski and Blaxter (1965) conducted studies of up to 24 days in length with sheep and showed no marked fecal loss of energy from intraruminal infusion of up to 88 g of C_{18} unsaturated acids per day. Ward et al. (1964) calculated that of the C_{18} fatty acids fed to sheep only about 11% was excreted, and some lipids may have originated from bacteria in the lower gut. Paul and McCay (1943) chemically hydrogenated cottonseed oil and found that it was absorbed well when included as 6% of the ration of sheep. The longer-chain fatty acids (C_{16}-C_{18}), saturated and unsaturated, only slightly diminished dry matter digestibility in vivo (Brooks et al., 1954).

Armstrong and Ross (1966) state that in most experiments the addition of fat to beef and sheep rations has caused a depression in digestibility of dry matter and of crude fiber. Hungate (1966) in a similar statement confirms that in many cases added fats cause a decrease in the digestibility of forages. Brethour et al. (1958) observed in sheep that the addition of 15% animal fat to a basal ration containing 35% cottonseed hulls significantly reduced the digestibility of dry matter and organic matter. Ward et al. (1957) fed a much lower level of vegetable fat (2.4% maize oil) in a similar basal ration, a semipurified diet containing 55% cottonseed hulls, to sheep and got no reduction in the digestibility of any components. Digestibility of

maize oil to a cottonseed hull containing basal ration and the addition of 3% maize oil to a maize cob-containing basal ration caused a significant reduction in digestibility of dry matter and organic matter, but not of ether extract. Likewise, in a cattle feeding trial the digestibility of all ration components except ether extract was reduced by the feeding of a 10% corn oil in a ration containing cottonseed hulls. Grainger, Stroud and Bradley (1960) reported that the isocaloric addition of 5% tallow to the feed of sheep and cattle significantly lowered digestible energy. The addition of 7% tallow to a steer ration (Erwin, Dyer and Ensminger, 1956) decreased the digestibility of dry matter and crude fiber. Robertson and Howke (1964) found that addition of plant oils or whale oil to the rumen or in vitro system resulted in a depression of digestibility of fibrous components. Dietary additions of lipids above 5% were reported by Viviani (1970) to interfere with cellulose digestion.

In some studies the addition of fat either had no effect on digestibility or enhanced it. Esplin et al. (1963) fed a 4% tallow or 4% hydrolyzed vegetable or animal fat, containing a high unsaturated C_{18} acid content, in a fattening ration of 30% alfalfa hay, 57% grain, 7% molasses, 5% cottonseed meal, and 1% dicalcium phosphate. The digestibility of dry matter, crude protein, fiber and gross energy was improved, but not significantly. There was, however, a significant increase in the digestibility of ether extract. Roberts and McKirdy (1964) evaluated the effect of 5% crude rape seed oil, 5% crude sunflower seed oil, and 5% prime animal tallow on steers. Dry matter or

energy digestibilities were lowered by fat additions, but not significantly. Ether extract digestibilities of the fat rations were significantly increased. The addition of 4% tallow to an 80% concentrate ration (Hale, Thiel and Saba, 1965) had no effect on the digestion of any nutrients. The effect of fats on digestibility of other nutrients is thought to be caused by an effect on the type and activity of rumen microorganisms (Brooks et al., 1954, Nieman, 1954).

Fatty alcohols as a ruminant energy source. Czerkawski and Blaxter (1966) administered oleyl, lauryl and sulfated alcohols through the fistula of sheep, in order to measure the effects on digestion and metabolism. Oleyl alcohol, administered at the rate of 66 g per day, had no effect on CH_4 production or on excretion of nonlipid energy but caused an increase in fecal energy excretion by increasing lipid excretion. The largest portion of the excreted lipid consisted of unchanged oleyl alcohol. However, there was also an increase in the excretion of fatty acids to the extent of 9 g per day. It was postulated that this amount of excreted fatty acid may have been dissolved in the oleyl alcohol that was excreted. The effect of oleyl alcohol on energy metabolism was an increase in energy retention of 285 kcal.

Lauryl alcohol was infused at the rate of 12.9 g per day. There was no effect on CH_4 production or on cellulose digestion. It was suggested that nonlipid absorption was enhanced. The heat of combustion of the feces increased, but the increase was less than that accounted for by excretion of lipids. Heat

production also increased slightly, and there was a depression of energy retention of 23 kcal. This depression was not considered significant.

Fatty sulfates (sulfated C_{18} and C_{16} alcohols) were also evaluated. The sulfating of these fatty alcohols reduced their energy value. One sheep was fed 25.4 g of the sulfate paste which supplied 9.4 g of alkyl sulfates and 0.8 g of fatty alcohols per day. There was a decrease in energy retention of 186 kcal.

The only known production study to evaluate the feeding of fatty alcohols was a lactation trial conducted by E. E. Bartley (unpublished data). In this experiment 12 lactating Holstein cows were divided into three groups and fed three levels (0, 2 and 6%) of the product NPD 2. The 6% level caused an apparent increase in grain intake. A slight increase in fat content of milk and body weight was also observed. Other parameters were not affected. No NPD 2 was detected in the milk by gas-liquid chromatographic analysis, and an organoleptic analysis detected no difference in the milk of NPD 2-fed cows and controls.

EXPERIMENTAL PROCEDURE

Lactation study

The experimental feed supplement, NPD 2,[1] is a mixture of long-chain linear primary alcohols. The mixture can be made by hydrogenation of oils of vegetable origin, especially rape seed oil, or can be made by mixing the individual alcohol components obtained from natural oils or by chemical synthesis. When prepared by chemical synthesis, the starting materials are aluminum, ethylene, hydrogen and air. The product is a white, odorless, waxy, granular powder.

Twenty-four lactating Holstein cows were divided into three groups (designated I, II, III) as similar as possible in milk production, body weight, and grain consumption. Concentrate rations containing 3 levels of NPD 2 (0, 3 and 6%) were tested in an 18-wk experiment divided into three 6-wk periods. Each group of cows received each of the concentrate rations for one period during the experiment. The experimental design is shown in Table 1. The first 2 wk of each experimental period were used to adapt each group of cows to its respective ration. Following the preliminary period one group of cows received the control grain ration and the other two received the same ration with NPD 2 added at levels of 3 or 6%. The cows in each group were adjusted to the rations containing NPD 2 by gradually increasing NPD 2 from 0.5% to the final level during a 2-wk adjustment period. Following the adjustment period the groups

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[1]Furnished by the Esso Research and Engineering Co., Linden, New Jersey.

Table 1

Experimental design

Period	NPD 2 content of grain ration (%)		
	0	3	6
	----------(Group)----------		
1	I	II	III
2	II	III	I
3	III	I	II

Table 2

Ration formulas and proximate analyses of feeds

Ingredients	Grain rations			Alfalfa hay
	Control	3%	6%	
	--------(%)----------			
Sorghum grain	87.0	84.4	81.8	
Soybean meal (44%)	12.4	12.0	11.6	
Trace mineralized salt	0.5	0.5	0.5	
Vitamin A and D sup.[a]	0.1	0.1	0.1	
NPD 2	0.0	3.0	6.0	
Average proximate analyses				
Moisture	12.8	12.5	12.5	8.9
Crude protein	13.6	13.1	13.3	15.6
Ash	2.3	2.4	2.2	6.7
Ether extract	2.5	5.5	7.7	2.0
Crude fiber	2.2	2.3	2.1	29.5
NFE	66.6	64.2	62.3	37.2

[a]Vitamin A and D supplement supplies 2000 IU of A and 2000 IU of D per .45 kg of the ration.

were maintained on their respective rations for 4 wk. Data collected during the adjustment periods were not considered in the statistical analysis of the results.

Each cow was fed 1.5 kg alfalfa hay per 100 kg body weight per day. The alfalfa hay was of good quality. To obtain maximum production from and to test acceptability of each fatty alcohol supplement, the quantity of grain fed each cow was established by adjusting the quantity of grain fed daily to the maximum amount readily consumed. The quantity of hay fed was likewise adjusted until consumption reached 1.5 kg per 100 kg body weight. The amount of hay fed was maintained at this level as long as it was readily consumed. The composition and proximate analyses of feeds are shown in Table 2. The grain ration received by all groups of cows during the preliminary period was a simple ration designed to meet the minimum requirements of the cows.

All cows were confined to individual stalls from 3 pm until 9 pm and from 7 am until 10 am each day and were allowed to exercise in a lot during the remainder of the day. The cows were milked twice daily at 5 am and 3 pm.

Individual milk weights were recorded at each milking. The amount of hay and grain refused by each cow was weighed and recorded at 10 am each day. All cows were weighed on two consecutive days at the end of the preliminary and adjustment periods and at 2-wk intervals during the experimental period. At the same times 24-hour composite milk samples were collected from each cow for analyses of milk constituents.

Milk protein, ash and total solids were determined by official AOAC methods (AOAC, 1970). Milk fat determinations were made by the Milko-Tester method (Shipe, 1969). Lactose was calculated from these data by difference. Samples of milk were analyzed by Esso Research and Engineering Co., Linden, New Jersey, to determine the presence of NPD 2.

Samples of hay and grain rations were collected periodically and composited for analysis. Proximate compositions of grain and hay were determined by AOAC methods (AOAC, 1970). A sample of NPD 2 was bombed for determination of gross energy content by a Parr calorimeter.

Digestion study

During the final week of each experimental period, two cows (the same cows each period) were removed from each group and placed in appropriate stalls for the digestion study. Feces were collected for a 5-day collection period. Three digestion trials were conducted. The cows were fed and milked twice daily, and water was always available. The cows received the same rations that they were receiving prior to the digestion study. Feed was reduced approximately 10% 3 or 4 days prior to the start of each trial to insure that they would clean up all the feed each day. Feed refusals, if any, were weighed and recorded daily. Samples of hay and the three experimental rations were taken during the trial for proximate analysis.

All feces were collected manually day and night and stored in a closed container behind each cow. The feces were weighed, mixed and sampled every day. Samples were dried in an oven at

60 C until they failed to lose weight upon reweighing. The daily samples from each cow were composited and ground for analyses. Proximate analyses were run on all samples. Samples were also taken for analysis of NPD 2 by the Esso Research and Engineering Co., Linden, New Jersey. At the end of each collection period the cows were returned to their respective groups.

RESULTS

Lactation study

One cow (128E) in Group I ceased to produce sufficient milk to evaluate treatment response adequately and was removed from the lactation study during Period 3. The results are based on seven cows in Group I and eight cows in each of the other two groups. The results of the lactation study are presented in Tables 3 and 4. A summary of the analysis of variance is given in Table 5.

The largest effect of treatment was on feed intake. Hay intake was affected most. Hay consumption by cows fed a ration containing 6% NPD 2 increased 7% over controls. This increase was statistically significant ($P < .10$). Cows receiving 3% NPD 2 in their ration had an increase in hay intake of 4.6% above controls, but this increase was not statistically significant. There was an increase in hay intake over controls at both the 3 and 6% levels in all groups. Grain intake was also increased by about 5.5% in both groups receiving the 3 and 6% NPD 2 containing rations. This increase was not significant. The NPD 2-fed cows consumed more grain than did the controls in all cases except Group I at the 3% level in Period 3.

There was no significant change in body weight or milk production as a result of treatment. Milk constituents likewise showed no significant treatment effect. However, milk fat percentage was increased slightly in cows receiving the NPD 2 containing rations, but the increase was not significant.

Table 3

Average daily hay intake, grain intake, milk production, fat-corrected milk and body weight change by 4-wk periods for cows receiving rations containing 0, 3 or 6% NPD 2

Period	NPD 2 level	Group	Hay	Grain	Milk	FCM	Body weight change
	(%)		(kg)				
Prelim.	0	I	3.54	11.11	20.96	16.51	---
	0	II	4.17	11.20	21.00	15.61	---
	0	III	4.22	11.20	21.27	16.81	---
1	0	I	5.65	12.40	19.35	16.89	12.45
	3	II	5.90	12.91	19.60	17.50	5.75
	6	III	6.10	12.70	19.48	17.59	7.65
2	6	I	6.38	14.75	17.37	15.66	6.65
	0	II	6.17	13.40	13.29	16.21	5.05
	3	III	6.42	15.47	19.53	17.34	6.65
3	3	I	6.19	13.10	15.79	14.96	-3.20
	6	II	6.51	14.23	17.85	16.36	-0.90
	0	III	5.88	13.69	17.67	16.22	-4.30
Avg of Periods 1, 2, 3	0	---	5.90	13.16	18.44	16.44	4.40
	3	---	6.17	13.83	18.31	16.60	3.07
	6	---	6.33	13.89	18.23	16.54	4.47

Table 4

Average daily milk composition by 4-wk periods for cows receiving rations containing 0, 3 or 6% NPD 2

Period	NPD 2 level	Group	Milk fat		Protein		Lactose		Ash		Total solids		Solids not-fat	
	(%)		(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)
	0	I	2.6	.54	2.9	.60	5.4	1.13	.77	.161	11.6	2.42	9.0	1.88
Prelim.	0	II	2.3	.48	2.7	.57	5.5	1.15	.75	.157	11.2	2.36	8.9	1.87
	0	III	2.6	.55	2.7	.58	5.6	1.19	.74	.157	11.6	2.47	9.0	1.92
	0	I	3.2	.61	2.9	.57	5.2	1.02	.75	.145	12.3	2.32	8.8	1.71
1	3	II	3.3	.65	3.0	.58	5.3	1.04	.75	.147	12.0	2.41	9.0	1.77
	6	III	3.4	.66	3.0	.58	5.4	1.05	.75	.146	12.5	2.43	9.1	1.78
	6	I	3.4	.58	3.3	.56	5.2	.91	.78	.136	12.6	2.19	9.2	1.61
2	0	II	3.2	.59	3.3	.61	5.3	.98	.79	.145	12.6	2.32	9.4	1.73
	3	III	3.3	.64	3.4	.67	5.3	1.04	.80	.156	12.8	2.49	9.5	1.86
	3	I	3.7	.58	3.0	.47	5.9	.93	.77	.121	13.2	2.10	9.7	1.53
3	6	II	3.5	.62	3.0	.54	6.0	1.07	.78	.139	13.3	2.36	9.7	1.73
	0	III	3.5	.61	3.1	.54	6.0	1.05	.78	.138	13.2	2.33	9.7	1.73
Avg of	0	---	3.3	.60	3.1	.57	5.5	1.02	.77	.143	12.7	2.32	9.3	1.72
Periods	3	---	3.4	.62	3.1	.57	5.5	1.00	.77	.141	12.7	2.33	9.4	1.72
1, 2, 3	6	---	3.4	.62	3.1	.56	5.5	1.01	.77	.140	12.8	2.33	9.3	1.71

Table 5

Analysis of variance summary of significant (sig.) differences

Response	Period	Group	Treatment
Grain intake	Not sig.	Not sig.	Not sig.
Hay intake	Sig. 90%	Not sig.	Sig. 90%
Body weight	Sig. 95%+	Sig. 95%+	Not sig.
Milk prod.	Not sig.	Not sig.	Not sig.
% Fat	Not sig.	Not sig.	Not sig.
% Protein	Sig. 95%+	Sig. 90%	Not sig.
% Lactose	Sig. 95%+	Not sig.	Not sig.
% Ash	Sig. 95%	Not sig.	Not sig.
% Total solids	Sig. 95%	Not sig.	Not sig.

Significant period differences occurred in hay intake, body weight, and percentage of milk protein, lactose, ash, and total solids. The period differences in hay intake may have been due to changes in weather. The experiment was initiated in August and the weather became cooler as the experiment progressed. As lactation progresses, dairy cows are expected to gain in body weight. This probably explains the significant period difference in body weight gain. As stage of lactation progresses, milk production declines, milk fat percentage increases, and other milk constituents usually decrease. However, there was no significant period change in milk production or milk fat percentage, but other milk constituents changed significantly up and down. As would be expected, due to stage of lactation, total solids percentage increased significantly ($P < .05$) between periods.

No significant group effects occurred except in body weight and protein percentage. Animals in Group II, following the preliminary period, were lighter ($P < .05$) than those in the other two groups throughout the trial. Group I cows were significantly different ($P < .10$) from those in Group III in protein percentage.

NPD 2 appeared to have no deleterious effect on animal health or well-being. The palatability of NPD 2 was good, and there was no difficulty adjusting the cows to the treatment rations.

Digestion study

Cow (128E) that was removed from the lactation study in Period 3 was one of the six cows selected for the digestion study. She was allowed to remain in this study. The results of the digestion study are shown in Tables 6 and 7.

The greatest effect of treatment was on ether extract digestibility. The digestibility of ether extract by the cows receiving the ration containing 3% NPD 2 was 32.7% lower than the digestibility of ether extract by the cows fed the control ration. The digestibility of ether extract by the cows receiving the ration containing 6% was 50.7% lower than that of the controls. For some unknown reason the digestion coefficient of ether extract in the third digestion trial was considerably lower than the values for the first and second trials. In spite of the lowered digestibility of the ether extract of the 6% ration, the groups receiving this ration digested more kilograms of ether extract per day than did the other groups, except in the third trial. This was due to a higher percentage of ether extract in the ration and to an increased intake of feed.

Dry matter digestibility of the 6% NPD 2 ration was 5% lower than that of the control ration. The dry matter of the 3% NPD 2 ration was only slightly less digestible than that of the control ration. The animals receiving NPD 2 at both levels retained about the same quantity of dry matter as did the control-fed cows because of the increased dry matter intake of the NPD 2-fed cows. The digestion coefficient of crude fiber in the 6% ration was 8.6% lower than the crude fiber digestibility of

Table 6

Quantity of each proximate principle digested per day for each ration

NPD 2 level	Trial	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	Nitrogen-free extract
(%)		(kg)					
0	1	10.06	1.78	.23	1.01	.29	6.77
	2	12.74	1.98	.20	.98	.38	9.18
	3	10.76	1.57	.20	1.17	.28	7.55
	Avg	11.19	1.78	.21	1.05	.32	7.83
3	1	10.78	1.76	.41	1.09	.31	7.24
	2	12.48	2.11	.21	1.15	.49	8.51
	3	11.28	1.40	.15	.90	.19	7.30
	Avg	11.51	1.76	.26	1.05	.33	7.68
6	1	10.36	1.74	.33	1.09	.29	6.94
	2	10.97	1.95	.33	.78	.32	7.59
	3	11.58	1.60	.11	.90	.22	8.75
	Avg	10.97	1.76	.26	.92	.28	7.76

Table 7

Average digestion coefficients for proximate principles and NPD 2 for each ration

NPD 2 level	Trial	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	Nitrogen-free extract	NPD 2
0%	1	63.6	66.7	48.5	47.6	43.6	67.5	
	2	66.2	63.4	42.3	47.9	48.7	71.8	
	3	63.9	61.5	41.3	53.8	40.8	68.5	
	Avg	64.6	63.9	44.0	49.8	44.4	69.2	
3%	1	63.1	65.3	39.4	52.7	42.4	68.2	52.2
	2	63.0	64.7	23.1	50.3	56.5	68.1	73.2
	3	63.2	57.4	26.4	43.9	29.0	68.1	58.2
	Avg	63.1	62.5	29.6	49.0	42.6	68.1	61.2
6%	1	62.2	65.7	26.7	50.3	43.3	69.0	51.6
	2	58.9	62.5	25.8	40.7	41.3	65.9	63.3
	3	62.8	59.3	12.6	45.5	33.0	72.9	52.5
	Avg	61.3	62.5	21.7	45.5	39.2	69.3	55.8

the control ration. The crude fiber digestibility of the 3% ration was only slightly lower than that of the control ration. Ash digestibility was reduced by 11.8% in the 6% NPD 2 ration and 4% in the 3% NPD 2 ration. Nitrogen-free extract and crude protein digestibility were not affected by the addition of NPD 2 at either the 3 or 6% level.

The digestibility of the fatty alcohol product itself was also determined. The digestion coefficients for NPD 2 were higher than those for total ether extract. The digestion coefficients for NPD 2 when fed at the 3% level ranged from 52.2 in one trial to 73.2 in the other with an average of 61.2. When NPD 2 was fed at the 6% level, the digestion coefficients ranged between 51.6 and 63.3 with an average of 55.8. Increasing the NPD 2 in the ration from 3 to 6% resulted in a decrease of 8.8% in its digestibility.

DISCUSSION

The fatty alcohol product (NPD 2) appears to enhance feed intake. In an earlier study at this station (E. E. Bartley, unpublished data) grain intake of NPD 2-fed cows was 18% greater than that of controls. In the present study there was a greater effect on hay intake than on grain intake. This may have been due to hay being limited in the first study to 1 kg per 100 kg of body weight and being offered in the present study at the rate of 1.5 kg per 100 kg of body weight. Perhaps in the first study the limited hay intake prevented the appetite-stimulating effect of NPD 2 to express itself on hay so the major influence was on grain.

Although fats and fatty alcohols have a high gross energy value, they must be digestible before they can be of use to the ruminant. The data indicate that NPD 2 reduces digestibility of ether extract, especially when fed at the 6% level. However, the digestibility of the fatty alcohol itself was relatively high and the reduction in digestibility considerably less when the level was increased from 3 to 6% than was the reduction in the digestibility of the total ether extract. Fatty alcohols may have an effect on increasing non-fatty alcohol lipid excretion. Czerkowski et al. (1966) reported an increased fatty acid excretion from the ruminal infusion of oleyl alcohol and suggested that the fatty acids may have been dissolved in the oleyl alcohol that was not absorbed. These workers, however, also reported high digestibility of the fatty alcohol they tested,

and regardless of the increased lipid excretion from the infusion of oleyl alcohol a net increase in energy retention was reported.

The data from the present lactation and digestion studies indicate that although digestibility of ether extract is substantially reduced, especially at the 6% level, performance is not affected. Milk production and body weight were unchanged by treatment, indicating the ability of NPD 2 to substitute equally well for a portion of the other energy components of the ration. This may have been due in part to the high gross energy content of NPD 2 and in part to increased intake of feed.

If the undigested fatty alcohols absorb fatty acids as Czerkowski et al. suggest, it is conceivable that if ways could be found to increase the digestibility of fatty alcohols, the amount of fatty acid excreted could be greatly reduced. A resulting increase in energy retention might then occur, permitting fuller utilization of the high energy of fatty alcohols. One critical area of need for such a product in the dairy field is in early lactation of high producing cows, when negative energy balance occurs. At this time the high yielding dairy cow has a greater energy requirement than can be supplied from common energy sources. This results in a depletion of body reserves and eventual reduction in milk production.

In the previous study (E. E. Bartley, unpublished data) fat content of milk was higher in each period that the cows received NPD 2. In the present trial the fat content of milk was also equal to or higher in all periods for cows receiving NPD 2 than for controls, but the difference was not statistically

significant. It would appear that long-chain primary fatty alcohols at least maintain milk fat percentage and probably have a tendency to increase it. They would be somewhat similar to saturated medium-chain length fatty acids in this respect (Kirchgessner et al., 1967).

The reduction in digestibility of dry matter and crude fiber of the 6% NPD 2 rations was not greater than what is often reported for conventional types of fats fed at a similar level. Data reported by Dyer, Ensminger and Blue (1957) show a 10% reduction in dry matter digestibility and a 21% reduction in crude fiber from the feeding of 7% tallow to steers. Davison and Woods (1963) showed a reduction in digestibility of organic matter of 5% and a reduction in digestibility of cellulose of about 21% from the feeding of 5% corn oil to sheep.

The reduction in ash digestibility due to NPD 2 may have been the result of increased excretion of minerals due to their combining with fatty acids to form soaps. It was shown by Grainger et al. (1961) that corn oil fed to lambs increased the excretion of fecal soaps and decreased apparent digestibility of calcium. Other workers have shown similar results, but Davison and Woods (1963) suggested that there is more involved in the calcium-fat relationship than the formation and excretion of soaps. They showed that the feeding of additional calcium alleviated the depressing effect that fats have on cellulose digestibility. Camien and Dunn (1957) stated that in the presence of calcium the fatty acids are precipitated as calcium soaps permitting the remainder of the digesta to be fermented normally.

The fatty acids and calcium are then believed to dissociate to a larger degree at the lower pH of the abomasum and duodenum and be absorbed. There evidently is no large increase in excretion of soaps from increasing the level of calcium in the ration. It may be possible to overcome the reduction in dry matter and crude fiber digestibility from the feeding of NPD 2 by increasing the calcium content of the ration.

The effect of NPD 2 on the digestibility of nutrients was similar to the effect that has been observed when animal fats and plant oils are included in the diet. However, the stimulating effect that NPD 2 appears to have on appetite is especially interesting since NPD 2 lowered the digestibility of dry matter. Perhaps NPD 2 speeds rate of removal of dry matter from the rumen, thus lowering its digestibility. Increased removal rate would provide more rumen space for additional feed.

NPD 2, by increasing nutrient intake, can be of value to the high producing cow whose production is limited by insufficient nutrient intake. However, the nutrients must be utilized efficiently or the benefit of an increased intake is inconsequential. Further research is warranted to determine whether benefits can be derived from the increased nutrient intake resulting from NPD 2. However, the mechanism for the increased intake must be elucidated first.

SUMMARY

A major factor limiting milk production and causing a loss in body weight of high producing cows is an inadequate energy intake. This research was designed to evaluate a new high energy product (NPD 2) for use in dairy rations.

NPD 2 is a mixture of long-chain, linear, primary alcohols with a gross energy content of 10.5 kcal per gram. It is an odorless, nondusty granular powder that can easily be mixed with other ration ingredients. This product has a distinct advantage over liquid fats because it can be transported and stored by conventional bag or bulk methods. Various fatty alcohols are known to be biodegradable and are found in small amounts as natural constituents of common livestock feeds.

Milk production, grain intake, body weight change, and milk constituent changes were criteria used to evaluate NPD 2 as an energy supplement for lactating dairy cows. The digestibility of NPD 2 and the effect of NPD 2 on the digestibility of other ration components was determined.

The palatability of NPD 2 was high and cattle adjusted easily to the treatment rations. The cattle receiving the 3 and 6% levels of NPD 2 consumed more grain than did the control animals. However, these differences were not statistically significant. NPD 2 also appeared to increase hay intake. Hay intake increased significantly ($P < .10$) over the control animals in those receiving the 6% level.

There were no significant treatment effects on milk

production, milk constituents, or body-weight change. Milk fat percentage increased in the animals receiving NPD 2, but the increase was not statistically significant.

The digestibility of NPD 2 was relatively high, demonstrating ability of the ruminant to digest fatty alcohols. The average digestion coefficients for NPD 2 when fed at the 3 or 6% levels were 61.2 and 55.8, respectively. However, there was a significant reduction in the digestibility of ether extract when NPD 2 was included in the ration. The digestibility of ether extract by the cows receiving the 3 or 6% levels was 32.7, or 50.7% less than that of the control cows. The total ether extract retained by each cow in the treatment group was, however, increased in all but the third digestion trial, because of a higher percentage of ether extract in the ration and an increased intake of feed.

Ash digestibility was reduced about 12% in groups receiving 6% NPD 2. The digestibility of other ration constituents was not changed greatly.

Fatty alcohols that are not digested may absorb fatty acids and decrease ether extract digestibility. If this is true, an increased solubility and digestibility of the fatty alcohols may permit a fuller utilization of the high energy content of fatty alcohols.

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APPENDIX

Table 8

Average daily hay intake, grain intake, milk production, fat-corrected milk and body weight change by 2-wk periods for cows receiving rations containing 0, 3 or 6% NPD 2

Period	2-wk periods	NPD 2 level	Group	Hay	Grain	Milk	FCM	Body weight change
		(%)		----------(kg)----------				
Prelim.	1	0	I	3.54	11.11	20.96	16.82	---
		0	II	4.17	11.20	21.00	15.61	---
		0	III	4.22	11.20	21.27	16.81	---
	2	0	I	3.54	11.11	20.96	16.20	---
		0	II	4.17	11.20	21.00	15.61	---
		0	III	4.22	11.20	21.27	16.81	---
1	1	0	I	5.49	12.04	19.60	16.68	11.50
		3	II	5.63	12.97	20.05	16.73	5.30
		6	III	6.03	12.27	19.50	17.19	3.10
	2	0	I	5.81	12.84	19.10	17.10	13.40
		3	II	6.17	12.84	19.14	18.27	6.20
		6	III	6.17	13.13	19.46	17.99	12.20
2	1	6	I	6.65	14.85	17.64	16.04	6.40
		0	II	6.17	13.63	18.57	16.62	2.20
		3	III	6.71	15.88	19.46	16.83	10.60
	2	6	I	6.10	14.65	17.10	15.28	6.90
		0	II	6.17	13.18	18.01	15.80	7.90
		3	III	6.12	15.06	19.60	17.84	2.70
3	1	3	I	6.12	13.40	15.83	14.43	0.90
		6	II	6.71	14.56	18.33	16.38	8.40
		0	III	5.81	14.29	17.96	16.10	-2.90
	2	3	I	6.26	12.79	15.74	15.48	-4.10
		6	II	6.30	13.90	17.37	16.34	-9.30
		0	III	5.94	13.09	17.37	16.34	-5.70

Table 9

Average daily milk composition by 2-wk periods for cows receiving rations containing 0, 3 or 6% NPD 2

Period	2-wk period	NPD 2 level	Group	Milk fat		Protein		Lactose		Ash		Total solids		Solids not-fat	
		(%)		(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)
Prelim.	1	0	I	2.7	.56	2.9	.60	5.5	1.14	.79	.166	11.8	2.47	9.1	1.91
		0	II	2.3	.48	2.8	.59	5.5	1.15	.75	.156	11.4	2.39	9.1	1.90
		0	III	2.6	.55	2.8	.61	5.6	1.19	.73	.156	11.8	2.51	9.2	1.96
	2	0	I	2.5	.52	2.8	.59	5.3	1.11	.75	.157	11.3	2.37	8.8	1.85
		0	II	2.3	.48	2.6	.55	5.5	1.14	.75	.157	11.1	2.33	8.8	1.85
		0	III	2.6	.55	2.6	.55	5.6	1.19	.74	.157	11.5	2.44	8.9	1.89
1	1	0	I	3.0	.59	2.8	.55	5.1	1.00	.76	.148	11.6	2.28	8.6	1.69
		3	II	2.9	.58	2.8	.57	5.2	1.05	.75	.151	11.7	2.35	8.8	1.77
		6	III	3.2	.63	2.9	.56	5.3	1.03	.76	.147	12.1	2.36	8.9	1.74
	2	0	I	3.3	.63	3.0	.59	5.4	1.03	.74	.142	12.4	2.36	9.1	1.73
		3	II	3.7	.71	3.1	.59	5.4	1.03	.74	.142	12.9	2.47	9.2	1.76
		6	III	3.5	.68	3.1	.60	5.5	1.06	.74	.145	12.8	2.49	9.3	1.81
2	1	6	I	3.4	.60	3.2	.56	5.1	.90	.77	.137	12.5	2.20	9.1	1.60
		0	II	3.3	.61	3.3	.61	5.2	.98	.78	.146	12.6	2.35	9.3	1.73
		3	III	3.1	.60	3.4	.67	5.3	1.03	.79	.154	12.6	2.45	9.5	1.85
	2	6	I	3.3	.56	3.3	.56	5.4	.92	.79	.135	12.7	2.18	9.4	1.61
		0	II	3.1	.57	3.3	.60	5.4	.98	.79	.144	12.5	2.29	9.4	1.72
		3	III	3.4	.67	3.4	.67	5.4	1.05	.80	.157	12.9	2.53	9.5	1.86

Table 9 (Concluded).

Period	2-wk period	NPD 2 level	Group	Milk fat		Protein		Lactose		Ash		Total solids		Solids not-fat	
		(%)		(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)
3	1	3	I	3.4	.54	3.1	.48	5.9	.93	.78	.123	13.1	2.08	9.7	1.54
		6	II	3.3	.60	3.0	.54	6.0	1.09	1.79	.145	13.0	2.39	9.7	1.78
		0	III	3.3	.59	2.9	.52	6.0	1.08	.79	.142	13.0	2.33	9.7	1.74
	2	3	I	3.9	.61	3.0	.46	5.9	.93	.76	.119	13.5	2.12	9.6	1.51
		6	II	3.6	.63	3.0	.53	5.9	1.04	.76	.132	13.3	2.32	9.7	1.69
		0	III	3.6	.63	3.3	.56	5.8	1.01	.77	.134	13.4	2.33	9.8	1.71

Table 10

Quantity of each proximate principle digested per day per cow on each ration

NPD 2 level	Cow number	Trial	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	Nitrogen-free extract
			(kg)					
	B178	1	9.90	1.73	.26	.49	.25	7.18
0	128E	1	10.21	1.82	.20	1.52	.32	6.36
3	151E	1	11.21	1.87	.45	1.11	.27	7.53
4	165E	1	10.35	1.64	.36	1.07	.35	6.95
6	B184	1	8.37	1.42	.28	.57	.21	5.89
6	B122	1	12.35	2.05	.38	1.60	.36	7.98
0	151E	2	14.01	2.18	.19	.97	.40	10.24
0	165E	2	11.46	1.78	.20	.98	.36	8.12
3	B184	2	10.14	1.78	.14	.93	.42	6.86
3	B122	2	14.82	2.44	.27	1.37	.55	10.16
6	B178	2	10.38	1.89	.36	.55	.26	7.33
6	128E	2	11.55	2.01	.30	1.00	.38	7.85
0	B184	3	9.08	1.33	.18	.75	.20	6.63
0	B122	3	12.44	1.81	.22	1.59	.36	8.47
3	B178	3	10.70	1.28	.20	.51	.14	7.03
3	128E	3	11.86	1.52	.09	1.28	.23	7.56
6	151E	3	12.00	1.68	.12	1.11	.27	8.82
6	165E	3	11.15	1.52	.09	.69	.17	8.68

Table 11

Average digestion coefficients for the two cows in each group for proximate principles and NPD 2 for each ration

NPD 2 level	Cow number	Trial	Dry matter	Crude protein	Ether extract	Crude fiber	Ash	Nitrogen-free extract	NPD 2
0	B178	1	63.75	67.25	53.77	39.63	47.06	66.99	
0	128E	1	63.43	66.22	43.26	55.57	40.22	67.97	
3%	151E	1	60.58	64.48	40.66	50.10	34.48	65.35	57.5
3%	165E	1	65.53	66.18	39.22	55.27	50.33	71.06	46.8
6%	B184	1	60.47	65.83	24.90	43.30	43.52	67.25	49.7
6%	B122	1	63.86	65.60	28.57	57.23	43.01	70.82	53.5
0	151E	2	65.40	62.82	36.84	46.82	48.10	70.60	
0	165E	2	67.04	64.01	47.78	48.99	49.38	72.93	
3%	B184	2	63.29	67.17	19.61	52.04	60.53	67.39	72.6
3%	B122	2	62.77	62.27	26.94	48.63	52.38	68.71	73.9
6%	B178	2	56.61	61.91	26.15	40.33	39.05	61.62	59.9
6%	128E	2	61.22	63.14	25.38	40.97	43.45	70.16	66.7
0	B184	3	63.04	61.38	45.35	50.93	37.93	67.33	
0	B122	3	64.75	61.51	45.79	56.73	43.72	69.57	
3%	B178	3	59.86	53.71	25.88	36.57	25.62	62.56	54.9
3%	128E	3	66.58	61.13	13.01	51.27	32.28	73.66	61.5
6%	151E	3	63.61	60.66	11.30	50.20	37.82	72.95	56.6
6%	165E	3	62.06	57.99	7.82	40.80	28.15	72.77	48.4

EFFECT OF FEEDING A FATTY ALCOHOL PRODUCT TO DAIRY COWS ON FEED INTAKE, DIGESTIBILITY, MILK PRODUCTION AND MILK COMPOSITION

by

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A major factor limiting milk production and causing a loss in body weight of high producing cows is an inadequate energy intake. This research was designed to evaluate a new high energy product (NPD 2) for use in dairy rations.

NPD 2 is a mixture of long-chain, linear, primary alcohols with a gross energy content of 10.5 kcal per gram. It is an odorless, nondusty granular powder that can easily be mixed with other ration ingredients. This product has a distinct advantage over liquid fats because it can be transported and stored by conventional bag or bulk methods. Various fatty alcohols are known to be biodegradable and are found in small amounts as natural constituents of common livestock feeds.

Milk production, grain intake, body weight change, and milk constituent changes were criteria used to evaluate NPD 2 as an energy supplement for lactating dairy cows. The digestibility of NPD 2 and the effect of NPD 2 on the digestibility of other ration components was determined.

The palatability of NPD 2 was high and cattle adjusted easily to the treatment rations. The cattle receiving the 3 and 6% levels of NPD 2 consumed more grain than did the control animals. However, these differences were not statistically significant. NPD 2 also appeared to increase hay intake. Hay intake increased significantly ($P < .10$) over the control animals in those receiving the 6% level.

There were no significant treatment effects on milk production, milk constituents or body weight change. Milk fat percentage increased in the animals receiving NPD 2, but the

increase was not statistically significant.

The digestibility of NPD 2 was relatively high, demonstrating ability of the ruminant to digest fatty alcohols. The average digestion coefficients for NPD 2 when fed at the 3 or 6% levels were 61.2 and 55.8, respectively. However, there was a significant reduction in the digestibility of ether extract when NPD 2 was included in the ration. The digestibility of ether extract by the cows receiving the 3 or 6% levels was 32.7 or 50.7% less than that of the control cows. The total ether extract retained by each cow in the treatment group was, however, increased in all but the third digestion trial, because of a higher percentage of ether extract in the ration, and an increased intake of feed.

Ash digestibility was reduced about 12% in groups receiving 6% NPD 2. The digestibility of other ration constituents was not changed greatly.

Fatty alcohols that are not digested may absorb fatty acids and decrease ether extract digestibility. If this is true, an increased solubility and digestibility of the fatty alcohols may permit a fuller utilization of the high energy content of fatty alcohols.