INFLUENCE OF DIFFERENT AMOUNTS OF WHEAT MIDDLINGS IN THE RATION ON PRODDUCTION RESPONSES OF DAIRY COWS

By

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CHAPTER I

INTRODUCTION

It is a widely recognized fact that a certain amount of concentrate feed is needed by dairy cows in order to sustain high milk yields for long periods of time. In order to meet the current demand for fluid milk and manufactured dairy products and simultaneously turn out a profit, dairymen must obtain from their cows as high a milk yield as they possibly can; even though this statement is correct when viewed on a global basis, it may not be descriptive of the current conditions of the dairy industry in the United States. No known forage would provide enough nutrients to meet the maintenance, growth, and lactation requirements of a dairy cow; therefore, the resulting nutrient deficiencies must be covered by including concentrate feeds in the diet of the cow.

Cereal grains like corn, wheat, oats, and barley have been used as major ingredients of concentrates for many years. Besides their undeniable feeding value, the supply of grain was, by far, larger than the demand for grain to be used as human food. However, the situation has changed substatially in the last quarter of a century; the huge grain surpluses of major grain producing countries like the

United States, Argentina, and Australia have been steadily decreasing and will continue to do so, while other countries that were small exporters or self- sufficient in regard to cereal grains are today net grain importers (Wortman and Cummings 1981).

Farmers and ranchers in important grain producing countries can still use a substantial amount of cereal grains in concentrates and will continue to do so in the forseable future. However, the situation is not that clear in countries where grain deficits exist; those countries have to rely on costly imported grain, and many of them can barely afford to purchase enough grain to feed their people. At this point, it becomes evident that an alternative to feeding cereal grains in animal concentrates must be found if the production of foods of animal origin is to be improved. One of such alternatives could be the increased use of available crop and processing industry by-product feeds. Emphasis on the research and use of by-product feeds is ovbiously crucial for developing countries going through the situation of grain scarcity just referred to, and in the long run, it might be beneficial for developed grain producing nations as well.

Many by-product feeds are widely used today in feeding livestock while, research and use of other potentially beneficial ones have been neglected. Oilseed meals (soybean, cottonseed, coconut, peanut) are by-products that have been widely used as protein sources in concentrates for many years because of their digestibility and high content of high quality protein. Other by-products such as cereal straws, wheat bran, and cottonseed meal have been widely used as fiber sources for ruminants. Brewer's and distiller's residues as well as other cereal grain processing by-products have not been as widely used as those menctioned above. One of the reasons for this is the lack of knowledge about the feeding value of cereal grain processing by-products; another important reason is the variability of their quality and composition and the low feeding value of some cereal by-products.

Wheat is primarily a human food but it has been occasionally used as concentrate for domestic livestock when its price is competitive with that of other cereal grains. The wheat milling industry produces a variety of by-products when flour is manufactured for human consumption. These by-products are made of the part of the kernel that contains a large portion of the total kernel protein; however, some of them are quite high in fiber.

Among the different wheat by-products used to feed livestock, wheat middlings appear to be very promising; however, very little research has been done about its characteristics and feeding value, specially regarding feeding it to dairy cows. Wheat middlings appear to be a satisfactory substitute for both protein and energy sources in dairy cow concentrates. Some researchers have found palatability problems when wheat middlings comprise 40% or more of the concentrate (Loosli, 1970), whereas others have reported no palatability problems whatsoever with a proportion of wheat middlings higher than 40% of the concentrate mix. Some researchers have reported that high proportions of wheat middlings in the concentrate causes reduced milk yields while others have said that wheat middlings does not affect yield even when it is used as the only ingredient of the concentrate (Loosli, 1970).

The objective of this investigation was to evaluate productive responses such as milk yield, milk fat, feed intake, and protein utilization of lactating dairy cows when different proportions of wheat middlings, ranging from 0% to 60%, are included in their concentrate mix.

CHAPTER II

LITERATURE REVIEW

Introduction

Wheat (Triticum aestivum) as we know it today originated in the highlands of Ethiopia and Mesopotamia (today known as Iraq). There is documented evidence that it was used by Swiss lake inhabitants as early as 10,000 to 15,000 years ago; likewise, the Egyptians knew about and used wheat. Wheat was introduced in the Americas by the early Spanish expeditions. In North America, wheat was introduced around 1530 by the Hernan Cortes and subsequent Spanish expeditions and settlements in Mexico (Waldern, 1970).

Wheat is primarily used as human food; however, it has been used occasionally to feed livestock in areas where it is produced heavily. In The United States, wheat is the single most important cereal crop, but most of it is used in the manufacturing of flour for human consumption. A considerable part of the U.S. wheat crop is exported, and wheat grain left after flour manufacturing and export is then fed to livestock if its price is competitive with that of other grains. Also, it is common practice to feed wheat grain that does not make the milling grade, or damaged (i.e.

cracked) wheat to livestock; such a practice has usually given satisfactory results (Morrison, 1956).

The wheat kernel outer layer consists of a seed coat or bran that comprises about 13% of the kernel; this seed coat alone is higher in protein than the entire kernel, but it is also higher in fiber. The germ or embryo is located on the base of the kernel; it is high in protein and minerals and represents 2% of the kernel. The remaining part is called endosperm and is rich in carbohydrates, especially starch. The endosperm comprises about 85% of the wheat kernel (Maynard et al., 1979; McDonald et al., 1981). When flour is manufactured, most of the endosperm is removed from the kernel, leaving the germ and the outer coverings. A good portion of the germ is used for human consumption, and the seed coats or bran are used as fiber source for ruminant animals (McDonald et al., 1981), with the added advantage of their content of protein that is superior to that of the entire kernel (Morrison, 1956). The rest of the wheat milling by-products are combinations of outer coverings, aleurone, germ, and flour in different proportions. They are a good source of protein and phosphorus for dairy cattle (Waldern, 1970); however, they are, as most cereal grains, deficient in calcium, magnasium, vitamin A, vitamin D, riboflavin, and vitamin B_{12}. Their energy content is quite variable (Morrison, 1956). The wheat flour manufacturers must turn out flour with a required composition in order for it to be acceptable for human consumption; in addition, this flour output must be uniform both in quantity and quality. The requirements imposed on the milling industry help explain the compositional variability of wheat and other cereal by-products which must absorb the fluctuations both in quantity and, most important, in quality (Shellenberger, 1970).

Use of Wheat Grain in Dairy Rations

Composition

Wheat composition varies according to many different factors, among which the most important are type and variety of wheat, climate, soil fertility, and geographical area where the wheat is grown (Waldern, 1970 ; Morrison, 1956). Crude protein is one of the most variable nutrients in wheat. Morrison (1956) reported theat hard spring wheat was higher in protein (15.8%) than hard winter wheat (13.5%) while soft winter wheats were the lowest, barely making it to 10.0% crude protein. Waldern (1970) reported similar results but shows much more variability, giving ranges of 12 to 19% crude protein, 10 to 15% crude protein, and 8 to 12% crude protein for hard red spring wheat, hard red winter wheats, and soft wheats, respectively. Energy content seems to be less variable among the different types of wheat than that of protein (Waldern, 1970 ; McDonald et al., 1981`). The average digestibility coefficients for wheat protein, fiber, and nitrogen-free extract are, respectively, 84%, 70%, and 91% (Morrison, 1956).

Wheat is an excellent source of energy for dairy cattle, it is adequate in phosphorus but deficient in vitamins A, D, riboflavin and B_{12} as well as in calcium and magnesium (Waldern, 1970). The most recent figures on composition of the different types of wheat are those of the National Research Council (1982) which are shown in Table I

Amount of Intake, Acceptability, and Impact on Milk Yields

One of the major questions, and often a matter of controversy, that arises when using wheat in dairy rations is what percentage of wheat should be included in the concentrate. The answer to this question is very important because the proportion of wheat included in the concentrate has a direct impact on acceptability of the wheat concentrate by the cows and thus, on milk yields (Waldern, 1970). Much of the research about this topic was done in the 1930's and 40's when wheat surpluses were abundant and wheat prices were low. Those circumstances made wheat very attractive as concentrate feed ingredient.

The earliest reports of dairy cows fed wheat are from Maine and Ontario, Canada during the 1890's. Those reports say that dairy cows were fed for ten days with concentrates containing from one-half to all wheat. The concentrates were

TABLE I

NUTRIENT COMPOSITION OF DIFFERENT WHEATS

Item (%)	Hard Red spr.	Soft Red wtr.	Red wtr.	White wtr.	White wtr PC
Dry Matter	88.00	88.00	88.00	89.00	89.00
TDN	78.00	78.00	78.00	79.00	79.00
NE_1 (Mcal/Kg)	1.81	1.80	1.82	1.84	1.82
Crude protein	15.10	12.70	11.50	10.10	10.00
Crude fiber	2.50	2.50	2.20	2.30	2.50
Ash	1.60	1.70	1.80	1.60	1.90

Source: NRC. United States-Canadian Tables of Feed Composition, 1982.

well accepted by the cows; however, milk flows were lower for cows fed wheat rations than for those eating mixed control rations (Waldern, 1970).

In 1931, Jacobs of the Oklahoma Panhandle Station reported that two-thirds of the grain ration could be made up by wheat without deleterious effects on milk production. Likewise, in other studies, 40% wheat grain was included in the concentrate ration of lactating dairy cows without affecting either milk production or palatability. In this experiment, the cows were producing approximately 15 kg of fat corrected milk (FCM) per day, and were fed 1 kg of grain per 2.5 kg of milk produced (Hayden and Monroe, 1931). Researchers at the Ohio Agricultural Experimental Station (1934) fed two cows for a full lactation with a concentrate consisting of 98% ground wheat; the cows averaged 4434 kg in the 365-day lactation (12.2 kg/day) and 4.84% butterfat. That production may seem low for Jersey cows today, but at the time when the experiment was performed it was a fairly high milk production.

In the early 1930's, several researchers found wheat to be a suitable grain for dairy concentrates and recommended levels of wheat grain as high as one-third of the concentrate ration (Kentucky Experimental Station, 1931 ; Ontario Department of Agriculture, 1932). Kansas researchers reported that wheat could be fed to dairy cows at up to 57% of the concentrate mix; however, at those high levels some cows tended to go off-feed (Fitch and Cave, 1932). Dice

(1932) fed several concentrates containing up to 66% wheat grain and reported neither palatability problems nor milk yield decreases; the actual intakes of the cows were not reported. These results are consistent with those of Bateman (1942), who fed an "all chopped wheat grain ration" which sustained normal milk yield, butterfat percentage, and feed intake. Researchers at the Oregon Station (1940) fed 5 pounds of wheat in different physical forms (rolled, coarsely ground, medium, and finely ground) to supplement low quality hay and silage without drops in feed intake in any of the different treatments. Morrison (1956) summarized the results of earlier research by stating that ground wheat was a satisfactory ingredient for dairy cow concentrates when fed at a maximum level of one-third to one-half of the concentrate. He also pointed out that wheat had been successfully fed as the only concentrate. In any case, it was recommended to feed plenty of roughage when giving high levels of concentrate.

It is important to point out that most of these early studies were short experiments with few cows and in many of them the kind and amount of roughage fed to the cows was not specified. It is also important to take into account that the results and recommendations reported by these researchers may not be appropriate for more productive dairy cows which are fed higher levels of concentrate relative to roughage.

No extensive research on feeding wheat grain to dairy cows was done in the late 40's, 50's, and early 60's; however, growing surpluses in the late 60's produced renewed interest on the matter. McPherson and Waldern (1969) fed pelleted grain rations containing 93, 83, 73, 63, 53, and 20% white Gaines soft wheat in a lactation and acceptability trials. Wheat substituted for oats, barley, and cottonseed meal. Alfalfa hay was used as the only source of roughage; it was fed at a 55:45 roughage to grain ratio in the lactation trial and restricted to 1% of body weight in the acceptability trial in which concentrates were offered for ad libitum consumption. The different proportions of wheat in the concentrate made no difference in milk yields which averaged 21.6 kg. Intakes for all treatments were no different either; the same results were achieved in milk protein and solids-non-fat. Milk fat percentage was slightly higher for rations containing 93, 83, and 73% wheat, being highest in the third one (3.9%). The hay:concentrate ratio achieved in the acceptability trial was 35:65 which could account for the lower fat percentages and milk yields registered in that trial. All rations were readily consumed by the cows which did not show special preference towards any one of them. Those results were not consistent with those of a more recent experiment in which soft red winter wheat was fed at 33% and 67% of the concentrate mix. Roughage was provided by alfalfa hay and corn silage. Cows receiving the 67% wheat ration had lower milk yields than those on lower wheat concentrates (26.3 vs. 27.9 kg/day), and also had lower milk fat percentage (Cunningham et al., 1971).

It seems logical to say that wheat grain is an adequate ingredient for dairy concentrates; however, it should be used cautiously when it comprises high levels of the concentrate since there is some evidence of palatability problems and reduced milk yields under those conditions. However, since wheat is grown primarily as human food, its use in livestock concentrates will not be determined by the advantages or potential problems mentioned above but by the economics of wheat use around the world.

Metabolic Problems and Digestive Disturbances

In the dairy industry today, increasing amounts of grain are fed to dairy cows in order to provide the energy required to sustain very high milk yields for extended periods of time. Such a practice makes possible milk production levels unthinkable a few decades ago; nevertheless, it has some drawbacks, among which the most common are digestive disturbances such as cows going off-feed, and displaced abomasums; metabolic disturbances such as decreased butterfat test and acidosis are also observed.

There is little information about the occurrence of these problems when wheat is fed in large quantities. Wheat has not been a very common ingredient of dairy concentrates, except for periods of time characterized by high surpluses and low prices. Until recently, the amounts of wheat, or any cereal grain for that matter, sufficient to cause those disturbances were not commonly fed. However, as early as the 1930's, some researchers reported a tendency of some cows to go off-feed when wheat was raised up to 57% of the concentrate (Fitch and Cave, 1932). More recently, Bailey (1965) reported "off-feeds", drops in milk production, and laminitis in herds that were fed very high amounts of wheat during a shortage of roughage due to severe drought in New South Wales, Australia. On the other hand, these problems seem to be rare if the cows are not fed an excessively high percent of concentrate, wheat or otherwise, in the diet, and if abundant roughage is provided (Waldern, 1970).

The major concern when feeding high grain diets to ruminants is acidosis; it is caused when large amounts of starch and sugars enter the rumen, creating a favorable environment for the growth of lactic acid producing bacteria such as Streptococcus bovis and lactobacilli spp (Slyter et al, 1970). Oltjen (1970) compared the concentration of lactobacilli in the rumen of steers fed diets consisting of 90% corn, 90% wheat, and 60:30 mixes of both grains and found that wheat fed steers (both 60 and 90% wheat diets) had higher number of lactobacilli as well as lower rumen PH and higher VFA concentrations. Increased rumen acidity leads to absorption of lactic acid in concentrations and forms (D-lactate) that the animal cannot possibly utilize (Dunlop and Hammond, 1965 ; Dunlop et al., 1964). This increased blood acidity causes symptoms like dehydration, decreased blood volume, decreased renal function, depressed activity of rumen, heart, and other organs which may be followed by coma and death. Acidosis can cause complications such as liver abcesses due to migration of micro-organisms to the liver via portal blood as a result of the deterioration of the ruminal epithelium; laminitis can also be a complication of acidosis (Dunlop, 1970).

The problems just referred to are not likely to occur in dairy cows fed high wheat diets because those high proportions of concentrate are seldom, if ever, used in dairy diets. If they were, the cows would go off-feed and experience decreased milk production long before they showed symptoms of acidosis.

Comparison of Wheat with Other Cereal Grains

Abundant information is available regarding the comparison of the feeding value of wheat to that of other cereal grains; however, it must be pointed out that most of this was obtained from experiments in which the cows were fed small amounts of concentrate compared to those used in dairy herds today. Waldern (1970) in his review article on the subject reports that as early as 1896, a trial was done by Maine researchers in order to compare wheat to corn as concentrates for dairy cows; no differences were found among milk yields of the cows fed corn and those of the cows eating wheat, which reportedly gained more weight during the trial.

During the 1930's several experiments were done comparing wheat to other grains. In one of them, wheat was similar to oats and barley in maintaining milk and butterfat production; in addition, wheat was found to contain 84% TDN compared to 71.5% and 78.7% for oats and barley, respectively (Bowstead, 1930). Copeland (1933) compared the feeding values of milo and wheat in concentrates containing 50% of each grain. There were no significant differences in milk production and feed intake of the cows fed the respective grains; on the other hand, cows fed wheat had higher body weight increases, and wheat was found to be slightly higher in TDN content than milo. In an Ohio trial, corn and wheat rations were fed to dairy cows and similar results were accomplished, but, this time, cows fed corn gained slightly more weight than those fed wheat (Hayden and Monroe, 1931).

Morrison (1956) did a comprehensive comparison of the feeding values of wheat and corn in which he stated that wheat protein is of low quality, like most cereal protein, but it was thought to be superior to that of corn. Wheat has slightly less energy (ENE) than corn, but energy digestibility is about the same for both grains. Wheat contains more phosphorus than corn; has the same vitamin deficiencies as do other cereal grains but is superior to corn in niacin content.

Five rations containing 95% of Pacific Northwest soft wheat, corn, milo, oats, and barley, respectively, and a control mixed ration were used in a switchback lactation trial and an acceptability trial to compare the feeding value of the grains. Alfalfa hay was the sole roughage source and was given at hay to concentrate ratios of 55:45 and 33:67 in the lactation and acceptability trials, respectively. The grains were dry rolled and pelleted. Milk yields were not significantly different among treatments in both the lactation and acceptability trials; in the lactation trial, cows fed oats had the highest fat test and those fed milo the lowest. Corn was the least consumed grain and oats and milo were the most consumed grains in the acceptability trial; wheat and the control mix were consumed at the same level. Contrary to the results of some earlier research work, cows fed wheat gained the same, and even tended to gain less, weight that did cows fed the other rations. It is important to note that this is the only recent experiment in which reasonably high producing cows were used (Tommervik and Waldern, 1969).

In a recent experiment, corn and wheat (unspecified type) concentrates were compared. Corn and wheat were included at Ø, 19, 38, 57, and 77% of the concentrate, wheat substituting for corn. The sole roughage source was napier grass. Both the roughage and the concentrate were offered ad libitum and the animals regulated themselves to an average concentrate to roughage ratio of 68:32. No treatment effects were observed in 4% fat corrected milk which averaged 12.7 kg/day; however, the cows on the 57% and 77% wheat concentrates tended to produce slightly less milk. Likewise, there were no signnificant differences in milk fat, protein, or total solids. Dry matter intakes of cows fed the concentrates containing 57% and 77% wheat were significantly lower (Cribeiro et al, 1979).

In summary, the evidence in the literature suggests that wheat has a feeding value for dairy cows similar to that of most other cereal grains; however, when given in high proportion of the diet, the animals might be more succeptible to digestive distubances.

Description of Wheat By-Products

When the wheat kernels are subjected to the milling process, their component parts are separated by mechanical means. The starchy part of the kernel, called endosperm, is used to make flour for human consumption while the seed coats, aleurone layer, and germ are left as residue. Wheat by-products are combinations of these three parts of the kernel plus small amounts of endosperm. Wheat by-products contain more protein of better quality than the endosperm, or even the entire kernel (Morrison, 1956); wheat by-products are also superior in B vitamins, fat, and mineral matter (Maynard et al, 1979). The detailed composition of the different wheat by-products is presented in Tables II and III.

The wheat milling by-products more commonly fed to dairy cows are bran, middlings, and mixed feed; in addition, red dog and shorths are occasionally used in dairy concentrates.

Wheat bran is defined by the Association of Feed Control Officials as "the coarse outer covering of the wheat kernel as separated from cleaned and scoured wheat in the usual process of commercial milling" Schellenberger, 1970). Wheat bran contains, on the average, about 15% crude protein and 10% fiber; it is a good source of phosphorus but is low in calcium and practically devoid of vitamins A and D (Morrison, 1956 ; McDonald et al., 1981). Bran is often used as a source of fiber for ruminants but advantage is also taken of the superiority of its protein over that of cereal grains. during the first half of this century, bran was used to formulate slightly laxative rations to feed dairy cows just prior and after calving (Morrison,1956). It was widely assumed that wheat bran should not add up to more than 25% of the concentrate for dairy cows; however, in a trial during the 1950's, bran composed as much as 60% of the concentrate without affecting milk yields or intake. No detailed milk production values were given (Battaglini, 1954). More recently, Peruvian researchers compared wheat

TABLE II

NUTRIENT COMPOSITION OF WHEAT MILLING BY-PRODUCTS

Item	DM %	CP %	NE_l Mcal/Kg	TDN %	CF %	Ca %	P %
Bran	89.0	15.2	1.42	63.0	10.0	.11	1.22
Br.shorts	88.0	16.5	1.48	71.0	6.8	.09	.81
Red dog	88.0	15.3	1.66	72.0	2.6	.09	.49
Middlings	89.0	16.4	1.40	68.0	7.3	.11	.88
Mxd. feed	90.0	15.4	1.63	71.0	8.2	.10	1.02

Source: NRC, United States-Canadian Tables of Feed Composition (1982)

TABLE III

DIGESTION COEFFICIENTS OF WHEAT MILLING BY-PRODUCTS

Item	Protein	Fiber	TDN
Bran	81	49	67
Brown Shorts	85	60	74
Red Dog	88	34	86
Middlings	83	60	77
Mixed Feed	83	--	70

Source: Morrison, Feeds and Feeding, 22nd, ed.(1956)

bran to other crop and processing by-products in an experiment using Holstein cows which were offered two concentrates, one containing 50% wheat bran and the other the same proportion of ground maize cobs and cottonseed hulls. The rest of the concentrate was composed by cottonseed meal and molasses. In this trial, the bran concentrate was by far superior to the other in maintaining higher milk yields with the same feed intake; however, no detailed milk yield figures were provided (Rojas and Zeballos, 1972). Indian researchers using Hariana cows (a milking Zebu strain) compared a concentrate containing 80% bran and a protein supplement to another comcentrate containing 40% barley, 35% bran, and 25% protein supplement. The cows had free access to low quality roughage. No significant differences were encountered in milk yields and length of lactation when the cows were given 1 kg of concentrate per 2.5 kg of milk produced; cows receiving the wheat bran concentrate had a higher fat test, probably due to increased crude fiber (Shrivastava, 1973 ; Shrivastava, 1972).

Literature on wheat middlings will be reviewed separately from that of other wheat milling by-products, but for the sake of uniformity, wheat middlings will be defined in this section. The Association of Feed Control Officials defines wheat middlings as "fine particles of wheat bran, wheat shorts, wheat germ, wheat flour, and some of the offal from the "tail of the mill". This product must be obtained in the usual process of commercial milling and must not contain more than 9.5% crude fiber (Shellenberger, 1970).

Wheat mixed feed consists of wheat bran and brown shorts; it is also known by the name of "mill run". Mixed feed is lower than bran in fiber and contains more TDN; both by-products are about equal in protein content (Morrison, 1956). Waldern and Cedeno (1970) compared two rations containing 98% wheat mixed feed and 98% barley respectively to a control concentrate; all three rations were offered in meal and pelleted form; alfalfa hay was the roughage source. The researchers found that the TDN of wheat mixed feed, digestibility of dry matter and energy was lower than for the other rations. Intake of wheat mixed meal was lower than that for all the other rations. Milk yields which averaged 21.5 kg/day were not significantly different among treatments.

Other wheat milling by-products such as wheat shorts and red dog are sometimes used to feed dairy cows, but little, if any, research has been done about their feeding value. Wheat shorts consists of particles of bran, germ, a little flour, and offal from the "tail of the mill"; shorts contain less than 7% crude fiber. Wheat red dog contains less than 4% crude fiber and consists of the "tail of the mill" plus some particles of bran, germ, and flour (Schellenberg, 1970).

Characteristics and Use of Wheat Middlings

Wheat middlings contain 16-18% protein, 83% of which is digestible. This protein is believed to be of higher quality than that of the entire wheat kernel (Morrison, 1956). Wheat middlings contain 68-71% total digestible nutrients and, on the average, 7.3% crude fiber; in addition, middlings are a good source of phosphorus but low in calcium and vitamins A and D (Waldern, 1970 ; U.S.-Canada Feed Composition Tables-NRC, 1982). Details regarding the composition and digestion coefficients of wheat middlings are given in Tables II and III.

Not much research has been done in regard to feeding wheat middlings to dairy cows; however, the data available provide evidence that they are a suitable ingredient for dairy concentrates (Waldern, 1970). Wheat middlings were used in the past to provide a cheaper energy source than cereal grains; Morrison (1956) recommended the substitution of bran with middlings in order to increase the energy content and reduce the fiber content of dairy concentrates. More recently, middlings have been used to substitute a sizable part of energy sources like cereal grains and also part of the protein provided by supplements like soybean meal and cottonseed meal (Yamdagni et al., 1967 ; Kertz et al., 1983 ; VanHorn, 1982).

Responses of Dairy Cows to Wheat Middlings

Concentrates containing wheat middlings, and for that matter most other concentrates, can be offered to dairy cows in meal or pelleted form. Yamdagni et al. (1967) used a mixed concentrate containing 23% wheat middlings in both forms and foud no treatment effect on milk yields which averaged 21.6 kg/day. Cows receiving pelleted rations had slightly depressed fat tests. These results are not completely consistent with other research work. In one experiment in which a mixed concentrate containing wheat bran was offered to cows in meal and pelleted forms, cows receivieng pelleted concentrates produced 20.3 kg of milk per day versus 19.7 kg/day for cows fed the meal ration; in addition, cows eating pellets had a decreased fat percentage when compared to those eating meal concentrates. The cows eating pellets also had a slihgtly better TDN utilization than those fed meal (Bishop et al., 1963). Waldern and Cedeno (1970) using barley, wheat mixed feed, and a control ration reported increased milk yields (22.3 vs. 20.7 kg/day), milk protein , and solids-non-fat for cows eating pelleted rations; they also reported decrease in milk fat when high levels of pelleted rations were offered to the cows. Crude protein digestibility was slightly but not significantly higher for meal rations; however, TDN digestion coefficients were higher for pelleted rations than those for meal rations. The intake for wheat mixed feed meal was lower than that for the other rations; otherwise, no intake differences were encountered. Finally, Loosli (1970) reported better intakes with pelleted wheat middlings than those observed in cows fed finely ground middlings when they comprised a high proportion of the concentrate.

In the past, there has been some concern about the negative effects of wheat middlings on feed intake and milk production. Morrison (1956) recommended not to feed then over one-third of the concentrate in order to avoid reduced feed intake and the concomitant drop in milk production. More recently higher proportions of wheat middlings have been included in the concentrate without adverse effect on intake and milk production. Loosli (1970) reported intake problems when ground middlings were included in the ration at "much over 40%" , but those problems were taken care of by adding molasses or pelleting the ration; furthermore, it was reported that the cows accepted pelleted middlings as the only concentrate without problems. No milk production figures were given in this study.

In a Florida experiment, wheat middlings were fed as high as 45% of the concentrate without deleterious effects on milk yields, feed intake, and milk fat percentage (VanHorn, 1982). Kertz et al. (1983) fed 60% wheat middlings in the concentrate and reported no significant effect on feed intake when this ration was compared to opthers containing 50% and 35% middlings, respectively. No milk production figures were given in this experiment.

CHAPTER III

INFLUENCE OF DIFFERENT AMOUNTS OF WHEAT MIDDLINGS IN THE RATION ON PRODUCTION RESPONSES OF DAIRY COWS

Summary

Eighteen lactating dairy cows were in each of two switchback trials to evaluate rations containing different proportions of wheat middlings. Concentrates containing 0, 20, and 40% wheat middlings, and 0, 40, and 60% wheat middlings were fed to the cows in trials 1 and 2, respectively. Alfalfa hay was the sole roughage source and comprised 40% of the total ration. All concentrates were formulated to be isocaloric and iso nitrogenous.

Milk yields were 30.8, 29.6, and 29.5 kg/day for cows receiving concentrates containing 0, 20, and 40% wheat middlings in the first trial. There was a slight but not statistically significant decrease in milk production with each successive addition of wheat middlings to the ration; however, milk fat percentage as well as total dry matter and protein intake were similar for all groups. There was a significant linear increase in rumen ammonia and blood urea concentrations at 3 hr after concentrate feeding which may

be associated with the corresponding decrease in milk yields as the proportion of middlings in the ration increased.

The cows in the second experiment produced 26.2, 25.9, and 24.8 kg of milk per day when fed concentrates containing 0, 40, and 60% wheat middlings, respectively. There was a significant quadratic trend for a decrease in milk yields with each successive addition of middlings to the ration, the reduction being greater when middlings were raised from 40 to 60% of the concentrate. Milk fat percentage and total dry matter and protein intakes were similar for all groups. There were no significant differences among groups in concentration of blood urea and rumen ammonia.

The inclussion of wheat middlings up to 60% of the concentrate had no effect on feed intake. Milk yields were reduced when wheat middlings were added to the concentrate, especially if middlings comprised more than 40% of the mixture. Reduced milk yields of cows receiving a high percentage of wheat middlings in their diets may be associated with reduced efficiency of nitrogen utilization.

Introduction

Wheat middlings are a by-product of the wheat milling industry composed of fine bran particles, shorts, germ, some flour, and the residue called "tail of the mill". Wheat middlings contain about 17% crude protein (as fed basis) of which 83% is digestible, and no more than 9.5%

crude fiber (Morrison, 1956; NRC, 1982; Shellenberger, 1970).

Some wheat middlings can be included in the concentrate mixture without deleterious effects on milk yield, fat test, or protein and dry matter intake (Morrison, 1956; Waldern, 1970). However, the earlier research on feeding wheat middlings was with cows consuming much lower amounts of concentrate than is common in dairy herds today (Waldern, 1970). Little information is available on the effects of high concentrations of wheat middlings in rations for dairy cows, particularly under current conditions of high milk production and concentrate intake.

In the past, it was common practice to feed wheat middlings in proportions no larger than one-third of the concentrate (Morrison, 1956). However, the feeding of much higher proportions of wheat middlings in dairy concentrates has been recommended in recent years (Loosli, 1970; Van Horn, 1982; Kertz et al., 1983). Loosli (1970) reported some intake problems when finely ground middlings were included in the ration at over 40% of the concentrate, but if pelleted, wheat middlings could be fed as the sole ingredient of the concentrate without problems. In a recent experiment, wheat middlings comprised 25% of the diet (45% of the concentrate) without noticeable adverse effect on milk yields, feed intake, and milk fat percentage (Van Horn, 1982). Moreover, Kertz et al. (1983) fed dairy cows a concentrate containing 60% wheat middlings and reported no significant effects on feed intake when this ration was compared to others containing 50 and 35% wheat middlings, respectively.

The objective of this study was to compare the effect of concentrate diets containing different concentrations of wheat middlings on the production of dairy cows.

Materials and Methods

Experiment 1

Eighteen lactating dairy cows, 16 Holsteins and 2 Ayrshires, were used in a switch-back trial consisting of three five-week periods (Lucas, 1956). Three treatments were included in the experiment: one control and two experimental concentrates containing wheat middlings. All cows were given the control ration during a 2-week pre-trial adaptation period and then randomly allocated to one of six feeding sequences, each of which included two treatments (Appendix, Table XII), one applied in the first and third periods, and the other applied during the second period. All treatments were applied the same number of times.

The treatments consisted of three pelleted (3/8 inch pellets) concentrate mixes: a control mix containing corn and sorghum as energy sources and cottonseed and soybean meal as protein sources, and two experimental concentrates containing 20 and 40% wheat middlings, respectively. The three concentrates were formulated to be isocaloric and isonitrogenous. In order to accomplish that, each kilogram of wheat middlings added to the concentrate substituted for .15 kg. of corn, .65 kg. of sorghum grain, and .20 kg. of cottonseed meal. By calculation, all the concentrates contained 15.7% crude protein (as fed basis), net energy for lactation 1.6 Mcal/kg, and about 3.5% crude fiber (Table IV).

Alfalfa hay was the sole roughage source; it was fed at a ratio of concentrate to roughage of 60:40. Both concentrate and alfalfa hay were fed separately twice per day. The concentrate was given just before milking at 4:00 a.m. and 4:00 p.m. whereas the hay was offered after milking at 7:00 a.m. and 7:00 p.m.. Enough of both concentrate and hay was given to the cows to allow for a small amount of weighback. Feed offered and feed refused were weighed daily. The total feed intakes were calculated and summarized on a weekly basis; afterwards, the weekly dry matter and protein intake were calculated. Weekly samples of hay and the three concentrates were ground and dried in the oven at 100°C. for 24 hours to determine their dry matter content. The samples were then analyzed for crude protein (N x 6.25) with the macro-Kjeldahl method (A.O.A.C, 1975). The content of soluble nitrogen of the samples was analyzed using the procedures outlined by Krishnamoorty et al. (1981), which prescribe the addition of a borate-phosphate buffer to the samples and their incubation in a water bath provided with a shaker for 60 minutes at 39°C. The shaker was set at 110-120 rotations per minute; after incubation the samples were

TABLE IV

CONCENTRATE COMPOSITION - TRIAL 1

Item	Ration		
	Control	20% Mids	40% Mids
Ingredients, % as fed			
Corn, ground	30	27	24
Sorghum grain, ground	41	28	15
Wheat middlings	--	20	40
Cottonseed meal	10	6	2
Soybean meal	10	10	10
Molasses, liquid	7	7	7
Dicalcium phosphate	1	1	1
Salt	1	1	1
Calculated analysis, as fed			
NEl, Mcal/Kg	1.6	1.6	1.6
Total protein, %	15.6	15.7	15.8
Crude fiber, %	3.1	3.8	4.4

filtered and the nitrogen content of the residue was determined by macro-Kjeldahl procedure.

Milk weights were recorded twice daily, and milk samples were taken from four consecutive milkings each week and analyzed for milk fat percent with a Milkotester MK III F-3140 apparatus. Body weight of each cow was recorded on two consecutive days at the beginning of the trial and at the end of each period. The cows were weighed just before milking; therefore, the weight of milk at the subsequent milking was substracted from the respective body weight.

During the last week of each period, a sample of rumen liquid was obtained from each cow by stomach tube; subsequently, 8 ml of a 50% dilution of concentrated hydrochloric acid were added per each 100 ml of rumen liquid to stop microbial activity and to bind the ammonia into more stable ammonium chloride. The samples were strained through a double layer of cheesecloth and frozen in order to preserve them. Later on, the samples were thawed and centrifugued at 2000 r.p.m. (698 g.) for 10 minutes, and two 50 ul aliquots of the supernatant solution from each sample were assayed for rumen ammonia following the procedure of Broderick and Kang (1980). The concentration of ammonia was determined on the basis of absorbance read in a Varian DMS 90 ultra violet-visible espectrophotometer, using a wave length of 630 nm.

During the last week of each period, a blood sample was taken from the tail vein of each cow; .2 ml of oxalic acid were added for each 20 ml of blood to prevent coagulation. The samples were quickly chilled by putting them on ice and later were centrifugued at 4000 r.p.m. (2790 g.) for 30 minutes; The plasma was separated and frozen for future analysis. A combination of the methods described by Fawcett and Scott (1960) and Searcy et al. (1961) was used to assay the plasma samples for blood urea. A standard curve was developed to relate absorbance with urea concentration using known urea standards; two 50 ug aliquotes were taken from each plasma sample and added to phenol and sodium hypochlorite reagent solution which developed a color readable by the spectrophotometer set at 625 nm.

Average daily milk yield, milk fat percent, average daily FCM, dry matter intake, protein intake, body weight, weight gain, protein requirement, percent of protein requirement consumed, blood urea, and rumen ammonia from the last 4 weeks of each period were calculated and summarized on a "per period" basis for further statistical analysis.

The data were analyzed using the Statistical Analysis System (SAS). A switch-back analysis of variance (Lucas,1956) was performed on the data. The adjusted treatment means were compared using pre-planned orthogonal contrasts, i.e., linear and quadratic effects.

Experiment 2

The materials and procedures used in the second experiment were similar to those followed in the first trial. However,there were some important differences. A control concentrate similar to that of trial 1, and two experimental concentrates containing 40% and 60% wheat middlings were fed to 18 lactating Holstein cows (Table V). The concentrates were isocaloric and isonitrogenous; in order to achieve that, each added kilogram of wheat middlings substituted for .15 kg. of corn, .64 kg. of sorghum grain, and .21 kg of cottonseed meal. For all concentrates,calculated crude protein content was 15.2% (as fed basis), and net energy for lactation was 1.6 Mcal/kg. Crude fiber varied slightly, being 3.2, 4.5, and 5.1% for the control, 40, and 60% middlings concentrates, respectively. Finally, it is important to call attention to the fact that most of the cows used in trial 2 were in their first or second lactation whereas those used in trial 1 were older animals (Appendix, Tables XIV and XV).

Results and Discussion

Experiment 1

Milk yields of all cows averaged 29.9 kg per day; successive increments of wheat middlings percentage in the concentrate to 20 and 40%, respectively, resulted in slight but not significant (P>.05) decreases in milk production. The average for 4% FCM was 26.7 kg per day; the tendency for a decrease in milk yield was not evident for the FCM values; this could be attributed to the higher fat content produced

TABLE V

CONCENTRATE COMPOSITION - TRIAL 2

Item	Ration		
	Control	40% Mids	60% Mids
Ingredients, % as fed			
Corn, ground	28.5	22.5	19.5
Sorghum grain, ground	43.0	17.5	5.0
Wheat middlings	--	40.0	60.0
Cottonseed meal	13.0	4.5	--
Soybean meal	6.0	6.0	6.0
Molasses, liquid	6.0	6.0	6.0
Dicalcium phosphate	1.0	1.0	1.0
Salt	1.0	1.0	1.0
Sodium bicarbonate	1.0	1.0	1.0
Magnesium oxide	.5	.5	.5
Calculated analysis, as fed			
NEl, Mcal/Kg	1.6	1,6	1.6
Total protein, %	15.2	15.2	15.2
Crude Fiber, %	3.2	4.5	5.1

by cows receiving the 40% wheat middlings concentrate. No significant differences were noted among treatment groups regarding milk fat percentages, which averaged 3.3, 3.2, and 3.4% for cows receiving the control, 20, and 40% wheat middlings concentrates (Table VI). The average fat test for all three treatment groups was slightly below the breed average in spite of the fact that intake of concentrate was only 60% of total feed intake. This fat test depression may be the response of the cows to pelleted concentrates which have been known to be the cause of reduced milk fat percentages in dairy cows (Yamdagni et al., 1967).

Results of this experiment differ from those in an University of Florida experiment in which a slight, but non-significant, increase in milk yields occurred when wheat middlings comprised up to 45% of the concentrate given to the cows (Van Horn, 1982). In addition, Yamdagni et al. (1967) reported similar milk yields for cows fed a concentrate containing 23% wheat middlings and a control concentrate.

The dry matter and protein intake from both hay and concentrate was similar for the three treatment groups (Table VII), indicating that there was no problem with acceptability of concentrate mixes containing up to 40% wheat middlings. The absence of acceptability and palatability problems may be attributable to the practice of feeding pelleted concentrates; pelleting was observed to alleviate palatability problems otherwise noted in cows fed

TABLE VI

MILK YIELD AND MILK FAT PERCENTAGE OF COWS-TRIAL 1

Item	Ration		
	Control	20% Mids	40% Mids
Milk yield, kg/day	30.8	29.6	29.3
Ave. FCM, kg/day	27.4	26.0	26.7
Milk fat,%	3.3	3.2	3.4

TABLE VII

FEED INTAKE - TRIAL 1

Item	Ration		
	Control	20% Mids	40% Mids
Dry matter intake			
Concentrate DM, kg/day	12.3	11.9	12.3
Hay DM, kg/day	8.0	7.9	8.1
Total DM, kg/day	20.3	19.9	20.4
Protein intake			
Concentrate protein, kg/day	2.1	2.0	2.1
Hay protein, kg/day	1.4	1.4	1.4
Total protein, Kg/day	3.5	3.4	3.5
Protein requirement, kg/day	2.9	2.8	2.8
Protein consumption, % of req.	123	125	126
Weight change, kg/day	.23	.17	.18

concentrates containing high percentage of wheat middlings (Loosli, 1970). Feed intake values are consistent with those of other recent studies in which wheat middlings were included in dairy concentrates in as high a proportion as that used in this experiment (Van Horn, 1982; Kertz et al., 1893). Morrison (1956) reported that the inclusion of wheat middlings in proportions over one-third of the concentrate mix would result in reduced feed intake, but it must be taken into account that the cows used at that point in time were fed at much lower concentrate to roughage ratios and produced much less milk than the high producing dairy cows we have today.

Body weight gains were not statistically different among treatment groups and averaged .19 kg/day (Table VII). These results are consistent with those of Waldern and Cedeno (1969) who obtained similar weight gains by a group of cows fed wheat mixed feed and another group fed a control concentrate. In addition, Tommervick and Waldern (1969) demonstrated that wheat and most of its by-products can sustain weight gains in dairy cows as high as those sustained by other cereal grains.

Crude protein content (as fed basis) determined by analysis was 15.66, 15.61, and 15.97% for the concentrates containing 0, 20, and 40% wheat middlings, respectively (Appendix, Table XVI). These figures are slightly higher than the calculated values obtained when the concentrates were formulated; this small discrepancy is probably due to the use of a tabular value of 16.4% (NRC,1982) which was lower than the actual crude protein content (17.5%) of the wheat middlings used in this experiment (Appendix, Table XVIII). In fact, the crude protein percentage of wheat middlings has been found to be rather variable (Shellenberg, 1970);

Total protein intake was similar for all treatment groups; it averaged 3.48 kg per day, and was 24.6% higher than the calculated crude protein requirement. No significant (P>.05) treatment effects on protein intake and requirement were found among treatment groups (Table VII).

There was significant linear trend (P>.05) toward higher concentrations of blood urea and rumen ammonia measured 3 hr. after concentrate feeding (Table VIII) as the percentage of wheat middlings in the ration increased. Furthermore, the percentages of soluble nitrogen were 25.8 and 25.2% of total nitrogen for the 20 and 40% wheat middlings experimental concentrates, slightly higher than that for the control concentrate (22.9%). This is probably due to the higher percentage of soluble nitrogen (34.7%) exibited by wheat middlings (Appendix, Table XVIII). Protein contained in wheat middlings concentrates tends to be more readily degraded by the ruminal micro-organisms (Nocek et al., 1979) and, therefore, is used less eficiently for milk production.

The increases in blood urea, rumen ammonia, and percentage of soluble nitrogen are consistent with the

TABLE VIII

NITROGEN UTILIZATION - TRIAL 1

	Ration		
Item	Control	20% Mids	40% mids
Blood urea, mg/dl[a]	16.4	17.5	18.5
Rumen ammonia, mg/dl[a]	10.1	15.9	16.3
Soluble nitrogen,% of total N	22.9	25.8	25.2

[a]Significant linear trend (P>.05)

tendency shown by the cows to produce less milk when the proportion of wheat middlings in the concentrate mix was increased. Morever, reduced milk yields may be associated with less efficient utilization of proteinwhen rations containing high levels of middlings are offered to dairy cows.

Experiment 2

Milk yields of cows fed rations containing wheat middlings were lower than those of cows fed the control concentrate (Table IX). Although the yield of cows fed the concentrate containing 40% middlings did not differ greatly from the control, there was a significant (P>.05) quadratic trend for reduction in milk production as the percentage of middlings was increased in the concentrate. The reduction in milk yield was sharper when middlings were raised from 40 to 60% of the concentrate. Milk production figures for other experiments in which 40% or more of wheat middlings have been included in concentrates fed to dairy cows are not available; however, the results of this trial are consistent with those of an experiment in which cows fed a concentrate containing a very high proportion of wheat mixed feed produced significantly less milk than cows fed a control concentrate (Waldern and Cedeno, 1970).

There was no consistent concentrate effect on milk fat percentage which averaged 3.66%. Average 4% FCM values were similar for cows receiving the control and the 40% middlings

TABLE IX

MILK YIELDS AND FAT PERCENTAGE OF COWS - TRIAL 2

Item	Ration		
	Control	40% Mids	60% Mids
Milk yield, kg/day[a]	26.5	25.9	24.8
Ave. FCM, kg/day	24.7	24.7	23.8
Milk fat, %	3.6	3.7	3.7

[a]Significant quadratic trend (P<.05)

concentrate; FCM for the group receiving the concentrate containing 60% wheat middlings was slightly but not significantly (P>.05) lower than the other two groups (Table IX), reflecting the similarity of the fat test for each and every group.

No treatment effects were observed regarding dry matter and protein intake from both hay and concentrate (Table X). Similar feed consumptions for all treatment groups indicated no acceptability problems when wheat middlings were included at proportions as high as 60% of the concentrate mix. This is consistent with the findings of recent studies in which percentages of middlings ranging from 45 to 60% were included in the concentrate of dairy cows without adverse effects on feed intake (Van Horn, 1982; Kertz et al. 1983); furthermore, our figures tend to support the assertion that pelleted wheat middlings can comprise very high percentages, and even the totality, of dairy concentrates without deleterious effects on feed intake (Loosli, 1970). No digestive disturbances were observed in this trial.

Body weight gains of cows fed the experimental concentrates were close to .7 kg per day (Table X), which is quite high for lactating dairy cows, but this is explained by the fact that many of the cows used in this trial were in their first or second lactation, a time at which they are still growing and, thus, gaining weight quite rappidly. The weight gain value for cows receiving the control concentrate is not representative of that group of cows because two

TABLE X

FEED INTAKE - TRIAL 2

Item	Ration		
	Control	40% Mids	60% Mids
Dry matter intake			
Concentrate DM, kg/day	12.2	12.6	12.3
Hay DM, kg/day	8.0	8.2	7.8
Total DM, kg/day	20.2	20.8	20.1
Protein intake			
Concentrate protein, kg/day	2.1	2.2	2.1
Hay protein, kg/day	1.6	1.6	1.5
Total protein, kg/day	3.7	3.8	3.6
Protein requirement, kg/day	2.7	2.7	2.6
Protein consumption, % of req.	136	139	136
Weight change, kg/day	.43[a]	.74	.78

[a]Two cows omitted due to illness.

young cows were omitted from the calculations due to illness, and the lower gains experienced by older cows in the group lowered the average value.

Crude protein content of the concentrates determined by analysis corresponded with the calculated values, except for the concentrate containing 60% wheat middlings which was slightly higher in protein (Appendix, Table XVII).

Total protein intake averaged 3.69 kg per day; it was about 38% higher than the amount of protein needed to meet all maintenance, growth, and lactation requirements of the cows.

Blood urea and rumen ammonia concentrations 3 hr after concentrate feeding were similar for all treatment groups (Table XI); The increasing tendency shown by blood urea and rumen ammonia in the first experiment was not evident in this second trial probably because of the excess of protein consumed by the cows; In addition, management of the animals (i.e., whether they were given water prior to or after sampling, time of sampling, etc.) may have had some influence, especially on rumen ammonia concentration. The high blood urea concentrations are attributable to the high dietary nitrogen intake (Van Soest, 1983). Percentages of soluble nitrogen were 22.4, 23.3, and 40.0% for the control, 40, and 60% wheat middlings concentrates, respectively (Table XI). Reduced milk yields of cows when levels of wheat middlings in the concentrate were raised to 40 and 60% could be associated with lowered efficiency of protein utilization

TABLE XI

NITROGEN UTILIZATION - TRIAL 2

Item	Ration		
	Control	40% Mids	60% Mids
Blood urea, mg/dl	22.7	21.0	21.8
Rumen ammonia, mg/ dl	8.2	8.3	8.5
Soluble nitrogen, % of total N	22.4	23.3	40.0

when wheat middlings comprise high proportions of the concentrate.

Since a sizable part of the corn and sorghum grain, which have a very low ADF content, was substituted by wheat middlings, it is logical to ask wether the energy content of the experimental rations was affected. However, wheat middlings also substituted for cottonseed meal which is quite high (2Ø%) in ADF content. The net gain in ADF per each kilogram of wheat middlings added to the ration was .Ø28 kg ADF. The total increases in ADF were .56, 1.12, and 1.68% for the rations containing 2Ø, 4Ø, and 6Ø% wheat middlings, respectively. These amounts of added ADF are considered very small to have an important effect in the energy content of the rations; especially if the amount of energy provided by alfalfa hay is taken into account. Therefore, the energy content of the rations in both trials does not seem to be a limiting factor for milk production.

Conclusions and Recommendations

Inclusion of wheat middlings in proportion as high as 6Ø% of a pelleted concentrate had no adverse effect on feed intake and digestive function; on the contrary, there is some evidence that favors feeding even higher percentages of wheat middlings in dairy concentrate mixes. Reduced feed intakes are often symptoms of digestive disturbances. Such disturbances should be infrequent when concentrate to roughage ratios are similar to the 6Ø:4Ø used in this study;

however, caution should be exerted when including high levels of wheat middlings in the concentrate of dairy cows fed at higher proportions of concentrate.

Milk yields of cows were reduced when wheat middlings were added to the concentrate, especially when middlings constituted more than 40% of the concentrate mix. Wheat middlings is a satisfactory substitute for grain and protein supplements as both energy and protein source, especially in areas where grain and protein are expensive or scarce and by-products may be a more economical option. Nevertheless, levels of wheat middlings higher than 40% of the concentrate should be avoided because they tend to reduce milk yields.

Reduced milk yields of cows fed concentrate mixes containing a high percentage of wheat middlings may be associated with reduced efficiency of nitrogen utilization. This conclusion was reached on the basis of blood urea concentration, rumen ammonia concentration, and percentage of soluble nitrogen in the feeds. These are not direct measurement of digestibility and degradability of protein in the digestive tract, but mere estimates; therefore, a more critical evaluation for protein in the different mixtures to be degraded in the rumen is needed, possibly by means of the in vivo dacron bag procedure.

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APPENDIX

TABLE XII

TREATMENT SEQUENCE CODES - TRIAL 1

Trt. Seq.[a]	Code number
1-2-1	1
2-3-2	2
3-1-3	3
1-3-1	4
3-2-3	5
2-1-2	6

[a] Control = 1

20% Wheat middlings = 2

40% Wheat middlings = 3

TABLE XIII

TREATMENT SEQUENCE CODES - TRIAL 2

Trt. Seq[a]	Code number
1-2-1	1
2-3-2	2
3-1-3	3
1-3-1	4
2-1-2	5
3-2-3	6

[a] Control = 1

40% Wheat middlings = 2

60% Wheat middlings = 3

TABLE XIV

LACTATION, CALVING DATE, TREATMENT SEQUENCE, NUMBER OF DAYS LACTATING WHEN STARTED, AND MILK PRODUCTION PER PERIOD OF EACH INDIVIDUAL COW
TRIAL 1

Cow #	Lact. #	Calving Date[a]	Trt. Seq.	Days Lact[b]	Av. milk yield Per 1	Per 2	Per 3
305	1	11/22	3	53	61.4	57.8	55.7
331	1	11/25	1	50	74.3	69.2	66.9
250	2	12/03	2	56	76.3	60.6	54.3
092	3	12/05	5	61	71.6	68.8	65.3
834	6	12/07	4	59	86.2	77.8	77.8
260	2	12/08	6	58	65.9	60.1	53.4
077	3	12/10	1	56	90.3	77.6	78.2
059	4	12/11	3	55	71.0	64.6	62.2
929	4	12/12	2	54	72.2	57.6	54.6
018	4	12/12	4	61	69.8	66.8	60.0
179	2	12/13	6	60	66.8	69.3	44.9
902	5	12/14	5	59	63.1	60.3	53.4
352	1	12/16	1	57	57.2	53.0	54.1
961	4	12/16	2	57	75.4	66.6	62.6
197	4	12/28	3	59	55.2	52.8	43.4
226	2	12/29	4	60	66.8	58.8	49.3
725	7	01/19	6	60	94.7	97.1	86.3

[a]Calving dates are from the years 1982 and 1983.

[b]Day of lactation when cows started the experiment.

TABLE XV

LACTATION, CALVING DATE, TREATMENT SEQUENCE, NUMBER OF DAYS LACTATING WHEN STARTED, AND MILK PRODUCTION PER PERIOD OF EACH INDIVIDUAL COW
TRIAL 2

Cow #	Lact. #	Calving Date[a]	Trt. Seq.	Days Lact[b]	Av. milk yield Per 1	Per 2	Per 3
098	4	08/05	1	62	64.0	63.1	51.4
960	5	08/08	3	59	75.6	78.8	73.8
294	3	09/10	2	63	48.3	44.7	48.4
410	1	08/26	4	54	61.2	54.6	58.0
381	2	08/25	5	57	53.4	53.9	51.8
416	1	08/29	6	53	51.0	53.2	47.4
414	1	08/29	1	60	57.8	56.9	57.0
413	1	08/30	2	59	54.6	51.6	49.2
388	2	08/31	3	58	57.6	59.2	55.4
392	1	08/31	4	58	67.5	56.2	47.7
382	2	09/01	5	57	62.2	63.0	61.3
390	1	09/05	6	53	59.6	60.2	56.8
424	1	09/01	1	57	53.5	52.8	53.6
396	1	09/05	2	53	52.9	50.4	50.9
395	1	09/04	3	54	53.0	57.2	53.8
383	2	09/06	4	71	54.7	52.3	55.4
399	1	09/14	5	75	55.7	56.6	56.3
450	1	09/10	6	81	50.0	53.3	55.0

aCalving dates are from the year 1983.

[b]Day of lactation when cows started on experiment.

TABLE XVI

CHEMICAL ANALYSIS OF FEEDS (DRY BASIS)

TRIAL 1

Item	Control	20% Mids	40% Mids
Dry matter, %	87.30	87.39	87.35
Crude protein, %	17.39	17.35	17.74
Soluble nitrogen, %[b]	22.95	25.76	25.23
ADF, %	4.80	a	8.19

[a]Not available.

[b]As % of total nitrogen.

TABLE XVII

CHEMICAL ANALYSIS OF FEEDS (DRY BASIS)

TRIAL 2

Item	Control	40% Mids	60% Mids
Dry matter, %	87.88	88.26	88.01
Crude protein, %	16.81	16.38	17.73
Soluble nitrogen, %[a]	22.40	23.33	40.00
ADF, %	4.80	8.19	8.67

[a]As % of total nitrogen.

TABLE XVIII

WHEAT MIDDLINGS COMPOSITION (DRY BASIS)

Item	Calculated	Actual
Dry matter, %	90.00[a]	91.87
Crude protein, %	16.40[a]	17.45
Soluble nitrogen, %[d]	37.00[b]	34.70
ADF. %	c	13.11

[a]NRC. 1982. U.S.-Canadian Tables of Feed Composition.

[b]VanSoest, P.J. 1983, Nutritional Ecology of the Ruminant.

[c]Not available.

[d]As % of total nitrogen.

TABLE XIX

ALFALFA HAY COMPOSITION (DRY BASIS)

Item	Calculated	Actual
Dry matter, %	90.00[a]	89.50
Crude protein, %	19.00[a]	20.56
Soluble nitrogen, %[c]	30.00[b]	35.75
ADF, %	32.00[a]	18.17

[a]NRC. 1982. U.S.-Canadian Tables of Feed Composition.

[b]Van Soest, P.J. 1983. Nutritional Ecology of the Ruminant.

[c]As % of total nitrogen.

TABLE XX

AVERAGE WEIGHT OF COWS
TRIAL 1

Cow #	Trt. Seq	Weight, kg Per. 1	Per. 2	Per.3
305	3	538	548	552
331	1	507	525	525
250	2	557	570	583
92	5	624	629	637
834	4	597	597	608
260	6	552	552	555
77	1	643	661	678
59	3	593	606	617
929	2	643	652	659
18	4	575	584	575
179	6	557	575	565
902	5	661	656	643
352	1	579	588	579
961	2	567	570	575
197	3	467	470	475
226	4	678	674	683
725	6	665	674	688

TABLE XXI

AVERAGE WEIGHT OF COWS
TRIAL 2

Cow #	Trt. Seq.	Weight, kg Per. 1	Per. 2	Per. 3
98	1	688	733	729
960	3	715	729	720
294	2	688	688	697
410	4	448	471	480
381	5	575	602	606
416	6	493	516	520
414	1	561	588	602
413	2	480	498	507
388	3	552	543	525
392	4	566	606	592
382	5	611	634	647
390	6	588	629	643
424	1	557	584	602
396	2	566	593	615
395	3	651	688	706
383	4	638	647	674
399	5	588	602	624
450	6	457	480	503

VITA

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