1980

Feeding Value of High Protein Oat Silage Versus Corn Silage for Dairy Cows

Tilahun Sahlu

FEEDING VALUE OF HIGH PROTEIN OAT SILAGE VERSUS CORN SILAGE FOR DAIRY COWS

BY

TILAHUN SAHLU

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Dairy Science, South Dakota
State University
1980

FEEDING VALUE OF HIGH PROTEIN OAT SILAGE VERSUS CORN SILAGE FOR DAIRY COWS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Howard H. Voelker Date
Thesis Adviser

John G. Parsons Date
Head, Dairy Science Dept.

ACKNOWLEDGMENTS

The author wishes to thank Dr. H. H. Voelker for his support and guidance. I would like to express my sincere appreciation to Dr. David J. Schingoethe for his continual guidance, support, and constructive criticism throughout writing of this paper. I would like to thank Fenton Ludens, Lennis Baumiller, and the rest of the farm crew for their assistance during the course of this study.

Appreciation is extended to Dr. John Parsons, Dr. L. Tucker, Myers Owens, and my fellow graduate students who lent their support during my studies.

The author wishes to thank Marlys Moberg for her excellent work in the preparation of this thesis.

A very special thanks is given to my host family, Dr. Don Gustin, Mrs. Sharon Gustin, and their family for their constructive advice and making my stay in Brookings very pleasant and they will always be remembered.

I thank my wife, Shetaye Mulugeta, and my sons, Yonathan and Sahlu for their love, support, and encouragement that knows no bounds.

Finally, I wish to dedicate this work to my Fellowship sponsor, The African American Institute, and the people of South Dakota for making it possible for me to complete this work. Without their continuous support my studies would never have been completed.

TS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Corn accounts for 80% of the total silage production in the United States while oats ranks second as a feed grain crop. Oats are a major crop in areas of the world where temperatures are cool and short growing seasons are not well suited for corn production. South Dakota is the leading oat producing state in the nation with 1.68 million kilograms of oats produced annually. Oats play an important roll as animal feed because among common cereals in the United States it ranks highest in both protein and lysine content. Due to the wide genetic diversity of oat protein content, it seems possible to raise protein quantity in cultivated oat cultivars.

Oat silage contains higher crude protein and a higher percent of digestible protein than corn silage, sorghum silage, and barley-pea silage. However, corn silage is superior to oat silage in total digestible nutrients (TDN) and digestible energy (17, 56, 96). The protein yield in oat groats (dehulled kernels) of Spear (Neal x Clintland 64 cross) oats is one of the highest of currently available varieties. This high average protein yield indicates a combination of high protein percent and adaption to South Dakota's environment. The grain contains 7% oil as compared to 5 or 6% for most other varieties (21, 68). In addition, Spear oat has a stiff straw and moderate rust resistance which makes it favorable to farmers who grow it for livestock feeding.

Regular oatlage has been compared to corn silage by various workers at various times, but no comparison has been made between corn silage and oat silage from high protein oat varieties. Therefore, the objective of this study was to compare the high protein oats variety (Spear) to corn silage as a sole forage for lactating cows.

LITERATURE REVIEW

Corn Silage for Dairy Cattle

Corn silage is well known for yielding more energy per hectare than any other crop (17). Total digestible nutrient (TDN) values for corn silage usually range from 60 to 70% compared to 73% TDN for ear corn (61). The average percent composition of corn silage, on a dry matter (DM) basis, for crude protein, ether extract, crude fiber, and nitrogen free extract are: 8.3, 3.0, 25.1, and 57.6, respectively (42, 61).

As the corn plant matures, there is an increase in the dry matter of the total plant, but expressed on a DM basis, there is a decrease in crude protein, crude fiber, and ash contents (17). Many workers (17, 96) have shown that the stage of maturity has little effect on the digestibility of corn silage DM. However, Gordon et al. (32) and Owens et al. (66) reported a decrease in lactic acid production with advancing maturity of corn ensiled for silage.

Several researchers (13, 35, 85) reported similar body weight gains, milk and milk fat production, and persistency of production for cows that consumed only corn silage as compared to cows that received corn silage and alfalfa hay. Cows fed corn silage as their only forage continued to produce well during successive lactations and responded similarly to those which received hay. Thomas et al. (80) fed cows either corn silage or alfalfa hay as the only roughage for three lactations. Production of fat corrected milk (FCM), fat, and solids-not-fat (SNF) was similar when cows were fed corn silage, hay, or their combinations for one lactation. When continued on only corn silage or only hay for two or three consecutive lactations, those fed corn silage consumed less forage DM, produced similar amounts of milk and FCM with similar persistencies, consumed slightly more grain, and had less weight loss.

Considerable research has determined the relative milk production when cows were fed corn silage only or various combinations of corn silage and hay. Owens et al. (65) found no significant difference in milk production when corn silage was supplemented with orchard grass or mixed hay. However, one probably would not have expected to find differences in milk production since two groups of six animals were fed hay that contained 6% digestible protein for short periods. Waugh et al. (91) found no significant differences in fat corrected milk production of cows fed corn silage ad libitum and hay at 0, .25, .50, and 1.00% of body weight. Holter et al. (40) fed corn silage plus either wilted mixed grass silage or mixed grass hay in a 60:40 DM ratio and found no significant differences in either nutrient digestibility or energy balance data.

In a 4 yr lactation trial, Holter et al. (39) found no difference in milk production of cows fed corn silage or corn silage supplemented with grass hay even though DM intake was higher on hay rations. Thomas et al. (80) fed medium quality alfalfa (14.7% crude protein) with different proportions of corn silage to 40 cows and concluded that dairymen could feed only corn silage and receive milk yields equal to or greater than yields achieved when they fed alfalfa hay or various proportions of both forages.

Belyea et al. (5) reported that cows fed corn silage, corn silage plus hay crop silage, and corn silage plus hay had similar feed intakes, milk production, and body weights, and concluded that there was no advantage for hay included with corn silage.

Moisture content, hay supplementation, and energy content of corn silage were studied as factors affecting DM intake and utilization by lactating cows (22). In experiment 1, a 2 wk delay in date of harvest resulted in an increase in DM content of silage, but this was associated with greater ($P<.05$) DM intake and fat corrected milk production for early maturing varieties. Harvest dates had no influence on solids-not-fat (SNF) content of the milk or body weight, but silage from early maturing varieties resulted in a higher ($P<0.05$) SNF content and greater loss in body weight. In experiment 2, feeding 4.7 kg of hay per day reduced ($P<0.05$) silage total DM intake and increased total ration DM intake but did not change milk production or composition when compared with feeding 2.3 kg of hay per day. In experiment 3, ear silage, stalk and leaf silage, and hay were compared as sources of roughage for lactating cows. Total ration DM intake was greater ($P<.05$) when hay was fed alone, but milk production was higher when ear silage was fed.

Moisture content is one of the major characteristics of corn silage controlling DM intake (91). Other factors which affect the acceptability of silage include digestibility of the DM (55), the percentage of crude fiber and crude protein, and the amount of hay fed with the silage (50, 91).

Health problems were encountered more frequently in the cows fed only corn silage (18). Incidence of ketosis and listeriosis was much greater in the all or high corn silage diet. Some (40, 62) attributed cases of metritis, mastitis, milk fever, retained placentas, and iodine deficiencies with forms of stress introduced by all corn silage feeding. Some cows in the all corn silage group had retained placentas and produced calves with goiters. It was concluded that cows can maintain high levels of milk production for successive years when fed corn silage as the sole forage (35, 85). Abomasal displacement occurred frequently in the studies reviewed and has been attributed to high grain feeding concurrent with feeding corn silage as the sole forage (19, 39, 82).

The high energy content of corn silage has led to problems in housing systems where cows in a herd are in one group and corn silage is offered free-choice. Overconsumption of energy by growing heifers leads to excessive gain rate which may be detrimental to later lactation ability and results in greater loss of cows from the herd because of reproductive failure (sterility). The same problem could occur from overfeeding dry cows (18, 61).

Field observations (18, 82) indicate that overconsumption of energy in mid to late lactation may cause the following: 1) depress production in the current lactation, 2) depress appetite in the following lactation, and 3) result in animals which are prone to develop clinical ketosis because of the overconditioning, a fundamental metabolic antagonism may exist between milk production and body fat which diverts excess dietary energy in late lactation to body fat rather than to milk production.

Corn silage is low in calcium, sodium, phosphorus, magnesium, and cobalt and may be deficient in iodine for ruminants in some geographical areas (18, 36). Other studies suggest that sulfur should be supplemented when urea is added and silage is fed as a major or only forage (45). Thomas et al. (79) reported that cows fed silage that is high non-protein nitrogen are more susceptible to sulfur deficiency than those fed normal corn silage. Even though many researchers (18, 79) recommend the supplementation of dairy feeds with vitamins A and D, others (36) feel that corn silage contains a sufficient quantity of vitamin A as carotene and vitamin D to satisfy the animals' requirements.

Oat Silage for Dairy Cows

Oats protein has three unique features relative to other cereal grains which are used for livestock feed. 1) It has a high biological value. Hischke et al. (38) found that protein from seven oat varieties had protein efficiency ratios of 2.3 to 2.4 when fed to rats. 2) The avenin content in oat protein is low, ranging from 12 to 20% whereas, protein of other cereals range from 30 to 60%. No direct comparisons have been reported between the amino acid composition of oat protein and those of high lysine types of corn, barley, and sorghum, but indirect evidence indicated that the protein composition of oats is nearly identical to those mutant forms (25). 3) The protein percentage of oats can be elevated by genetic means to very high levels. Generally, while grains of oats range from 9 to 16% protein (25) and the maximum protein in groats of commercial varieties has been quoted as high as 20% (6). Robbins et al. (20), from analysis of 289 oat lines from the world collection, reported a range of groat protein from 12.5 to 24.4 with the mean of 17.1%. This data suggests that it is possible to elevate the groat protein percentage of oats above the 14 to 17% found in commercial varieties. Even more encouraging, however, is another source of gene for high groat protein that exists in A. Sterilis, a weedy oat type collected near the Mediterranean Sea. Groat protein content in A. Sterilis has been reported up to 27.3% by Ohms et al. (60), to 28% by Campbell et al. (12), and to 35% by Frey et al. (30).

The biological value of oat protein doesn't deteriorate as the protein percentage increases. Frey (27) analyzed oat varieties with a range of grain protein from 9.3 to 15.8% and found that all had avenin: protein ratios of 0.18 or .19. Additionally, Robbins et al. (70) reported a very low correlation between groat protein percentages and lysine percentages in the protein. Analyses of A. Sterilis showed that amino acid percentages in the groat protein from this species also remained constant over the range of protein percentages from 17.0 to 25.1%, which transcends the range of A. Sativa studied by Frey (27).

Reports by various workers indicated that varietal and environmental conditions influence the amino acid composition of oat protein. Frey (28) demonstrated that a change in lysine, methionine, tryptophan content accompanied a change in total nitrogen level of oat samples. Differences in the lysine content of the varieties with varying protein content for any given year were very small. From year to year as the protein content increased, the glysine content expressed as a percentage of the total protein, also increased. McElroy et al. (57) found that the lysine content of nine samples of oats, ranging in protein content from 9.4 to 18.9%, remained uniform. The samples were of one pure variety, thus, variations in protein content reflected environmental influence.

Since the groat protein of oats has a good biological value relative to other cereals and its amino acid composition probably is constant over a broad range of protein percentages, plant breeders are concentrating efforts to increase groat protein percentages (29). Among common cereals in the United States, oats ranks highest in both protein and lysine content (67), and because of its wide genetic diversity, it seems possible to raise the protein quality in the oat cultivars. The inverse relationship of protein and yield (7, 43, 51, 59, 64, 78); however, presents a problem of how to combine high protein and high yield.

Research on swine feeding by Wahlstrom and Libal (89) indicated that high protein-high lysine oats can be used to advantage by reducing supplementary protein needs in growing-finishing diets for swine. Including oats as 60% of the grain portion of the diet allowed for a reduction of soybean oil meal by 43% in the growing period and 64% in the finishing period.

Many researchers (4, 11, 21, 40, 44, 46, 53, 54, 72, 74, 75, 76, 81) have reported that the protein and TDN content of the plant decreases with increasing maturity from the boot stage (before heads appear) to the dough stage of kernel development. Hutjens and Martin (44) reported highest NE at milk stage while Stallcup et al. (75) found no significant difference in NE at milk stage or dough stage, but both reported the TDN to be highest at boot stage. Figures 1 and 2 by Dale (74) show stages of development and nutritional composition with advances in stages of maturity. The yield of DM per hectare increases 25 to 50% from the boot stage to dough stage. Other researchers (37) suggest for an optimum compromise between dry matter yield and animal production per hectare, oats forage should be harvested when about 20% of the plant reach the flowering stage. In California (58), lamb production per hectare at this stage of maturity was 35% greater than at the boot or milk stage and 15% greater than if harvested when 42% of the heads were at the dough stage of maturity. Lignification of the fiber apparently occurs during the milk stage reducing the forage nutritional value. Grain development partially offsets the lower digestibility of the straw at the dough stage. These results suggest that if the situation doesn't permit harvesting at the 20% flowering stage, harvesting should occur at the dough stage in preference to

FIG. 1. Dry matter yield versus stage of maturity of oats forage.

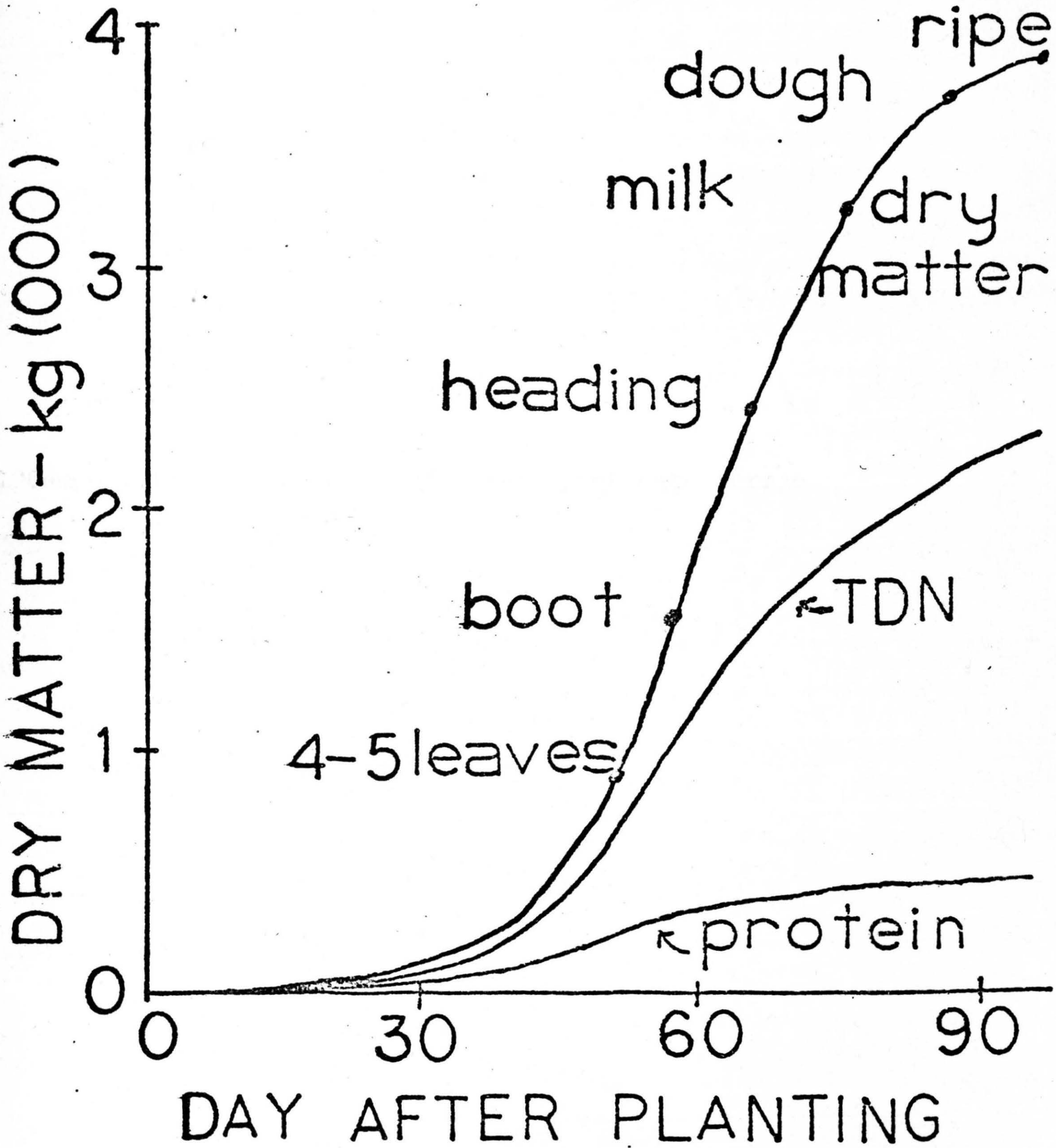
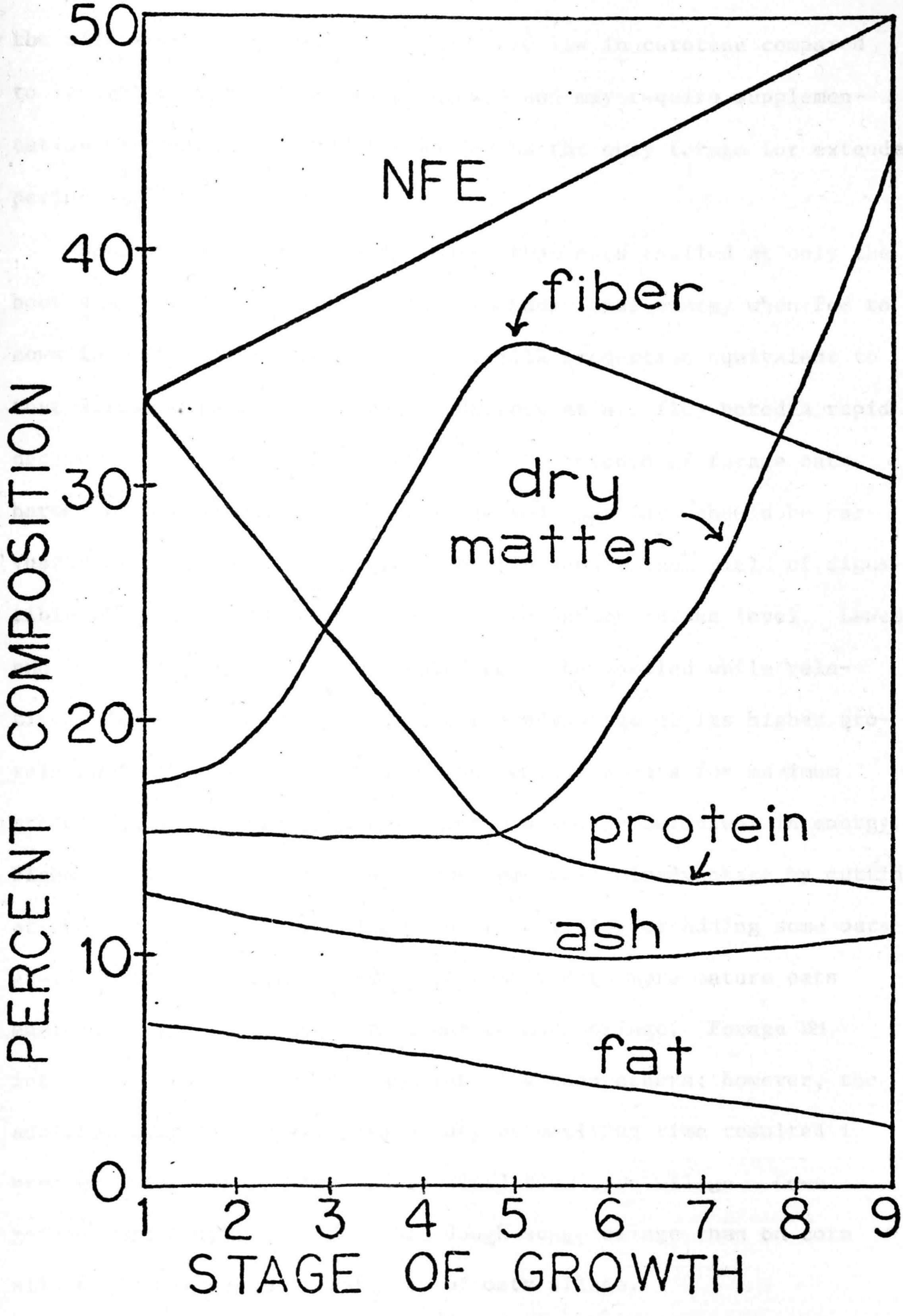

4
3
2
1
0
DRY MATTER - kg (000)
ripe
dough
milk
dry
matter
heading
boot
TDN
4-5leaves
protein
0
30
60
90
DAY AFTER PLANTING

FIG. 2. Composition versus stage of maturity of oats forage.


NFE
fiber
dry matter
protein
ash
fat
PERCENT COMPOSITION
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
STAGE OF GROWTH

the milk stage. Dough stage forages are low in carotene compared to forages at earlier stages of growth and may require supplementation with vitamins A and E when fed as the only forage for extended periods (37).

McCullough et al. (54) indicated that oats ensiled at only the boot stage of development required no additional energy when fed to cows in order to maintain a level of milk production equivalent to that attained from feeding corn. Burgess et al. (10) noted a rapid decline in the protein and digestible DM contents of forage oats harvested beyond milk stage and suggested that oats should be harvested at milk stage of growth to obtain the maximum yield of digestible DM while maintaining acceptable voluntary intake level. Lawes and Jones (49) suggested that oats should be ensiled while relatively immature in order to attain the advantage of its higher protein content relative to corn. Since ensiling oats for maximum protein content results in high moisture silage deficient in energy, Fisher et al. (23) attempted to overcome this disadvantage by cutting at the milk stage and wilting prior to ensiling or adding some oats grain during ensiling. These were compared to more mature oats ensiled at the soft dough stage and to corn silage. Forage DM intake was lower for milk stage maturity than others; however, the addition of grain to milk stage oats at ensiling time resulted in greater intake of DM than was obtained from corn silage. Cows gained more weight when fed soft dough stage silage than on corn silage or milk stage of maturity of oats silage.

Christensen et al. (16) used seven cultivars of barley, oats, and wheat harvested at the mid-dough stage in feeding 200 kg steers. The silages averaged 36.6% DM and 12.5% crude protein with the wheat and barley silages containing more protein than oat silage ($P<0.05$). Digestibility of energy averaged 65.4%. The wheat and barley cultivars contained more digestible energy than oat cultivars. Digestibility of crude protein averaged 68.5%. Voluntary intake of DM was higher for oats than barley or wheat cultivars.

Voelker et al. (88) reported that early dough oats silage contained less digestible energy than oats-barley-wheat silages. Crude fiber content of oats silage reached a peak at milk stage and then declined to hard dough stage (53, 81). Acid detergent fiber (ADF) increased with the stage of maturity and with wilting of oats silage (20), while crude fiber digestibility decreased from boot to milk stage and then increased to hard dough stage (81). Martz et al. (52) found out that the TDN value of oats silage remained relatively constant when harvested after milk stage.

Thurman et al. (81) reported a higher nutrient yield per hectare as opposed to (11, 52) when oats were harvested at milk stage. Higher protein content, lower crude fiber, and increased digestibility were reported when oats silage was harvested between boot to milk stages than in the late stage of maturity (11, 20, 71, 75, 81). McCullough et al. (54) did not observe normal milk production when cows were fed milk or dough stage silage as opposed to prebloom stage. They concluded that harvesting prior to milk stage doesn't have an effect on milk production. Martz et al. (52) reported that the utilization of TDN for milk production was similar at about early milk and soft dough stages of the oat silage. In a later study (53) animals fed boot stage silage gained more weight and produced more FCM. These researchers (52, 53, 90) concluded that boot stage or shortly thereafter, is the best for milk production even though oat silage could be made at varying stages of maturity.

Corn Silage vs Oatlage Nutrient Analysis

Amount of soluble nitrogen in oats is about twice that of corn (95). Oat silage contains more crude protein than corn silage, sorghum silage, and barley-pea silages (8, 48, 87); however, corn silage contains more TDN and digestible energy than oat silage (8, 9, 24, 48, 69, 75, 90). Burgess et al. (11) observed that oat silage contained more ADF than corn, barley, and wheat silages. Voelker et al. (88) reported higher crude fiber and ADF in low moisture early dough oat silage compared to low moisture, oats-barley-wheat silage.

Most cereal grains are deficient in lysine and the second limiting amino acids are tryptophan in corn (60) threonine in barley (41) and phenylalanine plus tyrosine in sorghum (26). The protein efficiency ratios of cereal grains indicate poor quality with the exception of oats (70). Oat groats contain approximately 16.5% protein and 0.6% lysine whereas, corn contains 0.2% lysine. In the effort to increase the protein content of cereal grains, plant geneticists have been hindered by the fact that lysine content increases little as the protein content increases. In the case of corn, the zein fraction, which is low in tryptophan and lysine, increased 40% to 95% faster than total protein in the course of selection (73).

Lassiter et al. (48) carried out a 2 yr experiment to evaluate corn vs oat silage as a roughage for dairy cattle. In the first year, cows fed the oat silage produced more milk, gained more weight, and consumed more forages than those fed corn silage, but these results were reversed in the second year. Lassiter et al. (47) reported that early dough oat silage contained less TDN than the dent stage of corn silage on DM basis. Cows produced more 4% FCM and gained more weight when fed oat silage than corn silage. They concluded that oat silage was at least equal to corn silage in feeding value on DM basis.

Burgess et al. (11) used corn, barley, wheat, and forage oats as a sole forage to feed 48 milking cows in two 12 wk feeding trials. In the first experiment, corn harvested at early dent stage, barley, and forage oats harvested in the dough stage were compared. Cows fed corn silage produced the highest amount of milk followed by those fed barley. The oat silage group had the highest DM intake followed by barley. In the second experiment, cows were fed wheat (35.7% DM), barley (29.8% DM), or forage oats (27% DM) silage harvested in the dough stage. Cows fed the barley silage produced the highest amount of milk followed by cows fed the oat silage, but DM intake was lowest with oat silage. Even though the corn silage DM intake was lower, it was more efficiently utilized for milk production than barley or forage oats. However, wheat, barley, and forage oats silage were similar in feeding value. The researchers (11) concluded that the higher amount of protein in the cereal silage is of little advantage because protein levels in the grain mixtures cannot be decreased appreciably compared to that fed with corn silage.

Breeding Groups of Cattle

Since there has been an increase in genetic ability of dairy cattle for milk production, this research planned for the use of two genetic groups of dairy cattle. One group was produced by using cows bred for high milk production; the other group was bred for high type.

Since 1929 when the Holstein-Friesian Association of America introduced the first official type classification system in the country, dairy cattle breed associations have developed classification systems with the hope that they might serve as phenotypic and/or genetic indicators of milk producing ability, longevity, and wearability. Additionally, dairymen have classified their cattle to identify conformational strength and weaknesses in individual cows and in the herd in general and for aesthetic value. Touchberry (83) studied official Holstein data and milk yield on 187 daughter dam pairs and reported a genetic correlation of -.18 between type score and milk production. Carter et al. (14) estimated relationships between official type production information on 8,287 Canadian Holsteins and reported the genetic correlation of milk yield with type traits ranged from -.06 for body capacity to .49 for dairy character, with a relationship between milk yield and final score of .12. Others (1, 33) have also reported a low phenotypic correlation from analyzing Dairy Herd Improvement (DHI) milk production records and an official type information on Holstein cows.

MATERIALS AND METHODS

The oat silage yielded 54.27% as much forage per unit of land as the corn silage. They were harvested at dent stage for the corn and dough stage for the oats and were ensiled in an oxygen limiting upright silo after the oats were wilted.

Twenty Holstein cows (10 type and 10 production breeding groups) at their peak of lactation were assigned to the two silage treatments based on their production and breeding groups. A 16% grain mix (Table 1) was group fed at the rate of 1 kg/3 kg of milk with

TABLE 1. Composition of concentrate mixture.[a]

Ingredient	%
Rolled shelled corn	41.5
Oat grain	41.5
Soybean meal	14.5
Trace mineral salt	1.5
Dicalcium phosphate	1.0

[a]Mixes contained 8,800 IU added vitamin A and 2,200 IU added vitamin D/kg

amounts adjusted weekly according to the previous week's milk production for 16 wk of the trial period. Cows were weighed 3 successive days at the beginning and end of the trial period. Both silages were fed ad libitum with the amount fed and refused weighed and recorded.

Samples of feeds were taken weekly and samples frozen for future analysis. Moisture contents of the feed were determined by drying it in a forced-air oven[1] at 60 C for 48 h. Then the feeds were ground to pass a 1 mm screen to be used for further analyses. Samples were analyzed for crude protein by the Kjeldahl procedure (3), for cell wall constituents (CWC), hemicellulose, ADF, cellulose, permaganent lignin, and ash by the method outlined by Goering and Van Soest (31). Milk samples were analyzed for milk fat by Foss Milk-O-Tester[2], protein by Pro-Milk (dye binding) method, and total solids by Mojonnier method (62). Solid corrected milk (SCM) was calculated according to Tyrrel and Reid (84).

The analysis of variance was carried out using the following model (77):

1) $Yijk = \mu + Fi + Wj + FWij + E(ijk)$ where:

μ = population mean prior to application of treatment (trt)

Fi = fixed effect of the ith feed

Wi = fixed effect of the jth week

FWij = fixed interaction of the ith feed and kth week

E(ijk) = random effect associated with experimental units

The linear model used to test the difference in milk yield and composition was $Yijkl = \mu + Ti + Gj + TGij + Wk + TWik + TGWjk +$

---

[1]Arthur H. Thomas Co., Philadelphia, PA.

[2]MK-II, N. Foss Electric, Hillerod, Denmark.

TGWijk + E(ijkl):

μ = pop mean prior to application of trt

Ti = fixed effect of the ith trt (feed)

Gj = fixed effect of jth group (breeding group)

TGij = fixed interaction of the ith trt and jth group

Wk = fixed effect of the kth week

TWik = fixed interaction of the ith trt and kth week

GWjk = fixed interaction of the jth group and kth week

TGWijk = fixed interaction of ith trt jth group and kth week

E(ijkl) = random effect associated with the experimental unit

Variance analysis was carried out to find out if real differences existed between the two breeding groups in terms of body weight gain, milk production, and milk composition. Interaction between feed and breeding groups were calculated but feed efficiency was not calculated because cows within the breeding group were not individually fed the corn silage or oatlage due to lack of facilities. The linear model used to test variance analysis was Yijk = μ + Bi + Tj + BTij + E(ijk):

μ = mean prior to application of trt (milk)

Bi = fixed effect of the ith breed

Tj = fixed effect of the jth treatment

BTij = fixed interaction of ith breed and jth treatment

E(ijk) = random effect of the experimental units

RESULTS AND DISCUSSION

Forage Composition

Oat silage contained more crude protein ($P<.01$) than the corn silage as expected (Table 2). The oat silage had also more ADF, cellulose ($P<.05$), ether extract, and total ash ($P<.01$) while the corn silage had more cell wall constituents and hemicellulose. The two feeds were not significantly different in the permanganate lignin composition. This makes the two silages more comparable from the nutritional standpoint because lignin binds itself to cellulose and hemicellulose which causes the digestibility of cellulose and hemicellulose to vary directly according to the lignin content (4, 17, 27, 40, 47, 74, 80, 81, 88, 91). Since the present author did not observe a significant difference in the lignin components, the two feeds could be equally available to the animal proportional to the rest of the components (4, 29, 40, 74, 81, 91, 95). The comparative compositions of the corn silage and the oatlage agreed with the analyses reported by Lassiter et al. (50) and Burgess et al. (11).

Body Weight Gain and Forage Consumption

Average initial weight, weight gain, and daily forage DM consumption are shown in Table 3. Average daily gains were greater ($P<.01$) with the corn silage; however, forage DM intake was greater ($P<.05$) with the oat silage. Therefore, corn silage was more efficient in producing weight gain than the oats silage. These results agreed with results reported by Burgess et al. (11) and

TABLE 2. Mean composition of corn silage and oat silage.

Component	Forage: Corn silage	Forage: Oat silage	SE[a]
Dry matter, %	41.3	57.7**	.40
Crude protein, % of DM	8.7	11.5**	.07
Cellulose, % of DM	24.6	29.4*	1.30
Hemicellulose, % of DM	26.4	16.5**	2.44
Permanganate lignin, % of DM	5.8	6.4	.27
Acid detergent fiber, % of DM	32.6	36.5*	.97
Cell wall constituents, % of DM	58.8	51.2**	2.44
Cell soluble material, % of DM	41.2	46.9*	1.58
Ash, % of DM	4.7	7.7**	.13
Ether extract, % of DM	2.4	3.8**	.02

[a]Standard error of mean

*Different from corn silage, $P<.05$

**Different from corn silage, $P<.01$

Lassiter et al. (50).

TABLE 3. Feed dry matter consumption and body weight changes.

Item	Forage: Corn silage	Forage: Oat silage	SE[a]
Forage intake/head/day, kg	11.00	11.60*	.02
Grain intake/head/day, kg	8.09	8.06	.01
Initial wt, kg/head	675.60	643.20	30.48
Average daily gain, kg/head/day	.32	.10**	.07

[a]Standard error of mean

*Different from corn silage, P<.05

**Different from corn silage, P<.01

Yield and Composition of Milk

Daily yield of milk and 4% fat-corrected-milk (FCM) were similar with both rations (Table 4). These results agreed with reports by Lassiter et al. (50) but not with Burgess et al. (11) who reported that cows fed corn silage produced more actual milk and FCM. Percent fat, protein, and amount of fat were similar while percent total solids, amount of solids-not-fat, and amount of solids-corrected-milk were higher (P<.01) from the cows fed corn silage than oat silage.

Despite similar production in this trial when fed either oat silage or corn silage, I cannot recommend substituting oat silage

TABLE 4. Yield and composition of milk from dairy cows receiving either corn silage or oat silage.

	Forage		
Item	Corn silage	Oat silage	SE[a]
Milk yield, kg/day	24.3	23.2	.44
Fat-corrected-milk, kg/day	22.3	22.0	.45
Solids-corrected-milk, kg/day	23.4	22.1*	.56
Fat, %	3.57	3.65	.07
Protein, %	2.73	2.70	.05
Total solids, %	12.96	12.54**	.12
Solids-not-fat, %	9.39	8.88**	.12
Fat, kg/day	.84	.85	.02
Protein, kg/day	.66	.62	.02
Solids, kg/day	3.12	2.91**	.52
Solids-not-fat, kg/day	2.28	2.07**	.44

[a]Standard error of mean

*Different from corn silage, P<.05

**Different from corn silage, P<.01

for corn silage without adjusting the protein supplied in the grain mix. In this trial, protein may have limited production by cows fed corn silage, whereas, it was not a limiting factor for cows fed oats silage. For example, the corn silage fed cows were only receiving 89% of their required protein based on guidelines recommended by the National Research Council (NRC) (61) while cows fed oats silage were receiving 107% of the recommended protein requirements (61).

Breeding Group

Production group cows produced more (P<.01) milk, fat-corrected-milk (FCM), and solids-corrected-milk, while the type breeding group cows produced milk with a higher percentage of fat and total solids (Table 5). Milk from the two groups contained a similar concentration of protein as well as similar amounts of protein, fat and protein. The type group cows gained more weight (.32 versus .22 kg/day, P<.01) than the production cows.

An interaction between the breeding groups and feed was observed. Production cows receiving the corn silage tended to produce more solids-corrected-milk and solids-not-fat while type cows produced a greater percent of total solids and solids-not-fat (Table 6). The quantity and composition of milk produced by the two breeding groups receiving the oats silage was not significantly different (Table 7).

This trial has shown a significant difference between type and production breeding groups in milk yield, FCM, SCM, total solids, and percent fat. These results may not be repeatable because of

TABLE 5. Yield and composition of milk from type and production trait cows.

Item	Breeding group		SE^a
	Type	Production	
Milk yield, kg/day	22.1	25.4**	.45
Fat-corrected-milk, kg/day	21.5	22.9**	.54
Solids-corrected-milk, kg/day	21.1	23.5**	.78
Fat, %	3.86	3.36**	.07
Protein, %	2.74	2.69	.05
Total solids, %	13.14	12.35	.12
Solids-not-fat, %	9.28	8.99**	.12
Fat, kg/day	.84	.85	.02
Protein, kg/day	.60	.68	.02
Total solids, kg/day	2.89	3.13	.07
Solids-not-fat, kg/day	2.05	2.28	.06

[a] Standard error of mean

** Different from type breeding group $P<.01$

TABLE 6. Yield and composition of milk from type and production breeding groups cows receiving corn silage.

Item	Breeding group		SE[a]
	Type	Production	
Milk yield, kg/day	21.3	27.3	.32
Fat-corrected-milk, kg/day	21.0	23.5	.26
Solids-corrected-milk, kg/day	22.1	24.8**	.29
Fat, %	4.00	3.14**	.04
Protein, %	2.78	2.67	.02
Total solids, %	13.64	12.27**	.06
Solids-not-fat, %	9.64	9.13	.15
Fat, kg/day	.83	.84	.01
Protein, kg/day	.58	.72	.01
Total solids, kg/day	2.88	3.34**	.04
Solids-not-fat, kg/day	2.05	2.49	.03

[a]Standard error of mean

**Different from type breeding group, $P<.01$

TABLE 7. Yield and composition of milk from type and production breeding groups cows receiving oats silage.

Item	Breeding group		SE[a]
	Type	Production	
Milk yield, kg/day	22.9	23.4	.39
Fat-corrected-milk, kg/day	21.9	22.1	.40
Solids-corrected-milk, kg/day	22.1	22.3	.40
Fat, %	3.72	3.58	.03
Protein, %	2.69	2.69	.01
Total solids, %	12.63	12.43	.07
Solids-not-fat	8.91	8.84	.08
Fat, kg/day	.85	.84	.02
Protein, kg/day	.62	.62	.01
Total solids, kg/day	2.89	2.92	.04
Solids-not-fat, kg/day	2.04	2.07	.01

[a]Standard error of mean

the few numbers of cows used and inconstency of the breeding groups to produce similarly with the two kinds of forages. Type traits and production traits of this kind can be valid in data collected from large numbers of animals (1, 2, 14, 15, 34, 63, 86, 92, 93, 94), but even then research on large volumes of data showed no or very little genetic relationships between type and production genetic groups and milk production.

SUMMARY

Conclusions that can be drawn from the results of these investigations are:

1. The oat silage contained more crude protein, acid detergent fiber, cellulose, ether extract, and ash while the corn silage contained more hemicellulose and cell wall constituents.
2. Milk production and 4% fat-corrected-milk were not significantly different when cows were fed either the corn silage or the high protein oat silage.
3. Even though cows fed the oat silage consumed more feed dry matter per day average daily weight gain was greater for the cows that are fed the corn silage.
4. Production trait cows produced more milk, fat-corrected-milk, solids-corrected-milk, total solids, and protein while the type trait cows produced more fat and solids-not-fat.

REFERENCES

1 Aitchison, T. E., A. E. Freeman, and G. M. Thomson. 1972. Evaluation of a type appraisal program in Holsteins. J. Dairy Sci. 55:840.

2 Allaire, F. R., and C. R. Henderson. 1967. Selection practices among dairy cows. III. Type appraisal and lactation traits. J. Dairy Sci. 50:194.

3 Association of Official Analytical Chemists. 1975. Official methods of analysis. 12th ed. Washington, DC.

4 Bartsch, B. D. 1976. Effect of hay or grain supplement on the milk protein production from cow grazing green oats. J. Dairy Sci. 11:493.

5 Belyea, R. L., C. E. Coppock, W. G. Merril, and S. T. Slack. 1974. Effect of silage based diets on feed intake, milk production, and body weight of dairy cows. J. Dairy Sci. 58:1328.

6 Briggle, L. W. 1971. A recessive gene for male sterility in hexaploid wheat. Bio. Abstr. 52(6):3256.

7 Brown, C. M., D. E. Alexander, and S. G. Carmer. 1966. Variation in oil content and its relation to other characters of oats (A. Sativa). Crop Sci. 6:190.

8 Brundage, A. L. 1973. Comparison of oat-pea and barley-pea silages as fed for dairy cows. Agroborealis 5(1):21.

9 Brundage, A. L., and W. J. Sweetman. 1967. A comparative feeding value of oat-pea forages ensiled at two stages of maturity. J. Dairy Sci. 50:690.

10 Burgess, P. L., E. A. Grant, and J. W. G. Nicholson. 1972. Feeding value of forage oats. Can. J. Anim. Sci. 52:448.

11 Burgess, P. L., J. W. Nicholson, and E. A. Grant. 1973. Yield and nutritive value of corn, barley, wheat, and forage oats as silage for lactating dairy cows. J. Anim. Sci. 53:245.

12 Campbell, A. A., and K. J. Frey. 1972. Inheritance of groat protein in interspecific oat crosses. Can. J. Plant Sci. 52:735.

13 Canon, C. Y., D. L. Espe, and H. Goble. 1933. Corn silage as the sole roughage for milking cows. J. Dairy Sci. 16:491. (Abstr.)

14 Carter, H. W., R. C. Rennie, and E. B. Burn-side. 1965. Causes of variation in type classification data. J. Dairy 48:790.

15 Cassell, B. G., W. E. Vinson, J. M. White, and R. H. Kliewer. 1973. Age correction factors for type traits in Holstein cows. J. Dairy Sci. 56:1178.

16 Christensen, D. A., B. D. Owen, G. Steary, W. L. Growly, and J. P. Mtimuni. 1977. Nutritive value of whole crop silage made from seven cereal cultivars. Can. J. Anim. Sci. 57:537.

17 Coppock, C. E., and J. B. Stone. 1968. Corn silage in the ration of dairy cattle: a review. New York State Coll. of Agr. Cornell, Misc. Bull. 89.

18 Coppock, C. E. 1969. Problems associated with all corn silage feeding. J. Dairy Sci. 52:848.

19 Coppock, C. E. 1974. Displaced abumasum in dairy cattle: etiological factors. J. Dairy Sci. 57:926.

20 Derbyshire, J. C., C. H. Gordon, and J. L. Humphrey. 1966. Effect of ensiling treatment and stage of maturity on oat silage. J. Dairy Sci. 49:716. (Abstr.)

21 Devlin, T. J., J. R. Ingallis, and H. R. Sharma. 1977. Evaluation of high fat oats in rations of growing and finishing ruminants. Can. J. Anim. Sci. 57:735.

22 Fisher, L. J., V. S. Logan, and R. B. Carson. 1967. Factors influencing dry matter intake and utilization of corn silage by lactating cows. Can. J. Anim. Sci. 54:169.

23 Fisher, L. J., J. R. Lessard, and G. A. Lodge. 1974. Evaluation of whole crop oat silage as a basal forage for lactating cows. Can. J. Anim. Sci. 54:169.

24 Foss, D. C., R. P. Niedermeier, B. R. Baumgardt, and R. D. Lance. 1961. Digestibility and intake of corn, oats, and sorghum silages. J. Dairy Sci. 54:1175. (Abstr.)

25 Frey K. J., and G. I. Watson. 1950. Chemical studies in oats. I. Thiamines, niacin, riboflavin and pantothenic acid. Agron. J. 42:434.

26 Frey, K. J. 1951. The interrelationships of protein and amino acids in corn. Cereal Chem. 28:123.

27 Frey, K. J. 1951. The relation between alcohol soluble and total nitrogen contents of oats. Cereal Chem. 28:506.

28 Frey, K. J. 1952. Variation in the protein and amino acid contents of different oat varieties. Cereal Chem. 29:77.

29 Frey, K. J. 1976. Cereal protein-quality and quantity. Maryland Nutr. Conf. 54:54.

30 Frey, K. J., T. McCarty, and A. Rosielle. 1975. Straw-protein percentages in avena sterilis. Crop Sci. 15:716.

31 Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analysis. USDA, ARS. Agr. Handbook No. 379.

32 Gordon, C. H., J. C. Derbyshire, and P. J. Van Soest. 1968. Normal and late harvesting of corn for silage. J. Dairy Sci. 51:1258.

33 Granthan, J. A., Jr., J. M. White, W. E. Vinson, and R. H. Kliewer. 1974. Genetic relationship between milk production and type in Holsteins. J. Dairy Sci. 57:1483.

34 Hansen, L. R., G. R. Barr, and D. A. Wieckert. 1969. Effect of age and stage of lactation on type classification. J. Dairy Sci. 52:646.

35 Hemken, R. W., and J. H. Vandersall. 1967. Feasibility of an all silage forage program. J. Dairy Sci. 50:417.

36 Hillman, D. 1967. Supplementing corn silage. J. Dairy Sci. 52:859.

37 Hillman, D., and Z. Helsel. 1978. Cereal grain forages for dairy cattle. University of Maryland Ext. Bull. E-1263.

38 Hischke, H. H., Jr., G. C. Potter, and W. R. Graham. 1968. Nutritive value of oats protein. I. Varietal difference as measured by amino acid analysis and oat growth response. Cereal Chem. 45:374.

39 Holter, J. B., W. E. Urban, Jr., W. S. Kenneth, and C. J. Sniffen. 1973. Corn silage with and without grass hay for lactating dairy cows. J. Dairy Sci. 56:915.

40 Holter, J. B., J. B. Leahey, and W. E. Urban, Jr. 1974. Corn silage with either hay crop silage or hay for lactating cows. J. Dairy Sci. 57:205.

41 Howe, E. E., G. R. Jansen, and E. W. Giltillan. 1965. Amino acid supplementation of cereal grains are related to the world food supply. Amer. J. Clin. Nutr. 16:315.

42 Huffman, C. F., and C. W. Duncan. 1960. Chemical composition, coefficients of digestibility, and total digestible nutrients content of corn silages. Mich. Agr. Exp. Sta. Quart. Bull. 43:261.

43 Hutchinson, J. B., and H. F. Martin. 1965. The chemical composition of oats. II. The nitrogen content of oats and groats. J. Agr. Sci. 45:419.

44 Hutjens, M. F., and N. P. Martin. 1977. Oatlage provides forage and aides new seedling. Hoard's Dairyman 122:734.

45 Jacobson, D. R., J. W. Barnett, S. B. Carr, and R. H. Hatton. 1967. Voluntary feed intake, milk production, rumen content and plasma-free amino acid levels of lactating cows on low sulfur supplemented diets. J. Dairy Sci. 50:1248.

46 Justin, J. R. undated. How about oats for silage? Univ. of Minnesota Agr. Ext. Serv., Agron. Fact Sheet No. 3.

47 Lassiter, C. A., C. F. Huffman, C. W. Duncan, and S. T. Dexter. 1957. Comparison of oat silage and corn silage as roughages for milking cows. J. Dairy Sci. 50:618. (Abstr.)

48 Lassiter, C. A., C. F. Huffman, S. T. Dexter, and C. W. Duncan. 1958. Corn versus oat silage as a roughage for dairy cattle. J. Dairy Sci. 41:1282.

49 Lawes, D. A., and D. I. H. Jones. 1972. Yield, nutritive value and ensiling characteristics of whole crop spring cereals. J. Agr. Sci. 76:479.

50 Logan, V. S., L. J. Fisher, and P. S. Haydon. 1968. Effect of maturity at harvest upon the value of corn silages for milk production. Can. J. Anim. Sci. 48:41.

51 Lyrene, P. M., and H. L. Shands. 1974. Groat protein percentages in avena sativa. L. fatuoids and in a fatuid x A. sterilis L. cross. Crop Sci. 14:760.

52 Martz, F. A., C. H. Noller, and D. L. Hill. 1957. The feeding value of oat silage for milking cows. Purdue Univ. Agr. Exp. Sta. Mimeo. DH-72.

53 Martz, F. A., C. H. Noller, D. L. Hill, and M. W. Carter. 1959. Intake and value for milk production of oat silages ensiled at three stages of maturity and preserved with sodium metabisulfite. J. Dairy Sci. 42:1955.

54 McCullough, M. E., L. R. Sisk, and O. E. Sell. 1958. Influence of stage of maturity and of ground snap corn or sodium metabisulfite as preservatives on the feeding value of oat silage. J. Dairy Sci. 41:796.

55 McCullough, M. E., L. R. Sisk, and O. E. Sell. 1964. Influence of silage dry matter intake on efficiency of milk production. J. Dairy Sci. 47:650.

56 McCullough, M. E. 1978. NFIA literature review on fermentation of silage. National Feed Ingredients Association, Iowa.

57 McElroy, L. W., D. R. Clandinin, W. Lobay, and S. I. Pethybridge. 1949. Nine essential amino acids in pure varieties of wheat, barley, and oats. J. Nutr. 37:329.

58 Meyer, H. J., W. C. Weir, L. G. Jones, and J. L. Hull. 1958. Feeding value of oat hay. California Agr. 12(5):4.

59 Mitchell, H. H. 1972. The protein value of foods in nutrition. J. Home Econ. 19:122.

60 Mitchell, H. H., and D. B. Smuts. 1972. The amino acid deficiencies of beef, wheat, corn, oats, and soybeans for growth in the white rat. J. Biol. Chem. 95:263.

61 National Research Council. 1978. Nutrient requirements of dairy cattle. 5th rev. ed., Nat. Acad. Sci., Washington, DC.

62 Newlander, J. A., and H. V. Atherton. 1964. The chemistry and testing of dairy products. Olsen Publishing Company, Milwaukee, WI.

63 Norman, H. D., and L. D. Van Vleck. 1972. Type appraisal: I. Effect of age and stage of lactation on type ratings. J. Dairy Sci. 55:1706.

64 Ohms, H. W., and F. L. Patterson. 1973. A six parent diallel cross analysis for protein in avena sterilis L. Crop Sci. 13:27.

65 Owens, D. F., Jr., C. R. Richards, and T. A. Baker. 1956. The effect of varying levels of hay and corn silage consumption on total digestible nutrient intake and milk production. J. Dairy Sci. 39:1427.

66 Owens, M. J., N. A. Jorgensen, and H. H. Voelker. 1968. Feeding value of high dry matter corn silage for dairy cattle. J. Dairy Sci. 51:1942.

67 Pomeranz, Y. 1973. A review of proteins of barley, oats, and buckwheat. Cereal Sci. Today 18:310.

68 Reeves, L. D. 1975. Spear oats. South Dakota State Univ. Agr. Exp. Sta. Bull. PR629.

69 Richardson, C. E., and E. E. Hatfield. 1978. The limiting amino acids in growing cattle. J. Anim. Sci. 46:740.

70 Robbins, G. S., Y. Pomeranz, and L. W. Briggle. 1971. Amino acid composition of oat groats. J. Agr. Food Chem. 19:536.

71 Rohweder, D. A., E. S. Oplinger, and W. T. Howard. 1976. Oats for forage. Wisconsin Ext. Bull, A2590.

72 Schroeder, T. L., H. H. Voelker, and D. J. Schingoethe. 1979. Evaluation of high protein oat forage for dairy cattle. J. Dairy Sci. 62:1979.

73 Shands, H. L., Forsberg, R. A., R. D. Duerst, and Z. M. Arawinko. 1974. Froker and Dal oats. Performance and breeding. Wisconsin Agr. Exp. Sta. Bull. 2569.

74 Smith, E. 1960. Yields and chemical composition of oats for forage with advance in maturity. Agron. J. 52:637.

75 Stallcup, O. T., and O. H. Horton. 1957. The nutritive value of oat silages made from plants ensiled in the boot, milk, and hard dough stages of maturity. J. Dairy Sci. 40:620. (Abstr.)

76 Stallcup, O. T., R. R. Roberson, C. O. Looper, and R. L. Thurman. 1961. The influence of stage of maturity on the nutritive value of oat silage. Univ. of Arkansas, Div. of Agr, Exp. Sta. Bull. 642.

77 Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York.

78 Stuber, C. W., V. A. Johnson, and J. W. Schmidt. 1962. Grain protein content and its relationship to other plant and seed characters in the parents and progeny of cross of Triticum aestivm L. Crop Sci. 2:506.

79 Thomas, J. W., R. S. Emery, L. D. Brown, and J. T. Huber. 1967. Corn silage alone or supplemented for dairy heifers. J. Anim. Sci. 26:1487. (Abstr.)

80 Thomas, J. W., R. S. Emery, L. D. Brown, and R. S. Emery. 1970. Corn silage compared to alfalfa hay for milking cows fed various levels of grain. J. Dairy Sci. 53:342.

81 Thurman, R. L., O. T. Stallcup, J. L. Stephens, and N. E. Justus. 1957. When to harvest oats for hay and silage. Univ. of Arkansas Agr. Exp. Sta. Bull. 586.

82 Trimberger, G. W., H. F. Tyrrell, D. A. Marrow, J. T. Reid, M. J. Wright, W. F. Shipe, W. G. Merrill, J. K. Loosli, C. E. Coppock, L. A. Moore, and C. H. Gordon. 1972. Effects of liberal concentrate feeding on health, reproductive efficiency, economy of milk production, and other related responses of the dairy cow. New York's Food and Life Sci. Bull. No. 8.

83 Touchberry, R. W. 1951. Genetic correlations between five body measurements, weight, type, and production in the same individual among Holstein cows. J. Dairy Sci. 34:242.

84 Tyrrell, H. F., and J. T. Reid. 1965. Predection of the energy value of cows milk. J. Dairy Sci. 48:1215.

85 Vandersall, J. H., and R. W. Hemken. 1970. All corn silage forage program: effect of consecutive lactation and dry matter consumption. Proc. Md. Nutr. Conf. 90.

86 Van Vleck, L. D., P. J. Karner, and G. R. Wiggans. 1980. Relationships amont type tracts and milk yield of Brown Swiss cattle. J. Dairy Sci. 63:120.

87 Voelker, H. H. 1957. Oat silage. South Dakota Farm and Home Research 7:29.

88 Voelker, H. H., G. L. Beardsley, J. A. Rook, and F. G. Ludens. 1975. Yields, feeding value, and composition of oatlage versus oats-barley-wheat combination. J. Dairy Sci. 60:1083.

89 Wahlstrom, C. R., and G. W. Libal. 1975. Varying level of high protein oats in diets for growing finishing swine. J. Anim. Sci. 41:809.

90 Ward, R., and D. Reeves. 1974. Oat forage experiment. South Dakota State Univ. Agr. Exp. Sta. Bull. PR. 74.

91 Waugh, R. K., H. S. Poston, R. D. Mochrie, W. R. Murley, and H. L. Local. 1955. Addition of hay to corn silage to maximize feed intake and milk production. J. Dairy Sci. 1:688.

92 White, J. M., J. E. Legates, and K. L. Koonce. 1967. Environmental and genetic factors affecting type appraisal scores. J. Dairy Sci. 50:974.

93 White, J. M. 1974. Genetic parameter of conformitional and managemental traits. J. Dairy Sci. 57:1267.

94 Wilcox, C. J., K. O. Pfau, R. E. Mather, and J. W. Bartlett. 1958. Effects of season, age, and stage of lactation upon type rating of Holstein cows. J. Dairy Sci. 41:1065.

95 Wohlt, J. E., E. J. Sniffen, and W. H. Hoover. 1973. Measurement of protein solubility in common feedstuffs. J. Dairy Sci. 56:1052.

96 Youngs, V. L., K. D. Gilchrist, and D. M. Peterson. 1973. Protein, the current emphasis in oat quality. Cereal Sci. Today 18:409.