3-1961

Comparison of production and composition of milk from cows grazing gahi-1 and Starr Pearl millets

Kunjukrishnapilla Parameswaran Nair

To the Graduate Council:

I am submitting herewith a thesis written by Kunjukrishnapilla Parameswaran Nair entitled "Comparison of production and composition of milk from cows grazing gahi-1 and Starr Pearl millets." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

W. W. Overcast, Major Professor

We have read this thesis and recommend its acceptance:

L. J. Boyd, R. W. Beamer, J. T. Miles

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

March 1, 1961

To the Graduate Council:

I am submitting herewith a thesis written by Kunjukrishnapilla Parameswaran Nair entitled "Comparison of Production and Composition of Milk From Cows Grazing Gahi-1 and Starr Pearl Millets." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

W W Overcast
Major Professor

We have read this thesis
and recommend its acceptance:

Rufus W. Beamer

Louis J. Boyd

J. T. Miles

Accepted for the Council:

H. E. Spivey
Acting Dean of the Graduate School

COMPARISON OF PRODUCTION AND COMPOSITION OF MILK FROM COWS GRAZING GAHI-1 AND STARR PEARL MILLETS

A Thesis

Presented to

The Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Kunjukrishnapilla Parameswaran Nair

March 1961

2P
33

ACKNOWLEDGEMENT

The writer expresses his gratitude to Dr. W. W. Overcast and Dr. L. J. Boyd for their guidance and helpful criticisms throughout this study. Appreciation is also expressed for the help rendered by Dr. E. W. Swanson. The cooperation of Professor S. A. Hinton in the use of the cows and farm facilities and the cooperation of T. B. Harrison in the use of the laboratory were much appreciated.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	4
	Value of Summer Supplemental Pasture	4
	Systems of Grazing and Management	5
	Feeding Value of Millets and Sudan	7
	Agronomic Studies on Gahi-1 and Starr Millets	8
	Animal Studies on Pearl Millets	9
	Methods for Butterfat Determination	12
	Methods for Total Solids Determination	17
III.	METHOD OF PROCEDURE	20
	Duration	20
	Establishment of Paddocks	20
	Pairing of Cows	20
	Feeding and Care of Cows	21
	Rotational Grazing	22
	Milk Production, Butterfat, Total Solids and Body Weights	22
	Dry Matter Determinations of Forages	23
	Preparation of Composite Samples	24
	Butterfat Test by the Babcock Method	24
	Butterfat Test by the Mojonnier Method	25
	Total Solids Tests by the Mojonnier Method	26
	Total Solids Tests by the Cenco Moisture Balance Method	27

CHAPTER PAGE

IV. RESULTS AND DISCUSSION 28

Establishment of Paddocks 28

Milk Production, Butterfat and 4 Percent Fat-Corrected Milk 28

Total Solids and Solids-Not-Fat 34

Body Weights 34

Consumption of Hay and Concentrates 36

Observations on the Forages, Grazing Habits and Weather Conditions 36

Comparison of Butterfat Tests 37

Comparison of Total Solids Tests 39

V. SUMMARY AND CONCLUSIONS 41

REFERENCES 43

APPENDICES 48

LIST OF TABLES

TABLE		PAGE
I.	Comparison of Average Values of Babcock Above Roese-Gottlieb or Mojonnier Obtained by Different Workers . . .	15
II.	Average Milk and 4 Percent Fat-Corrected Milk Production, Butterfat Percent, Percent Total Solids and Hay Consumption of 11 Cows Grazing Gahi-1 and Starr Millets for 10 Weeks	29
III.	Comparison of the Babcock and Mojonnier Methods for Butterfat Determinations and the Cenco Moisture Balance and the Mojonnier Methods for Total Solids Determinations in Milk from Cows Grazing Gahi and Starr Millets	38

LIST OF FIGURES

FIGURE PAGE

1. Average Milk Production, Percent Butterfat and 4 Percent Fat-Corrected Milk of Cows Grazing Gahi-1 and Starr Millets 31

2. Average Weekly Percent Total Solids of Milk from Cows Grazing Gahi-1 and Starr Millets 35

CHAPTER I

INTRODUCTION

During midsummer, maintenance of milk flow is a problem to most dairy farmers. In general, shortage of high quality forage during the dry summer months reduces the milk yield. Permanent pastures in this area are usually less productive during this period. The varying topography, responsive soils and livestock potential offer wide scope to build up a year round pasture management program. The main objective should be to find an adapted species that has good persistency, disease resistance and a high yield in tonnage and total digestible nutrients for seasons.

Gahi-1 and Starr are two varieties of pearl millet (*Pennisetum glaucum*) recently introduced for summer grazing in this area of the United States. Both varieties are known to have a wide range of soil adaptation, resistance to drought and foliage diseases and a high leaf-stem ratio. Absence of prussic acid gives more preference to them than other summer pastures and they are more productive than common pearl millet.

Studies have been made comparing Sudan and pearl millets since the millets became popular in this area. But little work has been done to compare the various varieties of millets or to evaluate the quality of Gahi-1 and Starr on the basis of milk yield and composition.

The future dairy industry has to face a problem of great economic interest. The fallacy, that regular intake of milk fat in the diet may predispose heart attack, prevails among a section of the milk consuming public. This fear may have created in many people the tendency to lower the intake of fat by decreasing the intake of fluid milk. The nutritional significance of milk fat -- a powerful energy source of high caloric value has been underestimated. To avoid this dreadful disease, many have considered skim milk to be the safest for consumption. Today the per capita consumption of skim milk and other beverages containing milk solids - not - fat, has increased rapidly. Should we need milk laden with fat or total solids? Are the available methods of detecting fat and total solids accurate enough to satisfy the quality demands?

To standardize dairy products and to satisfy quality demands and legal requirements, a correct estimation of both total solids and fat content of milk has become a routine in dairy plants. Several volumetric and gravimetric methods are in use for the determination of fat. The Cenco Moisture Balance and the Mojonnier are the two commonly used methods for the estimation of total solids. The use of the Babcock test for estimating the fat content has been universally accepted as a routine, reliable and quick method and the Mojonnier fat test method has been used to compare the accuracy of the Babcock method. The Cenco Moisture Balance was introduced recently in the dairy industry for the estimation of total solids and has not yet obtained official recognition. Varying results obtained, in other parts of this country, necessitated a repeated testing of the instrument as to its efficiency in estimating total solids when compared with other accepted methods like the Mojonnier. Results so far obtained in estimating total solids with the Cenco Balance seem to be quite encouraging and it holds promise for the near future. Simplicity in operation, less expense and saving of much labor and time are certain advantages with the instrument.

The two objectives of this investigation were to find the relative summer feeding value of Gahi-1 and Starr millets in terms of milk yield, percent butterfat, percent total solids and body weight changes; and the relative efficiency of the Babcock versus the Mojonnier method for estimation of butterfat and the Mojonnier versus the Cenco Moisture Balance method for total solids of milk samples collected from cows grazing Gahi-1 and Starr millets.

CHAPTER II

REVIEW OF LITERATURE

A search of the literature was made to determine the value of summer supplemental pastures, and the best forages to be used for supporting summer milk production. Agronomic and animal studies on pearl millets and also the literature dealing with the various methods for determining fat and total solids in milk were reviewed.

Value of summer supplemental pastures. Dow (10) observed that when grazing facilities were provided from May to mid-October, there was a 46 percent reduction in the amount of grain fed, 86 percent in the roughage fed other than pasture and 31 percent less labor used daily in caring for the cow. The average reduction in feed and labor cost per cow per day was 48 percent below that for the winter feeding period.

O'Neil (38) reported the value of summer fodder crops as providing succulence when it was most needed. The crops were found especially useful for cows in calf and for extending production into the summer.

Hazelwood (17) fed one group of Jersey cows on an all roughage ration throughout the year, supplemented when necessary with alfalfa hay and silage and another group was fed a grain mixture. Under Tennessee conditions, it was found that cows declining in production during June would increase their production when given access to supplemental summer pasture.

Jones et al. (27) studied the use of Sudan pastures and other feeds for beef production. Sudan grass was found to be a vigorous growing annual summer pasture and could be used as an emergency crop. Under good management, one acre of Sudan grass provided grazing for two or more cows during the summer.

Paul (41) reported that 25 acres of Sudan grass provided adequate grazing for 25 dairy cows from July until frost. These cows were rotated on two plots every week. Some cows increased their daily production as much as 10 to 15 pounds per day and showed no decrease in fat test.

Foley (13) observed that the most economic ration for the summer months for dairy cattle was an abundance of good quality pasture. A two year feeding trial was conducted to determine the most economical feed for dairy cattle. In the first year, two groups were fed for 100 days. One group received concentrates plus all the pasture they would consume. The other group received pasture and all the roughage they would eat plus a little concentrate. In the second year, three experimental groups were used. Two received the same rations as the previous year, while the third group received three pounds of oat feed per animal per day and no hay. All animals in the trial were found to be in good milking condition. The group on concentrates and pasture gained more weight, whereas the group that received concentrates, pasture and hay averaged eight pounds of milk per pound of grain fed. The group that received oat feed and no hay decreased in body weight. The results indicated a reduction of 22 cents per 100 pounds of milk, in the feed cost for the hay group. A wider grain to milk ratio on good pasture and mixed hay, would lower milk production cost during the summer months.

Systems of grazing and management. Owen *et al*. (39) compared rotational grazing, strip grazing and green feeding of Tift Sudan grass.

Three groups of ten cows each were rotated on three paddocks of two acres each. Pasture was found to be quite adequate for a 63 day period. There was no significant difference between the three systems of grazing in the average production of fat-corrected milk. At the end of the experiment, the forage left in the rotational grazing plot was found to be more healthy and vigorous than the plots used for strip grazing or green feeding.

Gordon *et al.* (14) worked on the relative merit of rotational grazing, strip grazing and soiling and the effects on milking cows. The experimental plots consisted of twelve one-acre plots on which Orchardgrass - Ladino clover pasture was established. Grazing groups were rotated at intervals of five to ten days. The value of these plots for supporting milking cows was measured as the calculated total digestible nutrients furnished to milking cows plus total digestible nutrients removed as excess forage. No differences were observed in the amount of forage grazed per acre, milk production or body weights. The conventional rotational system was found to be the most desirable, when managed properly.

Hawkins *et al.* (18) compared three groups of five cows each, on three different treatments of continuous grazing, soiling and rotational grazing. To get good quality forages, an initial growth of 15 - 18 inches and two or three paddocks to shift the grazing cows to new growth at two-week intervals was observed to be necessary. Good grazing in summer was dependent on locality of the farm, soil fertility, rainfall and stage of maturity of the grass. Maintaining pasture growth at fifteen inches was found to be satisfactory to get high quality.

Hoveland and McCloud (24) recommended a height of 2½ feet for Starr millet as the right height for grazing.

Feeding value of millets and sudan. Wrather (51) reported on a summer reversal feeding experiment comparing Piper Sudan grass and Starr pearl millet fed by the soiling technique to lactating dairy cows. Statistical analyses of milk production, four percent fat-corrected milk, butterfat production, body weight changes and total solids showed no significant differences between the two forages. The two groups derived approximately the same quantity of total digestible nutrients from each forage; but the average daily consumption of millet forage exceeded Sudan grass by 18 pounds. Sudan grass was infested by a leaf disease and this with early maturity decreased the consumption of Sudan forage. The yield of dry matter was 1.7 tons per acre for both forages.

Hawkins et al. (18) compared Starr millet with Sweet Sudan grass and Johnsongrass under identical management conditions. Cows grazed on these three varieties did not differ in milk production or persistency. At similar stages of growth, Johnsongrass, Sweet Sudan grass and Starr millet were found to be about equal as feed for milking cows.

Roark et al. (43) studied the relative feeding value of pearl millet with grain sorghum and Tift Sudan grass. Cows on the experiment did not receive any other roughage except concentrates fed according to production. Pearl millet was seen to be a higher yielding forage than grain sorghum or Tift Sudan grass. Cows used in the comparison obtained 2,056 pounds of total digestible nutrients per acre from pearl millet and only 1,480 pounds of total digestible nutrients per acre from the Sudan grass. Digestive disturbances were noticed with those cows fed grain sorghum.

Miller et al. (33) compared the relative merit of Tift Sudan and

Starr millet when fed to dairy cows. They measured differences in fat-corrected milk production, butterfat percent, persistency, weight change, digestibility and forage consumption. The cows were rotationally grazed. Total digestible nutrient yields were measured by the animal requirement and cage clipping methods. The Starr millet group gave low butterfat tests; but more total digestible nutrients per acre were obtained in one year of the study. The best measure of evaluating forages was found to be digestibility.

Underwood et al. (50) compared Tift Sudan grass and Starr pearl millet when fed to lactating dairy cows. Two equalized groups of seven Jerseys and Holsteins, were rotationally grazed for three weeks. After three weeks rotation, the groups were switched to the other forage. The average daily production of four percent fat-corrected milk for the Sudan group and millet group was 22.2 and 21.8 pounds, respectively. The butterfat test was found to be the same for both groups. Cows on Sudan grass gained an average of 1.1 pound daily, which was significantly more than the 0.7 pound daily gain per cow on pearl millet. Sudan was found to be slightly more digestible than the millet.

Agronomic studies on Gahi-1 and Starr millets. Broyles and Fribourg (4) studied the effects of nitrogen fertilization and cutting intensities on the dry matter yield and nitrogen content of Piper, Sweet Sudan, Gahi pearl millet and German millet. This experiment was conducted at Knoxville, Tennessee during the summer of 1957. Gahi-1 produced more dry matter than the other varieties in all cutting intensities Gahi was also found to be best at all nitrogen levels. At a height of 30 inches, maximum yield in tonnage and nitrogen was obtained. Gahi-1 was found to be the highest producing grass and was considered the best for hay, silage, or pasture.

Cragmiles, Baird, and McCullough (8) studied the digestibility, chemical composition, leafiness and other factors influencing the quality of Sudan grass and millets. Stems and leaves dried and as green forages were fed separately to sheep in order to determine digestibility. Sudan grass was found to contain a little more total digestible nutrients than millet. Dried materials from these two species were poorly digested as compared with the green forages. Starr millet had the most desirable leaf to stem ratio.

Sullivan (48) studied the relative adaptation of hybrids and varieties of Sudan grass, pearl millet and forage sorghum for Pennsylvania conditions. Place to place variation was observed in the yield of Gahi-1 millet and very little difference was noted in the composition of Sudan grass and pearl millet. There was a difference between locations and among varieties. Sudan was found to be higher in dry matter yield than pearl millet. Gahi-1 pearl millet had the highest yield in Central Pennsylvania.

Baxter *et al.* (3) observed contrasting appearance of Gahi-1 and Starr millet forages. Starr millet plants appeared to be finer stemmed. The cows grazed Starr plants closer to the ground, while they grazed the blades only from the Gahi-1 plants and refused to graze the tall stalks.

Animal studies on pearl millets. Baxter *et al.* (3) compared Gahi-1 and Starr varieties of pearl millets on a rotational grazing trial with two paired groups of seven Jersey cows each. The concentrate fed was based on a ratio of one pound of grain to each four pounds of milk produced. The cows on Starr millet averaged 35.1 pounds of milk and those on Gahi-1 produced 34.5 pounds of milk per day. Both groups showed a decline in butterfat percent. Most cows on Starr millet gained body weight, while those in the Gahi-1 group lost body weight. Starr millet appeared to be a better variety for summer pasturing of dairy cows.

Gross et al. (16) ran grazing trials for two years using three millet varieties and Sudan grass. Milking Jersey cows were grazed on these pastures for the season. Heifers were used to prevent any spotty growth. Concentrates were fed at the rate of one pound for each four pounds of four percent fat-corrected milk. They observed a significant difference between the millets and Sudan in that more total digestible nutrients and fat-corrected milk were obtained per acre from the millets. However, there was no significant difference in fat-corrected milk production between the groups on the millet varieties. It was predicted that Gahi-1 millet may surpass other varieties as a summer pasture for dairy cattle.

Marshall et al. (30) studied rotational grazing on three plots of pearl millet with lactating Jersey and Guernsey cows. Grazing began when the millet was 14 to 22 inches tall. Cows were continuously on pasture except for milking. Early weed and grass growth was controlled by cultivation. Lactating cows grazing millet produced an average of 30.3 pounds of four percent fat-corrected milk daily and the total digestible nutrients obtained daily were found to support body maintenance plus ten pounds of four percent fat-corrected milk. Persistency of milk production was found to be good.

Cathcart (6) reported a three-year study of the value of pearl millet as a pasture and as silage. An average of 740.58 pounds of total digestible nutrients per acre was obtained which furnished grazing for 68.5 cow days per acre. Pearl millet gave 42.9 percent more nutrients per acre when grazed, than when harvested as silage.

Good grazing facilities for milking cows during the summer months have maintained milk flow and reduced feed cost and labor. Studies have shown that one acre of Sudan grass under good management will provide enough grazing for two or more cows during the summer months. Milking cows rotationally grazed on well managed pasture, produced as much milk, as on strip grazing or soiling and in addition, the rotationally grazed plot was found to be more healthy and vigorous than the plots used for strip grazing or green feeding. The quality of pasture is dependent on the height to which it is grazed. In general, the quality of pasture will not deteriorate if pasture growth is maintained at 15 inches height and grazing cows shifted at intervals of two weeks to new pasture. The feeding value of millets for milking cows have been observed to be about the same as Johnsongrass and Sudan grass. Several workers found that pearl millets produced more total digestible nutrients per acre than other grasses like Tift Sudan. Agronomic observations on millet varieties have shown greater yields in tonnage from Gahi-1 millet and a more desirable leaf-stem ratio, than other varieties of millet. Fluctuations in the tonnage yield of Gahi-1 millet were observed at different locations in Pennsylvania. Contrasting appearance of Gahi-1 and Starr millet has been noted by Baxter et al. (3). The Gahi-1 millet plants appeared to be taller with broader leaves, than the Starr millet plants. However grazing cows showed a tendency to refuse the tall stalks of the Gahi plants and a little more milk production and gain in body weight were obtained from the cows on Starr millet. Gross _et al_ (16) found no significant difference between the two varieties in milk production and 4 percent fat-corrected milk. He did predict that Gahi-1 millet may surpass other varieties, as a summer feed for milking cows. There are conflicting reports as to the feeding value of Gahi-1 and Starr millets. Therefore, this study was made to compare the relative feeding value of these varieties.

Methods for butterfat determination. Phillips (40) prepared composite milk samples by mixing night and morning milk and compared the fat test by the Babcock and Roese-Gottlieb (Mojonnier) methods. The Babcock results gave a higher butterfat test than the Mojonnier. The average of 50 comparisons was found to be 0.0588 percent higher than the Mojonnier and the variations between the two methods were from 0.005 to 0.126 percent.

In a study of the Babcock test at Iowa (1) it was reported that readings from the top of the upper meniscus to the bottom of the lower meniscus were higher than those obtained by the gravimetric methods. Of the 190 samples studied, the difference was 0.06 percent above gravimetric methods.

Bailey (2) made comparisons on 190 milk samples and reported that the Babcock tests were 0.06 percent higher than the gravimetric methods. Those variations were influenced by readers of the test, breed of the cow and stage of lactation. The latter was due to variation in the size of the fat globules and also to variation in the fat percentage of the sample. In the Babcock test, there was 0.13 percent butterfat, found in the liquid below the fat column. Impurities in the butterfat column averaged 0.78 percent of the reading. If meniscuses were not included, the Babcock test read about 0.11 percent low.

Dahlberg, Holm and Troy (9) compared the Babcock method with the Gerber and the Roese-Gottlieb methods. These tests were carried out in three different laboratores and four dairy control laboratories with 925 samples of milk and cream. Differences between laboratories were obtained in the Roese-Gottlieb tests. Duplicates of the Roese-Gottlieb agreed within 0.5 percent, after the preliminary tests had been made. Duplicate Roese-Gottlieb tests made at the same laboratory agreed within 0.16 percent in individual tests and the tests of any two laboratories usually agreed with each other within 0.50 percent. The Babcock and Gerber methods agreed within 0.40 percent whereas the Babcock and Roese-Gottlieb tests agreed within 0.50 percent.

Fahl, Lucas and Baten (11) investigated the factors involved in the accuracy of the Babcock test. Out of 513 samples of milk tested by the Mojonnier and Babcock methods, it was found that varying temperature considerably affected the butterfat test. Also a significant difference was noticed between the Babcock and the Mojonnier methods. The Babcock method yielded results varying from 0.041 to 0.082 percent higher than the Mojonnier. Analysis of the above data by Hileman, Rush and Moss (22) showed a standard deviation of the butterfat test to be 0.092 and the standard deviation between the methods was 0.082. They observed a higher Babcock reading than in the Mojonnier method in both milk and cream.

Fisher and Walts (12) determined the fat content on sixteen samples of fresh, sweet whole milk in quadruplicate by the Babcock, the

Gerber and the Roese-Gottlieb methods. Results indicated a reasonably close agreement between these methods. The Babcock and Gerber methods gave results, which in 68.75 percent of the samples were higher than the Roese-Gottlieb method.

Herrington (20) observed that errors in Mojonnier butterfat tests occur whenever the room temperature varies during the course of analysis. Experiments were conducted to study errors due to temperature variation, and their control in the Mojonnier butterfat test. Variation of only one degree in temperature caused a change of approximately three-fourths milligram in weight, which was equivalent to an error of 0.078 percent butterfat, when testing cream.

Holland (23) in a study to determine factors responsible for low butterfat tests, concluded that the Babcock test on composite samples drops about 0.1 percent below the average as compared to daily tests on fresh milk. This decline was found to be more in the first two days of the storage, both on the Mojonnier and Babcock methods. The factors responsible were oiling off, churning and packing of the fat globules.

Jack and Abbot (25) stressed the need for further investigation of the accuracy of the Babcock method, since this test has been blamed frequently for giving too high a fat percentage. The work of several investigators, as shown in Table 1, reveals that the Babcock values are above Roese-Gottlieb or Mojonnier by 0.011 to 0.116 percent.

Jenness and Herreid (26) conducted a series of experiments on milk samples to find the effect of temperature at the time of reading on the accuracy of the Babcock test. Temperatures at various depths in the columns of the Babcock fatty materials were compared with temperatures

TABLE I

COMPARISON OF AVERAGE VALUES OF BABCOCK, ABOVE ROESE-GOTTLIEB OR MOJONNIER, OBTAINED BY DIFFERENT WORKERS

Investigator	Year of Comparison	No. of Comparisons	Ave: Babcock Above Roese-Gottlieb or Mojonnier	Percent of Babcock Tests which were Higher than Roese-Gottlieb
Bailey	1919	190	0.060	92.1
Mojonnier & Troy	1922	14	0.022	64.3
Hoyt	1922	28	0.116	100.0
Hoyt	1922	5	0.079	100.0
Dahberg A. O.	1922	32	0.100	93.7
Phillips	1923	50	0.059	100.0
Dahlberg A. C.	1926	60	0.011	55.0
Lucas	1937	500	0.070	—

Source: Jack, E. L. and Abbot, F. H. The Status of the Babcock Test Proceedings 23rd. Annual Meeting Western Division American Dairy Science Association 1937.

in a dilatometer containing purified milk fat. This work indicated that a temperature of about 53.5° C. for the fatty material fulfills, on the average, the conditions necessary to regulate the butterfat density to 0.9. Holding for five minutes in a water bath at 60° C. was found to be satisfactory. The coefficient of expansion of the column was responsible for the difference in the reading.

Mojonnier and Troy (35) worked on the relative efficiency of the Babcock method as compared with the Mojonnier method for testing fresh milk. A wide variation in results obtained by the same operator and also between two different operators was observed. Total solids determinations by the Mojonnier method gave accurate and consistent results. A single estimation could be made in 21 minutes and duplicates in 30 minutes. Both fat and total solids could be determined in 35 minutes. The Babcock test showed higher readings than Mojonnier. This was due to the presence of substances other than pure fat in the fat column.

Trout and Lucas (49) compared the Babcock, Gerber, Minnesota, Pennsylvania and Mojonnier methods. Duplicate tests for each of these methods were made on twenty-four samples of homogenized milk and found that all samples tested slightly more than non-homogenized, by the Mojonnier method. The non-homogenized milk averaged 0.057 percent higher by the Babcock method than by the Mojonnier method. The Gerber test was found to be most satisfactory of all methods for making butterfat test on homogenized milk. The Minnesota and Pennsylvania methods tested lower than the Mojonnier and therefore, could not be recommended.

Nelson (37) made an extensive study of the Babcock test on 2,000 samples of unpreserved milk. The probable error of reading the test was

$\pm$0.02 percent with a possible variation between readers of 0.10 percent. On each of six samples of milk, 44 tests were made by the Babcock method and 16 by the Mojonnier. The average of the two methods was found to be within the probable error of the Babcock method.

Methods for total solids determination. Mickle et al. (34) took a total of 1,448 composite samples from 63 Holstein cows over a period of 20 months. The results of the total solids determinations by the Cenco Moisture and Mojonnier methods were found to differ significantly at the five percent level in favor of Mojonnier. When another trial of 40 total solids determinations was run from a single sample by the Mojonnier, Cenco and Fischer methods, no significant difference was observed. The mean values obtained were 12.80, 13.05 and 12.83 percent for the three methods, respectively. The Cenco values were found to be within 0.38 to 0.36 percent of the Mojonnier values and Fischer values were within 0.73 to 0.11 percent of the Mojonnier values.

Lowenstein (29) observed no significant difference between the Cenco and Mojonnier values in the estimation of total solids. A total of 686 samples was tested by both methods. The mean values for the Mojonnier and Cenco tests were 12.31 and 12.20 percent, respectively. The average difference between methods for individual samples was 0.244 percent. The Mojonnier test gave results averaging slightly higher in total solids than did the Cenco test. The standard error computed in the statistical analysis was $\pm$0.245.

Stein (47) stated that the gravimetric methods of total solids determinations, like the Mojonnier, Dietert-Detroit Solid Determinator and the Barbender-Semi Automatic Moisture Tester and the Cenco Moisture Balance are in use at present. Comparisons between the Cenco and standard oven drying tests, indicated little or no significant difference in the results. The time required for the Cenco test was shortest of all gravimetric methods and it varied from 12 to 13 minutes. The Cenco method closely agreed with the official gravimetric method.

Herrington (20) reported two important sources of error in total solids determination; one was the transformation of lactose during the drying process and the other the chemical action between protein and lactose, when the two are heated. The physical state of lactose while drying, altered the total solids value of the sample by 0.2 percent. The interaction of protein with lactose, lowered the Mojonnier value by 0.25 percent. No known methods are in existence at present, to prevent this reaction during the test by the Mojonnier method. Drying at a lower temperature may reduce the lactose-protein reaction, but this might raise other complications. Total solids estimation by various methods, therefore raised the problem of accuracy of a particular method. To fix a basis for pricing milk and to standardize values obtained by different methods, a clear definition of total solids in milk and a knowledge to control the physical state of lactose would be required.

The relative efficiency of the Babcock and the Mojonnier methods of butterfat determinations has been fully studied. There is a general agreement among workers, that the Babcock test read slightly more than the Mojonnier. But opinions differ as to the efficiency of Cenco Moisture Balance and Mojonnier methods for the estimation of total solids. Simplicity in operation, saving of much labor and time with the Cenco

Balance encourages re-testing of the instrument to see how results agree with the other official methods. Nutritional significance of milk fat and total solids has become so very important especially now when milk fat has been criticized. As butterfat and total solids in milk are governed by State law, it was thought necessary to find out the composition of milk from cows on the experiment and to see that they meet the standard for Tennessee.

CHAPTER III

METHOD OF PROCEDURE

<u>Duration</u>. The grazing experiment was conducted for ninety-eight days during the summer of 1960, from June 21 through September 26. It consisted of a two week pre-experimental, ten week experimental and a two week post-experimental period.

<u>Establishment of paddocks</u>. On June 1, 1960, a two and one-half acre paddock was seeded to Gahi-1 millet and a comparable paddock was seeded to Starr millet both at the rate of 20 pounds of seed per acre. The paddocks, located on the University of Tennessee dairy farm, were fertilized alike at the time of seeding on June 1. The fertilization rate was 100 pounds of 33 percent ammonium nitrate, 50 pounds of 52 percent phosphate and 50 pounds of 60 percent muriate of potash per acre. The Gahi-1 field was a fertile river bottom and the Starr millet field was located adjacent to it. Hereafter for simplification, Gahi-1 pearl millet and Starr pearl millet will be referred to as Gahi millet and Starr millet, respectively. A second seeding of each forage was made on two additional comparable paddocks on June 15.

A fortnight between the first and second seeding dates was provided so that initial grazing would be spread over a longer period of time and to facilitate rotational grazing. The seeding and fertilization rates were the same as for the first seeding on June 1. All paddocks were fenced separately with an electric barbed wire.

<u>Pairing of Cows</u>. The 22 lactating dairy cows used in this study

were selected from the University of Tennessee Holstein dairy herd. They were divided into two groups, as comparable as possible with regard to milk production, body weight, age, stage of lactation and stage of gestation. The information on each cow used in selecting the pairs is shown in Appendix A.

<u>Feeding and care of cows.</u> The two groups of cows were handled in the same manner during the pre-experimental period which extended from June 21 to July 4. Throughout the experiment, both groups were fed the same grain mixture. The grain mixture contained one part of corn, two parts of oats and one part of cotton seed meal. Both cows in each pair were fed the same amount of grain each day which was set at the rate of one pound of grain for each four pounds of milk produced. The rate of grain feeding was set at the beginning of the experiment on the basis of the average production for each pair and was held at this level throughout the experiment.

The hay fed was poor quality alfalfa and contained small quantities of bluegrass and Johnsongrass. Every afternoon shortly after milking, sufficiently large quantities of hay were weighed on platform scales and fed to the cows in each group. A portion of the weighed hay was put in a concrete feed manger located in the holding area and the other portion placed in feed bunkers located in the lane leading to each paddock. The cows had free access to their respective paddocks and to the hay in the feed bunker at all times. Approximately one hour prior to each milking the two groups were placed in a separate holding area where the cows had access to the hay located in the concrete feed manger. The refused hay was weighed back every day and fed to cows not on experiment. Hay consumption was measured on the group basis.

The cows had constant access to salt and a mineral mixture. Drinking facilities were provided in the feed lots leading to the paddocks, holding areas and in each paddock. The paddocks and the feed lot or lanes which extended approximately 400 yards from the barn to the paddocks were provided with shade-trees.

Rotational grazing. The two groups were turned into the first seeded paddock of each forage on July 5 with one group on Gahi and the paired mates in the other group on the Starr paddock. After the cows began initial grazing on July 5, the two paddocks seeded to each millet were rotationally grazed. The paddocks were inspected at frequent intervals in an attempt to evaluate the quantity and quality of forage available for grazing. Each group was rotated five times at varying intervals of 8 to 20 days. On two occasions, clean-up cows from the regular herd were selected to graze down the spotty growth remaining after the experimental cows had been switched to the other paddock.

On September 12, the terminal day of the experimental period, all cows from both groups were turned with the regular herd after recording body weights and the paddocks were closed.

During the post-experimental period, from September 12 through 26, silage was added and hay was fed ad lib as usual with the same grain ration at milking time.

Milk production, butterfat, total solids and body weights. All cows were milked twice daily at approximately 3:00 p.m. and 4:00 a.m. and their production recorded at each milking. Composite samples of milk from individual cows were obtained at weekly intervals for butterfat and total solids determination. Butterfat test was determined by the Babcock method and total solids, the Cenco Balance method. The pounds of milk and butterfat produced were converted to four percent fat-corrected milk, using the formula:

0.4 (pounds of milk) + 15 (pounds of butterfat) = 4 percent fat-corrected milk.

Body weights were taken on five different occasions during the entire experiment. One day weights were taken at the beginning of the pre-experimental period, at the beginning of the experimental period, once during the experimental period, at the end of the experimental period and at the termination of the post-experimental period. These weights were taken in the afternoon before milking.

Statistical significance of differences in milk and butterfat production and four percent fat-corrected milk was determined by analysis of variance of the individual responses (5). The difference between the two groups of cows in the total solids content of the milk was checked for significance by the t test (46).

<u>Dry matter determinations of forages</u>. At approximately weekly intervals samples of the two forages were taken from the respective fields. They were obtained by hand plucking and were immediately weighed and placed in an oven to dry at 60° C. Dry weight was determined after drying for approximately 24 hours and then setting for 12 hours. The value obtained was used to calculate the dry matter content. The dry matter content of the hay was determined in the same manner. A total of seven dry matter

determinations was made on each forage and five on the hay fed during the experiment.

Preparation of composite samples. All experimental cows were milked twice daily and composite samples of milk were taken one day each week for analysis. Every Monday evening approximately a 70 milliliter sample of milk was obtained from each cow and on the following morning an equal amount was mixed with it and stored in eight ounce sample bottles using one milliliter of formalin as the preservative. The samples were brought to the laboratory on Tuesday and were tested immediately for butterfat by the Babcock method. Total solids determinationsby the Cenco and Mojonnier methods and the Mojonnier fat test were determined during the course of the week. All samples were refrigerated immediately after arrival at the laboratory.

The composite samples of milk from each cow were tested weekly for butterfat by the Babcock and Mojonnier methods and for total solids by the Mojonnier and Cenco Moisture Balance methods. All tests were made in duplicate.

Butterfat test by the Babcock Method. Association of Official Agricultural Chemists Babcock butterfat method as outlined in the Laboratory Manual (32) was followed. This was briefly as follows: a thoroughly mixed, 17.6 milliliters sample of milk tempered to 60° - 70° F. was transferred into an 18 gram test bottle. An equal amount of sulphuric acid at 60 - 70° F. was added and allowed to flow gently down the neck of the test bottle, as it was rotated slowly. The mixture was vigorously agitated by shaking until it assumed a dark chocolate color. The samples were then centrifuged for 5 minutes. Hot tap water at 140° F. or above was then added and again centrifuged for two minutes when a sufficient amount of water was added to bring the level of the fat to the top of the graduated portion of the bottle. This was again centrifuged for one minute. The bottles were then immersed in a water bath held at 140° F., so that the top of the fat column was below the water level and were left there for 5 minutes. The fat columns were measured with the dividers removing one bottle at a time from the water bath.

Butterfat test by the Mojonnier Method. The Association of Official Agricultural Chemists Mojonnier method for butterfat test as outlined in the Laboratory Manual (32) was followed. After thorough mixing of the milk and tempering to 60 - 70° F., a 10 gram sample was weighed into a Mojonnier extraction flask.

The two ether extractions were as follows:

1. Added 1.5 milliliters of NH_4OH, to neutralize any acid present and to dissolve casein. The content of the extraction flask was then thoroughly mixed by vigorous shaking.

2. Added 10 milliliters of 95 percent grain alcohol, to prevent the formation of a precipitate with ethyl ether, to be added subsequently. This was shaken for one and one-half minutes.

3. To this mixture, 25 milliliters of ethyl ether were added and again shaken for one and one-half minutes.

4. 25 milliliters of petroleum ether were then added and shaken for one and one-half minutes.

The last two extractions were for dissolving the fat and taking out moisture.

A set of eight extraction flasks were placed conveniently in a Mojonnier extraction flask holder and the above procedure was hastened, by the addition of each reagent with simultaneous shaking of eight samples for the specified time.

5. These samples were then centrifuged 30 turns, taking one and one-half minutes.
6. The ether solution was then decanted carefully into the Mojonnier aluminium fat dish, which had undergone preheating to 275° F. in the fat oven for five minutes and seven minutes subsequent cooling in the fat cooling desiccator.

The procedure for the second extraction was the same as the first except the volume of each reagent added was smaller and no ammonia was added. After decanting, the ether was evaporated from the ether mixture containing the butterfat, by placing over an electric hot plate at 275° F. After ether evaporation, the aluminium dish containing the fat was transferred to the vacuum oven at 275° F., for five minutes with 20 inches of vacuum. The dish was then cooled in the cooling desiccator with the circulating water at room temperature for seven minutes, after which the dish was rapidly weighed and the weights recorded.

Percentage of fat was then calculated as follows:

$$\text{Percentage of fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Total solids test by the Mojonnier Method. Two grams of milk were weighed from the thoroughly mixed sample into the solid dish which had been previously heated for 10 minutes in the solids oven at 212° F. and subsequently cooled for five minutes in the solids cooling desiccator and weighed. The weighed sample contained in the dish was spread evenly over the bottom by tilting. The sample was uniformly dried on a hot plate with the use of a contact-maker, until the residue turned light brown. The dish with the dried residue was then transferred to the solids vacuum oven at 212° F. and held for 10 minutes with 20 inches of vacuum. The dish was then transferred to a cooling desiccator and after five minutes removed and weighed with the dish covered.

Percentage of total solids was calculated as follows:

$$\text{Percentage of total solids} = \frac{\text{Weight of solids}}{\text{Weight of sample}} \times 100$$

To save time a set of four samples was duplicated and tested for fat and total solids simultaneously.

<u>Total solids test by the Cenco Moisture Balance Method</u>. The procedure as outlined in the <u>Laboratory Manual</u> (32) was followed. The balance was adjusted by setting the scale on 100 percent and moving the knob up or down until the pointer was directly in line with the index. About five milliliters of milk were pipetted over the aluminium disposable pan, to bring the pointer in line with the index line. The lamp-housing was closed and the infra-red lamp turned on. As the moisture evaporated, the pointer moved upward which was continuously brought back in line with the index, until no further change was noted in the pointer for a period of one to three minutes. The percentage of moisture in the sample was read directly. From this the total solids was determined by difference.

CHAPTER IV

RESULTS AND DISCUSSION

Establishment of paddocks. The cows began the initial grazing of the paddocks on July 5 which was 35 days after the first seedings were made. They were shifted to new pasture growth in the second seeding paddocks, 30 days after the second seedings were made. The Gahi was approximately 16 inches high and the Starr, 12 inches. Gahi plants appeared to be more prolific and had relatively taller stems and broader leaves than Starr plants.

Milk production, butterfat and 4 percent fat-corrected milk. The Gahi group averaged 39.4 pounds of milk per day, whereas the Starr group averaged 39.8 pounds per day. These averages are shown in Table II and Figure 1A. The two groups differed very little in milk production, which agreed with the milk production results of Baxter (3). Despite this small difference between the two groups, an analysis of variance of the individual responses in milk production of the 11 pairs of experimental cows showed a significant difference between the Gahi group and the Starr group at the five percent level. The method of analysis was dependent upon the representative performance of each cow during the pre-experimental period. As shown in Appendix A, one cow in the Gahi group had calved just prior to the beginning of the experimental period and of course, she increased rapidly to her peak of lactation during the first part of this period. Another cow in the Gahi group calved during the second week of the pre-experimental period and followed a similar pattern to the other one in

TABLE II

AVERAGE MILK AND 4 PERCENT FAT CORRECTED MILK PRODUCTION, BUTTERFAT PERCENT, PERCENT TOTAL SOLIDS AND HAY CONSUMPTION OF 11 COWS GRAZING GAHI AND STARR MILLETS FOR 10 WEEKS

	- WEEKS -											
	1		2		3		4		5		6	
	Gahi	Starr	Gahi	Starr	Gahi	Starr	Gahi	Starr	Gahi	Starr	Gahi	Starr
Daily Milk (lb.)	45.0	45.4	44.4	43.0	43.4	42.5	41.3	40.9	41.1	40.3	39.7	38.3
% Butterfat	3.3	2.9	3.3	2.9	3.2	3.0	3.3	3.1	3.4	3.4	3.4	3.2
Daily 4% F.C.M. (lb.)	40.1	38.0	39.5	38.4	38.3	36.1	36.7	35.9	36.5	37.1	36.3	34.0
% Total Solids	11.1	10.7	11.0	10.8	11.0	10.8	11.1	10.6	11.1	10.8	11.1	10.7
Hay Consumption (lb.)	9.6	8.7	9.5	7.9	5.6	6.0	10.3	11.3	10.3	9.3	13.3	10.5

TABLE II (continued)

	- WEEKS -									
	7		8		9		10		ALL	
	Gahi	Starr	Gahi	Starr	Gahi	Starr	Gahi	Starr	Gahi	Starr
Daily Milk (lb.)	39.0	39.1	36.8	38.4	32.7	36.0	30.8	33.9	39.4	39.8
% Butterfat	3.5	3.1	3.6	3.1	3.4	3.3	3.5	3.3	3.4	3.1
Daily 4% F.C.M. (lb.)	36.5	32.2	34.4	33.7	29.6	31.9	28.8	30.2	35.7	34.8
% Total Solids	11.4	10.7	11.0	10.7	11.2	10.9	11.3	10.8	11.1	10.7
Hay Consumption (lb.)	11.8	11.2	16.9	17.1	20.5	20.9	15.5	18.6	12.4	12.2

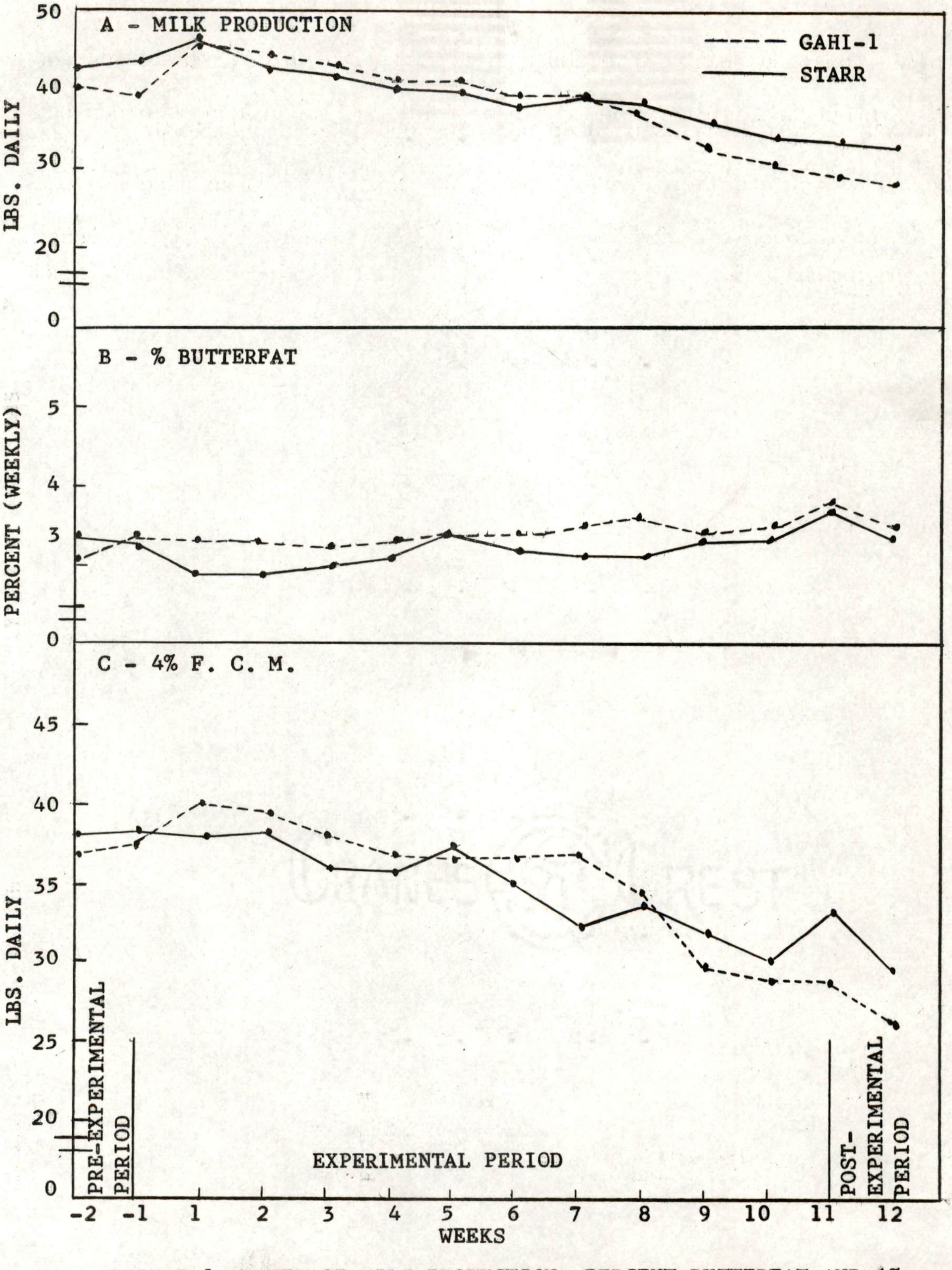

FIGURE 1. AVERAGE MILK PRODUCTION, PERCENT BUTTERFAT AND 4% F. C. M. OF COWS GRAZING GAHI-1 AND STARR MILLETS.

increasing her production. Both of these cows showed extremely high responses in milk production, compared to their mates in the Starr group. The production response of one cow was 12.46, compared to 1.77 for her paired mate and the response of the other cow in the Gahi group was 13.62 compared to 1.87 for her mate. Therefore, these two pairs were omitted and an analysis of the production responses was made on the nine remaining pairs, which showed no significant difference between the two groups in milk production. The analyses of variance of the data are shown in Appendix B. On the basis of the latter analysis, this study agrees with the previously mentioned observation of Baxter *et al.* and it was concluded that the two forages did not differ in their effect on milk production.

The Babcock butterfat test was run each week on the milk from each experimental cow throughout the entire experiment. On the average, the Gahi group tested 3.2 percent butterfat during the pre-experimental period and it went up to a height of 3.6 percent during the eighth week of the experimental period. The Starr group averaged 3.3 percent during the pre-experimental period and did not show any marked increase during the experimental period. The average butterfat test for the experimental period was 3.4 and 3.1 percent for the Gahi group and Starr group, respectively. Average butterfat percent for each week is shown in Table II and Figure 1 B. The analysis of variance of the responses in butterfat production for all 11 pairs showed a significant difference at 1 percent level between the Gahi and Starr groups. When a second analysis of variance, as outlined above for calculating the milk production responses, was made on the remaining nine pairs, there was still a significant difference at 1 percent level of probability. The reasons for a higher fat test in the Gahi group were not clear. The Gahi group did contain more animals in an advanced stage of lactation than the Starr group as shown in Appendix A. The average daily milk production of the Gahi group was 0.4 pounds less than the Starr group. Perhaps, this combined with the more advanced stage of lactation for the Gahi cows may have been responsible for the higher fat test. This increase in fat test by the Gahi group appeared to be within physiological limits and showed the negative correlation between milk production and butterfat secretion (28). However, from the statistical analysis it may be reasoned that the Gahi forage did influence butterfat secretion and may have contributed, at least partly, to the overall group increase in butterfat.

The average daily four percent fat-corrected milk produced was 35.7 pounds for the Gahi group and 34.8 pounds for the Starr group. These averages are shown in Table II and Figure 1 C. On the fat-corrected milk basis, the Gahi group showed a higher average than the Starr group. The analysis of variance of individual responses in fat-corrected milk by all cows showed a significant difference at the five percent level. Whereas, the analysis of the responses of the 9 pairs of cows (Appendix C) showed a significant difference between the Gahi group and Starr group at the one percent level. This indicates that the higher butterfat test of the Gahi cows resulted in a significantly higher production of fat-corrected milk. Gross *et al.* (16) observed no significant difference in fat-corrected milk production between cows grazing Gahi and Starr millets and remarked that both forages could support milk production equally well. The highly statistically significant difference obtained in this study, thus, disagrees with the findings of Gross et al. However, the higher responses in fat-corrected milk shown by the Gahi group substantiates the prediction of Gross et al. (16) in that Gahi-1 millet may surpass other varieties of millets as a summer pasture for dairy cattle.

Total solids and solids-not-fat. The Cenco Moisture Balance method was used in making duplicate total solids tests each week during the experimental and post-experimental periods. Cows in the Gahi group averaged 11.1 percent total solids and the Starr group averaged 10.7 percent during the experimental period. The weekly average percentage of total solids for each group is shown in Table II and Figure 2. The t-value obtained in testing the difference between the two groups was not significant at the 5 percent level (46). The total solids in the milk of both groups did not change very much from what it was at the initial stage of the experiment.

The solids-not-fat averaged 7.7 percent for the Gahi and 7.6 percent for the Starr group. These values were far below 8.5 percent, which is the minimum legal standard for Tennessee.

Body weights. The cows in the Gahi group averaged 1,354 pounds when they started grazing Gahi and 1,341 pounds at the end of the experimental period with an average loss of 13 pounds. The Starr group averaged 1,355 pounds at the beginning of the experimental period and 1,360 pounds at the end for a gain of 5 pounds per cow. At the end of the post-experimental period both groups had gained in weight with the Gahi group gaining an average of 44 pounds and the Starr group 48 pounds. Loss of

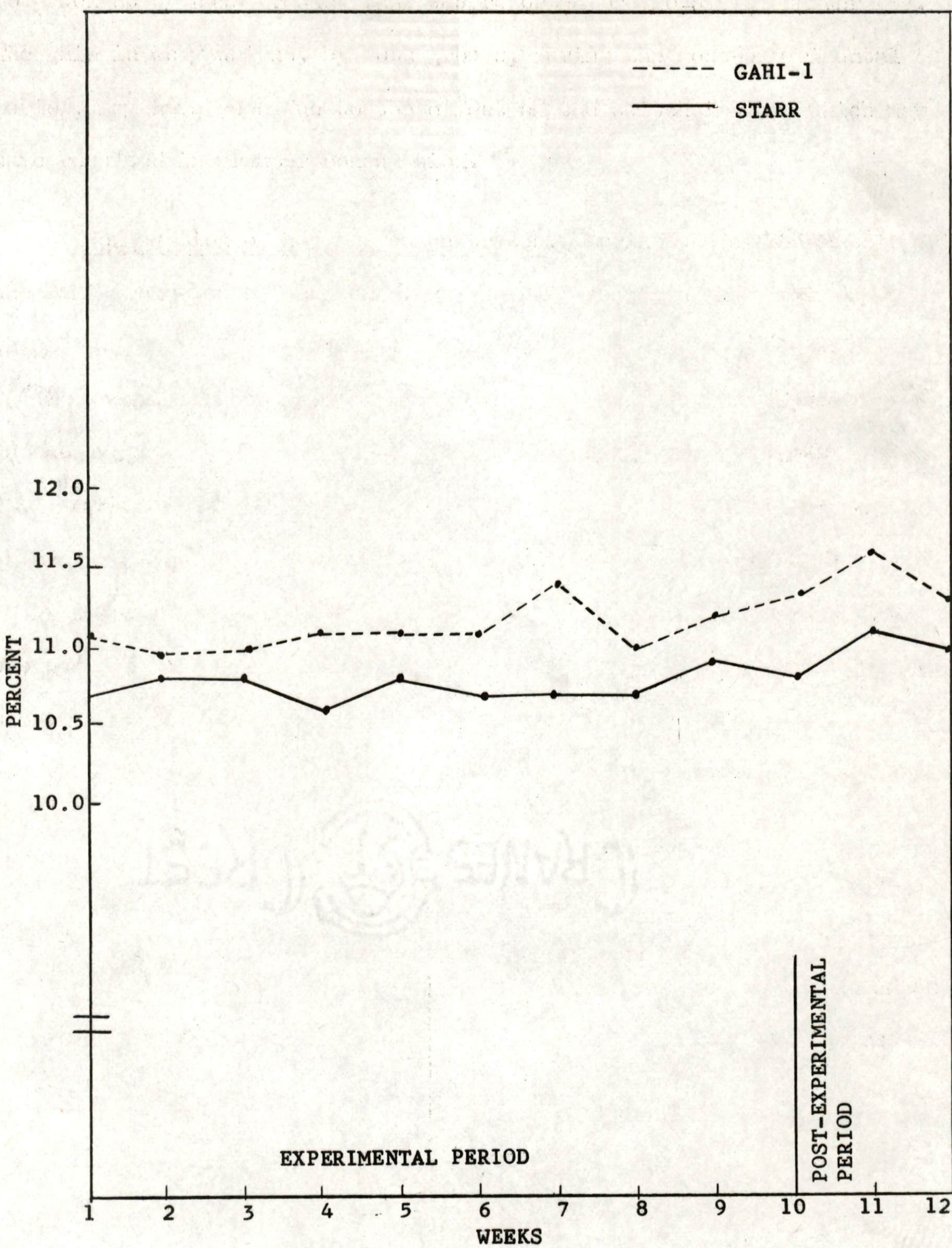

FIGURE 2. AVERAGE WEEKLY PERCENT TOTAL SOLIDS OF MILK FROM COWS GRAZING GAHI-1 AND STARR MILLETS.

body weight by cows grazing Gahi was reported previously by Baxter (3). The gain in body weight, by both groups, during the post-experimental period, may have been due to the effect of the switch in feed which may have resulted in greater consumption.

Consumption of hay and concentrates. During the experimental period, the Gahi group was offered an average of 193 pounds of hay each day of which 22.8 percent was refused. The Starr group received 192 pounds per day with a refusal of 23.9 percent. Table II shows the weekly average hay consumption for each group. The average daily hay consumption was 12.4 pounds for the Gahi group and 12.2 pounds for the Starr group. On an average, the Gahi group consumed 0.2 pounds more hay per day than the Starr cows. An appreciable decrease in hay consumption by both groups was observed in the third week of the experimental period. Both groups showed a gradual increase in hay consumption towards the end of the experimental period with the highest average consumption occurring during the ninth week.

The paired cows were fed the same amount of the standard grain mixture which averaged 16.5 pounds per cow daily for each group.

The dry matter analyses of seven samples of each forage showed an average of 16.6 percent dry matter for the Gahi millet and the Starr millet averaged 15.7 percent. The dry matter content of the hay averaged 87.8 percent. Fluctuations were observed in the dry matter content of both millets.

Observations on the forages, grazing habits and weather conditions. The Starr millet paddocks were very weedy, as well as the Gahi paddocks to some degree. The Gahi millet headed out much faster and seemed to mature more rapidly than the Starr millet. The Gahi was very stemmy and the cows refused a large part of the plant after grazing only the top portion of the millet plants. Losses due to trampling and treading were also observed to be very heavy in the Gahi millet paddocks. There were slight to moderate rains in June and July for 11 days. The cows were not allowed on the paddocks on July 10 due to heavy rains, the preceeding night. The Gahi millet group was not on pasture on August 1 due to fence repairs. These factors may have made it difficult to estimate the potential level of grazing and proper evaluation of the merit of both varieties of millets.

This part of the forage evaluation study was of a preliminary nature. However it appears, that under perfect pasture management, Gahi-1 millet may surpass Starr millet in the support of milk production.

Comparison of butterfat tests. Results of this phase of the study are presented in Table III and show a lower average butterfat test for the Mojonnier method than the Babcock method. This agrees with the findings of Phillips (40), Fahl, Lucas and Baten (11), Fisher and Walts (12), Hileman (22), and Trout and Lucas (49). The values obtained on 260 duplicate samples tested during the experimental period by the Babcock and Mojonnier methods, were found to average 3.3125 percent and 3.2568 percent, respectively, with a difference of 0.0557 percent in favor of the Babcock method. A variation within 0.041 to 0.082 percent was observed between the two methods by Fahl, Lucas and Baten (11) with 513 samples. The difference of 0.0557 percent observed between the two methods in this study, seemed to fall within this reported range and therefore, substantiated

TABLE III

COMPARISON OF THE BABCOCK AND MOJONNIER METHODS FOR BUTTERFAT DETERMINATIONS AND THE CENCO MOISTURE BALANCE AND MOJONNIER METHODS FOR TOTAL SOLIDS DETERMINATIONS IN MILK FROM COWS GRAZING GAHI AND STARR MILLETS

	Percent Butterfat				Percent Total Solids			
Weeks	Babcock Method		Mojonnier Method		Cencos Method		Mojonnier Method	
	Gahi	Starr	Gahi	Starr	Gahi	Starr	Gahi	Starr
1	3.3	2.9	3.2825	3.0722	11.1	10.7	11.8762	11.4308
2	3.3	2.9	Not taken		11.0	10.8	Not taken	
3	3.2	3.0	3.1341	3.0870	11.0	10.8	11.6548	11.8738
4	3.3	3.1	3.2225	3.0534	11.1	10.6	11.7851	11.4154
5	3.4	3.4	3.2341	3.3325	11.1	10.8	12.1117	11.5667
6	3.4	3.2	3.2810	3.1090	11.1	10.7	11.9690	11.5233
7	3.5	3.1	3.4545	3.0264	11.4	10.7	12.1851	11.7449
8	3.6	3.1	3.2222	3.0547	11.0	10.7	12.0149	11.4822
9	3.4	3.3	3.3980	3.3098	11.2	10.9	12.2699	11.9755
10	3.5	3.3	3.5673	3.2964	11.3	10.8	11.1833	11.6323
11	3.8	3.7	3.5056	3.3167	11.5	11.2	12.6310	12.2850
12	3.5	3.3	3.4536	3.2365	11.3	11.0	12.3671	11.8657
Average	3.3		3.2568		11.0		11.8565	

the previous finding.

The two methods used to compare the values of butterfat percent showed a positive correlation (r = 0.7865) which was significant at the 1 percent level of probability. The b-value obtained was 0.78. In this study, it was found that for every one unit increase by the Babcock method the Mojonnier method value increased by only 0.78. In terms of the butterfat test, the same sample showed a higher fat test by Babcock, than by the Mojonnier.

Comparison of total solids tests. The values obtained on 260 duplicate samples tested by the Cenco Moisture Balance and the Mojonnier methods (Table III) were found to average 11 percent and 11.8565 percent, respectively. The Mojonnier method value was 0.8565 percent higher than the value obtained by the Cenco method. Mickle et al. (34) observed a significant difference between the Cenco and Mojonnier methods while Lowenstein (29) and Stein (47) reported no significant difference between these two methods. Herrington (21) suggested that no known methods of analysis for total solids were perfectly accurate. Therefore, when the conflicting results and observations made by the above workers are considered it might lead one to think that the Cenco method has great promise in the years ahead and might replace the Mojonnier for routine milk analysis. The saving of time, simplicity and economy in operation are advantageous features of the Cenco method.

The results of the Cenco Moisture Balance and Mojonnier methods for total solids showed a positive correlation (r = 0.7598) and was significant at the one percent level of probability. However, the higher Cenco Moisture Balance value obtained in this study may be due to factors like temperature variation, size of the sample, time and techniques of weighing. The b-value obtained was 1.5. For every one percent increase in total solids by the Cenco method, there was a corresponding increase of 1.5 percent by the Mojonnier method.

Visual estimation of color change in both methods gave greater chances to err, in the experiment. If this factor could be controlled in some way during the test, probably the Cenco method would show more accurate results. The most critical error with the Cenco balance was found to be the inability to balance the disposable pan during the operation which would cause an uneven evaporation rate at the milk surface. Based on the results observed elsewhere and those obtained in this study, it was concluded that the results of these two methods are substantially different.

Possibly, modifications in the instrument or refined technique on the part of the operator would enable closer checks with the Mojonnier method and would give the dairy industry a valuable and very useful procedure. A further contimuation of this project under controlled laboratory conditions seems to be necessary to learn the agreement between the Mojonnier method and Cenco Moisture Balance method, for total solids estimation of milk.

CHAPTER V

SUMMARY AND CONCLUSION

Two groups of 11 Holstein cows each were grazed separately on Gahi-1 millet and Starr millet forages for a period of ten weeks. A comparison was made of the production and composition of the milk produced by each group. During a 70 day experimental period, the two groups of cows were compared on the basis of their milk production, butterfat tests, four percent fat-corrected milk, total solids, hay consumption and body weights. The Mojonnier and Babcock methods were compared for determining the butterfat test and the Cenco Moisture Balance and Mojonnier methods were compared for determining total solids.

The eleven cows in the Gahi millet group averaged 39.4 pounds of milk per day, whereas the Starr millet group averaged 39.8 pounds per day. The average butterfat test was 3.4 percent for the Gahi millet cows and 3.1 for the Starr millet group and the average percent of total solids was 11.1 for the Gahi and 10.7 for the Starr group. The average daily four percent fat-corrected milk production during the experimental period was 35.7 pounds for the cows on Gahi millet and 34.8 pounds for the cows on Starr millet.

The cows in the Gahi millet group lost an average of 13 pounds in body weight while on the experiment, whereas the cows in the Starr group gained an average of 5 pounds body weight. Both groups gained in body weight during the post-experimental period.

The Gahi group consumed an average of 12.4 pounds and Starr group, 12.2 pounds of hay per day.

Statistical analysis of variance of the responses in milk production showed a significant difference between groups. However, when two pairs of cows, which showed unusually high responses, were eliminated from the analysis the difference in milk production between the groups was not significant.

The Gahi cows produced significantly more four percent fat-corrected milk than the Starr millet cows. It was postulated that the higher fat test of the Gahi cows was responsible for this significant difference.

The average butterfat test by the Babcock method was 3.3 percent and 3.2568 percent, by the Mojonnier method. Percent of total solids averaged 11.0 percent by the Cenco method and 11.8565 percent by the Mojonnier method.

The average of 260 duplicate samples tested by the Mojonnier method was 0.0557 percent lower in butterfat than the Babcock and 0.8565 percent higher for total solids than the Cenco Moisture Balance method.

On the basis of the data in this trial, there is not sufficient evidence to warrant the superiority of one variety of millet over the other for summer supplemental pasture. Milk samples from the experimental cows, tested for butterfat by the Babcock method were found to be higher than Mojonnier method. For total solids estimation, Mojonnier method gave higher values than the Cenco Moisture Balance.

REFERENCES

REFERENCES

(1) Anonymous. Study of Babcock Test for Butterfat in Milk. Iowa Agr. Expt. Sta. Ann. Rept. 30. 1918.

(2) Bailey, D. E. Study of Babcock Test for Butterfat in Milk. J. Dairy Sci., 2:331. 1919.

(3) Baxter, H. D., Owen, J. R., and Ratcliff, L. Comparison of Two Varieties of Pearl Millet for Dairy Cattle. Tenn. Agr. Expt. Sta. Progr. Rept. 33. p. 4. 1960.

(4) Broyles, K. R., and Fribourg, H. A. Nitrogen Fertilization and Cutting Management of Sudan Grasses and Millets. Agron. J. 51:277. 1959.

(5) Burt, A. W. A. The Effect of Variation in Nutrient Intake upon the Yield and Composition of Milk. III. A Note on Experimental Methods. J. Dairy Research., 25:1. 1958.

(6) Cathcart, S. L. Pearl Millet for Grazing and Silage. 57th. Ann. Rept. South Carolina Agr. Expt. Sta. Feb. 1945.

(7) Cole, M., Seath, D. M., Lassiter, C. A., and Rust, J. The value of Alfalfa Hay and Alfalfa Silage When Fed as Supplements to Cows on Pasture. J. Dairy Sci., 40:252. 1957.

(8) Cragmiles, J. P., Baird, D. M., and McCullough, M. E. Quality Evaluation of Sudangrass and Millet Forage. Georgia Expt. Sta. Mimeo Sers. N. S. 48. 1958.

(9) Dahlberg, A. C., Holm, G. E., and Troy, H. C. A Comparison of Babcock, Gerber and Roese-Gottlieb Methods for Determining the Percentage of Fat in Milk and Cream. NY (Geneva). Agr. Expt. Sta. Tech. Bull. 122.

(10) Dow, G. F. Seasonal Production Data, 1923-1928. Maine Agr. Expt. Sta. Bull. 483. p. 28. 1950.

(11) Fahl, J. R., Lucas, P. S., and Baten, W. D. Factors Involved in the Accuracy of Babcock Test. Michigan Agr. Expt. Sta. Tech. Bull. 158. 1938.

(12) Fisher, R. C. and Walts, C. C. A Comparative Study of Methods for Determining the Percent of Fat in Dairy Products. Conn. (Storrs) Agr. Expt. Sta. Bull. 131. 1925.

(13) Foley, R. C. The Proper Supplementary Ration for Milking Cows on Fertilized Pasture. J. Dairy Sci., 16:407. 1933.

(14) Gordon, C. H., Hunt, O. J., Mowly, G. R. and Harvey, W. K. A Comparison of Relative Efficiency of Three Pasture Utilization Systems. J. Dairy Sci., 42:1686. 1959.

(15) Goss, E. F. Techniques of Dairy Plant Testing. Copyright 1953, The Iowa State College Press, Ames.

(16) Gross, H. D., Hollow, B. F., Mochrie, R. D., and Woodhouse, W. W. Millet for Summer Grazing for Eastern North Carolina. Rept. No. FC-5. AI-28, DH-15, MY, 1957.

(17) Hazelwood, B. P. All Year Pasturing With or Without Concentrates for Dairy Cows. Tenn. Agr. Expt. Sta. Bull. 207. 1950.

(18) Hawkins, G. E., Smith, L. A., and Kelly, W. B. A Comparison of Starr Millet, Sweet Sudan Grass, and Johnson Grass as Dairy Forages. Leaflet No. 60. Agr. Expt. Sta. Alabama Poly. Tech. Inst. (1958).

(19) Hanson, A. A. Grass Varieties in the United States. U. S. Dep. Agr. ARS. Handbook. 170: 1953.

(20) Herrington, B. L. Temperature Errors in Weighing and Their Control in Mojonnier Fat Test. J. Dairy Sci., 27:67. 1944.

(21) Herrington, B. L. Testing Methods and Marketing Aspects of Protein vs. Solids-Not-Fat. J. Dairy Sci., 43:1521. 1960.

(22) Hileman, J. L., Rush, K. K., and Moss, C. The Relation of Errors in the Babcock Test to Losses in Cream Plants. J. Dairy Sci., 25:373. 1942.

(23) Holland, R. F. The Cause and Prevention of Decrease in Fat Test of Composite Samples. J. Dairy Sci., 21:141. 1938.

(24) Hoveland, C. S. and McCloud, D. E. Manage Millet for Better Yields. Florida Agr. Expt. Sta. Res. Rept. 2. 1957.

(25) Jack, E. L. and Abbot, F. H. The Status of the Babcock Test. Proc. West. Div. Am. Dairy Sci., Assoc. 23rd. Ann. Meeting, 1937.

(26) Jenness, R. and Herreid, E. O. The Effect of Temperature of Reading on the Accuracy of the Babcock Test for Fat in Milk. J. Dairy Sci., 28:591. 1945.

(27) Jones, J. H., Jones, J. M., Hall, R. A. and Neal, E. M. The Use of Sudan Grass Pastures and Other Feeds for Beef Production. Tex. Agr. Expt. Sta. Bull. 599. 1941.

(28) Knott, J. C. Hodgson, R. C., and Ellington, E. V. Methods of Measuring Pasture Yields with Dairy Cattle. Wash. Agr. Expt. Sta. Bull. 295. 1934.

(29) Lowenstein, M. Cenco Test Confirmed. Milk Plant Monthly., 44:3. 1955.

(30) Marshall, Sidney P., Sanchez, A. B., Somers, H. L., and Dix Arnold, P. T. The Value of Pearl Millet Pasture for Dairy Cattle. Florida Agr. Expt. Sta. Bull. 527. 1953.

(31) McCullough, M. E., and Sele, O. E. Conditions Influencing Forage Acceptability and Rate of Intake. J. Dairy Sci., 42:571. 1959.

(32) Milk Industry Foundation. Washington. Laboratory Manual. Methods of Analysis of Milk and Its Products. 3rd. Ed. Milk. Ind. Foundation, Wash. 6, D.C. 1959.

(33) Miller, W. J., Beaty, E. R., and Underwood, L. M. A Comparison of Tift Sudan and Starr for Dairy Cows by Several Techniques. Georgia Agr. Expt. Sta. Tech. Bull. N. S. 16. Sept. 1958.

(34) Mickle, J. B., Musgrave, S. D., Walton, R. E., Graybill, F. A., Lowenstein, M., and Johnson, P. E. Comparison of Mojonnier, Cenco Moisture Balance and Karl Fischer Titration as Methods of Determining Total Solids in Fluid Milk. Okla. A and M College. Tech. Bull. T-67. Feb. 1957.

(35) Mojonnier, T., and Troy, H. C. The Technical Control of Dairy Products. Mojonnier Bros. Co., Chicago, Ill. 49. 1922. 2nd Ed. 1925.

(36) Morrison, F. B. Feeds and Feeding. 22nd ed. 3rd Print. The Morrison Publ. Co., Ithaca, New York. 1959.

(37) Nelson, D. H. A Statistical Study of the Babcock Test. J. Dairy Sci., 11:108. 1928.

(38) O'Neil, J. M. Summer Fodder Crops. Green Grazing When Stock Need It Most. South Australian Agr. J., 60:514. 1957.

(39) Owen, J. R., Miles, J. T., and Cowsert, W. C. A Comparison of Systems of Grazing A Summer Annual Pasture. J. Dairy Sci., 40:1392. 1957.

(40) Phillips, C. A. A Comparison of the Babcock and Roese-Gottlieb Methods for Determination of Butterfat in Milk. J. Dairy Sci., 6:549. 1923.

(41) Paul, R. H. Growing Sudan Grass. Holstein-Fresien W. 32:334. MY-4. 1935.

(42) Reid, J. T., Kennedy, W. K., Turk, K. L., Slack, S. T., Trimberger, G. W., and Murphy, R. P. Effect of Growth Stage, Chemical Composition and Physical Properties Upon the Nutritive Value of Forages. J. Dairy Sci., 42:567. 1959.

(43) Roark, D. B., Miles, J. T., Lusk, J.W., and Cowsert, W. C. Milk Production from Pearl Millet, Grain Sorghum and Tift Sudan Grass. Proc. 49th. Ann. Convention of Assoc. Sou. Agr. Workers. p. 76. 1952.

(44) Seath, D. M., Lassiter, C. A., Bastin, G. M. and Elliot, R. F. Effect of Kind of Pasture on the Yield of T. D. N. and on Persistency of Milk Production of Milk Cows. Kentucky Agr. Expt. Sta. Bull. 609. 1954.

(45) Smith, V. R. Physiology of Lactation. 5th ed. The Iowa State University Press. Ames. 1959.

(46) Snedecor, G. W. Statistical Methods. 5th ed. The Iowa State College Press, Ames, Iowa. 1958.

(47) Stein, F. Methods of Milk Solids Determination. Am. Milk Rev. 20:32 July, 1958.

(48) Sullivan, E. F. Performance of Supplemental Summer Forage Crops in Pennsylvania. 1957-1959. Pennsylvania Agr. Expt. Sta. Prog. Rept. 25. 1950.

(49) Trout, G. M. and Lucas, P. S. A Comparison of the Babcock, Gerber, Minnesota, Pennsylvania and Mojonnier Methods for Determining the Percentage of Fat in Homogenized Milk. J. Dairy Sci., 30:145. 1947.

(50) Underwood, L. M., Miller, W. J., Dalton, H. L., and Rogers, T. A. A Comparison of Tift Sudan and Starr Millet as Temporary Summer Pasture for Milking Cows. Proc. 52nd. Ann. Convention of Assoc. Sou. Agr. Workers. p. 86. 1955.

(51) Wrather, J. W. Comparison of Piper Sudan Grass and Starr Pearl Millet Fed to Lactating Dairy Cows. M. S. Degree Thesis. Univ. Tenn. 1958.

APPENDICES

APPENDIX A

INFORMATION USED AS A BASIS FOR PAIRING COWS FOR A GRAZING STUDY COMPARING GAHI-1 AND STARR MILLETS

Pair	Cow		Age at Last Calving Yr.	Mo.	Days in Lactation June 1, 1960	Days in Gestation June 1, 1960	Average Daily Milk Production *	Body Weight June 9, 1960
1	Dinah	S**	4	7	92	18	53.2	1406
	Debby	G**	4	4	104	Open	52.7	1434
2	Elnora	S	7	4	147	48	49.5	1340
	Becky	G	5	1	90	Open	42.9	1421
3	Elsie	S	5	11	134	85	35.5	1624
	Hope	G	4	9	197	97	41.5	1415
4	Viola	S	4	3	4	4	57.6	1146
	Gay	G	7	4	130	46	58.2	1318
5	Amelia	S	4	11	Dry	270	47.1	1488
	Lillie	G	5	1	Dry	?	40.0	1568
6	Beverly	S	2	0	177	88	36.5	1181
	Carolyn	G	2	10	234	Open	32.9	1181
7	Carrie	S	2	9	172	78	37.7	1185
	Lucy	G	2	8	123	48	36.1	1130
8	Marie	S	7	11	151	54	52.8	1376
	Della	G	8	2	174	68	53.9	1395
9	May	S	3	0	170	25	49.6	1307
	Edith	G	2	11	180	111	42.2	1264
10	Frances	S	4	6	91	Open	52.5	1421
	Olive	G	8	9	Dry	255	Dry	1474
11	Sunbeam	S	4	0	58	58	39.3	1312
	Eileen	G	2	7	148	35	37.4	1119

* Average production from March to June 25th.

** Indicates treatment - G (Gahi) and S (Starr)

APPENDIX B

ANALYSIS OF VARIANCE OF RESPONSES IN MILK PRODUCTION OF 11 PAIRS OF COWS GRAZING GAHI AND STARR MILLETS FOR 10 WEEKS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total Variation	21	259.34		
Between Groups	1	51.225	51.225	5.12*
Within Groups	20	208.115	10.405	

ANALYSIS OF VARIANCE OF RESPONSES IN MILK PRODUCTION OF 9 PAIRS OF COWS GRAZING GAHI AND STARR MILLETS FOR 10 WEEKS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total Variation	17	44.25		
Between Groups	1	6.88	6.88	2.95
Within Groups	16	37.37	2.33	

* Significant at $P = \angle .05$

APPENDIX C

ANALYSIS OF VARIANCE OF RESPONSES IN FAT-CORRECTED MILK OF 11 PAIRS OF COWS GRAZING GAHI AND STARR MILLETS FOR 10 WEEKS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total Variation	21	230.38		
Between Groups	1	60.85	60.85	5.54 *
Within Groups	20	219.53	10.97	

ANALYSIS OF VARIANCE OF RESPONSES IN FAT-CORRECTED MILK OF 9 PAIRS OF COWS GRAZING GAHI AND STARR MILLETS FOR 10 WEEKS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total Variation	17	47.31		
Between Groups	1	20.97	20.97	13.1 **
Within Groups	16	26.34	1.60	

* Significant at P = $\angle$ .05

** Significant at P = $\angle$ .01