

UNIVERSITY OF GHANA  
THE BALME LIBRARY

BALME LIBRARY THESES

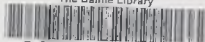
1. Balme Library theses are available for consultation in the Library. They are not normally available for loan, and they are never lent to individuals.
2. All who consult a thesis must sign an undertaking not to copy or quote from it without the consent of the author and of this University.



BOOK NUMBER

SF95.Am1  
Theses Room  
(G279261)

The Balme Library



3 0692 1079 4146 8

COCOA HUSK-AND SUGARCANE  
BAGASSE-BASED DIETS AS FEEDLOT  
FINISHING RATIONS FOR LOCAL  
BEEF CATTLE

A Thesis submitted to the Board of Graduate Studies  
University of Ghana in Partial Fulfilment of the  
Requirements for the Degree of MASTER OF SCIENCE

By

Kofi Amanning-Kwarteng



Department of Animal Science  
University of Ghana  
Legon

August, 1978.


SF 95, Am 1

Thurs 10/11

G 279261

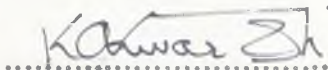
DECLARATION

I hereby declare that, except for references to other people's work which have been duly cited, this work is the result of my own original research and that this thesis either in whole or in part has not been presented for another degree elsewhere.



.....

Prof. E.N.W. Oppong, (Supervisor)  
Department of Animal Science,  
University of Ghana,  
Legon.



.....

Kofi Amaning-Kwarteng

Date: August 1978  
.....



.....

Dr. E.O. Otcere, (Supervisor)  
Department of Animal Science,  
University of Ghana,  
Legon.



Date: August 1978  
.....

ACKNOWLEDGEMENTS

My acknowledgements are due particularly to Dr. E.O. Otchere and Prof. E.N.W. Oppong (Supervisors), whose fatherly guidance, assistance and encouragement during the course of this study were unlimited.

Funds and other facilities for undertaking the project were provided by University of Ghana's Agricultural Research Station, Kpong. My indebtedness goes to the staff of the Station, especially Messrs. A.N. Aryeetey (Senior Research Officer, in-charge) and A.A. Quarcoopome (Principal Farm Supervisor) for their timely advice and special interest in the project; and Messrs. E. Logo, N. Siameh and T. Kaklewa for assisting in data collection and general management of the bullocks.

I also wish to acknowledge Messrs. M.N. Daniel (Nutrition Laboratory) and S.K. Doamekor for analysing feed and faecal samples; Dr. Kow Benyi for his assistance with experimental design and statistical analysis; Mrs. A. Barnes and Mr. B.K. Ashaley for helping in the collection of carcass data; Cocoa Research Institute of Ghana, Tafo, for the gift of cocoa husks and University of Ghana's Agricultural Research Station, Legon, for the supply of feed ingredients.

Finally, my hearty appreciation to my wife Grace and Children Shirley and Awura ~~Anna~~ for their enduring patience, understanding, encouragement and prayers during the tenure of this study.

Kofi Amaning-Kwarteng

August 1978

University of Ghana, Legon.

TABLE OF CONTENTS

	Page
Title Page .. .. .	i
Declaration .. .. .	ii
Acknowledgements .. .. .	.iii
Table of Contents .. .. .	iv
List of Tables.. .. .	.vii
List of Figures .. .. .	ix
SUMMARY .. .. .	x
INTRODUCTION .. .. .	1
LITERATURE REVIEW .. .. .	4
Cattle Feedlot Finishing .. .. .	4
Nutrient Requirement of Finishing Beef Cattle .. .. .	6
Utilization of Lignocellulose by Ruminants .. .. .	9
Physical and Chemical Procedures Used to .. .. .	
Increase Cellulose Availability to Rumen Microbes .. .. .	10
Studies on Cocoa Husk .. .. .	12
Feeding Trials with Sugarcane Bagasse .. .. .	14
Regulation of Feed Intake .. .. .	17
Urea-Molasses Supplementation .. .. .	19
Effect of Intensive Feeding on Carcass Traits .. .. .	21
MATERIALS AND METHODS .. .. .	24
Location .. .. .	24
Animals Housing and Health .. .. .	24
Experiment 1 .. .. .	25
Experimental Design and Treatment .. .. .	25
Feeds .. .. .	26

Feeding and Adjustment Period .. .. .	26
Digestibility Studies .. .. .	27
Statistical Analysis .. .. .	27
Experiment 2 .. .. .	29
Experimental Design and Treatment .. .. .	29
Feeds .. .. .	29
Feeding and Adjustment Period .. .. .	30
Digestibility Studies .. .. .	30
Statistical Analysis .. .. .	30
Carcass Evaluation .. .. .	30
RESULTS .. .. .	33
Chemical Composition .. .. .	33
Experiment 1 .. .. .	33
Experiment 2 .. .. .	35
Feed Consumption, Growth and Feed Efficiency .. .. .	37
Experiment 1 .. .. .	37
Experiment 2 .. .. .	41
Experiment 1 <u>Irs.</u> Experiment 2 .. .. .	48
Health .. .. .	48
<u>In Vivo</u> Digestibility Studies .. .. .	50
Experiment 1 .. .. .	50
Experiment 2 .. .. .	53
Experiment 1 <u>Irs.</u> Experiment 2 .. .. .	54
Carcass Evaluation .. .. .	54

	Page
Feed Costs .. .. .	59
Experiment 1 .. .. .	59
Experiment 2 .. .. .	61
Experiment 1 <u>Vrs.</u> Experiment 2 .. .. .	66
DISCUSSION .. .. .	67
Chemical Composition .. .. .	67
Feed Consumption, Growth and Feed Efficiency .. .. .	69
<u>In Vivo</u> Digestibility Studies .. .. .	73
Carcass Evaluation .. .. .	75
Feed Costs.. .. .	76
CONCLUSION .. .. .	78
LITERATURE CITED .. .. .	80
APPENDIX .. .. .	90

LIST OF TABLES

TABLE	Page
1	77
2	80
3	84
4	86
5	88
6	90
7	94
8	95
9	99
10	51

TABLE		Page
11	Mean Squares of Analysis of Variance for Digestibility coefficients in Experiment 1.	52
12	Apparent Digestion coefficients of Experimental Rations and Digestible Nutrients consumed by Bullocks in Experiment 2.	54
13	Mean Squares of Analysis of Variance for Digestibility coefficients in Experiment 2	55
14	Effect of Experimental Rations on Average shrink Losses and Carcass Traits in Experiment 2.	57
15	Mean Squares of Analysis of Variance for Carcass Traits in Experiment 2.	59
16	Average Consumption of Feed During Experiment 1 and the corresponding Feed Costs.	61 - 62
17	Average Consumption of Feed During Experiment 2 and the corresponding Feed Costs.	64 - 65

LIST OF FIGURES

FIGURE		PAGE
1	Effect of Roughage on Combined Average Cumulative Weight Gain in Experiment 1.	41
2	Effect of Protein Level of Rations on Combined Average Cumulative Weight Gain in Experiment 1.	43
3	Effect of Roughage - Yellow Corn Combination on Cumulative Weight Gain in Experiment 2.	47

## SUMMARY

Two separate experiments, each lasting 84 days, were carried out on the University of Ghana's Agricultural Research Station, Kpong.

The primary objectives of the study were to:

- (i) Formulate cocoa husk - and sugarcane bagasse - based diets,
- (ii) Assess the acceptability of diets to local beef cattle,
- (iii) Determine the effect of roughage and protein level (if any) on feedlot performance of the animals
- (iv) Find out the extent to which soaking dried sugarcane bagasse overnight in fresh water would improve consumption of bagasse-based rations
- (v) Observe to what extent (if any) the addition of 20 percent yellow corn would improve the Total Digestible Nutrient (TDN) values of cocoa husk - and bagasse-based rations, and
- (vi) Formulate a standard finishing ration for local beef cattle and compare its efficiency with that of cocoa husk - and sugarcane bagasse-based diets.

Parameters examined were:

- (1) Chemical composition of the roughages as well as the experimental diets.
- (2) Feed consumption, growth and feed efficiency.
- (3) Health of the animals during the study.
- (4) In Vivo digestibility studies on the rations.

- (5) Carcass evaluation (in experiment 2) and
- (6) Feed costs.

crossbred

Four N'dama and one Santa Gertrudis crossed West African Shorthorn/ bullocks were randomly selected from 16 N'dama and 4 Santa Gertrudis bullocks and assigned to each of four diets in experiment 1. The diets (A, B, C and D) represented the treatments of a 2 x 2 factorial experimental design. The factors were the major sources of roughage and crude protein levels. Diets A and B contained cocoa husk and diets C and D sugarcane bagasse; whilst diets A and C had about 13 percent crude protein and B and D about 17 per cent. The levels of roughages in the diets were: A, 60.4; B, 47.5; C, 55.4 and D, 46.3 percent.

During experiment 2 twenty N'dama bullocks were randomly allotted into 4 treatments groups with 5 animals in each group. The treatments were the four diets - A, B, C and D; all of which had a crude protein level of about 17 percent. The major sources of roughages were: diet A, 50 percent cocoa husk; diet B, 30 percent cocoa husk and 20 percent sugarcane bagasse; diet C, 48.1 percent bagasse and diet D (standard), 20 percent Panicum maximum hay.

The feed for the animals in each treatment in both experiments consisted of a major roughage source, a Protein - Energy - Vitamin - Mineral Supplement (PEVMS), urea and molasses. Water and mineral licks were supplied to the bullocks ad libitum.

The results of the study indicated that:

- (1) Both cocoa husk - and sugarcane bagasse-based rations were

acceptable to local beef cattle without any detrimental physical or physiological manifestations resulting from the rations. The average daily dry matter consumed in experiment 1 was 4.80, 4.04, 2.74 and 2.67kg for rations A, B, C and D respectively; while that in experiment 2 was 6.17, 4.44, and 2.51 for rations A, B and C respectively.

(2) The type of roughage significantly ( $P < 0.01$ ) influenced dry matter consumption and hence feedlot performance of the bullocks. The cocoa husk-based rations were more consumed, effected more weight gain and were more efficiently utilized than the sugarcane bagasse-based diets.

(3) The level of protein in the rations did not have significant effect on the feedlot performance; indicating that the nitrogen requirement of the animals was met by the rations.

(4) Incorporation of 20-percent yellow corn significantly ( $P < 0.01$ ) improved the TDN value of the cocoa husk-based rations and hence the feedlot performance of the bullocks.

(5) The combined effect of soaking the bagasse in fresh water overnight and addition of 20 percent yellow corn did not enhance dry matter consumption. The treatment, however, improved the daily live-weight gains of the animals and thus indicated better efficiency of feed utilization.

(6) The standard finishing ration formulated from 50 percent yellow corn, 20 percent hay, 8 percent molasses, 10 percent wheatbran, 0.8 percent urea and 11.2 percent supplement was the most efficient in terms

of weight gain, feed conversion, fat formation and feed cost. The other rations were also commendable in terms of weight gain, feed conversion, fat formation and feed cost. The average figures for rations A, B, C and D were: Daily liveweight gain, 0.38, 0.33, 0.12 and 0.68kg; Feed conversion, 16.38, 13.39, 20.53 and 7.97; percent kidney fat, 1.94, 2.03, 1.44 and 3.29 and Feed cost per kg. weight gain, 5.61, 4.69, 7.81 and 3.08 cedis.

It is anticipated that with the recommended means of improvement such as grinding of sugarcane bagasse and addition of pure starch to cocoa husk-based diets, rations containing cocoa husk and sugarcane bagasse could serve as feedlot finishing rations for local cattle.

## INTRODUCTION

World demand for beef is increasing more rapidly than supply which grew at only 2.3 percent a year in the decade 1963-72. Ghana Veterinary Services Department (1975) put the national increase in beef supply as 18.6 percent as against the 24.7 percent increase in demand for beef cattle between 1969 and 1974.

Associated with the growing world shortage, the progressive increase in market prices are offering better opportunities to public and private investors to embark on more improved methods of beef production. Beef cattle production in Ghana, however, has for far too long, relied solely on natural pastures. For multiple reasons these pastures are nutritiously poor and unproductive for a considerable part of the year and available only in limited quantities. There has therefore been an alternating seasonal gain and loss pattern of growth with overwhelming evidence of undernutrition and malnutrition in the animals.

improved

It is generally believed that / management of existing rangelands would lead to increased production of fodder and meat. But it must be recognised that this is a long term approach under prevailing socio-ecological conditions. Furthermore, the improvement of the efficiency of existing rangelands is likely to cause a decrease in the present livestock populations. The introduction of a large scale industrial system involving feedlot technique has a greater potential to yield good quality beef cattle which would reach market weight in

a shorter time.

Millions of tons of lignocellulosic materials go to waste every year as unavoidable by-products around industrial sites such as sugar-mills, cocoa industries and sawmills. The Cocoa Research Institute of Ghana has estimated that Ghana produces about 1 million tons of dry cocoa husk annually most of which is left to rot. These fibrous materials have low nitrogen content, low digestibility for livestock and consequently low animal production potential. They could, however, be made to contribute significantly to increased animal production by simple inexpensive treatments which will increase lignocellulose breakdown. The effective use of these materials by livestock will offer the potential to convert waste products to animal protein. It will also assist in the partial alleviation of disposal and pollution problems associated with the waste products.

Studies on cocoa husk-based rations have indicated the husk as an alternative cheap source of energy for cattle during the dry season. Similarly dried sugarcane bagasse has been found to be a fibre source for lactating cows.

There is need for further studies on the utilization of lignocellulosic by-products by local cattle. The results from such studies could be extended to feedlot system in the country.

This study was to: (a) formulate cocoa husk - and sugarcane bagasse-based diets, (b) assess the acceptability of the diets to local beef cattle, (c) determine the effect of roughage and protein level (if any) on feedlot performance of the animals, (d) find out the extent

to which soaking dried sugarcane bagasse overnight in fresh water would improve consumption of bagasse-based rations, (e) observe to what extent (if any) the addition of 20 percent yellow corn would improve the Total Digestible Nutrient (TDN) values of cocoa husk- and bagasse-based rations, and (f) formulate a standard finishing diet for local beef cattle and compare its efficiency with that of cocoa husk- and sugarcane bagasse-based diets.

LITERATURE REVIEW

Cattle Feedlot Finishing

The finishing of cattle implies the laying on of fat. According to Ensminger (1970), and Morrison (1973), the ultimate aim of the finishing process is to produce meat of improved flavour, juiciness, tenderness and quality which result from "marbling".

Between 1930 and 1967, cattle finishing expanded from 3 million to 11.3 million head in the U.S.A. (Ensminger, 1970). The quality beef was achieved through the feeding of high energy rations to young animals (6 - 30 months old). In developing countries, however, with the exception of Southern Brazil, North-East Mexico, Cuba and Kenya, the bulk of beef production still comes from extensive system (Auriol, 1974). In the traditional system of beef production (natural pastures without any feed supplementation and using unimproved Boran breeds) animals are, according to the writer, slaughtered at 6-7 years of age at 400kg. In a slightly improved system (unimproved breeds under slightly improved management) with feedlot feeding for 150 days, 400kg. is achieved at 36 months; while in the more improved system (improved breeding (Hereford x Boran) and management, based on improved pasture in the first year) with feedlot feeding for 150 days, animals are slaughtered at 30 months weighing 435kg.

Unpublished data at the Department of Animal Science, Legon, indicate that beef cattle (N'dama) raised under extensive systems on the University of Ghana's Research Station at Legon are slaughtered

on the average at 76 months with an average weight of 248kg.

Fattening of young cattle has developed into an important industry in Yugoslavia. According to Bacvanski, Cobic and Vucetic (1973) most Yugoslave cattle are raised on small private farms, while fattening is carried out mainly in large scale co-operatively owned units. These units buy large numbers of calves weighing 80 - 220kgs. from the rearing areas and fatten them up to 420-450kg (male) and 400kg (female).

Squire and Creek (1973) reported of a viable example of a feedlot project in Kenya known as custom feeding of cattle. According to Squire (1976), though the basic price ratio of live weight beef to grain was 4 : 1, while the conversion ratio of grain to liveweight beef was, at least, 8 : 1, after 6 years of operation an average of \$16.6 profit per steer for 87 days was obtained. Thus an owner of 300 steers made \$5,000 in 87 days.

Wyatt, Lusby, Gould, Watters, Whiteman, and Totusek (1977) have determined the effect of breed of dam on post-weaning feedlot performance of steers and heifer calves from Hereford, Hereford x Holstein and Holstein cows. The ration composition for the individually fed steers was: whole corn, 87.0%; cotton seed hulls, 5.0% and supplement, 8.0%. The constituents of the supplement were: soybean meal, urea, cotton-seed meal, wheat middlings, NaCl, KCl, CaCO<sub>3</sub>, trace minerals and vitamin A. As percentage of Holstein blood increased, daily feed intake and feed consumed per kg. liveweight gain increased. The Holstein progeny, crossbred and Hereford progeny consumed 9.1, 8.2 and 8.1 kg of feed daily. Feed required per kg. gain was 9.04, 8.26 and 6.86kg in the same order.

Ababio (1966) and Owusu-Domfeh and Antwi (1972) have carried out feedlot studies in Ghana. Ababio investigated the performance of three indigenous cattle (N'dama, West African Shorthorn (W.A.S.) and Sanga) on rations of corn and cob, groundnut cake and molasses supplemented with corn silage and millet hay. The investigation lasted six months. He observed significant differences in the rate of gain as well as the feed efficiency among the breeds. The Sanga was the best gainer and most efficient user of feed. The N'dama and the W.A.S. appeared similar in both traits. The average daily gain for N'dama, W.A.S. and Sanga was 0.38, 0.45 and 0.62kg. respectively while the average feed for kg. gain was 32.1, 27.7 and 19.6kg. in the same order.

Owusu-Domfeh and Antwi (1972) evaluated the performance of mature trade Zebu cattle finished on wheatbran and sugarcane bagasse. Based on the high cost of the animals, and their poor health which resulted in their inability to gain weight, the workers reported that it was uneconomical to fatten trade cattle before slaughter. The trial was, however, not repeated with healthy animals and it is doubtful if a ration of only wheatbran and bagasse could furnish the required TMR for fattening.

#### Nutrient Requirement of Finishing Beef Cattle

Dry Matter and Total Digestible Nutrients: The National Research Council (NRC) feeding standards (1970) reported that finishing beef cattle consumed feed equal to 2.5% to 3.0% of their liveweight. Older cattle consumed less feed per unit body weight than younger animals. In absolute

figures Morrison (1973) put the daily dry matter required by an 182kg. growing beef cattle as 4.2 to 5.2kg, and 4.86 to 5.91kg for a 227kg beef cattle fed for rapid growth; while NRC (1970) put it at 5.6kg for a 200kg small breed beef cattle gaining an average of 0.7kg a day.

Lack of sufficient TDN could be a common deficiency in beef cattle fattening. According to Morrison (1973) the first requirement for fattening animals is an abundance of TDN or net energy (NE). Unless a large surplus of the nutrients was left after the maintenance requirements of the body had been met, the rapid formation of fatty tissue was impossible. The NRC (1970) suggested a TDN of 58% or 3.2kg as a daily minimum TDN required by a 200kg fattening beef cattle, while Morrison (1973) recommended a range of 3.27 to 3.8kg for a 227 beef cattle.

### Protein

The quality of protein or balance of essential amino acids, is not a critical factor in beef cattle finishing ration because bacteria in the rumen "manufacture" proteins of high quality that are used by cattle. For this reason, it makes little difference to a bullock whether its protein comes from one source or several. Yet according to Ensminger (1970), a mixture of different protein sources could be more palatable than a single source. Ensminger (1970) further suggested that the percent protein supplement to add to a ration depended on the age of the animal, the kind an amount of roughage and the protein content of the carbonaceous concentrate being fed. He nevertheless recommended a crude protein level

of 10.0 to 11.5% (on DM basis) in the ration. For a finishing beef cattle Kay, Bowers and McKiddie, (1968) had found that a diet containing 11.0% crude protein and supplying 205g digestible crude protein (DCP) reduced liveweight of cattle by 14% compared with that containing 16.8% C.P. and supplying 315g DCP per day. Morrison (1973) and NRC (1970) respectively put the daily DCP required by a 227 and a 200kg finishing cattle as 393g and 330g.

### Roughage

Cattle require some amount of roughage in their ration. Experiments have established that concentrate to roughage ratios falling between 30 : 70 and 70 : 30 are satisfactory in promoting liveweight gains in fattening cattle.

The feeding of all-concentrate diets resulted in fluctuations in feed intake and caused in-appetance (Kay, 1969). McDonald, Edwards and Greenhalgh (1973) observed that acid production could be unusually rapid and saliva secretion low in animals given predominantly concentrate diets. In such cases the pH of the rumen could be as low as 4.5. There could also be increased incidence of digestive disturbances such as bloat, gastric impaction and increased occurrence of rumen papillae degeneration.

It is generally accepted that roughages should be fed dry. They could be either in big or long form, or chopped or cracked form. Ensminger (1970) recommended the chopped or cracked form and argued that such could be stored in a smaller area, was easier to handle, had higher dry matter digestibility and could therefore promote better weight gains. He, however,

cautioned against the grinding of roughages. McDonald, et al (1973) also reported that ground roughages passed through the rumen faster than the chopped materials and their fibrous components were less completely fermented. The grinding of roughages, according to the writers, reduced the digestibility of the crude fibre as much as 20% and that of the dry matter as a whole by 5 - 15%. They, however, reported that grinding increased the acceptability of roughages to ruminants.

#### Utilization of Lignocellulose by Ruminants.

The search for feed sources that do not provide direct competition between livestock and man as it is with most concentrates has resulted in the extensive use of many lignocellulosic materials as feed ingredients for livestock. Examples of materials used are newsprint, bagasse, wood and sawmill residues, cocoa husk and cereal straws.

Chemical Composition: Investigators have for a time now employed Chemical analysis to assess the feed value of woody by-products. Beckman (1915) analysed several different woods for nitrogen, fat, starch and ash. He found their value to be much lower than those obtained for straw.

Kitts and Krishnamurti (1970) reported that wood and wood residues contained 70-85% carbohydrates, 15-30% lignin, 1-2% crude protein and 0.2 - 0.4% ash. Pigden and Bender (1972), on the other hand put the combined cellulose/hemicellulose content of grasses, straw, hardwoods

and bagasse between 60 and 75%. They found the lignin level to be between 5 and 25%.

From nutritional point of view Pigden and Bender (1972) grouped lignocellulose into 3 fractions; viz:

- (a) The lignin which is essentially unavailable to the rumen microbes.
- (b) The digestible energy (DE) fraction which is readily available, and
- (c) The potentially digestible energy (PDE) fraction which is very resistant to bacterial attack but which could be made available by special processing like grinding, alkali treatment, steaming and N supplementation.

#### Physical and Chemical Procedures Used to Increase Cellulose Availability to Rumen Microbes.

Herbivores are unable to utilise fully the carbohydrate portion of wood, straw and other lignocellulosic materials. Various methods have been used to study the effect of treating these materials to increase their digestibility. Procedures which include alkali treatment (Huffman, Kitts and Krishnamurti, 1971; Randel, 1972; Carrero, Valencia, Ramirez and Randel, 1972), alternate treatment with alkali and acid (McDonald et al., 1973); urea supplementation (Randel, 1970); ensiling (Donerfer, 1976); and gamma irradiation (Pritchard, Pigden and Minson, 1962; Kitts, Krishnamurti, Shelford and Huffman 1969; Huffman, Kitts and Krishnamurti, 1971) have been employed in the study.

Rendel (1972) compared the digestibility of rations containing raw sugarcane bagasse and 2-percent NaOH solution - treated bagasse. The mean apparent digestion coefficients in the treated bagasse - and raw bagasse-rations respectively were: DM, 68.6 and 55.7; OM, 76.1 and 62.0; CP, 79.6 and 71.0; EE, 86.4 and 83.0; CF, 67.0 and 57.5, NFE, 77.6 and 64.6; TDN, 67.4 and 55.8; and Calories 74.0 and 58.9/ percent. Excluding EE, all of the mean differences between the rations were statistically significant.

According to McDonald, et al, (1973) spraying straw with a small volume of concentrated alkali and neutralising the excess with acetic or propionic acid increased the dry matter digestibility of straw from 40% to 60 - 70%.

Sugar-fith (a term referring to fresh sugarcane stalk without the outer rind) is readily fermentable. Donefer (1975) reported of a trial in which the feeding value of ensiled and fresh sugar-fith was compared. Ensiling resulted in substantial decreases in intake and liveweight gains by cattle. These were largely reversed with molasses supplementation.

Kitts, et al (1969) subjected helmlock sawdust to gamma irradiation up to a maximum of  $1.46 \times 10^8$  rads and used it as a substrate for in vitro rumen fermentation tests. They observed that the percent dry matter disappearance and cellulose digestibility showed a steady increase with increasing irradiation levels. In a similar study, Huffman, et al (1971) investigated the chemical composition and in vitro rumen digestibility of alder, fir, poplar and sludge after gamma irradiation. Remarkable increase in the digestibility of the woody materials in response to increasing irradiation dosages of  $1 \times 10^7$ ,  $1 \times 10^8$  and  $2 \times 10^8$  rads was reported.

### Studies on Cocoa Husk

The exploitation of cocoa husk as animal feed is currently being studied in all the major cocoa-producing countries. Various workers have analysed the fibrous material for its proximate chemical composition. The percent nutrient composition observed by Kenten (1964), Acquaye (1966), Bateman and Fresnillo (1967), Oyenuga (1968) and Ankrah (1974) for the husk were: CP, 5.70 - 10.70; EE, 1.10 - 1.65; CF, 33.19 - 42.00; NFE, 44.20 - 51.27; Ash, 8.83 - 13.43. The ash of the husk contains high levels caustic substances. Dittmar (1958) and Ankrah (1974) reported that potash forms 30 - 40% of the ash. This is the basis for soap manufacturing.

Doamekpor (1977) analysed two batches of cocoa husk; one fairly fermented and the other fresh. He observed that fermentation remarkably lowered the CP, EE and NFE components of the husk while it resulted in increased crude fibre content. He attributed the observations to possible loss of the rich and soluble neutral and acidic polysacchrides during fermentation. This confirmed an earlier observation by Ademosum and Kolade (1973).

Alongside the proximate chemical analysis cocoa husk-based rations have been used in feeding trials with both ruminants and non-ruminants.

Alba and Basadre (1952) fed a cocoa pod-based ration to fattening pigs. Other ingredients of the ration were corn, sesame oil meal, fish meal and ripe bananas. They reported that cocoa pod meal offered good possibilities as forage for pig fattening.

The effect of cocoa husk meal on milk yield was investigated by Alba Garcia, Cano and Ulloa (1954). Two diets (one containing 50% cocoa

husk and the other 50% cassava) were fed. No significant difference was observed in the total milk yield of the cows. Haines and Echevaria (1955) obtained the following milk yields for a similar trial over a 28-day period using 12 cows: 2,462.0kg. for pod meal, 2,295.8 for corn and 2,244.3kg. for cassava meal. It was concluded that cocoa pod meal was 97% as efficient as corn meal.

Doamekpor (1977) fed diets containing 3 levels of cocoa husk (45, 60 and 75%) to sheep which indicated that maintenance rations could be formulated with dried cocoa husk if the level in the ration did not exceed 60%. The average daily liveweight gains were 7.4g, 8.9g and -300g, respectively.

Increasing levels of cocoa husk have been noticed to reduce dry-matter, crude protein and energy digestibility of rations (Adeyanju, Ilori, Ogutuga and Adegbola, 1975; Pessey, 1976; Doamekpor 1977). Kertesz (1951) explained that the lower digestibilities could be due to high mucilaginous pectic substances as well as the high proportion of lignocellulosic polysaccharides present in the husk. These according to him do not support rumen bacterial growth and hence could cause low digestibility. Bateman and Fresnillo (1967) observed that the reduced digestibility was compensated for by the high palatability of the cocoa husk-based diets. According to Bateman and Laragan (1966) cattle on fattening trials consumed enough of rations containing 40 and 60% cocoa pod meal to make liveweight gains comparable to gains in control animals on corn rations.

Theobromine, a toxic principle in cocoa germ, expeller cake, shell and husk, has been incriminated as the major limiting factor to the extensive

use of the materials by livestock. According to Oyenuga (1966), the methylated derivative of Xathine (3, 7 - dimethyl-Xanthine) is feebly basic and bitter.

Workers like Dittmar (1958), Greenwood-Barton (1964), Owusu-Domfeh (1972) and Adegbola and Omole (1973), have reported the alkaloid to be highest in the germ (3.0%), followed by the cake (2.5%), the Shell (1.0%) and the husk (0.2%). Knapp and Churchill (1937) had shown that theobromine was mostly confined to the nib in the fresh, unfermented beans, with very little in the shells. They argued that the significant amount of theobromine found in the shells (1 - 1.5 percent ) appeared to diffuse from the nib to the surrounding shells during the process of fermentation. Since actual fermentation takes place (after the removal of the beans) from the pod, the writers expected the cocoa husk to be relatively free from the alkaloid.

Theobromine poisoning has been reported in both ruminants and non-ruminants but the former have exhibited greater tolerance (Weiniger, Funk, and Gresse, 1956). Greenwood-Barton (1956) and Owusu-Domfe (1972) observed deaths in pigs, poultry and horses when theobromine intake was above 0.025g and 0.027 g/kg body weight respectively. One kg of shell meal per animal per day had earlier been suggested by Knapp and Churchill (1937) as an optimum quantity for cows (i.e. an optimum non-toxic level of about 0.036 g/kg body weight).

#### Feeding trials with Sugarcane Bagasse

Sugarcane bagasse as a possible livestock feedstuff has also been

a subject of interest in cane growing countries. Kirk, et al (1962) reviewed a number of reports, most of which indicated that bagasse was inferior to other common roughages in beef cattle rations. However, in a series of experiments extending over 7 years, the above investigators obtained satisfactory results with several bagasse-based rations.

During a 17-week feeding period, Beams (1961), tested bagomolasses, (a mixture of 30% bagasses and 70% molasses) in rations for 2-year old Hereford steers. Two rations which contained 70% bagomolasses (Equivalent to 21% bagasses and 49% molasses) and 13.5 or 9.4% crude protein resulted in average daily gains of 0.6kg and 0.7kg respectively. Another ration containing 50% bagomolasses proved superior, yielding an average daily gain of 1.0kg.

Randel (1970) fed sixteen Holstein-Friesian and Brown Swiss male calves on 4 mixtures containing finely ground sugarcane bagasse and concentrates. The calves weighed 73.7 to 154.1kg. at start of experiment and 454.3kg. at slaughter. The diets had two levels of bagasse (20 and 30%) and two levels of crude protein (12.5 and 16.0%). He observed that all the 4 formulae gave excellent and comparable results in growth response and carcass yield. The higher level of protein was not significantly beneficial, nor the higher level of bagasse significantly detrimental. The following were the respective average responses observed on diets A (low bagasse - low protein), B (low bagasse - high protein), C (high bagasse - low protein) and D (high bagasse - high protein): daily liveweight gain, 1.12, 1.19, 1.15 and 1.06kg; daily feed consumption,

8.77, 8.64, 9.32 and 8.95kg; and feed consumed per kg. of gain, 7.84, 7.28, 8.07 and 8.45kg.

Donefer (1976) reported trials in Barbados in which Holstein male calves were raised from initial liveweight of 120kg. on the average to an average slaughter weight of 430kg. The eighty calves were fed on daily prepared fresh sugar-fith given in combination with cane tops in a 70 : 30 ratio. On dry matter basis the fith constituted about 80% of the ration. From two trials with the sugar-fith/cane tops rations the average daily gains were 0.7 to 1.0kg. When additional sources of energy were supplied (molasses or maize grain), 10 - 30% increase in rate of gain was observed. It was suggested that the higher increase observed with maize was possibly due to the presence of more slowly digested starch.

Morrison (1973) have determined the percent chemical composition of dried sugarcane bagasse. The values for CP, <sup>CF</sup>EE, NFE and Ash were 1.2, 0.4, 46.7, 41.0 and 2.5 respectively.

Owusu-Domfeh and Antwi (1972) explored the possibility of feeding sugarcane bagasse to livestock when they attempted fattening mature cattle on bagasse-based rations. The rations which contained only bagasse and wheat bran could not provide the animals with the requisite TDN or N.E. It was therefore not surprising that the workers obtained negative results.

It would appear that not much work has been done in Ghana on the use of bagasse in livestock feed. More studies therefore need to be conducted to elucidate the feeding value of the material.

### Regulation of Feed Intake

Factors which influence feed intake by ruminants are many. Two major ones have received considerable study in the past three decades. These are: (i) Animal factors and (ii) Forage factors.

The animal factors studied include liveweight and age. Raymond (1948), working with sheep observed that the daily dry matter intake increased steadily as the sheep increased in body weight. Langlands (1968) found no significant relationship between dry matter consumption and liveweight. He, however, noted that the forage intake of two flocks of Merino wethers increased with age up to 41 months and then declined. The relationship observed by Conrad, Pratt and Hibbs (1964) was among digestibility of the feed, voluntary feed intake and liveweight. They observed that when digestibility of a diet was lower than 65% (on DM basis), voluntary intake was proportional to liveweight (i.e.  $W^{1.0}$ ); whereas with diets of higher digestibility it tended to be more closely proportional to metabolic liveweight (i.e.  $W^{0.75}$ ).

The forage factors, according to Jones (1971) include those physical factors which regulate the rate of passage through the gastro-intestinal tract and physiological factors. Examples of the latter factors are digestibility and chemical composition, which relate more to metabolic regulation.

Blaxter, Wainman and Wilson (1961) fed hay of poor, medium and good quality to mature wethers and found that dry matter intake per kg bodyweight and digestibility increased with feed quality. Intake was greater when hay of good quality (74% D.E.) was compared to that of

medium quality (59% D.E.).

In an experiment to investigate factors limiting feed intake Crampton (1957) fed dry forages to ewes. He concluded that voluntary intake was limited primarily by rate of cellulose and hemicellulose digestion which depended upon both the extent of lignification in the forages and the nitrogen available to the rumen microbes.

Maximum feed intake and milk yield by daily cows resulted when their diets contained approximately 16% crude fibre (Spahr, Branding, Kesler and Cloninger, 1966). At a higher level (19%) energy intake was depressed and cows failed to maintain body weight. Weight was, however, gained at a lower C.F. level (15%). The optimal 16% CF levels corresponded to a ration containing 45 to 55% concentrates.

Strozinski and Chandler (1971) have also studied the relationship between fibre content of the diet and feed intake in young calves. Crude fibre levels of the four test diets were 9.7, 16.0, 18.8 and 23.4% with their corresponding lignin levels as, 3.0, 4.0, 5.1 and 6.2%. Feed intake increased with increased fibre levels, reaching a plateau at 18.8% C.F. A quadratic equation showed that digestible dry matter intake declined when ration exceeded 12.1% fibre.

Cowsert and Montgomery (1969) in a study, on the other hand, observed that as the concentrate portion of the ration increased (0.33 and 67%) feed intake declined; digestibility, however, improved while energy intake was maintained at a constant level. Donefer, Lloyd and Crampton (1963) had suggested the possible role of pH as a

part of physiological control in this observation. Cowser and Montgomery (1969) reported a decrease in rumen pH from 7.1 to 5.4 when the proportion of concentrate in the ration increased.

There is considerable evidence to show that in ruminants, intake of low protein rations results in reduced feed intake. Moir and Harris (1962) fed a purified diet varying in nitrogen content to wether lambs. Dry matter intakes were reduced at the low CP level (6.2%). In a later work Weston (1971) fed 3 rations containing 11.7%, 15.8% and 19.1% Crude Protein respectively to wether lambs. The dry matter intake was lowest with the diet containing the 11.7% C.P. There was no significant difference between the 15.8% and 19.1% rations. Campling (1970) explained that the low N content of digesta could be a major factor limiting ruminal fermentation and hence the rate of passage of digesta.

#### Urea-Molasses Supplementator

Urea and molasses have been used by many workers either separately or together as supplements to improve the quality of roughages to ruminants.

Beams (1963) examined the possible use of urea in the drought feeding of cattle and observed that animals which could not survive on low quality roughages (3.5% C.P.) survived on urea-treated rations.

Winks and Leing (1972) and Amaning-Kwarteng (1974) also supplemented urea to cattle and reported that the animals fed urea-molasses supplements gained weight during the feeding period and performed

significantly better than the control during the dry season.

Because of the widely observed urea toxicity, the amount of urea to feed for optimum efficiency has been the concern of many. Studies by McNaught and Smith (1942), Coombe and Tribe (1963), Tillman and Swift (1953) and Oltjen (1965) have shown that the marginal advantage of urea diminished after certain levels and became negative and thereafter, a disadvantage. Humphrey (1950) advised that cattle should not be fed more than 113.5 per head per day. Although Meiske, Van Arsdell, Leucke and Moefler (1955) had fed a diet containing 3 percent urea and had obtained no harmful effects, Ensminger (1970) and Morrison (1973) suggested that the amount of urea to feed should not exceed 2 to 3 percent by weight of the ration.

The improved efficiency of urea utilization when fed together with readily available carbohydrate sources such as molasses and corn have been attributed to the contribution of the carbohydrates as readily available sources of energy to the rumen microbes (McNaught and Smith, 1942; McDonald, 1952).

The usefulness of molasses as an energy source for ruminants, according to Johnson, Hamilton, Mitchell and Robinson (1942) was, however, limited by the fact that its net energy (NE) for productive purposes decreased as the quantity fed increased beyond a certain maximum. Lefgreen and Otagaki (1960) in a study to determine the NE value of molasses for fattening beef steers observed that when fed at a level of 10% in the ration, molasses was efficiently utilized while increasing the level to 25% and 40% caused a marked depression in feed

consumption, weight and energy gains of the steers.

In a similar experiment with beef heifers, Lofgreen (1965) again observed that animals receiving levels of molasses at 5, 10 and 15% of the ration performed well while those receiving 20% required more feed when adjusted to equal energy gain.

#### Effect of Intensive Feeding on Carcass Traits

Carcass traits have been extensively used in in vivo feeding trials to evaluate the effect of experimental rations on animals.

Muriol (1974) reported that intensive feeding permitted a considerable increase in dressing percentage which rose from 45 to 55 or 66% in some cases. Expressed in feed units, the energy requirements for producing 1kg. of carcass were 39, 15 and 13 feed units for extensive, semi-intensive and intensive feeding of cattle. Animals on intensive feeding were stall-fed on feedlot rations while those on extensive system grazed all day. For the semi-intensive system, animals grazed till noon and returned to shed for supplements. Comparing the efficiency of feed conversion by animals on intensive and extensive feeding, it was concluded that intensive system of feeding of cattle could increase efficiency of meat production three fold.

In a 2 x 2 factorial experiment, Bandel (1970) investigated the effect of 4 rations (A, B, C and D) on average shrink losses and other carcass traits of male calves. Diets A and B contained 20% bagasse and C and D 30% while diets A and C had about 12.5% crude protein and

B and D 16%. During the 24 hour pre-slaughter feed withdrawal period the animals on rations A, B, C and D lost 3.10, 3.35, 5.13 and 5.09% of their final fed liveweights respectively. A combined average of rations A and B versus C and D showed that the animals on rations with higher percentage of bagasse had greater shrink loss. Average warm carcass weights ranged from 230.00 to 241.36kg. among the 4 groups. Upon chilling the carcasses of the animals fed diets A through D lost an average of 1.32, 1.33, 1.98 and 1.55 percent of their initial weights respectively. The loss was greater for diets C + D than A + B. The chilled carcass dressing percentages were 54.3, 54.8, 52.6 and 53.4. The advantage in dressing percentage in favour of the diets of lower bagasse content was not significant.

Kitts, et al (1969) fed non-processed raw and ground wood at different levels to beef cattle. They reported no significant difference in the dressing percentages of the animals. The values were 55.1, 56.5, 57.7 and 59.2% for the rations containing 35%, 27.2, 13.0 and 0.0% sawdust respectively. The trend observed here was similar to that reported by Randel (1970) in which animals on lower bagasse content also had higher dressing percentages.

In comparative studies with N'dama, West African Shorthorn (WAS) and Sanga cattle, Ababio (1969) observed that the degree of muscling as measured by the rib eye area (REA) at the 10th rib showed no significant difference/<sup>among</sup> the breeds. The average REA. values were 72.24, 61.92 and 53.54 sq.cm. for N'dama, WAS and Sanga respectively. The average dressing percentages based on 5 animals each were 53.2, 50.0

and 49.4 in the same order. The results showed apparent correlation between dressing percentage and the degree of mmscling.

Awuma (1976) reviewed the slaughter characteristics of local breeds and their exotic crossbreeds. The data used for the study were the records kept on all cattle slaughtered on the University of Ghana's Agricultural Research Station (A.R.S.), Legon between 1960 and 1975. The results indicated that under the extensive system of management the crossbreeds did not perform any better than the local purebreds by way of liveweight, carcass weight and dressing percentage. Among the local purebreds, however, the WAS showed significantly heavier liveweight at slaughter and better carcass weight. These observations were presumably due to age differences. The WAS were slaughtered at an average age of 114 months as opposed to 76 months for N'dama. A linear relationship was established between carcass weight and liveweight. This tallied with the findings of Willis and Preston (1968).

## MATERIALS AND METHODS

### Location

The experiments were conducted on the University of Ghana's Agricultural Research Station at Kpong on the North-East Accra Plains. The grid reference of Kpong is  $0^{\circ} 04' \text{N}$ ;  $06^{\circ} 07' \text{E}$ . It has a vegetation of open medium grassland with scattered coppice shoots. The area experiences a two-peak rainfall regime with an average total annual rainfall of 118cm (Anonymous, 1973). The major rains occur between March and July and the minor from September to November; the latter season being very uncertain. December through February is usually dry. The average annual relative humidity at 0900 hours, 1500 hours and 2100 hours GMT are 75, 58, and 87 respectively. The average annual maximum and minimum temperatures of the area are  $32.8^{\circ}\text{C}$  and  $22.2^{\circ}\text{C}$  respectively with a mean of  $27.8^{\circ}\text{C}$ . (Baranowski, 1970).

### Animals, Housing and Health

Sixteen N'dama bullocks with an average age of 28.8 months and four Santa Gertrudis crossed West African Shorthorn, averaging 41.0 months were used in the first experiment. The average weights of the N'dama bullocks and the Santa Gertrudis crosses were 228.4 and 259.3kg. respectively. During the second experiment 20 N'dama bullocks with an average age of 36.8 months and an average weight of 206.18kg. were used. All the bullocks had been weaned at an average age of 8 months. They had since then been raised on extensive system till the

time of the experiment.

Housing was in the form of an open shed with corrugated metal roofing and concrete floor, elevated above ground level. The shed was divided by wooden partitions into 20 pens (ten facing the East and the other 10 on the West). Each pen measured 4.3m long and 1.2m wide with roofing at 5.0m high. It accommodated one bullock and was equipped with a watering trough, a manger and a mineral lick rack. The construction of the shed was such that routine operations like cleaning, filling of troughs and manure removal could be done with minimum disturbance to the animals.

Hand spraying against ectoparasites was done each week. The drug used was Asuntol 50. Blood smears were taken every 28 days and examined for bloodborne parasites. Animals infested with Babesia parasites were treated with either Babesan<sup>2</sup> or Ithidium<sup>3</sup>.

#### Experiment 1:

Experimental Design and Treatment: Experiment 1 was to investigate the acceptability of cocoa husk - and sugarcane bagasse-based diets to cattle and to determine the efficacy of different crude protein

- 
1. O,O-Diethyl-O-(3-Chloro-4-methyl-7-coumarinyl)-Phosphorothic acid
  2. Quinuronium sulphate
  3. Homidium Bromide

levels of the diets on finishing beef cattle.

Four N'dama and one Santa Gertrudis <sup>crossbred</sup> West African Shorthorn/ bullocks were randomly selected from 16 N'dama and 4 Santa Gertrudis bullocks and assigned to each of four diets. The diets (A, B, C and D) represented the treatments of a 2 x 2 factorial experimental design. The factors were the major source of roughage and crude protein level. Diets A and B contained cocoa husk and Diets C and D sugarcane bagasse; whilst diets A and C had about 13 percent crude protein and B and D about 17 percent.

Feeds: The feed for the animals in each treatment consisted of a major roughage source, a Protein - Energy - Vitamin - Mineral supplement (PEVMS), urea and molasses. The urea and molasses were dissolved in water and added to the roughage - PEVMS mixture at feeding. The cocoa husk and sugarcane bagasse were both sun-dried and chopped with a cutlass to about 3.0cm pieces. The ingredients of the PEVMS were coarsely ground with a corn mill and mixed with a spade.

Water and mineral licks were supplied to the bullocks ad libitum. Table 1 shows the composition of the experimental diets and the four PEVMS used in trial 1.

Feeding and Adjustment Period: Each day's ration was offered in two equal portions at 8.00 a.m. and 2.00 p.m. animals were confined all day and let out on Mondays and Thursdays for a maximum period of 90 minutes. Weighing and Spraying were respectively done on these days.

A 28-day adjustment period preceded the actual feeding trial. It was to get the animals used to the diets and also to determine the

Table 1: Composition of Experimental Rations and Their Respective Protein - Energy - Vitamin - Mineral Supplements (PEVMS) in Experiment 1.

INGREDIENT	RATION (%)			
	A	B	C	D
Chopped Cocoa Husk	60.4	47.9	-	-
Chopped Sugarcane bagasse	-	-	55.4	46.3
P.E.V.M.S.	29.1	39.1	33.1	39.7
Urea *	0.5	1.0	1.5	2.0
Molasses *	10.0	12.0	10.0	12.0
Estimated Crude Protein	13.2	16.7	13.2	16.7
<u>Composition of PEVMS (Kg/Tonne)</u>				
Wheat bran	688	638	605	579
Groundnut cake	241	307	332	368
Bone Meal	34	26	30	25
Common Salt	34	26	30	25
Vitamin A-D Crumbles	3	3	3	3

\* Added at time of feeding.

maximum feed each could consume with minimum refusal. Chopped grass was initially added to the rations. The level of grass was gradually reduced until a week to the start of the experiment, all the animals were solely on their respective experimental diets. The feeding trial which lasted 84 days spanned between January 18th and April 11th, 1977.

Digestibility Studies: In vivo digestibility studies were carried out three weeks to the end of the feeding trial. Total faecal collection was undertaken for seven successive days. All the 5 bullocks in each treatment were used in the trial. The time of feeding each day and the amount of feed offered remained constant throughout the collection period.

Each day's faeces was bulked separately for each animal. A 500 g sample was then weighed into a metal pan. The faecal samples were dried for 2 days at 60°C and for one additional day at 80°C to constant weight. They were then reweighed for dry matter determination. Samples of the rations and their refusals were dried at 80°C for 2 days. The dried feed, refusals and faecal samples were subjected to proximate analysis according to the procedures of the Association of Official Analytical Chemists (A.O.A.C.), 1970.

Statistical Analysis: Single liveweights of the animals were taken every fortnight. The data pertaining to total live weight gain, dry matter consumption and feed conversion were subjected to analysis of variance for 2 x 2 factorial experiments as described by Steel and Torrie (1960). This was used to test the effects of the major sources of

roughage, the leve of crude protein and their interactions.

## EXPERIMENT 2

### Experimental Design and Treatments:

Experiment 2 was designed to formulate a standard finishing ration for beef cattle and compare its efficacy with that of cocoa husk- and bagasse-based diets. The results of experiment 1 showed a low dry matter consumption of bagasse-based diets. The chopped sun-dried bagasse fed in experiment 2 was therefore soaked overnight in fresh water to study the extent to which soaking would improve the consumption of bagasse-based diets.

Twenty percent yellow corn was also added to the rations fed in experiment 2 to study to what extent the addition of corn would enhance the TDN values of both cocoa husk- and sugarcane bagasse-based diets.

Twenty N'dama bullocks were randomly allotted into four treatment groups with 5 animals in each group. The treatments were the four diets - A, B, C and D; all of which had a crude protein level of approximately 17% (Table 2).

Feeds: The bagasse in diets A and B were, after weighing, soaked overnight in fresh water before mixing with the other ingredients at feeding. The hay was chopped to about 3.0cm pieces. All cocoa beans were picked before compounding the rations.

Twenty percent yellow corn was added to the PEVMS of each of diets A, B and C to improve their TDN values. Diet D, which was to

Table 2: Composition of Experimental Rations and Their Respective Protein - Energy - Vitamin - Mineral Supplements (PEVMS) in Experiment 2

I N G R E D I E N T	R A T I O N (%)			
	A	B	C	D
Chopped Cocoa Husk	50.0	30.0	-	-
Chopped Sugarcane Bagasse	-	20.0	48.1	-
<u>Panicum maximum</u> hay	-	-	-	20.0
P.E.V.M.S.	41.5	40.8	42.1	71.2
Urea*	0.5	1.2	1.8	0.8
Molasses*	8.0	8.0	8.0	8.0
Estimated Crude Protein	16.62	15.65	16.50	16.68
<u>Composition of PEVMS (Kg/Tonne)</u>				
Yellow Corn	482	490	475	702
Wheat bran	241	245	238	141
Groundnut cake	227	213	237	128
Bone Meal	24	25	24	14
Common Salt	24	25	24	14
Vitamin A-D Crumbles	2	2	2	1

\* Added at time of feeding.

be the standard finishing ration, had 50% yellow corn. Water and mineral licks were offered ad libitum. The composition of the experimental diets and their respective PEVMS are shown in Table 4.

Feeding and Adjustment Period: Feeding procedures were as described in trial 1. The actual experiment commenced on 20th September and ended on 13th December, 1977. This period of 84 days followed an adjustment period of 21 days. The animals weighed, on the average, 209.82kg., 210.27kg., 209.36kg. and 210.41kg. for diets A, B, C and D respectively before the start of the adjustment period. However, on the commencement of the feeding trial the average weights in the same order were 207.09kg., 207.09kg., 200.73kg and 210.41kg.

Digestibility Studies and Statistical Analysis: The experimental bullocks were employed to study the digestibility of the four rations used in feeding trial 2. Procedures for the study are as outlined for trial 1.

Techniques employed in the statistical analysis on the data are described by Snedecor and Cochran (1967). Dunnett's test as outlined by Steel and Torrie (1960) was further used to determine if the treatments were better than the standard.

Carcass Evaluation: Three best weight gained-bullocks in each group were slaughtered at the end of trial 2. The effect of the diets on various items of the carcasses were then compared. Feed was withheld

from the animals 24 hours before slaughter.

Standard procedures described by Wellington (1953) were used to cut the carcasses after chilling for 24 hours. Marphey's equation as reported by Wellington (1953) was used to estimate the percent boneless retail cuts from the round, loin, rib and chuck.

$$\begin{aligned} \text{i.e. Percent boneless retail cut} &= 52.56 - 4.95 (\text{fat thickness} \\ &\text{over rib eye muscle (ins)} - 1.06 [\text{Kidney fat (\%)}] + 0.682 \\ &[\text{REA (sq.ins.)}] - 0.008 [\text{Hot carcass weight (lbs)}]. \end{aligned}$$

RESULTS

The results presented herein will be discussed under the following sub-titles: (a) Chemical composition (b) Feed consumption, growth and feed efficiency, (c) Health, (d) In vivo digestibility studies, (e) Carcass evaluation and (f) Feed costs.

For brevity the following symbols will be used where appropriate:

CH	=	Cocoa husk-based ration without corn.
SB	=	Sugarcane bagasse - based ration without corn.
LP	=	Low protein-ration.
HP	=	High protein ration.
CH-LP	=	Cocoa husk-Low protein ration.
SB-LP	=	Sugarcane bagasse-Low protein ration.
CH-HP	=	Cocoa husk - High protein ration.
SB-HP	=	Sugarcane bagasse-High protein ration.
CH-YC	=	Cocoa husk-based ration containing yellow corn.
SB-YC	=	Sugarcane bagasse-based ration containing yellow corn.
CH-SB-YC	=	Cocoa husk-sugarcane bagasse-based ration containing yellow corn.
SD	=	Standard finishing ration.

Chemical Composition

Experiment 1.

Table 3 shows the chemical composition of the dried cocoa husk, dried sugarcane bagasse and the rations fed in experiment 1. The bagasse-based rations had lower dry matter content as compared with the cocoa-husk-based rations. The values for rations A, B, C,

**Table 3:** Chemical Composition of Cocoa Husk<sup>1,2</sup>, Sugarcane bagasse and Experimental Rations in Experiment 1 (Percent Dry Matter).

ITEM (%)	R A T I O N				Dried Cocoa Husk	Dried Sugarcane Bagasse
	A	B	C	D		
Dry Matter	71.12	81.41	63.30	73.33	79.32	85.81
Crude Protein	17.78	25.22	18.31	24.13	15.20	1.86
Ether Extract	5.60	5.45	3.20	3.12	10.01	0.89
Crude Fibre	28.01	19.45	27.89	20.67	34.42	43.61
Ash	13.69	12.58	6.10	6.72	14.40	3.12
Nitrogen-Free Extractives	32.92	37.30	44.50	48.36	25.97	50.73
Gross Energy (Kcal/g)	4.73	4.89	4.91	4.98	5.40	5.72
Calcium	0.91	1.01	0.52	0.44	0.63	0.22
Phosphorus	0.82	0.91	0.69	0.71	0.30	0.12
Theobromine	1.10	0.91	-	-	1.85	-

<sup>1</sup> All components, except dry matter, expressed on DM basis.

<sup>2</sup> Averages of 4 determinations each.

and D were: 71.12, 81.41, 63.30 and 73.33 percent respectively.

Crude protein levels of rations A (CH-LP) and B(CH-HP) were 17.78 and 25.22 percent respectively instead of the 13.20 and 16.70 percent. The sugarcane bagasse-based rations, C (SB-LP) and D(SB-HP) also had crude protein levels of 18.31 and 24.13 percent respectively instead of the estimated levels of 13.20 and 16.70 percent.

Theobromine content of the dried cocoa husk used in experiment 1 was 1.85 percent. Rations A and B, which contained 60 and 48 percent respectively of the husk, had 1.10 and 0.91 percent theobromine in the same order.

#### Experiment 2.

Presented in table 4 are the proximate composition of dried cocoa husk, soaked sugarcane bagasse, Panicum maximum hay, and the rations fed in experiment 2. The soaked sugarcane bagasse had a very low dry matter (17.47 percent). Compared with the dry matter of the dried bagasse used in experiment 1 (table 3) the soaked bagasse imbibed about 80 percent more water. The dry matter of Rations B and C were 48.01 and 27.52 percent respectively. Ration B contained 50 percent of the soaked bagasse while ration C contained 20 percent of it.

Crude protein levels of rations A, B, C and D were 16.86, 16.31, 16.56 and 16.74 percent respectively.

Ash content was highest in the cocoa husk (15.6 percent) followed by the hay (11.4 percent) and the sugarcane bagasse (3.0 percent). The same trend was observed in the cocoa husk-, hay-, and bagasse-based rations. The values for rations A(CH-YC), B(CH-SB-YC), C(SB-YC) and

Table 4: Chemical Composition of Cocoa Husk, Soaked Sugarcane bagasse, Hay and Experimental Rations, in Experiment 2 (Percent Dry Matter).<sup>1,2</sup>

ITEM (%)	R A T I O N				Dried Cocoa Husk	Dried Sugarcane Bagasse	Hay
	A	B	C	D			
Dry Matter	75.64	48.01	27.52	76.91	86.75	17.47	90.56
Crude Protein	16.86	16.91	16.56	16.74	10.64	2.01	5.08
Ether Extract	2.80	2.56	1.96	2.57	2.16	0.98	1.47
Crude Fibre	21.83	27.30	28.37	10.27	43.82	42.74	39.01
Ash	10.06	8.15	4.42	5.65	15.69	3.00	11.14
Nitrogen-Free Extractives	48.45	45.08	48.69	64.74	27.69	51.27	43.30
Gross Energy (Kcal/g)	4.35	4.40	4.08	4.37	3.84	4.56	4.23
Calcium	0.95	0.93	0.50	0.61	0.99	0.16	0.50
Phosphorus	0.71	0.53	0.45	0.66	0.25	0.04	0.20
Theobromine	0.23	0.14	-	-	0.42	-	-

<sup>1</sup> All components, except dry matter, expressed on DM basis.

<sup>2</sup> Averages of 4 determinations each.

D(SD) were 10.06, 8.15, 4.42 and 5.65 percent respectively.

Lower percent theobromine level was obtained for the dried cocoa husk which contained no beans (0.42 percent). The corresponding values for rations A and B were 0.23 and 0.14 percent.

### Feed Consumption, Growth and Feed Efficiency

#### Experiment 1.

A summary of the effect of the various rations on the experimental animals in feeding trial 1 is presented in table 5. The average daily dry matter intakes for groups A, B, C and D during the entire experimental period were 4.80, 4.04, 2.74 and 2.67kg. respectively. The consumption of the cocoa husk-based rations (A + B) per animal per day was significantly higher ( $P < 0.01$ ) than that of the sugarcane bagasse-based rations (C + D). There was, however, no significant difference in the intake between the low protein (A + C) and the high protein (C + D) rations. Analysis of variance did not reveal any significant interaction between roughage and protein level in respect of dry matter consumption (table 6).

Correlations of dry matter intake (I) with liveweight ( $W^{1.0}$ ) and metabolic liveweight ( $W^{0.75}$ ) were determined for animals in each group. The correlation coefficients pertaining to (I) and  $W^{1.0}$  were,  $r = 0.946$ ,  $r = 0.205$ ,  $r = 0.419$ , and  $r = 0.632$  for groups A, B, C and D respectively. The coefficients for A and D were significant at 1 and 5 percent probabilities respectively. Corresponding correlation coefficients between I and  $W^{0.75}$  were,  $r = 0.948$ ,  $r = 0.213$ ,  $r = 0.806$

Table 5: Effect of Experimental Rations on  
Animals in Feeding Trial 1.

I T E M	R A T I O N			
	A	B	C	D
Initial Age of Bullocks (Mo)	30.50	31.90	32.30	32.30
Duration of Trial (Dys)	84	84	84	84
Initial Liveweight (kg)	186.19	183.28	190.72	196.42
Final Lveweight (kg)	201.91	185.60	191.52	194.60
Total Liveweight gain (kg)	15.72	2.32	0.80	-1.62
Daily Liveweight gain (kg)	0.19	0.03	0.01	-0.02
Daily Dry Matter Consumed (kg)	4.80	4.04	2.74	2.67
Feed Efficiency (kg Feed/kg liveweight gain)	25.67	146.28	288.14	-123.25
Daily Feed Consumed per Metabolic Liveweight	0.09	0.08	0.05	0.05

and  $r = 0.625$ . Apart from group B all the coefficients were significant ( $P < 0.01$  for groups A, and C, and  $P < 0.05$  for group D).

Daily liveweight gains averaged 0.19, 0.05, 0.01 and -0.02kg. on rations A, B, C and D respectively during the experimental period of 84 days (table 5). Animals on cocoa husk-based rations (A + B) gained significantly more weight than those fed bagasse-based rations ( $P < 0.01$ ). The combined average daily liveweight gain on A + B was 0.11kg while that on C + D was -0.01kg. Protein level of rations had significant effect of the average daily weight gains with animals on LP gaining more weight than those on HP ( $P < 0.01$ ). The interaction between roughage and protein level was significant ( $P < 0.01$ ).

Figures 1 and 2 show the effects of roughage and protein respectively on the combined average cumulative liveweight gains. Figure 1 clearly shows that the rate of growth of animals on cocoa husk-based rations (A + B) was remarkably higher than that of animals on sugarcane bagasse-based rations (C + D). Similarly, the growth rate of animals on low protein rations (A + C) was higher than that of animals on high protein rations (B + D). This difference is portrayed in Figure 2. The combined average final cumulative weight gains for the various groups, as seen from the two figures, were: A + B, 9.53; C + D, -0.20; A + C, 6.29; and B + D, 0.54kg.

Rations B, C and D were poorly utilized by the experimental animals. Animals on ration D even showed a negative efficiency of feed conversion (table 5). The combined average feed per kg. liveweight gains on rations A + B, C + D; A + C and B + D were 85.98, 82.45; 156.91 and 336kg. respectively. Thus, there was no significant difference in the feed

Table 6: Mean Squares of Analysis of Variance for Performance Traits of Animals in Experiment 1.

Source	d.f.	T R A I T S			
		Daily DM Consumed	Daily Liveweight Gain	Feed Consumed Per Kg. Liveweight Gain	Daily DM Consumed Per Metabolic Liveweight
Roughage (R)	1	14.71 **	0.0638 **	8359.14 ns	0.00518 **
Protein (P)	1	0.87ns	0.0470 **	78924.54 **	0.00015 ns
R X P	1	0.59ns	0.0200 **	335565.59 **	0.00004 ns
Error	16	0.37	0.0005	2753.31	0.00013

\* Indicates significance at  $P < 0.05$

\*\* Indicates significance at  $P < 0.01$

ns Indicates non-significance.



KEY

- - - - ○ Growth rate on Cocoa Husk - based rations (A+B)
- - - - ○ Growth rate on Sugarcane Bagasse - based rations (C+D)

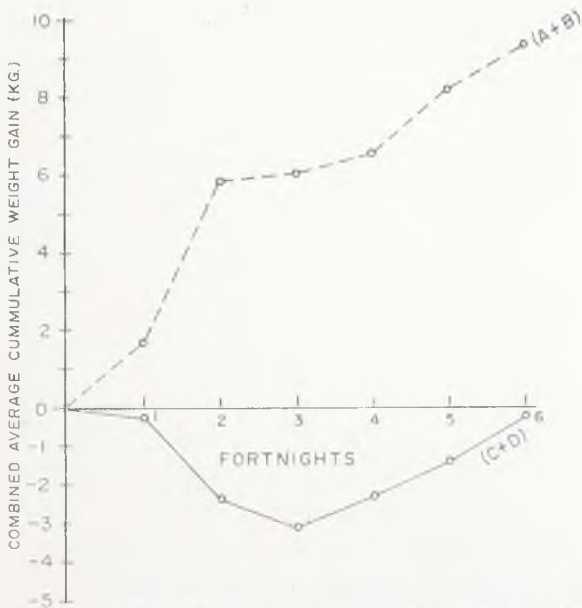


FIG. 1. EFFECT OF ROUGHAGE ON COMBINED AVERAGE CUMMULATIVE WEIGHT GAIN IN EXPERIMENT 1.

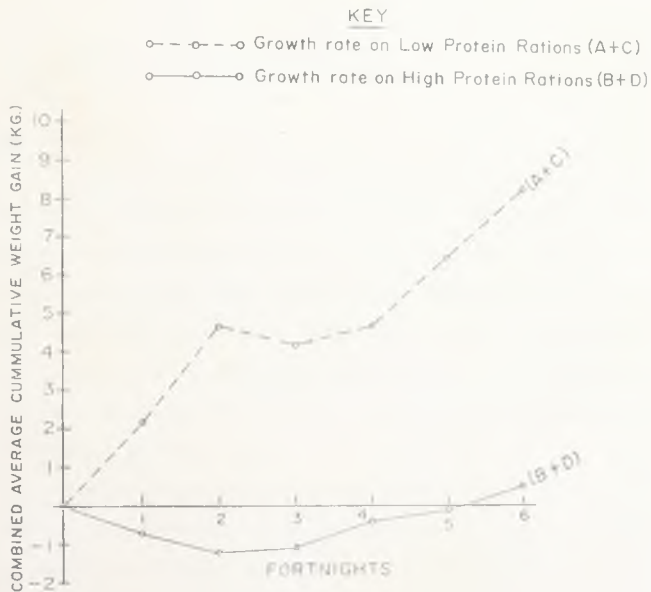


FIG. 2 EFFECT OF PROTEIN LEVEL OF RATION ON COMBINED AVERAGE CUMMULATIVE WEIGHT GAIN IN EXPERIMENT 1.

efficiency between animals on A + B and C + D. Animals on A + C, however, utilized their rations more efficiently than did those on B + D ( $P < 0.01$ ). A converse result was obtained with the daily feed consumed per metabolic liveweight. Whilst there was no significant difference between the daily feed consumed per metabolic liveweight of animals on A + C and B + D, animals on A + B consumed significantly more feed per metabolic liveweight than did those on C + D ( $P < 0.01$ ).

### Experiment 2.

Table 7 indicates the average feed consumption, growth and feed conversion responses of animals to the rations fed in trial 2. Dry matter intake per day averaged 6.17, 4.44, 2.51 and 5.40kg for groups A, B, C and D respectively. Analysis of variance showed treatment differences to be significant ( $P < 0.01$ ). However, a comparison of each treatment mean against the standard, using Dunnett's t-test, did not show the consumption of any test rations to be better than that of the standard finishing ration.

Significant correlations existed between I and  $\bar{W}^{1.0}$  for all the groups. The coefficients of correlation were:  $r = 0.998$ ,  $r = 0.638$ ,  $r = 0.681$  and  $r = 0.927$  for groups A, B, C and D respectively. The coefficients for groups A, C and D were significant at 1 percent while that of group B was significant at 5 - percent probability.

Significant correlations also existed between I and  $\bar{W}^{0.75}$ . The correlation coefficients for the various groups were: A,  $R = 0.996$  ( $P < 0.01$ ); B,  $r = 0.626$  ( $P < 0.05$ ); C,  $r = 0.676$  ( $P < 0.01$ ) and D,  $r = 0.926$  ( $P < 0.01$ ).

Table 7: Effect of Experimental Rations on Animals in Feeding Trial 2.

I T E M	R A T I O N			
	A	B	C	D
Initial Age of Bullocks (Mo)	35.20	38.40	36.20	37.80
Duration of Trial (Dys)	84	84	84	84
Initial Liveweight (kg)	207.09	206.91	200.73	210.00
Final Liveweight (kg)	238.73	234.73	211.00	266.91
Total Liveweight gain (kg)	31.64	27.82	10.27	56.91
Daily Liveweight gain (kg)	0.38	0.33	0.12	0.68
Daily Dry Matter Consumed (kg)	6.17	4.44	2.51	5.40
Feed Efficiency (kg Feed/kg Liveweight gain)	16.38	13.39	20.53	7.97
Daily Feed Consumed per Metabolic Liveweight	0.09	0.08	0.05	0.05

Table 8: Mean Squares of Analysis of Variance for Performance Traits of Animals in Experiment 2.

Source	d.f.	T R A I T S			
		Daily DM Consumed	Daily Liveweight Gain	Feed Consumed Per Kg. Liveweight Gain	Daily DM Consumed Per Metabolic Liveweight
Treatment	5	12.49**	0.227**	285.88	0.00250**
Error	16	0.64	0.021	50.56	0.00005

\*\* Indicates significance at  $P < 0.01$

The average daily liveweight gain on rations A, B, C and D were 0.38, 0.33, 0.12 and 0.68kg. respectively. The treatment differences were shown by analysis of variance to be significant ( $P < 0.01$ ). None of the groups, however, according to Dunnett's t-test gained better on the test rations than on the standard ration.

The effect of treatment on cumulative liveweight gains showed higher rate of growth on the standard finishing ration D than on the test rations A, B and C (figure 3). Rations A and B (which showed almost the same result) effected higher rates of growth than ration C. The average final cumulative liveweight gains were 31.64, 27.82, 10.27 and 56.91kg on rations A, B, C and D respectively.

Analysis of variance showed treatment differences in the efficiency of feed utilization to be significant ( $P < 0.01$ ). The feed per kg. liveweight gain on rations A, B, C and D were 16.38, 13.39, 20.53 and 7.97kg respectively. None of the test rations was more efficiently utilized than the standard ration.

The daily feed consumed per metabolic liveweight of the animals on rations A, B, C and D were 0.09, 0.08, 0.05 and 0.05 respectively. Treatment differences, according to analysis of variance, were significant ( $P < 0.01$ ). Dunnett's t-test showed only animals on ration A (CH-YC) to have consumed significantly more feed per metabolic liveweight than did animals on the standard ration D ( $P < 0.01$ ).

KEY

- - - ○ Growth rate on Cocoa Husk - Yellow Corn Ration (A)
- × - - × Growth rate on Cocoa Husk - Sugarcane Bagasse - Yellow Corn Ration (B)
- - - ○ Growth rate on Sugarcane Bagasse - Yellow Corn Ration (C)
- × - - × Growth rate on Standard Finishing Ration (D)

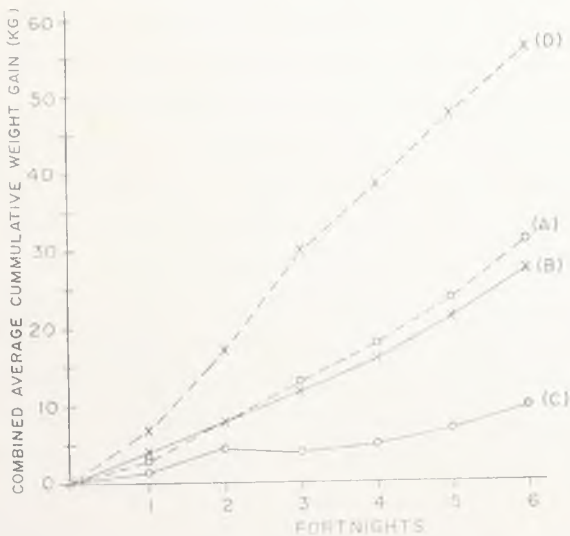


FIG. 3. EFFECT OF ROUGHAGE - YELLOW CORN COMBINATION ON CUMMULATIVE WEIGHT GAIN IN EXPERIMENT 2.

### Experiment 1 Vrs. Experiment 2

A comparison was made between the performance of animals on ration A of experiment 1 (CH) and that of animals on ration A of experiment 2 (CH-YC). On the average animals on CH consumed 4.80kg. while those on CH-YC consumed 6.17kg per day. The difference was not significant. Significant differences, however, existed between the two groups with respect to average daily liveweight gain ( $P < 0.01$ ) and feed consumed per kg. liveweight gain ( $P < 0.01$ ). The figures for animals on CH and those on CH-YC were: daily liveweight gain, 0.19 and 0.38; feed consumed per kg. liveweight gain, 25.67 and 16.38kg.

Similarly comparisons were made between animals on ration C of experiment 1 (SB) and those on ration C of experiment 2 (SB-YC). The combined effect of soaking the bagasse in fresh water overnight and incorporation of yellow corn did not induce a significantly higher daily dry matter consumption of SB-YC over SB. The animals on SB-YC, however, significantly gained more weight per day ( $P < 0.01$ ) and thus more efficiently utilized the ration than did the animals on SB. The respective figures were: daily dry matter intake, 2.74 and 2.51kg; daily liveweight gain, 0.04 and 0.12kg; and feed per kg. liveweight gain, 288.14 and 20.53kg. for SB and SB-YC.

### Health

In general, there did not appear any detrimental physical or physiological manifestations resulting from either the rations fed or management practices. The only health abnormality encountered was

Table 9: Mean Squares of Analysis of Variance for Performance Traits between Animals of Experiments 1 and 2.

Source	d.f.	COCOA HUSK RATIONS				SUGARCANE BAGASSE RATIONS			
		Daily DM Consumed	Daily Liveweight Gain	Feed/ Kg. Gain	TDN of Ration	Daily DM Consumed	Daily Liveweight Gain	Feed per Kg. Gain	TDN of Ration
Treatment	1	4.63ns	0.09*	127.14	1154.76	0.14ns	0.029**	118882.78	0.04ns
Error	8	1.29	0.01	7.43	2.11	0.11	0.002	1430.10	10.07

\* Indicates significance at  $P < 0.05$

\*\* Indicates significance at  $P < 0.01$

ns Indicates non-significance

the presence of Babesia parasites in the blood smears of six animals during experiment 1 and two animals in experiment 2. These animals lost appetite which showed itself in reduced feed intake. All the sick animals, however, responded to treatment.

At the conclusion of the experiment when the animals were slaughtered an examination of the offals showed all carcasses to be in excellent condition with no signs of gross lesions.

### In Vivo Digestibility Studies

#### Experiment 1.

The digestibility of the feed components in the rations fed in digestibility study 1 are presented in table 10. Apparent dry matter digestibility coefficients obtained for rations A, B, C and D were 24.86, 51.06, 61.78, and 63.12 percent respectively. The results indicated significant effect of roughage ( $P < 0.01$ ) on dry matter digestibility. The combined average digestibility coefficients for cocoa husk-based rations (A + B) against sugarcane bagasse-based rations (C + D) were 37.96 and 62.45 percent respectively.

The effect of roughage on the digestibility coefficients of CP, CF, Ash, NFE, Energy and TDN was also significant ( $P < 0.01$ ). The difference with respect to the digestibility of Ash was significantly in favour of A + B ( $P < 0.01$ ). The apparent digestibilities of the other feed components as well as TDN were, however, significantly higher for C + D than A + B ( $P < 0.01$ ). The difference in EE digestibility was not significant. The apparent digestibility coefficients

Table 10: Apparent Digestion Coefficients of Experimental Rations and Digestible Nutrients Consumed by Bullocks in Experiment 1.

Apparent Digestibility (%)	R A T I O			
	A	B	C	D
Dry Matter	24.86	51.06	61.78	63.12
Crude Protein	37.60	70.76	84.50	85.26
Ether Extract	73.98	79.40	82.28	84.66
Crude Fibre	15.10	18.77	52.47	39.09
Ash	58.88	49.02	39.02	44.15
Nitrogen Free Extractives (NFE)	11.97	58.17	59.58	64.90
Energy	14.21	44.72	58.45	61.83
TDN	24.18	52.94	62.51	63.48
<u>Digestible Nutrients Consumption</u>				
Daily TDN Consumed (kg)	1.16	2.14	1.71	1.69
Daily DCP Consumed (g)	320.64	720.74	423.06	479.80
Daily DE Consumed (Mcal)	3.26	8.89	8.63	9.61

Table 11:

Mean Squares of Variance for  
Digestibility Coefficients in Experiment 1.

Source	d.f.	Coefficient of Digestibility							TDN
		DM	CP	EE	CF	Ash	NFE	Energy	
Roughage (R)	1	2999.54 <sup>**</sup>	4713.06 <sup>**</sup>	157.14 <sup>ns</sup>	4228.23 <sup>**</sup>	764.71 <sup>**</sup>	3689.69 <sup>**</sup>	4706.51 <sup>**</sup>	2986.81 <sup>**</sup>
Protein (P)	1	947.65 <sup>**</sup>	1438.21 <sup>**</sup>	76.09 <sup>ns</sup>	106.91 <sup>ns</sup>	27.92 <sup>ns</sup>	3318.15 <sup>**</sup>	1433.80 <sup>**</sup>	1104.84 <sup>**</sup>
R X P	1	772.65 <sup>**</sup>	1312.52 <sup>**</sup>	11.60 <sup>ns</sup>	343.62 <sup>**</sup>	281.33 <sup>**</sup>	2089.17 <sup>**</sup>	919.64 <sup>**</sup>	965.08 <sup>**</sup>
Error	16	18.04	6.89	38.43	25.69	23.93	17.56	34.88	11.30

\* Indicates significance at  $P < 0.05$

\*\* Indicates significance at  $P < 0.01$

ns Indicates non-significance.

of rations A + B : C + D averaged: CP, 54.18: 84.88; EE, 76.69: 83.47; CF, 16.94: 45.78; Ash, 53.95: 41.59; NFE, 35.07: 62.24; Energy, 29.47: 60.14 and TDN, 38.56: 63.00 percent respectively.

Protein level showed significant effect ( $P < 0.01$ ) on the digestibility coefficients of DM, CP, NFE, Energy and TDN. All differences were in favour of high protein rations (B + D). The effect of protein level on the digestibilities of EE, CF and Ash was not significant. Apparent digestibility coefficients for the rations A + C as opposed to B + D were: DM, 43.32: 57.09; CP, 61.05: 78.01; EE, 76.69: 82.03; CF, 33.79: 28.93; Ash, 48.95: 46.59; NFE, 35.78: 61.45; Energy, 36.33: 53.28 and TDN, 43.35: 58.21 percent respectively.

#### Experiment 2.

The apparent digestibility coefficients of the rations fed in experiment 2 are shown in table 12. Analysis of variance showed treatment differences to be significant ( $F < 0.01$ ) with respect to the digestibilities of DM, CP, CF, Ash, NFE, and energy as well as TDN. A comparison of treatment means using Dunnett's t-test, however, did not show any of the test rations' digestibility coefficients to be better than those of the standard finishing ration. Treatment differences in the digestibility of EE were, according to analysis of variance, not significant.

Table 12: Apparent Digestion Coefficients of Experimental Rations and Digestible Nutrients consumed by Bullocks in Experiment 2.

Apparent Digestibility (%)	R A T I O N			
	A	B	C	D
Dry Matter	47.53	49.40	59.82	72.55
Crude Protein	57.33	64.58	78.29	76.62
Ether Extract	63.54	68.60	66.91	55.19
Crude Fibre	39.12	47.27	54.66	56.60
Ash	41.12	37.99	24.56	51.17
Nitrogen Free Extractives (NFE)	48.42	45.76	63.08	76.50
Energy	47.53	49.73	54.92	71.92
TDN	45.67	48.38	62.64	72.66
<u>Di-estible Nutrients Consumption</u>				
Daily TDN Consumed (kg)	2.82	2.15	1.57	3.92
Daily DCP Consumed (g)	596.64	484.85	325.30	692.82
Daily DE Consumed (Mcal)	12.77	9.72	5.6	16.96

Table 13: Mean Squares of Analysis of Variance for Digestibility Coefficients in Experiment 2.

Source	d.f.	Coefficient of Digestibility							TDN
		DM	CP	EE	CF	Ash	NFE	Energy	
Treatment	3	659.6 <sup>**</sup>	499.69 <sup>**</sup>	177.60 <sup>ns</sup>	316.04 <sup>**</sup>	622.13 <sup>**</sup>	1020.94 <sup>**</sup>	509.25 <sup>**</sup>	798.58 <sup>**</sup>
Error	16	2.72	73.75	120.81	5.08	6.37	5.75	6.03	2.805

\*\* Indicates significance at  $P < 0.01$

ns Indicates non-significance

### Experiment 1 Vers. Experiment 2.

A comparison between rations A of experiment 1 and A of experiment 2 indicated that the incorporation of 20 percent yellow corn effectively improved the apparent dry matter digestibility of the cocoa husk-based ration. The digestibility of other feed components that are constituents of organic matter (except EE) as well as TMN was also improved. The percent improvement for DM, CP, CF, NFE and TDN was 47.70, 34.41, 61.41, 75.28 and 47.05 respectively. The addition of yellow corn, however, depressed the apparent digestibility coefficient of ash by 30.16 percent.

Comparing rations C of experiment 1 and C of experiment 2, it was observed that the combined effect of soaking bagasse in water and the incorporation of 20 percent yellow corn did not show any marked change in the digestibility coefficients of any of the feed components of the sugarcane bagasse-based rations.

### Carcass Evaluation

The animals used in experiment 1 were not slaughtered at the end of the feeding trial. Three bullocks in experiment 2 were, however, randomly selected and slaughtered at the end of the second feeding trial. Table 14 shows a summary of the main effect of the rations fed in experiment 2 on the average shrink losses and carcass traits. During the 24-hour pre-slaughter starvation period, animals lost 9.97, 9.65, 8.93 and 10.04 percent of their final fed liveweights on rations A, B, C and D respectively. The lowest percentage weight loss occurred in animals on the ration with the highest crude fibre

Table 14: Effect of Experimental Rations  
on Average Shrink Losses and Carcass  
Traits in Experiment 2.

I T E M	R A T I O N			
	A	B	C	D
Final liveweight (kg)	279.70	239.24	225.61	280.86
Pre-slaughter starved liveweight(kg)	251.81	216.21	205.45	252.73
Starvation period weight loss as percentage of final liveweight (%)	9.97	9.65	8.93	10.04
Warm carcass weight (kg)	136.21	118.03	104.09	144.39
Chilled carcass weight (kg)	135.30	115.90	103.03	143.49
Chilling shrink loss as percentage of warm carcass weight (%)	0.67	1.80	1.02	0.62
Chilled carcass dressing percentage (%)	53.73	53.61	50.15	56.78
Total of 4 wholesale cuts (chuck, Rib, Loin, Round) weight (kg)	100.65	88.60	78.17	101.71
Percent of chilled weight (%)	74.39	75.93	75.87	70.88
Rib eye area (REA)-(sq.cm)	52.20	52.03	40.14	47.88
Percent kidney fat-(%)	1.94	2.03	1.44	3.29
Percent boneless retail cut (%)	53.62	53.88	53.44	51.59

content (ration C) while the highest loss occurred on the ration with the lowest fibre content (ration D. Thus an inverse relationship appeared to exist between the crude fibre content of the rations and the percentage pre-slaughter weight loss of the animals.

Correlations were determined between the chilled carcass weight and the final liveweight for the groups. The coefficients of correlation were: 0.923, 0.998, 0.980 and 0.987 for rations A, B, C and D respectively. All the coefficients were significant ( $P < 0.01$ ).

Upon chilling, carcasses from the animals on rations A, B, C and D lost an average of 0.67, 1.80, 1.20 and 0.62 percent of their warm carcass weights respectively. The differences in the loss which appeared greater for the bagasses-based rations were not significant.

The sum of the four wholesale cuts (chuck, rib, round and loin) represented 74.39, 75.93, 75.87 and 70.88 percent of the chilled carcasses from animals on rations A, B, C and D respectively. No significant effect of the rations on the four wholesale cuts as percent of the respective chilled carcass weights was found. Significant differences, however, existed among the treatments with regard to chilled carcass weight ( $P < 0.05$ ), chilled carcass dressing percentage ( $P < 0.01$ ) and the total weight of the four wholesale cuts ( $P < 0.05$ ). Treatment mean comparisons with Dunnett's t-test did not, however, show any of the rations to be better than the standard in any of the traits. The corresponding figures for groups A, B, C and D were: chilled carcass weight, 135.30, 115.90, 103.03 and 143.49; chilled carcass dressing percentage, 53.41, 53.61, 50.51 and 56.78; and total weight of the four wholesale cuts,

Table 15: Mean Squares of Analysis of Variance  
for Carcass Traits in Experiment 2.

Source	d.f.	CARCASS TRAIT						
		Starvation period percent weight loss	Chilled carcass weight	Chilled carcass dressing percent- age	Chilling percent shrink loss	Total weight of 4 whole- sale cuts	Rib eye area	Percent kidney fat
Treatment	3	0.72 <sup>ns</sup>	1011.87	21.49	0.54 <sup>ns</sup>	375.96	95.42 <sup>ns</sup>	2.03 <sup>*</sup>
Error	8	2.14	141.09	1.44	0.25	80.06	32.56	0.43

\* Indicates significance at  $P < 0.05$

\*\* Indicates significance at  $P < 0.01$

ns Indicates non-significance

100.65, 88.99, 78.17 and 101.71 percent respectively. Group D was highest in all the 3 traits followed by groups A, B and C in that order. Thus both chilled carcass dressing percentage and the total weight of the four wholesale cuts appeared to have a linear relationship with chilled carcass weight.

Variation among treatments in percent boneless retail cuts was not significant.

The slight treatment differences in respect of rib-eye area (REA) was also not significant.

Average percent kidney fat for animals on rations A, B, C and D were 1.94, 2.03, 1.44 and 3.29 respectively. The variation was significant at 5-percent probability.

### Feed Costs

#### Experiment 1.

Analysis of the feed cost was made to assess the economics of the feedlot finishing technique. Table 16 shows the average feed consumption and the corresponding costs during the experimental period 1.

The cost figures given for cocoa husk were made up of cost of transportation, chopping and drying of the material. Transportation formed 41 percent of the total expenses on the husk. The total transportation cost of the husk was \$214.00 while it cost \$312.00 to chop and dry the material throughout experiment 1.

Expenses on sugarcane bagasse comprised the purchase price of the material, the cost of chopping and that of drying. The cost of

**Table 10:** Average Consumption of Feeds During Experiment 1 and the Corresponding Feed Costs.

DATA ON FEED UTILIZED	R A T I O N			
	A	B	C	D
Average Total Feed Consumed (kg)	403.52	339.37	230.51	224.32
Chopped Cocoa Husk amount consumed (kg)	243.73	162.56	-	-
(Cost) <sup>1</sup> cedis	63.13	42.11		
Chopped Sugarcane bagasse Amount consumed (kg)	-	-	127.70	103.86
Cost <sup>2</sup> (cedis)			41.03	33.37
Wheat Bran Amount Consumed (kg)	80.70	84.84	46.10	51.59
Cost (cedis)	11.05	11.61	6.31	7.07
Groundnut cake Amount consumed (kg)	28.25	40.72	25.36	32.75
Cost (cedis)	13.59	19.59	12.20	15.75
Urea <sup>3</sup> Amount consumed (kg)	2.12	3.39	3.46	4.49
Cost (cedis)	-	-	-	-
Molasses Amount consumed (kg)	40.35	40.72	23.05	26.92
Cost (cedis)	13.52	13.64	7.72	9.02
Bone Meal Amount consumed (kg)	4.04	3.39	2.31	2.24
Cost (cedis)	5.39	4.52	3.08	3.00
Common Salt Amount consumed (kg)	4.04	3.39	2.31	2.24
Cost (cedis)	0.81	0.68	0.46	0.45
Vitamin A-D Crumbles Amount consumed (kg)	0.40	0.34	0.23	0.22
Cost (cedis)	0.62	0.53	0.36	0.34

<sup>1</sup> Made up of cost of transportation, chopping and drying.  
The Husks were collected free of charge from Cocoa Research Institute - Tafo.

<sup>2</sup> Made up of cost of the bagasse, chopping and drying.

<sup>3</sup> Supplied free of charge by the U.S.A.I.D.

Table 16 cont.

DATA ON FEED UTILIZED	A	B	C	D
Mineral Licks				
Amount consumed-(blocks)	2	2	2	2
Cost (cedis)	12.00	12.00	12.00	12.00
Cost of grinding (cedis)	11.31	12.78	7.35	8.57
Total feed costs (cedis)	131.42	117.84	90.51	89.57
Total liveweight gain (kg)	15.72	2.32	0.80	-1.82
Feed cost per kg. of liveweight gain (cedis/kg)	8.36	50.79	113.14	-49.21

all other feed ingredients entailed only their purchase prices. See appendix 14 for the sources of the ingredients and their unit prices at time of experiment.

It cost an average of \$1.48 to feed animals on rations A + B a day as against an average of \$1.08 for rations C + D. A saving of \$0.40 per animal per day was thus made on feeding bagasse-based rations. The performance on the sugarcane bagasse-based rations, by way of feed cost per kg. liveweight gain, was so poor that the saving made in feeding bagasse-based rations was uneconomical. It cost \$113.14 to feed an animal on ration C per kg. liveweight gain. The corresponding figure for ration D was negative due to the weight loss of animals on the ration.

Between the low-protein and the high-protein rations (A + C vs. B + D), a daily amount of \$0.08 was saved per animal by feeding high-protein rations (\$1.24 as against \$1.32). Again the saving was uneconomical considering the high cost of feeding both the low-protein and high-protein rations per kg. liveweight gain. Thus, none of the rations in experiment 1 performed commendably by way of the feed cost of producing a kg. of liveweight gain.

#### Experiment 2

Presented in table 17 are the average feed intake and the corresponding costs during experimental period 2. The areas of cost for the cocoa husk, the sugarcane bagasse and all other feed ingredients were as outlined for experiment 1. Transportation, this time, formed 37 percent of the total expenses on cocoa husk.

**Table 17:** Average Consumption of Feeds During Experiment 2 and the Corresponding Feed Costs.

DATA ON FEED UTILIZED	R A T I O N			
	A	B	C	D
Average Total Feed Consumed (kg)	518.42	372.62	210.84	453.54
Chopped Cocoa Husk				
Amount consumed (kg)	259.21	111.79	-	-
Cost <sup>1</sup> (cedis)	69.25	29.87		
Chopped Sugarcane bagasse				
Amount consumed (kg)	-	74.52	101.41	-
Cost <sup>2</sup> (cedis)		21.01	28.59	
<u>Panicum maximum</u> hay <sup>3</sup>				
Cost (cedis)				31.20
Amount consumed (kg)				90.71
Yellow corn				
Amount consumed (kg)	103.68	74.52	42.17	226.77
Cost (cedis)	31.93	22.95	12.99	69.65
Wheat bran				
Amount consumed (kg)	51.84	37.26	21.08	45.35
Cost (cedis)	7.10	5.10	2.89	6.21
Groundnut cake				
Amount consumed (kg)	48.73	32.42	21.08	41.27
Cost (cedis)	23.44	15.59	10.14	19.85
Urea <sup>4</sup>				
Amount consumed (kg)	2.59	4.47	3.80	3.63
Cost (cedis)	-	-	-	-
Molases				
Amount consumed (kg)	41.47	29.81	16.87	36.28
Cost (cedis)	13.89	9.99	5.65	12.15

<sup>1</sup> Made up of cost of transportation, chopping and drying.  
The husks were collected free of charge from Cocoa Research Institute - Tafo.

<sup>2</sup> Made up of cost of bagasse, chopping and drying.

<sup>3</sup> Consisted of the cost of fetching, chopping and drying.

<sup>4</sup> Supplied free of charge by U.S.A.I.D.

Table 17 cont.

DATA ON FEED UTILIZED	A	B	C	D
Bone meal				
Amount consumed (kg)	5.18	3.73	2.11	4.54
Cost (cedis)	6.90	4.97	2.81	6.05
Common salt				
Amount consumed (kg)	5.18	3.73	2.11	4.54
cost (cedis)	1.04	0.67	0.28	0.91
Vitamin A-D Crumbles				
Amount consumed (kg)	0.52	0.37	0.21	0.45
Cost (Cedis)	0.81	0.58	0.31	0.70
Mineral Licks				
Amount consumed (blocks)	2	2	2	2
cost (cedis)	12.00	12.00	12.00	12.00
Cost of grinding <sup>5</sup> (cedis)	11.05	7.81	4.56	16.58
Total feed cost - do -	177.41	130.54	80.24	175.50
Average feed cost/day -do-	2.11	1.55	0.96	2.09
Total Liveweight gain (kg)	31.64	27.82	10.27	56.91
Feed cost per kg. of liveweight gain (cedis/kg)	5.61	4.69	7.81	3.08

<sup>5</sup> Only the PEWES was ground.

The cost of the hay fed during experiment 2 consisted of fetching, chopping and drying the grass.

Yellow corn supplementation yielded significant and promising results as portrayed in daily cost of feeding figures for experiment 2. It cost an average of ₦2.11, ₦1.55, ₦0.96 and ₦2.09 a day to feed rations A(CH-YC), B(CH-SB-YC), C(SB-YC) and D(SD) respectively. The corresponding feed cost per kg. liveweight gain figures were: ₦5.61, ₦4.69, ₦7.81 and ₦3.06. The trend of efficiency here tallied with that of the efficiency of feed utilization (kg of feed per kg of liveweight gain). Ration D was most efficient in both traits followed by rations B, A and C in descending order.

It is remarkable that inspite of the high amount of corn in the standard finishing ration, the ration yielded the least cost of producing a kg. of liveweight gain.

#### Experiment 1 Vrs. Experiment 2

A comparison was made between the expenses incurred in feeding ration A of experiment 1 and that incurred in feeding ration A of experiment 2. An average <sup>saving</sup> of ₦0.55 was made per day in feeding a bullock on CH. However, when the total feed cost was divided by the total kg. of liveweight gain it was found that the average cost of feed per kg. liveweight gain was ₦2.75 lower on CH-YC than CH.

Similar comparisons between ration C of experiment 1 (SB) and ration C of experiment 2 (SB-YC) revealed a saving of ₦0.12 per animal per day when the bullocks were fed on SB-YC. The cost of feeding an animal for a kg liveweight gain was ₦105.33 lower on SB-YC than on SB.

### DISCUSSION

The primary objective of this study was to:

- (i) Formulate cocoa husk - and sugarcane bagasse-based diets,
- (ii) assess the acceptability of the rations to local beef cattle,
- (iii) determine the effect of roughage and protein level (if any) on feedlot performance of the animals,
- (iv) find the extent to which soaking dried sugarcane bagasse overnight in fresh water would improve consumption of bagasse-based rations,
- (v) observe to what extent (if any) the addition of 20-percent yellow corn would improve the TDN Values of cocoa husk and bagasse based rations, and
- (vi) formulate a standard finishing ration for local beef cattle and compare its efficiency with that of cocoa husk - and sugarcane bagasse-based rations.

### Chemical Composition

The percent nutrient composition obtained in this study for both the cocoa husk with beans and cocoa husk without beans were: CP, 15.20 and 10.64; EE, 10.01 and 2.01; CF, 34.42 and 42.74; NFE, 25.97 and 27.67; Ash, 14.40 and 15.69 respectively. Apart from NFE which was on the lower side, the figures obtained in this study for the husk without beans fell within the ranges obtained by Eanten (1964), Acquaye (1966), Bateman and Fresnillo (1967), Oyemuga (1968) and Ankras (1974). This suggested that the material worked on by these workers might have been devoid of cocoa beans.

Cocoa husk-based rations of experiment 1 had higher crude protein levels than estimated. This could have been caused by the beans that were mixed with the husk. When the beans were removed from the husk in experiment 2 the proximate crude protein levels tallied with the estimated values. The higher values of CF and EE and the lower level of ash obtained for the husk with beans as compared with the values for the husk without beans indicated the significant effect the beans had on the nutrient composition of the husk.

Theobromine content of the cocoa husk with beans compared with that without beans (1.85 and 0.42 percent respectively) showed that the beans increased the theobromine content of the husk by about 77 percent. The 0.42 percent obtained in the husk without beans was higher than the value reported by Dittmar (1958) for cocoa husk. The difference could be due to variations in treatment such as fermentation, drying and storage. It could also be brought about by climatic differences as well as differences in the variety of the cocoa analysed.

Average daily theobromine consumption on rations A and B in experiment 1 and A and B of experiment 2 were 0.262 and 0.198, 0.058 and 0.026g per kg. body weight respectively. Knapp and Churchill (1937) suggested an optimum non-toxic level of about 0.036g per kg. body weight for cows. No sign of theobromine poisoning was, however, observed in any of the animals in this study.

The sugarcane bagasse-based rations of experiment 1 had lower dry matter content than the cocoa husk-based rations. This could be explained by the fact that in an attempt to make the otherwise hard bagasse acceptable

to the bullocks more water was used to dissolve the urea and molasses meant for the bagasse-based rations.

Proximate composition of the bagasse used in this study showed higher values for CP, EA, NFE and ash than reported by Morrison (1973) for sugarcane bagasse. The higher CP value was reflected in the CP levels of the bagasse-based rations of experiment 1 which were higher than estimated. The higher proximate composition figures suggested that the bagasse used in this study might have contained more of the pulp than the rind. This in turn could have been caused by differences in the crushing operation as well as differences in the variety of the cane used.

#### Feed Consumption, Growth and Feed Efficiency

Finishing beef cattle, according to NRC (1970), consume feed equal to 2.5 to 3.0 percent of their liveweight. In absolute figures an 182 kg. beef cattle consume 4.2 to 5.2 kg. dry matter daily. The animals in experiment 1 of this study averaged 201.91, 185.60, 191.52 and 194.60kg. for rations A, B, C and D respectively. Their corresponding average daily dry matter intake was 4.80, 4.04, 2.74 and 2.67 kg. The intake represented 2.40, 2.20, 1.40 and 1.40 percent of the respective liveweights. It is obvious that on both percentage and absolute basis the dry matter consumption of animals on cocoa husk-based rations was very near the recommended values; while consumption of the bagasse-based rations was on the lower side. It is, however, difficult to make any rigid conclusion since the recommended values were for animals of different

breeds and ages fed on different rations. Judging from the amount of the various rations consumed it could be said that both the cocoa husk and sugarcane bagasse-based rations were acceptable to the local cattle.

The results showed a significant effect ( $P < 0.01$ ) of roughage on dry matter intake. The animals consumed more of the cocoa husk-based rations than the sugarcane bagasse-based rations. This is not unexpected. A higher degree of lignification in a feedstuff (as it is in sugarcane bagasse more than cocoa husk) would result in a slow rate of passage of digesta through the reticulorumen. Hence over a given time more cocoa husk based ration would be consumed than the sugarcane bagasse based rations.

The lack of significant effect of protein on dry matter consumption supported the findings of Weston (1971) who observed that when the nitrogen requirement was met the protein level of the <sup>ration</sup> /did not influence dry matter consumption.

Crude fibre content of both the cocoa husk - and sugarcane - based rations was very high. This could have limited the consumption of the rations. In an experiment to study the relationship between fibre content of a diet and dry matter intake Strozinski and Chandler (1971) observed that feed intake declined when the crude fibre content of the diet exceeded 18.6 percent.

Observations on the daily liveweight gains and efficiency of feed conversion showed that animals on cocoa husk-based rations performed significantly better ( $P < 0.01$ ) than those on bagasse-based rations. The magnitude of the weight gain, however, was such that none of the

rations fed in experiment 1 could serve as a feedlot finishing ration.

Comparisons between performances on the rations in experiment 1 and those on rations in experiment 2 showed that although there were no significant differences in the dry matter consumption, animals significantly gained more weight and more efficiently ( $P < 0.01$ ) utilized the rations containing yellow corn. A similar observation was made by Donefer (1976) when he fed Holstein male calves with rations of sugar-fith plus cane tops. When additional sources of energy (molasses or corn) were supplied, 10 - 30 percent increase in rate of growth was observed. It was suggested that the increased performances with corn supplementation was possible due to the presence of more slowly digested starch.

With the exception of the daily liveweight gain on SB-YC, all weight gain and feed conversion figures on rations containing yellow corn, cocca husk and/or sugarcane bagasse agreed with the data obtained by Ababio (1966) for Ndama. Although the daily liveweight gain on SB-YC was lower than observed by Ababio (1966) the animals of the present study more efficiently utilised the ration than did the animals studied by Ababio to their ration. The rations fed in Ababio's study comprised corn and cobs, groundnut cake, and molasses supplemented with corn silage and millet hay. The relatively lower weight gain on SB-YC could be due to insufficient intake of dry matter which in turn resulted from the too low percent dry matter content of the ration.

The effect of the standard ration on the performance traits of the local cattle was very significant. By way of daily liveweight gain

and feed conversion the animals on the standard finishing ration of this study did 44 percent and 303 percent respectively better than the animals studied by Ababio (1966).

Daily dry matter consumption and the daily weight gain of the animals on the standard ration were about the same as the recommended values by NRC (1970) for temperate breeds. They were also comparable to the figures obtained by Wyatt, et al (1977) when they investigated the post-weaning feedlot performance of steers from Hereford, Hereford X Holstein, and Holstein cows. The standard finishing ration of this study could therefore serve as a feedlot ration for cattle. The commendable performance of the N'dama bullocks on the standard rations suggested that local cattle could favourably respond to feedlot finishing if provided with the requisite ration.

The significant feature observed in the growth curves of this study was that the average cumulative weight gains increased at a higher rate during the last three fortnights in all the comparisons. This suggested that if the feeding period had been extended better results could have been obtained. Auriol (1974) in his investigation of the effect of feedlot feeding on growth pattern and feed conversion efficiency of cattle under different systems of management fed all animals for a period of 150 days. He had observed that cattle raised under the traditional extensive system (natural pastures without any feed supplement) were generally thin and somewhat small for their age and therefore required considerably longer fattening period to reach desired market condition.

### In Vivo Digestibility Studies

The results of this study indicated significant effect of roughage on the apparent digestibility coefficients of DM, CP, CF, ash, NFE Energy and TDN. With the exception of ash, the digestion of which was higher for cocoa husk-based diets, all other feed components showed higher digestibilities for sugarcane bagasse-based rations. Evidence that high levels of cocoa husk reduced DM, CP and energy digestibility of rations has been presented by Meyanju, et al (1977). Kertesz (1951) had incriminated the high mucilaginous pectic substances as well as the high proportion of lignocellulosic polysaccharides present in the husk as the possible cause of the low digestibilities. He explained that these materials did not support bacterial growth and hence could cause low digestibility. The possible role of saponification in the rumen as a contributory factor to the low digestibility is worth examining. With the high level of ash in the husk coupled with the high level of EE contributed by both the cocoa beans and the groundnut cake, it is possible that during fermentation soap and water would be formed in the rumen. While the excess water would dilute microbial population and hence reduce their effective activity the soap would cause a rapid movement of digesta through the reticulorumen and would also reduce microbial population.

The high digestibility of sugarcane bagasse-based rations could be attributed to the stimulatory effect the fibrous material had on rumination which in turn promoted a more sustained fermentation in rumen.

Digestibility study results for experiment 2 indicated that the incorporation of 20% yellow corn improved the apparent digestibilities of the feed components of the cocoa husk-based rations as well as their TDN values. The improved values were, however, less than those recommended by NRC (1970) and Morrison (1973) for fattening beef cattle. Yet the performance of the animals by way of weight gain and feed conversion efficiency was well within expected ranges. Perhaps the recommended values were for the bigger temperate breeds and therefore overestimated for our local cattle. If the efficiency of utilization of cocoa husk-based rations supplemented with 20% yellow corn was as high as that of highly digestible rations then research methods which will ensure effective fermentation of cocoa husk-based ration in the reticulorumen should be encouraged. Procedures like incorporation of pure starch in the ration should be investigated. Starch is more slowly digested, provides readily available energy and thus can more sustain bacterial growth.

Incorporation of 20 percent yellow corn did not enhance the TDN of the sugarcane bagasse based ration. The value was, however, higher than that of the cocoa husk-based ration. The main set-back of the bagasse-based rations in this study was its inadequate dry matter consumption. Perhaps it would be worthwhile grinding the bagasse before feeding. Workers like Ensminger (1970) and McDonald, et al (1973) observed that the grinding of roughages reduced the digestibility of both DM and CP. But since they agreed that grinding increased the acceptability of the roughages it is hoped that the increased dry matter consumption would compensate for the reduced digestibility.

The high dry matter consumption and the high TDN value of the standard finishing ration explain why the animals so efficiently utilized the ration. The figures for the percent TDN, daily TDN consumed and daily DCP consumed were all above the recommended values for temperate fattening beef cattle. This further substantiates the assertion that the standard finishing ration formulated in this study could adequately serve as fattening ration for cattle.

Conrad, et al (1964) observed that when the dry matter digestibility of a ration was lower than 65 percent, dry matter intake was proportional to the liveweight; whereas with diets of higher digestibility it tended to be more closely proportional to the metabolic liveweight ( $W^{.75}$ ) of the animals. The results of this study indicated that, with the exception of the standard ration, the dry matter digestibility of all other rations was below 65 percent. Significant correlations were, however, observed between the dry matter intake and both the liveweight and metabolic liveweights of the animals on almost all the rations. This could also be another proof of the fact that not all findings with heavier temperate breeds could be true for our local cattle. Generally the local cattle, under the traditional system of management, are unthrifty and therefore make slow and expensive gains. The Ndama is also nervous and active and would logically make less rapid gains as compared with the docile animals which would be inclined to "rest and lie down".



### Crude Fibre

An inverse relationship appeared to exist between the crude fibre content of the rations and the percent pre-slaughter starvation period weight loss. Animals on the ration with the highest crude fibre content had the lowest percentage weight loss and vice-versa. Logically since animals on lower fibre content ration consumed more dry matter they would have more food residues in their digestive tracts at the start of fasting which would result in greater weight loss. Randel (1970) observed contrasting results.

Significant correlation existed between carcass weight and the final liveweights of the animals. This agreed with the findings of Awuma (1976). Willis and Preston (1960) had earlier observed similar results for temperate cattle.

The chilled carcass dressing percentages of the animals on rations A through D were: 53.41, 53.61, 50.15 and 56.76 respectively. Similar figures were obtained by Randel (1970) for Holstein-Friesian and Brown Swiss cattle. Abadio (1969) observed dressing percentages of 53.2, 50.0 and 49.4 for N'dama, West African Shorthorn and Janga respectively. His findings showed a linear relationship between REI and dressing percentage. No such relationship was found in this study. Linear relationships, however, existed among chilled carcass weight, total weight of the four wholesale cuts and dressing percentage.

The variation among the treatments with regard to percent kidney fat in this study was significant. The average figures for ration A, B, C and D were: 1.94, 2.03, 1.44 and 3.28 percent. The same order was observed with efficiency of feed conversion.

### Feed Costs

Cost analysis showed that it was too expensive to finish the local cattle on cocoa husk and sugarcane bagasse-based rations devoid of corn. The animals consumed the rations but gained very little and in some cases lost weight.

Yellow corn supplementation, however, yielded economical results as portrayed in the average feed cost per kg. of liveweight gain. Comparing the treatments it was observed that it cost least to finish animals on ration D (3D), followed by B(CH-3B-YC), then A(CH-YC) and finally C(3B-YC). It would be recalled that the same trend was observed with efficiency of feed conversion and percent kidney fat. Based on these three traits (which are about the best criteria in this study for assessing the efficiency of the feedlot finishing) it could be said that the standard finishing ration, in term of cost, weight gain and fat formation, was the most efficient finishing ration. This was followed by ration B(containing cocoa husk, sugarcane bagasse and yellow corn); then ration A (containing cocoa husk and yellow corn), and finally, ration C(containing sugarcane bagasse and yellow corn).

CONCLUSION

The results of this study indicated that:

1. Both cocoa husk - and sugarcane bagasse-based rations were acceptable to local beef cattle without any detrimental physical or physiological manifestation resulting from the rations. The intake of the bagasse-based rations was on the low side but could be improved by grinding the roughage.
2. The type of roughage had significant effect on dry matter consumption and hence on feedlot performance. Animals consumed more of the cocoa husk-based ration, gained more weight and more efficiently utilised the ration.
3. The level of protein in the rations did not significantly affect the feedlot performance; indicating that the nitrogen requirement of the animal was met by the rations.
4. The incorporation of 20 percent yellow corn significantly improved the TDN value of the cocoa husk-based ration and hence the feedlot performance of the animals. The TDN value could, however, be improved further by addition of pure starch to the ration.
5. The combined effect of soaking the sugarcane bagasse over-night in fresh water and addition of 20 percent yellow corn did not enhance dry matter consumption due to the higher water content of the soaked material. The treatment, however, improved the daily liveweight gains of the animals and thus indicated better efficiency of feed utilization.

6. The ration formulated from 50% yellow corn, 20% hay, 8% molasses, 10% wheatbran, 0.8% urea and 11.2% supplement was most efficient in terms of cost, weight gain, feed conversion and fat formation. It could serve as a standard feedlot finishing ration for cattle.

7. The other rations containing different combinations of cocoa husk, sugarcane bagasse and yellow corn were efficient in terms of cost, feed conversion and fat formation and could, with the recommended means of improvement, serve as feedlot finishing ration for cattle.

Finally it should be said that Ghana has a great potential to improve beef production by feeding cattle, prior to marketing for slaughter, in confinement with lignocellulosic by-products along with the necessary supplementation. The establishment of a feedlot is, however, an expensive business involving a large capital outlay on stock and building. It needs a high level of managerial efficiency. This type of enterprise could be established by one or more businessmen, who would provide the capital and employ a manager to look after their investment. It could also be practised by groups of small farmers who will form themselves into a co-operative to fatten their stock. They could be financed by some interested government or semi-government agency and should be able to achieve successful results provided they work together and leave the running of the feedlot to someone who has the know-how. There is always a considerable disease hazard when large numbers of animals are confined on a small area. Herd prophylaxis must therefore be of a very high standard and veterinary services should be readily available.

L I T E R A T U R E     C I T E D

- Ababio, L.N.K. (1966). Dry-lot performance of three indigenous cattle - N'dama, West African Shorthorn and Sanga. Annual Report. University of Ghana Agricultural Research Station Legon.
- Acquaye, D.K. (1966). Mineralisation of pod husk. Rep. Cocoa Res. Inst. Ghana 1963-65.
- Adegbola, A.A. and Omole, T.A. (1973). A simple technique for preparing discarded cocoa bean meal for use as livestock feed. Niger. Agric. J. 10 : 72-81.
- Ademosun, A.A. and Kolade, J.O.Y. (1973). Nutritive evaluation of Nigerian Forages. Niger. Agric. J. 10 : 160-169.
- Adeyanju, S.A., Ogutuga, D.B.A., Ilori, J.O. and Adegbola, A.A. (1975). Cocoa Husk in Maintenance rations for sheep and goats in the tropics. Nutr. Rep. Intl. 11: 351-357.
- Adomako, D. (1975). Commercial Utilization of Cocoa by-products in Ghana. Cocoa Res. J. 10: 160-168.
- Alba, J. de and Basadre, J. (1952). Pig fattening trials using basic rations of cocoa-pods, maize and bananas. Turrialba Rev. Interam. Ciencias Agric. 2 (3): 106-110
- Alba, Je de, Garcia, E., Cano, F.P., and Ulloa, G. (1954). Valor nutritivo de la cascara de cacao para production de leche en comparacion con maiz molido y harina de yuca. Turrialba 4: 29-34.

- Amaning-Kwarteng, K. (1974). Supplementary feeding of cassava peels with urea and molasses to cattle.  
B.Sc. Diss. Fac. Agric. University of Ghana, Legon.
- Ankrah, E.K. (1974). Chemical studies of some plant wastes from Ghana.  
J. Sci. Fd. Agric. 25: 1229-1232.
- Anonymous (1973). Rainfall patterns for Agricultural Research Station, Kpong. Annual Report, University of Ghana, Agric. Research Station, Kpong. 1972-73
- Association of Official Analytical Chemists (1970).  
Official Methods of Analysis. 11th Ed. Washington. D.C.
- Auriol, P. (1974). Intensive feeding systems for beef production in developing countries. Wld Anim. Rev. (F.A.O.). 9: 18-23.
- Awuma, K.S. (1976). Slaughter characteristics of local cattle and their exotic crossbreds. B.Sc. Diss. Fac. Agric. Univ. Ghana, Legon.
- Bacvanski, S., Cobic, T. and Sofija Vucetic (1973).  
Fattening Young cattle in Yugoslavia. Wld. Anim. Rev. (F.A.O.) 8: 13-16
- Baranowski, A. (1970). Sugarcane in Ghana. Crop Res. Inst. Bull. 2: 7-10
- Bateman, J.V. and Fresnillo, O.I. (1967). Digestibility of Theobroma Cacao pods when fed to cattle. J. Agric. Sci. 86: 23-25
- Bateman, J.V. and Larragan, A. (1966).  
El uso de cacao en raciones para el engorde de bovinos.  
Turrialba. 16: 25-28

- Beams, R.M. (1961). Bagomolasses as the basis of a fattening ration for cattle. Que. J. Agric. Sci. 18: 425-436
- Beams, R.M. (1963) Provision of urea to cattle in a salt-urea-molasses block. Que. J. Agric. Sci. 20: 213-230
- Beckman, E. (1915). Food value of wood and straw. Chem. Abstr. 10: 3309-3312
- Baxter, K.L., Mainman, F.W. and Wilson, R.S. (1961). The regulation of food intake by sheep. Anim. Prod. 3: 51-61
- Burroughs, W. (1950). Cellulose digestion by rumen micro-organisms as influenced by cereal grains. J. Nutr. 40: 9-16
- Campling, R.C. (1970). Physical regulation of voluntary intake. In Physiology of Digestion and Metabolism in the ruminant (Ed. Phillipson, A.T.) pp. 266-284 Oriel Press, Newcastle. U.K.
- Campling, R.C., Freer, M. and Balch, C.C. (1962). Factors affecting the voluntary intake of food by cows. 3. The effect of urea on the voluntary intake of straw. Brit. J. Nutr. 16: 115-124
- Carrero, R., Valencia, I., Ramirez, A. and Bendel, P.F. (1972). Alkali-treated and raw sugarcane bagasses as roughages in complete rations for lactating cows. J. Dairy Sci. 55 (10): 1492-1495
- Conrad, F.R., Pratt, A.D., and Hibbs, J.W. (1964). Regulation of feed intake in dairy cows. I. Change in importance of physical and physiological factors with increasing digestibility. J. Dairy Sci. 47: 54-62.

- Coombe, J.B. and Tribe, D.E. (1965). Toxicity of Urea to sheep. Austr. J. Agric. Res. 14: 70-92.
- Cowsert, R.L. and Montgomery, M.J. (1959). Effect of varying forage -to-concentrate ratio of isonitrogenous rations on feed intake by ruminants. J. Dairy Sci. 42: 54-67
- Crampton, E.W. (1957). Interrelations between digestible Nutrient and energy content, voluntary dry matter intake and the overall feeding value of forages. J. Anim. Sci. 16: 546-552
- Dittmar, H.F.K. (1958). Untersuchungen and Kakao fruchtschalen. Gordian. 56: 48-49
- Doanekpor, S.K. (1977). Performance of sheep fed rations of cocoa husk. B.Sc. Diss. Fac. Agric. University of Ghana, Legon.
- Donefer, E. (1976). Beef cattle production from Processed sugarcane (sugar-fith). In Beef cattle production in Developing Countries (Ed. Smith, J.A.) pp 258-260. Edinburgh Univ. Press.
- Donefer, E., Lloyd, L.E. and Crampton, E.W. (1963). Effect of varying alfalfa a : barley rations on energy intake and volatile fatty acid production by sheep. J. Anim. Sci. 22: 425-428.
- Elliot, R.C. (1967). Voluntary intake of low-protein diets by ruminants. I. Intake of food by cattle. J. Agric. Sci. 69: 375-382.
- Ensminger, M.E. (1970). Stockman's Handbook; 4th ed. pp 63-163. Interstate Publ. Inc. Illinois.
- Greenwood-Barton, L.H. (1964). Cocoa beans and cocoa pods; have they Unconventional uses?. First Session, FAO Technical Working Party on Cocoa Production. Rome. Sept. 1964.

- Haines, C.E. and Echevarria, A.J. (1955). Cocoa pods as a substitute for corn in tropical dairy rations. Foreign Agric. 19: 99-101.
- Huffman, J.G., Kitts, W.D. and Krishnamurti, C.R. (1971). Effects of alkali treatment and Gamma irradiation on the chemical composition and In vitro rumen digestibility of certain species of wood. Can. J. Anim. Sci. 51: 457-464.
- Mumphrey, D. (1950). The utilization of urea as a protein supplement for ruminants (A review). Rhodesia Agric. J. 53: 241-256.
- Johnson, P.C., Hamilton, T.S., Mitchell, H.R. and Robinson, M.B. (1942). The relative efficiency of urea as a protein substitute in the ration of ruminants. J. Anim. Sci. 1: 236-245.
- Jones, G.M. (1971). Volatile fatty acids in concentrate rations for lactating dairy cows. J. Dairy Sci. 54: 1142-1149.
- Kay, M. (1969). Intensive beef production. Wld. Rev. Anim. Prod. 5 (21): 64-70.
- Key, M., Bowers, H.B. and McKiddie, C. (1968). Physiological and Physical factors limiting feed intake. Anim. Prod. 10: 37-41
- Kenten, R.H. (1954). Other uses of the cocoa bean and the by-products arising from the fresh pod. Intern. Memo Chem. 1 (54).
- Kertesz, Z.I. (1951). The pectic substances, pp. 385-391 Intersciences Publ. N.Y.
- Kirk, W.G., Peacock, F.M. and Davis, G.E. (1962). Utilization of bagasse in cattle fattening rations. Fla. Agric. Exp. Sta. Bull 641

Kitts, W.D. and Krishnamurti, C.R. (1970).

The possibilities of wood as livestock feed.

Can. Agric. Inst. Rev., Nov-Dec. Ed., pp 18-19

Kitts, W.D., Krishnamurti, C.R., Shelford, J.A. and Buffman, J.G. (1969).

Use of wood and woody by-products as a source of energy in beef cattle ration. In "Cellulases and their application" Adv. Chem.

Ser. 95: 219-241

Knapp, A.W. and Churchill, A. (1937). Cacao shell and its use as

an accessor. Fodder. Jnl. Soc. Chem. Ind., Lond. 61: 29-33

Langlands, J.F. (1968). The feed intake of grazing Sheep differing in

Age, Breed, Previous nutrition and Liveweight.

J. Agric. Sci. Camb. 71: 167-172.

Lofgreen, G.F. (1965). Net energy of fat and molasses for beef heifers

with observations on the method for net energy determination.

J. Anim. Sci. 24 (2). 480-487

Lofgreen, G.F. and Otagaki, K.K. (1960).

The net energy of blackstrap molasses for fattening steers as determined by a comparative slaughter technique.

J. Anim. Sci. 19 (2): 392-403

McDonald, I.W. (1952). The role of Ammonia in Ruminal Digestion of

Protein. Bio. J. 51: 86-90.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. (1973).

Animal Nutrition, 2nd Ed. pp 185-197. Oliver and Boyd. Edinburgh.

McNaught, M.C. and Smith, J.A.B. (1942) Nitrogen metabolism in the rumen.

Nutr. Abst. Rev. 17: 18-31

- Meiske, J.C., Van Arsdell, W.J., Luecke, R.W. and Hoefer, J.A. (1955).  
The utilization of urea and biuret as sources of nitrogen for  
growing fattening lambs. J. Anim. Sci. 11: 941-946.
- Minson, D.J. and Milford, R. (1968). Nitrogen availability and requirements  
for lignocellulose digestion. Aust. J. Agric. Anim. Husb.  
8: 269-276.
- Hair, R.J. and Harris, L.E. (1962). Ruminant flora studies in the sheep.  
x. Influence of nitrogen intake upon ruminal function.  
J. Nutr. 77: 285-298.
- Morrison, F.B. (1973). Feeds and Feeding. 9th ed. pp. 625-631  
Morrison Publ. Co. Ithaca. N.Y.
- Murphey, C.E., Hallett, D.K., Tyler, W.E. and Pierre, J.C. (1960).  
Estimating yields of retail cuts from beef carcasses.  
J. Anim. Sci. 19: 1240-1246
- National Academy of Science - National Research Council (1970).  
Nutrient Requirements of Beef Cattle. Publ. 1137. N.R.C.  
Washington D.C.
- Oltjen, R.R. (1965). Urea diet studies with sheep. Agric. Res. 13: 8-9.
- Owusu-Domfeh, K. (1972). The future of cocoa and its by-products in  
the feeding of livestock. Ghana J. Agric. Sci. 5: 57-64.
- Owusu-Domfeh, K. and Antwi, M.K. (1972). Some observations on fattening  
cattle on wheatbran and bagasse. Annual Report. Anim. Res.  
Inst Achimota. pp. 27-36.
- Oyenuga, T.A. (1968). Nigeria's Feedstuffs, Their Chemistry and Nutritive  
Value. 3rd Ed. Ibadan Univ. Press. Ibadan.

- Pessey, D.E. (1976). Preliminary studies on the nutritive value of some cocoa by-products. B.Sc. Diss. Fac. Agric. University of Ghana, Legon.
- Pidgen, W.J. and Bender, F. (1972). Utilization of lignocellulose by ruminants. Wld. Anim. Rev. (FAO). 4: 7-10.
- Fritchard, G.I., Pidgen, W.J. and Minson, D.J. (1962)  
Effect of gamma irradiation on the utilization of wheat straw by rumen micro-organisms. Can.J. Anim. Sci. 42: 205-217.
- Randel, P.F. (1970). Dairy beef production from mixtures of sugarcane bagasse and concentrates. Univ. Puerto Rico. J. Agric. 54: 237-246.
- (1972). A comparison of the digestibility of two complete rations containing either raw or alkali-treated sugarcane bagasse. Univ. Puerto Rico J. Agric. 56 (1): 18-25.
- Raymond, W.F. (1948). Evaluation of Herbage for grazing. Nature. 161: 937-938.
- Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. 6th ed. Iowa State Univ. Press Ames. Iowa.
- Spahr, S.I. Branding, A.E., Kesler, E.M. and Cloninger, W.H. (1966). Short-term effects of dietary fibre level of feed intake and production by well-fed cows. J. Dairy Sci. 49: 1046-1049.
- Squire, H.A. (1976). Experiences with the development of an intensive beef feeding systems in Kenya. In "Beef Cattle Production in Developing Countries". (Ed. Smith, J.A.) pp.150-153. Edinburgh Univ. Press.

- Squire, H.A. and Creek, M.J. (1973). Custom feeding of Cattle - a proposal for a standardized package approach to project formulation. Wld. Anim. Rev. (FAO) 8: 27-30.
- Steel, R.C.D. and Torrie, J.H. (1960)  
Principles and Procedures of Statistics. McGraw-Hill Book Co., N.Y.
- Strozinski, L.L. and Chandler, P.T. (1971).  
Effects of dietary fibre and acid-detergent lignin on body fill of ruminating calves. J. Dairy Sci. 54: 1491-1495.
- Tillman, A.D. and Swift, R.W. (1953).  
The utilization of ammoniated industrial by-products and urea by sheep J. Anim. Sci. 12: 201-212.
- Veterinary Services Department (1975).  
Livestock Census of Ghana. 1969-1974. Unpublished.
- Weiniger, J.H., Funk, K. and Gresse, F. (1956).  
Investigations on the feeding of theobromine and by-products of cocoa manufacture. Chem. Abst. 50: 1735-1736.
- Wellington, G.H. (1953). Recommended procedure for cutting beef.  
Proc. Recip. Meat Conf. 6: 73-81.
- Weston, R.H. (1971). Factors limiting the intake of feed by Sheep. V. Feed intake and the productive performance of the ruminant lamb in relation to the quantity of crude protein digested in the intestines. Aust. J. Agric. Res. 22: 307-320.
- Willis, M.B. and Preston, T.R. (1968). The performance of different breeds of cattle in Cuba. Anim. Prod. 10 (1): 77-83.

Winks, L. and Laing, A.R. (1972). Urea, Phosphorus and Molasses Supplements for grazing beef weaners. Proc. Aust. Soc. Anim. Prod. 9: 321-327.

Wyatt, R.D., Lusby, K.S. Gould, M.B., Walters, L.E., Whiteman, J.V., and Totusek, R. (1977). Feedlot performance and Carcass traits of Progeny of Hereford, Hereford X Helstein and Holstein coes. J. Anim. Sci. (5): 1131-1137.

APPENDIX 1: Individual Fortnightly Dry Matter Consumption (kg) In Experiment 1

WEEK	<u>GROUP A</u>					<u>GROUP B</u>					<u>GROUP C</u>					<u>GROUP D</u>				
	Animal					Animal					Animal					Animal				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	76.79	40.13	53.47	32.92	76.08	57.31	46.77	20.55	60.68	25.90	29.35	29.35	26.47	17.55	29.26	23.45	31.69	33.32	27.32	33.55
2	55.10	66.83	50.34	55.74	91.43	59.98	63.94	33.00	67.49	40.29	59.99	38.21	33.56	32.86	40.80	37.97	40.61	37.78	32.85	45.18
3	70.46	71.46	51.55	65.41	97.83	59.35	64.93	39.26	70.19	57.76	38.53	40.51	56.08	40.89	43.79	40.85	40.08	37.52	29.42	34.52
4	71.74	65.77	51.41	71.31	84.96	57.42	66.90	42.74	63.01	60.75	30.71	38.76	34.44	44.71	41.29	39.25	38.32	35.05	31.89	42.11
5	81.41	67.40	52.54	72.17	74.44	55.28	77.11	44.55	67.16	60.31	42.35	39.56	36.34	44.83	46.41	39.82	30.48	35.08	32.75	45.95
6	83.04	68.11	50.55	73.30	85.89	50.64	80.77	56.87	63.57	74.37	44.77	42.19	39.53	46.09	53.46	41.28	41.41	41.68	38.90	40.64

Blood smears showed presence of Babesia parasites.

APPENDIX 2:

Individual Fortnightly Dry Matter Consumption (kg) In Experiment 2

FORTNIGHT	<u>GROUP A</u> Animal					<u>GROUP B</u> Animal					<u>GROUP C</u> Animal					<u>GROUP D</u> Animal				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	98.44	104.86	66.07	96.55	62.60	56.57	47.59	46.52	67.39	42.93	30.70	31.20	32.40	43.04	33.48	68.49	71.07	63.77	68.45	80.17
2	90.32	94.66	71.65	98.26	64.22	66.01	60.65	50.37	64.53	57.29	30.75	31.11	34.95	42.92	34.90	17.30	74.11	72.50	72.34	88.69
3	94.38	90.39	66.63	98.36	65.14	65.58	63.07	47.55	72.99	52.64	24.49	28*95	32.15	39*59	36.26	69.24	76.52	71.52	68.39	91.11
4	100.60	94.04	60.16	99.81	56.49	68.06	69.96	55.43	74.14	55.25	33.46	25.67	36.55	47.50	38.39	74.40	72.93	69.60	70.58	83.39
5	109.96	100.16	68.32	105.99	64.36	69.42	68.94	64.83	72.93	64.38	31.98	27.80	31.57	42.78	41.68	75.61	75.16	69.15	71.43	98.41
6	108.27	105.59	72.34	108.20	74.54	71.25	63.93	64.79	72.37	65.74	34.84	30.30	32.50	48.72	42.58	74.01	73.45	70.37	75.44	102.17

Blood smears showed presence of Babesia parasites.

## APPENDIX 3:

## Individual Fortnightly Liveweights (kg) In Experiment 1

FORT- NIGHT	<u>GROUP A</u> Animal					<u>GROUP B</u> Animal					<u>GROUP C</u> Animal					<u>GROUP D</u> Animal				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	163.61	175.50	131.82	181.80	258.24	174.51	146.20	143.60	212.73	237.30	172.72	165.52	131.80	229.13	254.50	157.31	183.60	172.72	181.40	287.34
1	187.70	182.70	138.22	179.10	265.50	173.59	147.31	143.76	209.12	237.30	172.73	164.00	133.12	225.47	257.29	156.25	180.51	170.85	182.25	290.84
2	190.89	188.64	140.50	193.21	272.31	175.50	150.02	143.61	210.89	240.89	173.17	163.65	131.76	222.71	254.51	153.25	177.32	168.22	178.20	289.11
3	193.60	*	140.89	194.51	*	176.43	149.07	144.50	213.21	238.60	170.00	162.63	130.07	223.19	253.53	153.18	*	158.23	177.30	*
4	195.50	180.52	141.41	195.48	273.23	176.43	150.01	144.50	216.75	239.50	171.76	163.55	130.92	225.03	254.52	152.12	180.53	169.45	177.32	282.77
5	196.79	187.28	142.29	196.40	276.37	177.24	150.49	143.63	215.03	239.51	173.21	165.02	131.42	226.33	254.55	154.46	181.30	170.51	178.20	234.10
6	190.71	180.80	143.32	197.70	280.04	175.90	151.81	145.60	214.33	240.31	173.42	166.03	132.71	229.74	255.90	155.53	181.42	171.32	179.53	285.05

Blood smears showed presence of Babesia parasites.

## APPENDIX 4:

## Individual Fortnightly Liveweights (kg) In Experiment 2

FORT- NIGHT	<u>GROUP A</u> animal					<u>GROUP B</u> animal					<u>GROUP C</u> animal					<u>GROUP D</u> animals				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	223.64	254.55	152.73	241.82	162.73	204.55	196.36	200.00	240.91	192.73	183.64	184.55	171.92	242.73	230.91	200.00	208.18	201.82	210.91	229.09
1	225.45	259.09	155.45	247.73	164.55	208.18	200.91	202.73	244.55	197.27	182.27	185.45	173.64	246.36	223.64	209.09	212.73	204.55	217.73	241.81
2	232.73	263.64	158.64	251.82	166.18	211.36	204.55	205.91	248.64	204.55	182.73	189.55	176.82	250.45	226.36	221.36	219.55	215.45	226.36	253.64
3	241.82	269.55	162.73	256.36	171.82	214.55	208.18	210.00	251.82	210.45	182.73	193.64	178.64	240.91	228.64	232.27	233.64	226.82	235.45	270.45
4	244.55	274.55	164.55	265.45	175.00	219.09	211.36	214.55	255.45	215.45	183.64	187.27	180.91	245.45	230.91	241.82	238.18	235.45	244.55	284.55
5	250.00	280.00	170.00	275.91	178.18	222.73	215.45	230.00	259.55	224.09	185.45	188.18	183.18	249.09	233.64	254.55	245.45	242.73	253.64	294.55
6	263.64	289.09	172.73	286.36	181.82	226.82	220.00	227.27	265.45	234.09	188.18	190.00	186.82	253.64	236.36	262.27	253.64	248.18	263.18	307.27

\* Blood smears showed presence of Babesia parasites

APPENDIX 5: Percent Chemical Composition of the Refusals<sup>1,2</sup> in Experiment 1.

I T E M (%)	D I E T			
	A	B	C	D
Dry Matter	67.72	69.14	65.30	72.05
Crude Protein	14.09	21.61	16.08	22.00
Ether Extract	6.23	7.61	2.92	1.91
Crude Fibre	28.27	21.26	30.61	23.33
Ash	13.81	12.83	6.05	8.11
Nitrogen-free Extractives	37.50	36.69	44.34	44.65
Gross Energy (Kcal/g)	5.36	5.4	5.42	5.00
Calcium	1.11	1.10	0.83	0.72
Phosphorus	0.61	0.90	0.52	0.71
Theobromine	1.52	0.96		

<sup>1</sup> All components, except Dry Matter, expressed on DM basis.

<sup>2</sup> Average of 4 determinations each.

APPENDIX 6: Percent Chemical Composition of the Refusals<sup>1,2</sup> in Experiment 2.

I T E M (%)	D I E T			
	A	B	C	D
Dry Matter	61.88	61.75	33.79	74.31
Crude Protein	14.67	14.59	14.87	15.05
Ether Extract	3.16	1.52	1.05	1.99
Crude Fibre	23.33	31.61	35.24	13.18
Ash	13.08	10.34	8.24	6.86
Nitrogen-Free Extractives	45.76	41.94	40.60	62.92
Gross Energy (Kcal/g)	4.26	4.38	4.42	4.33
Calcium	1.07	0.86	0.63	0.94
Phosphorus	0.59	0.46	0.58	0.74
Theobromine	0.26	0.15		

<sup>1</sup> All components, except Dry Matter, expressed on DM basis.

<sup>2</sup> Average of 4 determinations each.

APPENDIX 7: Percent Proximate Chemical Composition of the Feces from Individual Bullocks in Digestibility Study 1.

RATION	BULLOCK	DM	CP	NE	CF	Ash	NFE	Energy <sup>2</sup>
A	1	28.89	15.30	2.20	30.11	8.81	36.75	5.02
	2	27.61	15.01	1.93	31.02	8.70	39.10	5.31
	3	27.27	14.95	1.42	31.71	7.55	38.62	5.40
	4	27.25	15.02	1.60	32.80	9.20	38.12	5.13
	5	27.50	15.30	2.60	32.31	9.31	37.70	5.61
B	1	29.61	15.32	2.01	31.10	12.71	31.82	5.46
	2	28.33	15.70	1.84	29.85	11.83	33.90	5.51
	3	27.85	15.23	2.00	34.20	13.70	32.91	5.50
	4	28.81	15.71	2.51	30.11	14.00	27.75	5.90
	5	29.80	14.46	2.70	35.01	13.72	34.11	5.24
C	1	17.00	7.83	1.01	33.90	9.75	47.63	5.43
	2	16.83	8.11	0.95	32.63	10.30	48.01	5.64
	3	17.21	8.41	1.31	32.23	10.81	47.35	5.81
	4	14.80	6.68	2.31	36.00	8.61	46.51	5.90
	5	15.11	7.31	1.94	34.61	9.32	47.01	6.61
D	1	15.74	9.10	1.13	32.05	9.42	47.23	5.73
	2	16.40	7.56	1.31	33.11	9.46	48.81	6.00
	3	15.55	7.83	1.05	32.21	9.60	48.63	6.90
	4	15.72	8.11	1.82	32.12	9.42	46.55	6.22
	5	16.91	9.00	2.10	33.90	9.80	45.26	6.71

1 All components, except DM, expressed on DM basis.

2 Expressed as Kcal/g of DM.

APPENDIX 8: Percent Proximate Chemical Composition of faeces from individual Bullocks in Digestibility Study.

DIET	BULLOCK	DM	CP	EE	CF	Ash	NFE	Energy <sup>2</sup>
A	1	28.10	13.35	1.30	24.83	11.99	38.53	4.60
	2	27.53	14.02	1.52	23.65	13.80	47.01	4.28
	3	30.30	13.65	1.20	25.48	11.24	48.23	4.45
	4	28.38	14.03	2.07	26.09	12.19	49.62	4.58
	5	29.03	14.10	2.64	25.93	12.92	44.41	4.49
B	1	25.91	12.70	2.23	27.94	11.61	45.52	4.42
	2	23.04	11.85	1.89	26.95	11.78	47.55	4.30
	3	23.28	12.23	1.25	27.77	12.49	46.26	4.39
	4	23.30	11.19	1.37	26.45	9.82	51.17	4.34
	5	26.01	13.07	1.92	28.06	10.89	46.06	4.37
C	1	18.02	7.60	1.82	29.07	11.65	49.86	4.39
	2	20.39	9.08	1.29	28.16	12.47	49.00	4.39
	3	19.21	10.09	1.20	30.26	15.12	43.23	4.59
	4	19.26	9.19	2.26	31.33	12.13	45.09	4.51
	5	21.94	9.65	2.32	31.62	10.17	46.24	4.59
D	1	25.44	15.11	3.02	15.65	11.39	51.83	4.44
	2	26.40	13.51	4.94	14.67	11.47	55.41	4.58
	3	26.97	13.57	5.92	15.95	12.06	52.50	4.44
	4	26.53	14.38	3.00	14.79	11.98	55.85	4.39
	5	25.46	14.88	4.62	15.09	10.13	55.28	4.37

1 All components, except DM, expressed on DM basis.

2 Expressed as Kcal/g of DM.

TABLE 3: Total Dry Matter Consumed and that eliminated in the faeces of individual bullocks during Digestibility Study 1.

Ration	Bullock	DW Consumed (kg)	DW Eliminated in Faeces (kg)
A	1	42.88	33.21
	2	34.79	26.94
	3	26.00	19.56
	4	36.55	26.41
	5	43.57	31.94
B	1	26.91	13.71
	2	40.73	21.97
	3	23.76	12.72
	4	33.09	17.52
	5	38.14	16.26
C	1	22.72	9.09
	2	21.48	8.04
	3	20.24	6.49
	4	24.57	10.77
	5	27.91	10.53
D	1	21.09	8.13
	2	21.91	7.09
	3	19.73	8.03
	4	20.33	8.39
	5	25.83	8.14

TABLE 10:

Total Dry Matter Consumed and that Eliminated in the Faeces of Individual Bullocks during Digestibility Study 2.

Ration	Bullock	DM Consumed (kg)	DM Eliminated in Faeces (kg)
A	1	57.89	31.10
	2	49.95	26.49
	3	35.27	18.23
	4	55.05	28.59
	5	23.87	12.40
B	1	33.66	18.16
	2	33.46	17.76
	3	32.99	15.90
	4	36.09	17.70
	5	30.29	14.76
C	1	15.61	6.02
	2	14.61	5.91
	3	19.09	8.05
	4	22.36	8.98
	5	21.64	8.56
D	1	39.42	11.05
	2	38.88	10.15
	3	35.51	9.45
	4	33.77	9.60
	5	50.59	14.26

Table 11: Coefficient of Apparent Digestibility, Digestible Energy and Total Digestible Nutrients determined in Individual Bullocks in Digestibility Study 1.

RATION	BUL- LOCK	DM (%)	CP (%)	St (%)	CF (%)	ash (%)	Fib (%)	Energy (%)	DE (kcal/kg)	TDN (%)
A	1	22.55	34.33	69.75	16.53	56.57	13.26	16.92	0.81	23.89
	2	22.56	36.08	73.96	14.09	57.50	6.81	11.11	0.53	21.93
	3	24.77	38.11	80.56	14.59	64.49	10.23	12.50	0.59	24.38
	4	27.74	41.31	79.10	15.10	58.70	14.40	19.64	0.93	26.28
	5	26.69	36.15	66.53	15.20	57.16	15.16	10.89	0.52	24.41
B	1	49.05	69.74	80.43	17.12	48.82	56.70	45.08	2.12	51.93
	2	40.06	66.89	81.40	16.24	49.61	51.12	39.20	1.93	49.09
	3	55.77	73.57	83.44	21.34	51.79	61.08	50.00	2.47	55.73
	4	47.05	67.61	74.14	17.01	41.24	60.79	36.42	1.80	52.15
	5	57.57	75.98	77.61	22.13	53.64	61.18	54.84	2.70	55.80
C	1	59.99	83.23	87.67	50.48	36.23	57.34	59.04	3.23	61.61
	2	62.57	84.03	90.00	54.91	36.64	59.79	61.21	3.30	63.74
	3	67.93	85.64	87.88	61.79	42.62	66.04	66.06	3.56	68.61
	4	56.17	84.46	68.34	42.58	37.58	54.37	51.52	2.78	56.43
	5	62.27	85.14	77.53	52.60	42.01	60.35	53.64	2.89	62.67
D	1	61.45	83.07	87.67	37.76	41.67	63.52	64.34	3.74	62.19
	2	67.64	88.35	88.00	46.22	51.80	68.14	67.67	3.94	65.31
	3	59.30	84.60	88.24	33.93	37.90	60.20	53.78	3.13	60.16
	4	58.73	83.81	79.17	32.75	37.30	61.61	56.40	3.40	59.80
	5	66.49	86.46	80.23	47.13	52.10	71.02	64.94	3.78	67.96

## APPENDIX 12:

Coefficient of Apparent Digestibility, Digestible Energy and Total Digestible Nutrients determined in Individual Animals in Trial 2.

RATION	BUL- LOCK	DE (%)	CP (%)	EE (%)	CF (%)	Ash (%)	SP2 (%)	Energy (%)	DE (kcal/g)	TDN (%)
A	1	46.28	57.70	72.79	38.78	33.35	46.28	45.25	1.88	45.21
	2	36.97	56.51	68.00	42.20	38.82	48.83	47.93	2.08	46.68
	3	48.31	57.93	75.28	39.45	45.19	48.72	44.40	2.06	46.72
	4	48.07	57.11	57.55	37.68	40.61	45.48	52.92	2.30	43.53
	5	48.03	57.42	44.07	37.46	42.65	52.78	46.15	2.01	45.21
B	1	46.05	60.65	57.45	42.71	37.76	46.37	45.95	2.02	46.13
	2	46.92	64.04	63.83	45.51	38.35	44.98	48.30	2.13	47.21
	3	51.79	66.08	78.02	49.49	37.42	51.16	51.72	2.28	52.23
	4	50.97	68.47	76.24	50.89	37.41	45.12	51.57	2.27	50.20
	5	51.29	63.65	67.44	47.73	39.01	41.19	51.13	2.25	46.15
C	1	61.43	82.90	68.57	56.25	27.84	62.96	57.38	2.34	64.31
	2	59.55	78.57	76.47	55.85	19.98	61.74	55.17	2.25	62.37
	3	57.83	74.92	75.61	52.71	29.70	63.79	51.32	2.09	61.72
	4	59.83	77.98	58.33	53.71	20.84	63.87	53.56	2.27	62.69
	5	60.44	77.07	55.56	54.76	24.42	63.03	55.17	2.25	62.39
D	1	71.96	74.96	68.27	55.75	49.60	76.34	71.51	3.12	72.03
	2	73.89	78.15	49.49	59.12	52.07	76.56	71.43	3.12	73.23
	3	73.38	78.81	40.43	56.61	51.49	76.53	73.08	3.19	74.40
	4	71.58	76.00	67.78	53.80	49.12	75.60	71.62	3.13	71.58
	5	71.82	75.18	50.00	57.68	53.55	75.99	71.95	3.14	72.06

APPENDIX 13: Carcass data on Individual Bullocks  
Slaughtered in Experiment 2.

CARCASS TRAIT (kg)	GROUP	ANIMAL		
		1	2	3
Pre-slaughter shrink weight	A	260.00	236.34	259.09
	B	200.91	231.82	215.91
	C	216.36	230.00	170.00
	D	233.64	236.18	286.36
Warm carcass weight	A	141.36	131.26	135.91
	B	110.91	129.09	114.09
	C	112.27	112.73	87.27
	D	132.27	138.18	162.73
Chilled carcass weight	A	139.55	130.91	135.45
	B	106.18	127.27	112.27
	C	110.45	111.82	86.82
	D	131.82	137.27	151.36
Weight of the chuck	A	34.35	29.90	31.35
	B	27.70	28.20	27.40
	C	28.10	29.25	20.70
	D	29.50	32.35	36.90
Weight of the Rib	A	13.10	13.80	13.85
	B	9.45	13.15	11.10
	C	9.25	9.75	7.40
	D	13.00	12.05	14.15
Weight of the Loins	A	15.10	15.00	13.85
	B	13.40	15.15	10.45
	C	12.40	12.80	11.00
	D	12.80	15.55	17.95
Weight of the Round	A	40.85	39.45	40.35
	B	32.39	38.20	37.50
	C	33.75	34.10	26.00
	D			

APPENDIX 14: Source and Unit Costs of Feed  
Ingredients at time of Experiment<sup>1</sup>.

Ingredient	Source	Unit	Unit Price (cedis)
Cocoa Husk <sup>2</sup>	1. Cocoa Research Institute - Tafo. 2. Univ. of Ghana's Agricul. Res. Station - Kade.	-	Free of Charge
Sugarcane bagasse	Local Gin Distillers in and around Kpong	5-ton truck full	10.00
Yellow corn	University of Ghana's Agricul. Research Station, Legon.	100kg	28.00
Wheat bran	Tema Food Complex Corporation	(40.9kg)	5.00
Groundnut cake	GHEOC Vegetable Oil Mill - Accra	1 tonne	486.78
Urea	Univ. of Ghana, Agricul. Res. Station - Legon.	75kg	Fee of Charge
Molasses	Ghana Sugar Estate Ltd., Accra	1 tonne	334.50
Bone meal	Vetrico	51kg	68.00
Common salt	Univ. of Ghana, Agricul. Res. Station - Legon	92.73kg	18.54
Vit. D Crumbles	University of Ghana's Agricul. Res. Station, Legon.	16kg	25.00
Mineral Lick	University of Ghana's Agricul. Res. Station, Legon.	1 block	6.00

<sup>1</sup> Cost of grinding was ₵2.00 per a bag of 100kg.

<sup>2</sup> Cost of transportation was ₵0.15 per km.

