

Research Methodology for Livestock On-Farm Trials

Proceedings of a workshop held at
Aleppo, Syria, 25–28 March 1985

يحيوي هذا الكتاب ملخصات باللغة العربية



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IDRC-242e

Research Methodology for Livestock On-Farm Trials : proceedings
of a workshop held at Aleppo, Syria, 25-28 March 1985. Ottawa,
Ont., IDRC, 1985. 313 p. : ill.

/Livestock/, /animal nutrition/, /on-farm research/, /research
methods/ - /animal breeding/, /forage crops/, /feed/, /cattle
production/, /appropriate technology/, /innovations/,
/experiments/, /research programmes/, /conference report/, /list
of participants/.

UDC: 636:001.5

ISBN: 0-88936-446-X

Microfiche edition available

Il existe également une édition française de cette publication.

هذا الكتيب متوفر باللغة العربية

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Editors: Thomas L. Nordblom, Awad El Karim Hamid Ahmed,
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no. 02

14 I 1988

Cosponsored by the
International Center for Agricultural Research in the Dry Areas
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International Development Research Centre

Abstract This document contains 12 studies describing methods used in the conduct of livestock on-farm trials (LOFTs), primarily in the Middle East/Africa regions. Also presented are five methodological summaries that reflect on main issues covered in the 12 studies and discussed at the LOFT workshop: (a) definition of research problems, (b) trial design for on-farm experimentation, (c) levels of farmer participation, (d) criteria for evaluation, and (e) future directions for LOFTs. The 40 authors and coauthors have worked in multidisciplinary teams as social and biological scientists conducting livestock research in direct cooperation with farmers. Animal classes (sheep, goats, beef, and dairy) and modes of production (farm, feedlot, and open range) differed across the studies, but all emphasized research methods used to test new technologies through LOFTs. There was consensus that LOFTs will never replace laboratory and on-station livestock research. Rather, LOFT is a complementary research mode that may be used to best advantage where questions revolve around livestock interactions with particular farming environments or on the acceptability of new livestock technologies by farmers.

Résumé Cet ouvrage présente 12 études qui décrivent les différentes méthodes de recherche utilisées essentiellement dans les régions du Moyen-Orient et de l'Afrique pour des essais d'alimentation sur le bétail. On présente aussi cinq résumés méthodologiques qui font écho aux principales questions soulevées dans les 12 études et discutées à l'atelier : (a) définition du problème, (b) choix d'un modèle d'expérimentation sur le terrain, (c) niveaux de participation des exploitants, (d) critères d'évaluation et (e) orientations pour l'avenir. Les 40 auteurs et coauteurs ont travaillé au sein d'équipes multidisciplinaires à titre de spécialistes des sciences sociales ou de biologie effectuant des recherches sur le bétail en collaboration directe avec des exploitants. Les systèmes de production animale (mouton, chèvre, boeuf, produits laitiers) et les modes de production (exploitation agricole, parc d'engraissement, grand pâturage) diffèrent d'une étude à l'autre mais portent surtout sur les méthodes de recherche utilisées pour mettre à l'essai de meilleures technologies d'élevage du bétail. Les auteurs et coauteurs étaient unanimes à l'effet que les essais d'alimentation sur le bétail ne remplaceraient jamais la recherche en laboratoire et la recherche appliquée sur le bétail. Ces essais constituent plutôt un mode de recherche complémentaire particulièrement utile lorsque des questions portent sur des interactions entre le bétail et des milieux d'exploitation particuliers ou sur l'acceptation de nouvelles technologies d'alimentation du bétail par les exploitants.

Resumen Este documento recoge 12 ponencias sobre los diversos métodos empleados en los experimentos con ganado en fincas (LOFT), principalmente en el Medio Oriente. Presenta además, cinco resúmenes metodológicos de los temas más importantes presentados en los 12 estudios, a saber : (a) definición del problema; (b) diseño de ensayos experimentales en fincas; (c) niveles de participación de los agricultores; (d) criterios de evaluación; y (e) perspectivas futuras. Los 40 autores y co-autores han trabajado en equipos multidisciplinarios como especialistas en ciencias biológicas y sociales, realizando investigación sobre ganado con la participación de los agricultores. Las clases de animales (ovino, caprino, ganado de carne o leche) y los modos de producción (campo abierto, parcela o hacienda) difieren en los estudios, pero todos hacen énfasis en los métodos de investigación empleados para someter a prueba las nuevas tecnologías mediante LOFT. También debemos señalar que hubo consenso general en cuanto a que los LOFT no reemplazarán nunca la investigación pecuaria hecha en las estaciones especializadas, pero se estuvo de acuerdo en que es un modo investigativo complementario que puede usarse con beneficio cuando los interrogantes se centran en torno a las interacciones del ganado con los medios agrícolas particulares o con la aceptación de las nuevas tecnologías por parte de los agricultores.

CONTENTS

Foreword	5
Introduction	9
Livestock On-Farm Trials	13
Survey and on-farm trials in private beef cattle finishing feedlots in the Khartoum area Saad El Medani Ahmed, Tagel Sir Ahmed Mohamed, and Mahgoub Gaafar El Hag	15
Feeding conserved forages to traditional cattle in the Nuba Mountains, Sudan W. Trent Bunderson and Richard H. Cook	41
Developmental approach to on-farm research: pilot project for improving small ruminant production in humid West Africa Akwesi Atta-Krah	65
Farmers' responses to three summer forages in the Nile Delta I.M. Soliman, E.A. Khafagi, M.E. Saleh Youssef, M.K. Hathout, and A.A. Moussa	83
On-farm trials with dual-purpose goats on small farms in Western Kenya A.E. Sidahmed, J.F.M. Onim, A.W. Mukhebi, R.S. Shavulimo, A.J. De Boer, and H.A. Fitzhugh	101
Design and implementation of in-herd/on- range trials: use of sentinel herds B. Fadlalla and Richard H. Cook	133

On-farm trials of mineral supplementation for small ruminants in West Java, Indonesia J.E. van Eys, S. Silitonga S., I.W. Mathius, and W.L. Johnson	153
On-farm trials with ammoniation of straw in Egypt H. Yackout, M.K. Hathout, H. El Nouby, and T.J. Barker	173
Irrigated summer forages for small dairy farms in the Rahad Agricultural Scheme (Sudan): on-farm trials R.S. Modawi, A.Y.M. Nour, A.H. Ahmed, A.B. Mohamed, and A.E.S. Ibrahim	191
On-farm trials in Northwestern Syria: testing the feasibility of annual forage legumes as grazing and conserved feed Dennis Tully, Euan F. Thomson, Ronald Jaubert, and Thomas L. Nordblom	209
Use of crossbred dairy cows as draft animals: experiences from the Ethiopian highlands Guido Gryseels and Frank M. Anderson	237
Beef production from Sudanese cattle fed diets based on agroindustrial by-products: trials in private feedlots A.Y.M. Nour and F.A. Hamza	259
Methodological Summaries	275
Definition of research problems H.C. Knipscheer	277
On-farm trial design J.E. van Eys	283
Levels of farmer participation J.A. Kategile	289
Criteria for evaluation R.H. Cook	297
Directions for future trials Frank M. Anderson	303
Participants	311

**BEEF PRODUCTION FROM SUDANESE CATTLE FED
DIETS BASED ON AGROINDUSTRIAL BY-PRODUCTS:
TRIALS IN PRIVATE FEEDLOTS**

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Abstract Traditionally, cattle feedlot operators (CFO) in the central region of Sudan finish their cattle for slaughter on diets made from sorghum grains and cakes. They prefer their diets to those prepared by the Kabaroo tenants union feed mill, which contains 50% wheat bran. Although inexpensive, it was rejected by CFO and this caused serious marketing problems for Kabaroo. For the producers, grain and cake prices skyrocketed. Their margin of profit narrowed and some operated at a loss. The objective of this work was to produce an inexpensive alternative of nutritionally balanced diets processed by Kabaroo that would capture the interest of CFO and fetch a better market than the old Kabaroo diet.

An informal survey was carried out and 10 out of 80 CFO were interviewed. The Kabaroo mill was visited and trials on their diet were made with no success. New diets were suggested, including a warming-up diet high in protein and a finishing diet high in energy and processed by Kabaroo. Arrangements were made and Kabaroo sold two of the CFO feeds at cost price. One of the CFO continued the experiments and trials were made on his feedlot. Cattle were randomly divided into two groups, one group was fed the CFO diet and the other received the new diets. Intake was monitored and days on feed were recorded and the degree of finishing was assessed subjectively. It took the group on the new diets 25 days longer, but the cost of feeding was less than the CFO diet.

The CFO ordered another 100 t from the warming-up diet. It was planned to replicate the experiment, however, because of the drought, a new feeding strategy was proposed. Three more CFO joined in and cattle were fed crop residues until the market conditions improved. Feeding grains to cattle is now prohibited because grains are needed by the human population. New diets based on alternative sources of energy were proposed. On-feedlot trials were planned and arrangements were made with Kabaroo. Diets will be critically evaluated using objective measurements of animal performance.

Résumé Selon la tradition, les exploitants de parcs d'engraissement (EPE), dans le centre du Soudan, assurent la finition des animaux de boucherie avec des rations composées de grains et de tourteaux de sorgho. Or ils préfèrent utiliser leurs propres rations plutôt que celles préparées par la minoterie de l'association des fermiers de Kabaroo, qui contient 50 % de son de blé. Bien que peu coûteuses, les rations de Kabaroo ont été refusées par les EPE, un refus qui a causé de sérieux problèmes de marketing à l'association. Le prix des grains et des tourteaux payé par les producteurs a monté en flèche. Leur marge de profit a diminué et certains ont travaillé à perte. L'objectif de la présente recherche a été de produire des rations substitutives, peu coûteuses, et nutritionnellement équilibrées, qui seraient préparées par Kabaroo et seraient susceptibles d'intéresser les EPE et d'avoir un meilleur marché que l'ancienne ration Kabaroo.

On a donc effectué un sondage informel et interviewé 10 des 80 EPE. On a visité la minoterie Kabaroo et fait l'essai de sa ration, mais sans succès. On a donc proposé de nouvelles rations, y compris une ration de réchauffement à teneur élevée en protéine et une ration de finition hautement énergétique, qui ont été préparées par Kabaroo. Suite à des arrangements avec l'association, celle-ci a vendu deux rations des EPE à prix coûtant. L'un des EPE a accepté de poursuivre l'expérience et des essais ont eu lieu dans son parc. Après avoir divisé aléatoirement le bétail en deux groupes, on a utilisé la ration des EPE pour l'un et les nouvelles rations pour l'autre. On a observé la consommation, enregistré le nombre de jours pendant lesquels les rations ont été administrées et évalué le degré de finition pour chaque sujet. Le groupe ayant

reçu les nouvelles rations a mis 25 jours de plus pour atteindre le point de finition, mais le coût de la finition a été inférieur à ce qu'il aurait été si la ration des EPE avait été employée.

Les EPE ont commandé un autre 100 t de la ration de réchauffement. On avait prévu de refaire l'expérience. Cependant, à cause de la sécheresse, on a proposé une nouvelle stratégie alimentaire. Trois autres EPE ont rejoint l'équipe des essais, et le bétail a été nourri avec des résidus de récoltes jusqu'à ce que le marché s'améliore. La distribution de céréales au bétail est maintenant défendue, celles-ci étant réquisitionnées pour l'alimentation humaine. De nouvelles rations composées de substituts énergétiques ont été suggérées, des essais dans les parcs prévus, et des arrangements avec Kabaroo conclus. Les rations doivent être scientifiquement évaluées à l'aide de mesures objectives de la performance des animaux.

Of the total domestic farm animals in Sudan (cattle, sheep, goats, and camels), cattle make up more than 35% (18×10^6) of the total. Cattle are raised by pastoralists who migrate with their herds in search of feed and water. More than 48% of the total cattle population is found in the Darfur and Kordofan regions of western Sudan. Cattle in these regions are predominantly of the western Baggara types. They make up 80% of the northern cattle population and provide the country with most of its beef requirements. Furthermore, they are the principal type of cattle exported. These cattle are shorthorn Zebu with body colours that range from white to dark red and dark brown. These cattle are mostly driven on the hoof when grasses are available on their routes. Recently, special livestock trains were also used for transportation of cattle to the major marketplaces in Omdurman and Wad Medani around which traditional and semimodern private feedlots are situated.

Cattle rearing, especially for those that are considered to be the major beef types (western Bagara), is mostly dependent on natural grazing. In local feedlots, crop residues and concentrate feeds are fed to cattle to finish them for slaughter or export. Other types of cattle such as the Kenana and Butana are kept mostly for their milk and are fed mainly

on irrigated forages supplemented with concentrates. Others, such as Umbaroro, Nilotic, and Dwarf cattle contribute to the local-market beef supply with very few used for export. Cattle on the range experience seasonal shortages of feeds that adversely affect live-weight gains, especially during summer. Such cattle require more intensive feeding in the feedlot. Cattle transported to the marketplaces are mainly finished for slaughter on grains, wheat bran, and oil cakes for 60-90 days. Animals destined for export will enter a fattening period the length of which depends on their condition and the requirements of the external market. Those sold for the local market are either slaughtered after grass feeding if they are in a good condition or fattened for a variable period that may extend to 120 days depending on their condition and expected selling price.

According to the Livestock Meat and Marketing Council (LMMC) (LMMC, personal communication), the producer price represents only 48% of the consumer price per head, whereas various duties and taxes represent 11% of the consumer price and the remaining 41% is accounted for by profit margins and the commission of various middlemen (AOAD 1982). However, feed costs account for 50% of the total inputs. The profit margin can be very narrow if prices of feeds increase. This has been especially true during the past 2 years when the shortage of grain forced the producers to rely heavily on oil cakes and brans. In addition, the competition for the exportation of oil cakes made their prices as cattle feeds skyrocket. The shortages of grains last year limited their use for cattle feeding except for those destined for export.

During 1985, grain production was low to the extent that it was unavailable even for the poultry industry. The prices increased five times over the previous year (1984). Also, sorghum grain (dura) feeding is not feasible in a country where dura constitutes the staple diet of the human population. The situation was aggravated by the drought and resulted in a decline in grain production by 1.5 t from the 1984 total grain production. Because energy is needed to raise and fatten cattle, alternative sources must be sought if cattle producers are to remain in business.

Cattle prices in the central markets (Omdurman and Wad Medani), before and after finishing, are affected mainly by the seasonal fluctuations in the supply of cattle. Cattle prices also increase due to the present high inflation experienced by the Sudanese economy (AOAD 1982).

The major beef-production systems are those of the Nomads complemented by fattening operations around Omdurman and Wad Medani. The current practice is to leave cattle on bare land on the outskirts of these towns and feed them on grains and agroindustrial by-products.

The condition of cattle coming from the range varies considerably depending on rainfall, the nutritive value of pasture grasses and legumes, the length of the journey to the marketplaces, and internal parasites and diseases. Cattle heading toward marketplaces are usually vaccinated against infectious diseases such as anthrax, rinderpest, haemorrhagic septicaemia (HS), and black quarter (BQ). However, in the feedlots they are not drenched with antihelminthic or sprayed against ticks. When fed during the rehabilitation period, animals experience compensatory gains before entering the fattening stages. A well-balanced diet is necessary to make decent gains, and profit depends on the efficiency of the whole operation and particularly on the initial cost of the cattle, availability and cost of feed, quality of feed gains, losses during transportation and feeding, related duties and other costs, and selling price.

Marketing channels are still dominated by wealthy merchants through a network of financial and personal contacts. Currently, LMMC provides market information and transport and is currently trying to adopt an auction system for marketing. Because of the general inaccessibility, however, to credit and capital, trading remains in the hands of the large merchants. Nevertheless, small producers have started to participate in the marketing process. The total capital of these producers is limited and they must rely on personal contacts to provide credit. They cannot afford to lose money, but this is inevitable when the price of feed rises sharply and there are no alternative feeding strategies to fall back on. A thorough knowledge of nutrition is, therefore, most helpful.

PROBLEM IDENTIFICATION

Recently, a general feed-processing industry was established. The first feed mill was established in 1970, and the number of feed mills increased gradually until the mid-70s when the number reached 27. The main purpose of the feed mills is to formulate least-cost rations for different production functions including poultry production and dairy and beef cattle fattening.

Poultry feeds, because of the several ingredients needed to meet their exacting requirements, gained popularity. However, the demand for processed feeds for finishing cattle is very low. This is because animals are either slaughtered off the range or are traditionally finished on ingredients such as dura, cakes, and brans. Traditional livestock producers believe that their cattle can perform better on their own blends than when fed feeds from the feed mills. In most cases, the feed they blend for their cattle is poorly balanced, some are low in protein and high in energy or high in protein and low in energy and are fed irrespective of the animal's needs. Some are even fed straight cottonseed cakes. Sorghum straw is usually fed as a filler.

The feed processed by the mills is generally formulated without the benefit or advice of an animal nutritionist. But even though some mill operators claim to follow scientific standards, the drawback is that they are formulated using exotic standards because the requirements of Sudanese cattle are not known.

Furthermore, because there is no quality control for feeds in the country, emphasis is on profit, which most of the time is at the expense of quality. At the feed mills, they are generally not inclined to conduct field trials on their diets. This is especially true for the Kabaroo feed mill near Hesahiesa in the central region. The mill was established as a sister plant to the Gezira and Managil tenants union's flour mill to make use of flour milling by-products, mainly wheat grain rejects and bran.

The Kabaroo feed mill produces a broad spectrum diet (Table 1) claimed to be useful for different production functions such as growth, fattening, and

Table 1. Ingredient composition of different diets (%).

Diet/ingredient	K	SWU	AWU	Finishing	P
Sorghum grains	-	-	-	-	20
Wheat grain rejects	25	25	25	32	-
Cottonseed cake (undecorticated)	15	33	33	28	60
Wheat bran	50	22	32	28	20
Molasses	9	7	7	9	-
Sorghum straw	- ^a	10	- ^a	- ^a	- ^a
CaCO ₃	-	2	2	2	-
Salt (NaCl)	1	1	1	1	-

Note: K = Kabaroo diet, SWU = suggested warming-up diet, AWU = actual warming-up diet, and P = producers' diet.

^aWith other diets sorghum straw is used as a filler.

dairy production. This feed is sold at a low price to livestock producers around Wad Medani and it often caused digestive disturbances and some fatalities were reported. It was, therefore, rejected by livestock producers and owners in the area, which created a serious marketing problem for Kabaroo feeds.

IDENTIFICATION OF THE BENEFICIARY AND PRODUCTION-ASSOCIATED PROBLEMS

Private Feedlot Operators

Survey

An informal survey was carried out where 10 of the 80 private feedlot operators around Wad Medani were interviewed. These 10 were selected at random after an initial visit to all feedlots. The operators expressed their willingness to cooperate because they were interested in cheaper diets. Several questions were asked in the interview including:

(a) What is the average number of cattle fed in each feedlot in each feeding cycle? What is the origin of the cattle, mode of transportation, and condition of cattle upon arrival?

(b) What is the purchase price and how long do cattle stay in the feedlot before being ready for market?

(c) Do you sell your cattle to the local market or to merchants who export them? Do you export cattle yourself?

(d) What are the feeds that you usually give your cattle? Do you always use them? What makes you decide on the type of feed? Do you receive any subsidies or free services? Do you use any supplements (minerals, etc.)?

(e) What are the methods used for assessing the degree of finishing or how do you judge that the animal is ready for the market? Do you sell on a weight basis? Do you feel that you are making a decent margin of profit? If no, what are the problems?

(f) Do you use any measures for disease control and prevention (infectious diseases, internal and external parasites, skin diseases, etc.)?

(g) Do you feel that you need to try a new diet if we are able to suggest diets and if the incentive is there and are you willing to use your own resources to try?

Survey Results

(a) Most of the feedlot owners' cattle originate from western Sudan. About 80% are from Darfur and 20% are from Kordofan. One of the producers uses only Kordofan (Rahad) cattle. The size of the herd ranges from between 60 and 90, however, most of them have 80 cattle in their lots.

(b) None of the producers was willing to tell the purchase price, however, nearly all talked about costs and duties. Cattle stay in the feedlot between 60 and 90 days and some up to 109 days. However, some are slaughtered directly off the range, especially when the

pasture is plentiful. Even those slaughtered off the range require a resting period of 10-15 days during which they are fed on cottonseed cake and dura.

(c) Most of the producers sell to the local market in Wad Medani and Omdurman. Some have connections with merchants who export cattle to the Arab countries. Invariably, wherever the local market demand decreases, they sell to the Omdurman market, however, no one exports his own cattle directly.

(d) Cattle feed includes a blend of dura and cottonseed cakes. Nearly all feed contains cottonseed as the protein supplement. The proportions vary, with some feeds at a mixture of 50% each and others at 60% cake. Another group prefers a blend of grains, cottonseed cakes, and wheat bran. However, few use straight cottonseed cakes. In all feedlots, sorghum straw was used as a filler, but groundnut hull is also used. No attention was given to mineral nutrition. In only a very few cases is common salt occasionally used. No subsidies or free services of any kind are given. The only free thing is the water of the Nile to which they transport their cattle a distance of 5-7 km twice a day.

The assessment of finishing was done subjectively through the observance of the physical condition of the animal. When the flank becomes full, the hind legs are wide apart, the round and brisket are full and smooth, and the coat is glistening the animal is considered to be "ready." The producers sometimes, however, keep their cattle for an extended period until the market prices are favourable. If this additional period is overly extended, they operate at a loss. When the question of profit was discussed most say "Alhumdulillah" (thanks Allah). However, frequently they operate at a loss because grain prices often rise unexpectedly. In addition, the export of cakes adversely affects their profit margin through reduced accessibility to the cakes for finishing cattle. In these circumstances, they tried molasses and urea, blending it with dura, bran, or hulls and cakes. However, they do not like to use this because handling molasses is difficult and in a few cases excessive fermentation has led to herd loss. They also mentioned that they do not know how much urea to use in the feed. Some tried Kabaroo

feed and rejected it, even though it is inexpensive, because it caused digestive disturbances and some claimed that it caused the death of some of their cattle.

Cattle are sold as a group or individually through mutual agreement by subjective evaluation and not on a liveweight basis. Producers did admit, however, that weighing could be helpful sometimes.

Cattle are vaccinated against infectious diseases, although some operators do not wish to vaccinate at this stage. Some vaccinate for one or two diseases, especially when other vaccines were not available. None of the producers treated his cattle against ticks, but some treated skin diseases because the finished animal did not look good.

Kabaroo Feed

The available daily by-products of flour milling that are utilized by the Kabaroo feed mill are (a) 0.27 ± 0.04 t of wheat-grain reject, (b) 15.7 ± 0.55 t of wheat bran, with other by-products being sold to animal owners directly without processing. The amount of by-products depends on the quality of wheat. Wheat is bought from the local market and milled throughout the year except during June-August when imported wheat is used for milling.

In addition to wheat by-products, the Kabaroo feed includes other ingredients (Table 1). The capacity of the mill is 5 t/hour and it produces 5840 t/year. They have in store 2400 t that never find a market. At present, Kabaroo goes into production whenever there is an order for a known quantity of feed. The feed mill produces a broad-spectrum diet that is claimed to be suitable for various production functions such as milk production and growing/finishing cattle and sheep. Chemically speaking, the diet may be suitable for growing/finishing cattle according to the National Research Council (NRC) (NRC 1976) guidelines (Table 2), however, the diet has been rejected by feedlot operators and has only found limited success with the dairy producer, in spite of the available credit system. The diet causes digestive disturbances and metabolic disorders because of the high amount of fermentable carbohydrates and bran. The Kabaroo diet is prepared

**Table 2. Nutrient content of different diets
(percentage of dry matter).^a**

Diet	CP	TDN	Ca	P
Kabaroo	16	70	0.8	0.6
Suggested warming-up diet	16	60	0.9	0.8
Actual warming-up diet	17	67	0.9	0.8
Finishing diet	15	71	0.9	0.4
Producer's diet	21	54	0.3	0.4
National Research Council (NRC)	10.4	77	0.3	0.25

Note: CP = crude protein, TDN = total digestible nutrients, Ca = calcium, P = phosphorus.

^aAssuming that 1% NaCl in the diet, with the exception of the producer's diet, satisfied the requirements for these minerals.

in a pelleted form of 2 cm in diameter, which is large for cattle. Kabaroo feed, therefore, faces a serious marketing problem and the owners are concerned.

There are clearly two sets of problems: (a) finding a suitable economical diet for livestock producers that can capture their interest as a viable alternative to the expensive diets based on grains and cakes, and (b) the marketing problem for Kabaroo feeds.

OBJECTIVES OF THE RESEARCH AND APPROACH

Objectives

The major objective of this work is to suggest and test a new, nutritional, but inexpensive, diet for the feedlot operators that will offer an alternative to the diets based on grains, which are difficult to obtain and expensive for cattle feeding. The second objective was

to evaluate the Kabaroo feed and try to improve it to increase its sale and to formulate new diets that can capitalize on the milling by-products and fetch a better market price than the old diet.

Approach

After the informal survey, four out of the 10 feedlot operators expressed interest in the trials and they were, therefore, approached. After briefing them about the objectives of the work and discussing possible incentives, such as getting a diet at cost price, two decided to try it. The Kabaroo mill was also approached and an initial agreement was reached:

(a) The team (which is composed of an animal nutritionist and a feed-processing senior student) should suggest an improvement for the existing diet (2400 t).

(b) The team should suggest new alternative diets that the Kabaroo mill could process and sell to the producers at the lowest price possible.

(c) The producer, if he finds the diet satisfactory, will order 100 t at a 10% discount.

(d) The team, through personal contact, will make arrangements so the producer can buy cakes, sorghum grains, and brans for the trials at a reasonable price.

(e) Half of the cattle will be fed a diet blended by the producer and the other half will be fed the newly suggested diets for a period of 90 days.

Protocol

Formulation of the New Diet

Realizing the fact that range cattle when admitted to the feedlot experience a period of compensatory gain before fattening, a warming-up diet was suggested that would be high in proteins, >16% crude protein (CP) and low in energy, <60% total digestible nutrients (TDN), while the finishing diet would provide <15% CP and >70% TDN. Initially, the warming-up diet was suggested to have 10% sorghum straw in it, however, the straw crusher broke and instead the diet has an additional

10% of bran (actual warming up). The suggested warming-up and actual warming-up and finishing diet are presented in Table 1 and diet composition is presented in Table 2.

For the feedlot operators' diets, the producer blended his own diet and fed it to half of the group. Table 1 gives the composition of the operators' diet.

Randomization of Diets to Experimental Animals

The herd was divided into two similar groups (30 animals each) by the team and the feedlot operator. Care was exercised to ensure that there were two groups who were at a similar starting condition. Evaluation was done subjectively by the operator only. The operators' diet and the experimental diets were assigned at random to the two groups. The two groups were separated and no mixing was allowed. Each group was allowed access to water and a liberal amount of sorghum stalks. The cattle were housed on a bare piece of land, near a water canal, with no provision for shade.

Measurements of Intake and Degree of Finish

A total of 22 t from the new diets were purchased by each producer from the Kabaroo feed mill. The operators' diet was blended and weighed. Cattle were group fed at the rate of 6 kg/head per day. A liberal amount of sorghum straw (not weighed) was given as well as free access to water. The degree of finishing was assessed subjectively using the feedlot operators' experience and perception. Subjective evaluation (visual appraisal) was the criterion used by the feedlot operators in the area to assess the degree of finish.

FINDINGS

One of the producers, after purchasing 22 t of the new diet, decided to quit. This report concentrates on one producer who continued in the experiment. Initially, the new diet was not accepted by cattle but, gradually, after 10 days, they got used to it. During the first week, minor bloat was experienced by 10% of the cattle on the new diets, but they recovered quickly. After the warming-up diet was fed during the first

45 days, cattle were switched to the finishing diet. Feeding on this diet continued for another 45 days at the end of which cattle were "ready." Cattle on the operators' diet were ready after 65 days from the start of the experiment. However, the cost of feeding the new diets is substantially less than the operators' diet (Table 3). The operator bought an additional 100 t from the warming-up diet. No statistical analysis was possible.

Improvement of Kabaroo Feed

An improvement trial took place at the University of Gezira to dilute the high amounts of wheat bran and

Table 3. Comparison of per head cost of feeding between the new diet and the operators' diet (in Sudanese pounds (SDP)).^a

	New diet	Operators' diet
Cost/kg		
Warming-up diet	0.20	0.40
Finishing diet	0.22	
Intake/animal per day (kg)	6	6
Days on feed		
Warming-up diet	45	65
Finishing diet	45	
Total cost of feed over the feeding period	113.4	175.5

Note: This table shows the cost of feeding only; however, those on the new diets were fed sorghum straw for another 25 days during finishing at a cost of SDP 7.5.

^aSDP 3 = US\$1.

wheat grain rejects in the diet. The diet resulting from this process will be referred to as the supplemented diet. In the first phase of the dilution process, 9% groundnut cake and 1% bone meal were added to 90% of the original diet. In the second phase, 15% groundnut straw, 3.5% groundnut cake, 1% bone meal, and 0.5% salt were added to 80% of the diet that resulted from the first phase. The formula of the supplemented diet consisted of 10.8% cottonseed cake, 10.7% groundnut cake, 36% wheat bran, 18% wheat grain rejects, 15% groundnut straws, 6.5% molasses, 2% bone meal, and 1% salt.

The dilution process results in reduction of the percentage of the fermentable carbohydrates to 50.5% of the diet. The Qoz Kabaroo diet was in form of pellets (2-cm diameter). These pellets, as mentioned earlier, were large for cattle and resulted in reduced intake. In addition, when the diet is supplemented, as described above, and fed to growing/finishing crossbred calves, selective intake took place with the result that the supplemented materials were eaten and the pellets were rejected. To solve this problem, the study suggests that, either the whole stored stock (2400 t) be supplemented, reground, or repelleted into smaller-diameter pellets (1-cm diameter). The other alternative is to sell the stored stock at a lower price if a market can be found.

Future Research and Demonstrations in Private Feedlots

After the completion of work in the first year, the findings were discussed at a meeting that included the Kabaroo feedmill manager, the feedlot operator, and the research team. It was agreed that the trials should be assessed more critically through feedlot performance data (intake, rate of gain, feed conversion efficiency, and carcass characteristics). However, because of the drought that so seriously affected the natural cattle-producing areas, cattle owners started to sell their cattle. This significant supply of cattle affected beef prices and, hence, the feedlots did not operate on time. A new feeding strategy was then developed. A system for "storing" cattle on agricultural by-products was suggested. The feedlot operators' cattle were driven for the first time to the Rahad Agricultural

Irrigated Scheme. Arrangements were made to buy the groundnut residues and sorghum straw. The cotton fields were grazed at no charge after the cotton had been picked. Three more producers joined in. Grain feeding is now prohibited by law because sorghum grains are badly needed for the human population. The trials will continue after the appropriate storage period and arrangements are made with the Kabaroo feed mill. Diets will be evaluated more critically using objective measurements of animal performance.

Acknowledgments

Thanks are due to feedlot operator Salih Ahmed Mohamed for cooperation in this study and to the Chairman of the Board of Directors of the Gezira and El managil Tenants Union, Sayed Abdel Galil Hassan, for encouragement. Special thanks are extended to Sayed Afif and Mustafa Faris of the Kabaroo feed mill for their interest in the study and their cooperation. We are indebted to senior animal science students Khadiga Mohammed Elamin and Abbas Adam for their help during the preparation of the manuscript. Special thanks are due to Ilham Abdelrahman for her interest and help throughout the experiment. The efforts of Salwa Abuobieda in typing the manuscript are also acknowledged.

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