PROCEEDINGS

of the AAASA/ILCA Workshop on the

Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa

17 – 21 Nov. 1980, Douala – Cameroun

1985

ASSOCIATION FOR THE ADVANCEMENT OF
AGRICULTURAL SCIENCES IN AFRICA (AAASA)

PROCEEDINGS OF THE AAASA/ILCA WORKSHOP ON THE UTILIZATION OF AGRICULTURAL, FORESTRY AND FISHERIES WASTE PRODUCTS IN AFRICA

Douala, Cameroun—17-21 November 1980

RAPPORT DU SEMINAIRE DE L'AAASA/CIPEA SUR L'UTILISATION DE DECHETS AGRICOLES, FORESTIERS ET DE LA PECHE EN AFRIQUE

Douala, Cameroun—17-21 Novembre 1980

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ASSOCIATION FOR THE ADVANCEMENT OF AGRICULTURAL SCIENCES IN AFRICAN (AAASA)

SECRETARIAT

Prof. M. El-Fouly

Acting

Administrative Secretary-General
AAASA, P.O.Box: 30087, Addis Ababa, Ethiopia

Temporary Address

c/o National Research Centre, Cairo-Dokki, Egypt
Tlx.: 94022 NAREC-UN, Cable: RESEARCH-CAIRO

Hon. Ed. Secretary: A.A.Abdel-Maguid,
c/o National Research Centre, Cairo-Dokki, Egypt.

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INTRODUCTION

At a time of rising costs, developing Africa cannot afford to lose what she has produced and must even try to find ways of using again what she would have normally thrown away. Hence this workshop.

The Workshop on the Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa was held in Douala, Cameroun, from 17-21 November (1980). It was attended by more than 60 agricultural research scientists and observers from 14 African countries. In addition, there were several observers from international organizations.

It was made clear from the papers read and from the discussions that followed that some African countries had already started research on the utilization of the above-said "waste" products. The Food and Agriculture Organization (FAO) had, as early as 1977, initiated seminars and follow-up studies on the subject in question in some African countries which today are carrying out feasibility pilot experiments on the use of certain by-products. The International Livestock Centre for Africa (ILCA) which had also decided to initiate similar studies in its field of domain and mandate decided to jointly organize this workshop with a view to expanding and strengthening its project within Africa. The Workshop resulted in a fruitful discussion enabling participants to make practical resolutions and recommendations to be passed on the African governments and organizations.

The Douala workshop was the third and last in a series of workshops jointly or anized by AAASA and interested bodies on the main theme APPROPRIATE TECHNOLOGIES FOR THE DEVELOPMENT OF AGRICULTURE IN AFRICA. The three workshops were designed so as to culminate in AAASA's Fourth General Conference to be held in Cairo, Egypt, in the latter part of 1981 on the above theme.

The proceedings herein contain the papers presented, the repporteurs' summary reports and discussions held, the workshop programme and a list of all the participants for easy reference.

Prof. R.O. Adegboye
Honorary General Secretary, and Acting
Administrative Secretary-General, AAASA

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OPENING ADDRESS

BY

Madame Christine Koloko

On Behalf Of

The Minister of Agriculture, United Republic of the Cameroun

Your Excellency Prof. Abdel-Akher,

Distinguished Guests,

Ladies and Gentlemen,

It is not only an honour but also a pleasure for me to be present this morning to declare open this important workshop on the Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa, on behalf of the Minister of Agriculture. The Government of the Republic of Cameroun is grateful to both AAASA and ILCA for deciding to organize this workshop in Douala. The Government is also very pleased to pay host to all of you who have travelled from many countries of the world to Douala to participate in this workshop and wish you all every success in your deliberations.

Mr. Chairman, Distinguished Guests, Ladies and Gentlemen: It is now my singular pleasure, on behalf of the Minister of Agriculture, to declare the joint AAASA/ILCA Workshop on the Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa officially open.

Thank you.

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SPECIAL ADDRESS

BY

H.E. Prof. M. Abdel-Akher

President

Association for the Advancement of Agricultural Sciences in Africa (AAASA)

Madame Koloko,
Distinguished Guests,
AAASA Members,
Ladies and Gentlemen,

On behalf of the Executive Committee and the Entire Members of the Association for the Advancement of Agricultural Sciences in Africa, I welcome all of you heartily to this Workshop on the Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa.

Our special thanks go to His Excellency the Minister of Agriculture of the Republic of Cameroun for kindly accepting our invitation and sending a worthy representative to open this Workshop on his behalf. We sincerely thank the Camerounian Government and people for their hospitality and for providing all facilities needed to hold the workshop in Douala. We thank Prof. Bol Alima and Dr. P. Fotzo and their staff of the University of Dschang for helping in the local organization of the Workshop.

Madame Koloko, Distinguished Guests, AAASA Members, Ladies and Gentlemen: This Workshop has been organized jointly with the International Livestock Centre for Africa (ILCA) and we both take this opportunity to express our gratitude to our donors who made this workshop possible, namely, the Organization of African Unity, the Ford Foundation, SIDA/SAREC, the Agricultural Institute of

Canada and the Canadian International Development Agency as well as the individual African Governments.

The present workshop deals with an important subject on Agricultural dvelopment in Africa. It is concerned mainly with the efficient economic utilization of agricultural by products and wastes. The terms, by products and wastes by themselves, may not express fully what lie behind their meanings. But if we were to think of the other half of the plant or the other half of the farm output we could readily realize the magnitude of the problem. By this I mean the amount of the expenditure in labour and inputs which will result due to the improper utilization of farm by products and wastes.

These Wastes of the farm by products are not useless. They are rich with their valuable components of proteins, carbohydrates, mucillages, cellulose, fisheries, waxes and so on which can supply existing industries with their requirements of such raw materials. The technology of agricultural wastes and by products is now developing, and successful industries based on such by products have been established all over the world including some African countries.

In fact your full participation and contribution to the recommendations at the end of the workshop will contributes greatly to the efficient utilization of the Agricultural, Forestry and Fisheries Wastes in Africa.

We are sure that your achievements will give AAASA and ILCA, a set of practical recommendations which they can pass on to the various African Governments and the relevant policy makers for implementation and thereby improving upon the income of the farmers of Africa.

Finally, Madame Koloko, Distinguished Guests, AAASA Members, Ladies and Gentlemen: I wish you the best of luck for a successful Workshop.

Thank you.

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SPECIAL ADDRESS

BY

Dr. L. J. Lambourne

On Behalf of

The Director-General of the International Livestock Centre for Africa (ILCA)

Mr. Chairman,
Madame Koloko,
Distinguished Guests,
Ladies and Gentlemen,

On behalf of the Director-General of ILCA, I also would like to welcom you to this joint conference on: Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa.

As you may know, the International Livestock Centre for Africa is one of the International Agricultural Research Centres funded by the Consultative Group on International Agricultural Research, and has its basic mandate as the improvement of livestock production systems, rather than single commodities or factors of production. Within this context its main focus is on selected production system within the ecological zones, e.g. transhumant and sedentary systems in the arid and semi-arid zones in Mali, a sedentary pastoral system of the subhumid zone in northern Nigeria, village small ruminant production systems in southern Nigeria, and mixed farming system in the highlands of Ethiopia, Further systems-oriented research is carried out by ILCA in livestock development projects in the arid zones of Kenya, Ethiopia and Botswana.

Through an initial problem analysis, the main constraints under which the production system concerned operates are identified and quantified. These constraints may be on the plant or animal as well as on socio-economic aspects, in fact, usually they take the form of interactions between these three factors.

In all the systems ILCA is working with, seasonal deficiencies in the quantity or quality of the natural vegetation available are being quantified. As population pressure increases, bringing an expansion of the areas under cultivation, the amount of fallow and pasture land will even be more reduced in the years to come. Crop residues will, therefore, have to play an increasingly important role in sustaining Africa's livestock production. This is the reason why ILCA is cosponsoring this workshop with AAASA.

In this introductory address I would like to indicate some of the constraints on the use of crop residues, constraints which should be the subject of further research. They may be summarized as follows:

1. The availability of agro-industrial by-products is very limited. Tentative estimate by ILCA indicate that the total availability of agro-industrial by-products is only 0.23 feed unit (F.U) per livestock unit per day. Such products can, therefore, supply only 10% of maintenance requirements of the ruminant population of Tropical Africa. Even this low figure can only be rechead on the assumption that all the agro-industrial products produced in tropical Africa are used for ruminant feeding, but of course there are quite a number of other forms of utilization, as we shall hear later during this conference and, as we all know, large quantities of agro-industrial by-products are in fact already being exported.

Regional imbalances, aggrevate the availability problem. Using the same tentative estmates, the average availability in East Africa is only 0.08 F.U./L.U./day, as against 0.07 F.U./L.Y./day for Central Africa. There are also regional imbalances in quality:23.8% digestible protein on average in the Sahel US 8.4% in SouthernAfrica.

There is obviously a need to focus research on the precise determination of the availability and quality of each by-products.

The most efficient utilization in terms of animal species, time of year and amount fed, as compared with alternative uses should also be researched, rather than continuing with the present tendency for isolated experiments in which different feeding levels of a single agro-industrial by-product are tested. However, I am aware that such an approach would make experimentation very complex owing to the many alternatives involved.

The development of mathematical models might assist in a preliminary assessment of the alternatives and opportunities. It is hoped that the model now being developed by ILCA, which will be operational by the end of this year will be of assistance.

2. Most of the crop by-products are produced and consumed at farm level. To develop more efficient utilization of these products, a general understanding of the whole farming system is required in order to design relevant experiments. Such a study should include quantification of the total amounts of crop residues available compared with the total number of animals and their present nutritional intake over the different seasons, but it would also have to cover aspects such as labour and cash availability in order to determine the development options.

An example taken from ILCA's work in Nigeria illustrates this point. ILCA has found that the mere feeding of household scraps reduces mortality by approximately 300%. However, the distribution of those scraps over the different season is unbalanced and closely follows the human food availability pattern. This means that the highest amount of household scraps are given at a time of the year when the feed value of the natural vegetation is also at its optimum. Obviously, we have here a resources of great importance to a production system which is widespread in West Africa. Its utilization can be improved, but so far, almost no efforts have been made to do this.

3. A third constraint, but one for which there are promising lines for research which ILCA will like to encourage, concerns treatment. Physical and chemical treatments are very labour and energy intensive, and in view of the rising cost of energy and the foreign exchange aspects, some scepticism as regards transferability is justified. I feel, however, that a concerted effort in the field of biological treatment is justified, and ILCA will certainly encourage efforts in this direction. ILCA sees its role in this respect as a catalyst, although at this moment not directly involved in experimental work, it can contribute through training activities, the dissemination of results and by fostering further cooperation in the design and implementation of experimental work. ILCA can also act as vehicle, attracting funds from other agencies for specific projects etc.

kThese ideas are the subject of more detailed proposals which will be outlined on Wednesday when, as you can see from the programme and entire afternoon will be set aside for discussions with the ILCA staff on the possiblities of a research network on crop by-products.

Mr.Chairman, Distinguished Guests, Ladies and Gentlemen: Until then I wish you, on behalf on the Director-General of ILCA, a most beneficial stay here at the conference.

Thank you.

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EXPRESSION OF THANKS

We, the participants at the AAASA/ILCA workshop on Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa here assembled in this magnificient Conference Hall of the Caisse Cacao building in Douala express our profoundest gratitude to the Government of the United Republic of the Cameroun for not only hosting this workshop but also for the excellent facilities provided which contributed greatly to the success of the workshop.

We further acknowledge with thanks the following organizations and governments which contributed significantly to the success of the workshop: The Association of the Advancement of Agricultural Sciences in Africa, the International Livestock Centre for Africa, the Agricultural Institute of Canada/Canadian Internationl Development Agency (AIC/CIDA), the Ford Foundation, the Development Agency (SIDA), the Swedish Agency for Research Cooperation (SAREC), the United States Agency for International Development (USAID) and the various governments of Africa.

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RECOMMENDATIONS

The participants, after serious deliberations for several days in the issues involved on the Utilization of Agricultural, Forestry and Fisheries Waste Products in Africa, do hereby recommend:

A) TO THE VARIOUS GOVERNMENTS OF AFRICA THAT:

1. In view of the immense benefits to be derived from agricultural, forestry and fisheries waste products due consideration should be given to their efficient utilization for both industrial and domestic uses in all developmental plans.

2. There is an urgent need for an inventory to be taken of all available agro-industrial by-products. Such an inventory should include amounts available, seasonality of production, possible uses and any further processing necessary for their use.

3. Simple technologies for collection, handling, storage, processing, feeding of animals, of agricultural wastes and agro-industrial by-products should be developed in order to reduce costs.

4. The use of less popular or little known agricultural waste products within the various localities should be investigated so as to take appropriate steps to popularize their utilization in animal feeding.

5. There is the urgent need to integrate crop production and animal rearing so as to make efficient economic use of agricultural waste products.

6. There is the need for more research to enable the efficient multipurpose utilization of agricultural, forestry and fisheries waste products.

7. They should explore all possible means of utilising fisheries waste products for animal feeds as well as for the production of oils, fertilizer, glue, etc.

8. There is an urgent need for more research efforts in the area of animal nutrition with a view to determining suitable levels for feeding indigenous breeds of animals.

9. In order to protect users of animal feeds from agro-by-product industries, there is the need for the institution of regulations, feeding standards and control measures for commercial animal fees. In this respect, standard Boards with adequate laboratory facilities should be established.

10. They should explore the possiblity of utilising gabbage, composts and human wastes as fertilizers. In this connection, adequate precautions should be taken to reduce health hazards, especially, in case of utilization of human wastes.

11. In order to prevent environmental pollution of big cities priority should be given to municipal composting and the utilization of sewerage and sullage.

12. Due attention should be given to alternative uses of agricultural, forestry and fisheries waste products, their availability, collection, transportation, ecological and socio-economic conditions.

13. In view of the multidisciplinary nature of the foregoing recommendations, each government is urged to constitute a standing technical committee to advise it on how best to implement them.

B) TO THE VARIOUS GOVERNMENTS OF AFRICA, THE OAU, AAASA, FAO, ILCA, ECA, IITA AND DONOR AGENCIES THAT:

As a matter of urgency, a research net-work involving institutions, individual scientists and donor agencies should be set-up within the various sub-regions of Africa to investigate and see to the efficient utilization of agricultural, forestry and fisheries waste by-products for animal production, manufacture of fertilizers and other products so as to reduce the use of scarce convertible currency in their importation.

C) TO FAO:

1. That having recognized its foresightedness in setting up a research net-work involving the University of Ife, Ile-Ife, Nigeria, the Institute of Zootechnical Research, Bamanda, Cameroun and the Ecole Inter-Etats des Sciences et Medecines Veterinaires, Dakar, Senegal with the main objective of desseminating, on the small farm level, the results of methods of fattening beef cattle based on the optimal utilization of cocoa husks and rice milling by-products, maize crop residues, groundnut hulls and molasses, it (FAO) is being urged to extend the net-work activities in conjunction with ILCA and other interested institutions to cover the other relevant subregions of Africa.

2. That being aware of its laudable idea in planning a workshop on the subject in Dakar in September (1981), it (FAO) is being urged to liase with relevant institutions, especially, AAASA and ILCA, with a view to jointly organizing such an important workshop and to deciding on the proper timing after considering other already scheduled conferences/seminars/workshops which will involve the same participants.

D) TO ILCA:

That being aware of its deep interest in the subject, so far as, especially, feeding of livestock is concerned, urge it (ILCA):

1. To coordinate its activities with FAO with a view to setting up research and extension net-works to cover the whole of the continent.

2. To initiate the publication of a Newsletter that will:
Report on current research on crop residues and agro-industrial by products;

Review special topics in by-product research;
Provide a forum for the presentation of interim reports and,
Draw attention to other developments in other parts of Africa in particular, and the world in general.

3. To assist and where possible, provide in-service training for young scientists to acquire proficiency in current techniques of crop residue treatment and uses as animal feeds.

4. To organize periodic discussion forums on crop residue uses.

5. To organize periodic visits to selected areas where crop residues are actively being studied or used, with view to reporting its findings in the proposed Newsletter for the information and necessary action of other researchers.

6. To suggest and make available formats for recording pertinent data on crop residue use.

7. Where possible to procure small equipment or solicit funds from bilateral agencies for projects that will focus attention on:
Interdisciplinary research geared towards systems of livestock production and,
Biological or mechanical treatment of roughages for animal feeding.

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REPORT OF THE CHIEF RAPPORTEUR

BY

Dr. H.B. Obeng

I. OFFICIAL OPENING CEREMONY: Monday, November 17 (1980) at 11:00 a.m.

Chairman: H.E. Prof. M. Abdel-Akher, President of AAASA.
Chief Rapporteur: Dr.H.B. Obeng, Acting Chairman, Editorial Board of AAASA.

The official opening ceremony commenced with a brief speech by prof. R.O. Adegboye, Honorary Secretary-General of AAASA, in which he warmly welcomed all participants who had travelled far and wide to the seminar and also introduced the distinguished personalities seated at the rostrum. These include H.E. Prof. M.Abdel-Akher, President of AAASA, as the Chairman for the Opening Ceremony, Madame Christine Koloko, from the Ministry of Agriculture of the United Republic of Cameroun, as a representative of the Camerounian Minister of Agriculture, Dr. L. J. Lambourne, Senior Animal Nutritionist at ILCA as representing the Director-General of that Organization and lastly, Dr. H.B. Obeng, Acting Chairman of the Editorial Board of the AAASA as the Chief Rapporteur. Prof. Adegboye then informed all present that the workhsop which was on the Utilization of Agricultural, Foresty and Fisheries Waste Products in Africa was jointly organized by the AAASA and ILCA and that it was the third in a series of workshops on Appropriate Technologies for the Development of Agriculture in Africa. At this juncture, he urged all participants to fully take part in the deliberations with a view to coming out with useful recommendations which would contribute to the efficient development of agriculture in Africa. Finally, he respectfully, requested the Chairman to steer the affairs of the opening ceremony to a successful end.

H.E. Prof. Abdel-Akher, after officially taking over the chair, requested Madame Koloko to address the participants. She intimated that it was not only an honour but also a pleasure for her to be present to open such a very important workshop on behalf of the Minister of Agriculture of the Government of the United Republic of the Cameroun. She there-upon expressed the warmest gratitude of the Camerounian Government to the AAASA and ILCA for deciding to organise the workshop in Douala and also to the visiting participants for coming over from their respective countries to take active part in the deliberations. Finally, she wished the workshop every success and all participants a fruitful workshop and a very happy stay in the Cameroun.

Special Addresses were then delivered by H.E. Prof. Abdel-Akher and Dr. Lambourne on behalf of the AAASA and ILCA, respectively. H.E. Prof. Abdel-Akher welcomed, on behalf of AAASA, all participants and thanked the President, the Government and the people of the United Republic of the Cameroun not only for their hospitality but also for providing such excellent facilities for holding the workshop in Douala. He then expressed the gratitude of the joint sponsors of the workshop-the AAASA and ILCA; to the OAU, the Ford Foundation, SIDA/SAREC, the Agricultural institute of Canada and CIDA as well as the individual governments of Africa, through whose generous contributions this workshop was made possible.

The President of the AAASA at this juncture, stated that the subject of the workshop was very important to the overal agricultural development of Africa since it concerned the efficient economic utilization of agricultural by-products and wastes. Such wastes and farm by-products, he intimated further, should not be considered as useless since they contained rich components of proteins, carbohydrates, mucilages, cellulose waxes etc. that could supply indigenous industries with badly needed valuable raw materials. He concluded by stating that the full participation of all present in the deliberations would result in useful recommendations which would, he was sure, contribute greatly to the efficient utilization of agricultural, forestry and fisheries waste products in Africa.

Dr. Labourne, began his special address by firstly, cordially welcoming all participants on behalf of the Director-General of ILCA to the workshop. He then explained briefly the functions of ILCA. ILCA, he intimated, formed an integral part of the International Agricultural Centres funded by the Consultative Group on International Agricultural Research. Its basic mandate, he went on further, was to see to the improvement of livestock production systems in Africa. In this respect, its main focus, had been on selected production systems within several of the ecological zones of Africa. These, he explained, involved trans-human and sedentary systems within the arid and semi-arid zones of Mali, a sedentary system within the arid and semi-arid zones of Northern Nigeria, village small ruminant production systems in Southern Nigeria, mixed farming systems within the highlands of Ethiopia and number of systems-oriented research dealing with livestock development within the arid zones of Kenya, Ethiopia and Botswana.

According to Dr. Lambourne, each of the production systems was subjected to an initial problem analysis with a view not only to identifying but also quantifying the main constraints on the plant or animal as well as the socio-economic conditions under which such a system operated. He then enumerated some of the constraints which, he maintained, should be the subject of further research. These included the very limited availability of agro-industrial by-products, the utilization of crop by-products on the farm and lastly. treatment of by-products. He went on further to advance ideas on how best research to overcome the constraints could be tackled and promised all present that such ideas would form part of more detailed proposals which would be outlined in the afternoon of Wednesday, the 19th of November (1980). He, finally, again, on behalf of the Director-General of ILCA wished all participants a most beneficial stay at the Workshop. At this juncture, the chairman declared the Opening Session closed to enable the technical sessions to start after a short break.

II. TECHNICAL SESSION I. Monday, November 17 (1980).
Chairman: Prof. C.P.M. Khamala.
Rapporteurs: Dr. H.B. Obeng, Chief
Prof. E.O. Asare, Papers in English
Mr. Gora Beye, Papers in French.

A) **Morning Session:** 11:20 a.m. - 1:30 p.m.

Three papers were presented as follows:

1. Utilization of agricultural waste products, by **Prof. M.O.Adeniji.**
2. Preliminary studies on the use of wood-ash solutions and dry wood-ash powder in the control of post-harvest wet-rot of tomato, by M.S.Ayodele.
3. Utilization of plantain/banana peels and palm oil/plam kernel oil for making soap, by Prof.E.V. Doku.

1. **Professor Adeniji** in his paper gave a comprehensive review of work done on the wastes from some of the major agricultural products such as cocoa pod husks, cashew nut meal, cow and poultry droppings, wheat, rice, oil seeds and sugar cane by-products, maize cobs and cassava tuber peels and leaves. He gave the composition of some of these by-products and indicated the problems which adversely affect their efficient utilization as animal feed, fertilizers, soap, sources of energy etc. He concluded by calling for the efficient agricultural waste by-products management to enable their maximum exploitation to meet the rising demand of power, fertilizers, livestock feeds etc.

2. **Mr. Ayodele** in his treatise on the preliminary studies on the use of wood-ash solutions and dry wood-ash powder in the control of post-harvest fungal wet-rot of tomato, indicated that after treating tomatoes inoculated with conidia andmycelium, growthof four of the casual fungi, namely Verticillium.

Fusarium, Geotrichum and Rhizotonia, with wood ash solution and powder, fungal diseases were greatly controlled. For example, application of wood-ash solution greatly reduced conidia germination and mycilial growth of Verticillium, Fusarium and Geotrichum while wood-ash powder curtailed wet-rot in tomatoes caused by Verticillium, Fusarium and Geotrichum but had no effect on Rhizotonia.

3. Lastly, **Professor Doku** in his paper intimated that soap making was among the several indigenous industries operated by Africans before the arrival of Europeans on the Continent and that in spite of serious competition from imported soap and that produced locally using caustic soad, this native soap, the production of which did not involve any imported item, still continued to thrive on a wide scale. He maintained that this was as a result of its special qualities of good lather production and skin oiling characteristics. He further intimated that on the basis of figures for plantain production in Ghana, it could be estimated that between 90,000 and 200,000 tons of caustic potash and similar quality soap could be produced annually if enough palm oil and palm kernel oil could be made available. He concluded by stating that the potentialfor local soap production within Africa was tremendous and that the AAASA was being urged to comission a survey of this potentialwith a view to working out a scheme for tapping and utilising such immense native resources for the economic well-being of all the peoples of the Continent.

A very lively discussion ensued after the three papers have been presented. It was pointed out that a number of agricultural waste products were not treated by Dr. Adeniji and that the paper should have been more comprehensive. Further, that waste products utilization should take cognisance of alternative uses, availability, collection and transportation. The social and economic aspects must also be given due consideration if useful policy decisions were to be taken.

Professor Doku's paper generated long discussion on the alternative uses of plantain and banana waste products. Some participants were of the opinion that these should be used in feeding livestock rather than for soap making. It was, however, finally agreed that the bast use to be made of plantain and banana waste products would depend on the needs of the particular locality.

Finally, there was exhaustive discussion on the definitions of waste products and by-products and which of the two was more appropriate. It was, however, generally agreed that what really mattered, so far as the workshop was concerned, was the potential used of the products which hitherto had not been fully exploited and to call attention of policy makers to their efficient utilization to improve the quality of life of our peoples and not to engage in unusually long argument as to the exact meanings of the two terms with a view to deciding on which one was more appropriate.

B) **Afternoon Session:** 3:00 p.m. - 4:30 p.m.
Chairman: Prof. Lamine Ndiaye.
Rapporteurs: Dr. H.B. Obeng, Chief.
Prof. E.O. Asare, Papers in English
Mr. Gora Beye, Papers in French.

Two papers were read as follows:

1. Les sous-produits agro-industriels au Mali, by Maimouna Salah Dicko et Jean Bourama Oulare.

2. L'embouche bovine avec utilisation maximale de melasse de canne, by Dr. Henry Peleton.

1. in her paper, **Madame Dicko**, discussed the agro-industrial by-products of Mali so far as their production, location and the constraints of their utilization in animal feeding were concerned. She highlighted how various research data were being effectively transferred to farmers to such an extent that they were demanding more by-products which unfortunately were not in abundance. She concluded that the Malian Government was making strenous efforts to improve the production of agro-by-products so as to eventually satisfy the demands of indigenous farmers.

2. Dr. Peleton in his presentation on the maximum utilization of molasses, touched on the objective of the project and described the steps being taken for fattening cattle, especially, the problem of proper feeding. In this respect, he intimated that good results had been obtained so far on the use of a local strain of penisetum purpureum and also Tripsacum Laxum. However, due to difficulties associated with the harvesting of Stylosanthes guyanensis during the rainy season, the fodder was better utilised as silage. In the case of molasses they were fed ad libitum according to the method of Preston, after an initial adaptation phase of 14 days. So far, he intimated, satisfactory results had been obtained. He concluded by stating that, molasses must be given priority in the feeding of cattle in order to quickly correct the present widespread protein defficiencies in animals.

In the discussions that ensued, general comments were made on the necessity of governmental action in subsidizing the cost of agricultural by-products with a view to enabling indigenous farmers to easily procure them. In this connection, the need was expressed for a more representative meeting which would involve not only scientists but also policy makers, farmers, extension officers and industrialists to exhaustively discuss how best agricultural by-products could be economically utilized for the benefit of all.

III. TECHNICAL SESSION II. Tuesday, November 18, (1980).
Chairman: Dr. Samu-Negus Haile-Mariam.
Rapporteurs: Dr. H.B. Obeng, Chief.
Prof. E.O. Asare, Papers in English
Mr. Gora Beye, Papers in French

A) **Morning Session**: 9:00 a.m. - 12:30 p.m.

Five papers were presented as follows:

1. Utilization of agricultural waste products in the context of rural development: Some implications for research policy, by Dr. A. Abidogun.

2. Biogas production: Improvements on the digestor; utilization of the gas as fuel and the sludge as fertilizer-the Ethiopian experience, by Mr. Beyene Megersa.

3. Construction et essais des disteurs a biogas, by Mr. E. Hamika.

4. Small-scale technologies of utilization of roughages suitable to small holders in Africa, by Prof. J.A. Kategile.

5. Utilization of Agro-industrial by-products in beef fattening rations, by Mr. R. Dia Ndumbe.

1. **Dr. Abidogun** in his paper intimated that utilization of agricultural waste products was a relatively new area of research in most African countries. He maintained, however, that such a research area was capable of attracting attention and resources in the coming years. He warned that investment in such a research endeavour could only be justified in terms of its contribution to social welfare, as a result there was the need for research policies and programmes to be decided upon in relationship to relevant social policy objectives.

According to him, for most developing countries, rural development remained the fulcrum of developmental policy as such the utilization of agricultural waste products in Africa should be viewed in the context of its impact on the rural economy.

2. In his paper **Mr. Beyene Megersa** discussed in detail the current energy supply position within the rural areas of Ethiopia and gave an account of the activities of a working group set-up to construct and instal biogas plants. He also dealt in some detail with research programmes being initiated to design and construct cheap biogas plants, portable cranes and the utilisation of bio-gas. He, finally, enumerated some of the many constraints that hinder the popularisation of bio-gas technology within Ethiopia. These, according to him, included the high cost of initial investment and the lack of proper coordination and directives at the national level and indicated how these bottlenecks were being tackled by the Ethiopian government with a view to overcoming them.

3. **Mr. Hamika,** on the other hand, highlighted on the objectives of the Camerounian biogas programme which invloved experimenting with and the construction of prototype of digestors within the different ecological zones of the country. He further discussed the availability of different agricultural wastes and intimated that twelve prototypes had so far been tested in relations with several kinds of waste products including those of human beings.

The discussions which followed centred around two essential topics. These were the socio-economic aspects and the problems associated with the collection and storage of human waste products and their associated health hazards.

4. **Prof. Kategile**, in his paper, indicated why it was necessary to utilize crop residues to supplement the feeding of ruminant livestock. He then enumerated the quantities of the different types of crop residues available in Tanzania. These included cereals, sisal etc. He finally described the methods of collection, handling, storage and feeding of agricultural waste products to animals in Tanzania.

5. Finally, in **Mr. Ndumbe's** paper, a report was given on the work being conducted jointly by the University of Ife in Nigeria, the Institute of Animal Research (IRZ) at Bambui-Cameroun and the FAO on the utilization of agro-industrial by-products in beef fattening rations. The author then classified agro-industrial by-products for animal production into four groups and gave estimated production of some of these by-products in Africa. The constraints to increased use of agro-industrial by-products in feeding animals in Africa were also outlined. He then stated that results so far obtained in the cocoa pod husk study indicate that dry matter intake on the tree diets used-control, 30% and 60%-cocoa pods-were similar. Mean daily weight gains of the animals at 112 days were better in the control diet but did not differ between the cocoa pod diets. In the case of rice and maize by-products study feed intake and feed efficiency were similar in all diets while mean daily gain was significantly better when rice brand replaced 70% maize compared to when the ration contained 40% and 50% maize. Finally, he explained that collaborative efforts were needed in the use of agro-industrial by-products in feeding animals in West and Central Africa.

In the long discussions which followed the presentation of the five papers, it was generally agreed that there was the need to underline the necessity to determine research priorities in the utilization of agricultural waste products. This was because funding for research was very limited, there should, therefore, be a reasonable indication of socio-economic feasibility now and in the future before deciding on specific lines of research which could easily attract funding. The need to find ways and means of reducing the cost of constructing agricultural and human wastes digestors with a view to making them easy to be obtained byrural inhabitants for lighting, cooking, heating etc. purposes, was also stressed.

B) **Afternoon Sesion:** 3:00 p.m. - 4:30 p.m.

Four papers were read as follows:

1. La fabrication de l'alcool: Sur pape de surete de l'**agriculture,** by Dr. Tang Bonga Jean Rene.
2. The utilization of sugarcane and by-products of the **sugar** industry for milk and meat production in mauritius, **by Prof.** J.A. Claude Delaitre.
3. The role of sunflower by-products as animal **feed, by Prof.** C.N.Karue.

4. Les sous-produits agro-industriels au Senegal-"Apercu sur les travaux de l'institut Senegalais de recherches agricoles, by Dr. Ndiaga Mbaye.

1. In his paper, Dr. Tang Bonga highlighted the manufacture of alcohol from sugarcane in the form of ethylene alcohol or ethanol by discussing in detail the biochemistry of alcohol fermentation and the process of its distillation. He then, briefly explained the employment of appropriate technology for the transformation of "glucidic" agricultural products to help solve energy problems etc. He concluded by stating that for the development of our economics we should make use of all available avenues of efficiently utilising agro-by-products in Africa.

2. Professor Claude Delaitre in his comprehensive paper gave a detailed account of the environmental conditions and overall agricultural potentialities of the Island of Mauritius. Specifically, he presented production figures and the chemical composition of different by-products of sugarcane. Further, he reported in detail encouraging results from several feeding experiments in which sugarcane by-products were fed to beef and dairy cattle as well as to deer. Lastly he elaborated plans for future research into the efficient utilisation of agricultural by-products within the Island of Mauritius.

3. Professor Karue in his paper, described an experiment which was conducted in Kenya using Zebu sheep to evaluate the nutritive value of sunflower by-products as sources of protein and energy for cattle. He intimated that, in this experiment, sunflower seedless headmeal, sunflower waste seed and sunflower cake (4 parts of sunflower seedless headmeal and one part of sunflower cake) were used. The CP content was lowest in sunflower seedless head and highest in sunflower waste seed.The results indicated that sunflower waste seed had a great potential as a supplement for grazing ruminants due to its high protein content and digestibility.

4. Dr. Ndiaga Mbaye in his paper, reviewed the different kinds of agricultural and agro-industrial by-products available in Senegal, distinguishing those obtained from rural sources from those derived from industrial wastes. He then assessed the quantities available and further highlighted the research results obtained so far, on these by-products in the area of animal fattening.

The author concluded by stating that agricultural and agro-'ustrial by-products were available in sufficient quantities and such good quality condition to enable their efficient utilisation . the widespread improvement of livestock production in Senegal.

During the discussions which followed the problems associated ·h the use of agro-by-products solely for meat production in rica while completely neglecting the milk production aspects ·re exhaustively discussed as not being in the best interest of the continent. It was finally agreed that it would be better for more efforts to be directed to the use of animal by-products for traction and milk production while at the same time aiming at improving meat production.

IV. TECHNICAL SESSION III. Wednesday, November 19 (1980) 9:00 a.m. - 12:30 p.m.

Chairman: Prof. A.A. Ademosun.
Rapporteurs: Dr.H.B. Obeng, Chief.
Prof. E.O. Asare, Papers in English.
Mr. Gora Beye, Papers in French.

Seven papers were read as follows:

1. Utilization of guinea grass-citrus pulp silage by sheep by Dr. F.O. Olubajo.

2. Utilization of oil seed cake meal as protein supplements for cattle on low-quality roughage diets, by Dr. L.J.Lambourne and D.J. Pratt.

3. Possibilities et contraintes dans l'utilisation des sons-produits de la peche au Cameroun, by Mr. J.C. Njock.

4. Technologies available on Fisheries residues and prospects of their utilization in Kenya, by Prof. C.P.M. Khamala.

5. Feedmills and agro-by-products: The Nigerian experience, by Dr. S.A. Ojo and Mr. A.N. Ema.

6. Economic and ecological aspects of solid waste disposal in developing economies: A case study of the Ibadan region, by Prof. A. Faniran.

7. Evaluation of cocoa-pod as a feed ingredient for cattle, by Dr. O.B. Smith and Prof. A.A. Adegbola.

1. In his paper, **Dr. Olubajo** reported on a study which involved guinea grass and guinea grass-citrus pulp silages using West African dwarf rams in digestion trials. The results indicated increases in dry matter and energy contents with increase in the amount of citrus pulp in the diet. Addition of citrus pulp led to imporved digestibilities of dry matter, crude protein and the energy content of the silages and higher intake by the experimental animals. Due to the low crude protein content and low energy intake the rams did not meet the demands for maximum digestible crude protein for maintenance.

2. **Dr. Lambourne** also reported on the results of experiments to study (i) the extent of seasonal variation in herbage quality and what could be done to improve utilization of poor quality forages and (ii) whether or not greater value might be obtained from limited amounts of the commenest protein by-products which seem to be the most useful supplementary feeds by chemical treatment to reduce their solubility. Altogether, the results of ten experiments

were reported upon. These confirmed the poor nutritive value of feeds with digestibility of less than 48-50% and protein content of less than 6-7%. They showed that poor nutritive value was accentuated by low voluntary intake.

3. In his paper, Mr. Njock assessed the amount of fisheries by products available, their implication in terms of environmental and socioeconomic conditions prevailing in the Cameroun. He further intimated that the wastes produced by fisheries activities were not enough to allow the setting up of a suitable by-products industries. Nevertheless this should be possible in the near future with the implementation of the current five-year development plan of the country.

4. Professor Khamala in his treatise reported that fisheries residues like shells, scales, fish skins, bones, tails, etc. which were available from fish filleting, salting, cleaning and drying plants and depots along the coasts of Kenya, Lake Victoria etc. were usually wasted. He said further that in countries like Japan, Britain and the Soviet Union these residues were used in the manufacture of fertilizers, fishmeal etc. He then went on to outline the processing of the above-mentioned waste products and indicated how they could be utilised. For instance, fish bones, scales, tails and other offal could be used in the making of fish scraps. These when steam cocked and acidified could be used in the making of fertilizers and animal feeds.

5. In his paper, Dr. Ojo reported that the shortage of animal feeds was a major contraint to livestock improvement programmes in Nigeria. He then examined factors such as cost, quality, etc. that affected availability of livestock feeds and discussed the role that agro-by-products could play in reducing competition for food between human being and livestock. He recommended that fluctuation in feed prices must be reduced through governmental controls.

6. Prof. Faniran's paper described the solid waste disposal problems of the city of Ibadan and indicated its effects on environmental hygiene. He then gave account of the systems of waste disposal, e.g. incinderation and compositing and the processes that took place during compositing. Further, he described compositing plants technology in some detail and discussed not only the uses of compost and their effects on soils but also the recycling and collection of solid waste products. Finally, the author concluded that man must see himself as an integral part of the ecosystem rather than emphasize the economic aspects of mannature relationships in which man saw nature as producing raw materials to be manipulated and controlled for the fulfilment of his goal.

7. Dr. Smith in his paper described two cattle feeding trials in which cocoa pods replaced varying levels of maize and guinea corn in an all concentrate feedlot diet. The cattle used were the

Keteku N'dama and N'dama-white Fulani crosses. In the first experiment the diets consisted of control, low cocoa-pod and high cocoa-pod diets. The experiment lasted for 112 days. Dry matter intake of the diets and daily gains of the cattle were similar.Cattle on the control, low cocoa-pod and high cocoa-pod diets required 6.6, 8.8 and 10.9 kg of dry matter, respectively. Carcass weight, dressing percentage etc. measured, were similar for all treatments. In a second experiment, the levels of cocoa-pod diets were 40 and 60% and guinea corn instead of maize was used as the main energy source. Daily weight gains on the three diets were similar. Many of the cattle fed on the 60% cocoa pod diet, lost weight. The author concluded that cocoa pod was of a good feeding and economic value and that cattle were the most suitable animals to be fed on it.

Most of the discussions which ensued were on silage, the importance of dry matter, date of harvesting on the quality of silage and its protein content. The problem of using cake in Australia in animal feed and the utilisation of household wastes were also stressed.

V. TECHNICAL SESSION IV. Wednesday November 19, (1980), 3:00 p.m. - 5:00 p.m.

Chairman: Prof. A.A. Ademosun.

Rapporteurs: Dr. H.B. Obeng, Chief.
Prof. E.O. Asare, Papers in English.
Mr. Gora Beye, Papers in French.

Topic: Network formation on the use and potential of crop residues and agro-industrial by-products in livestock nutrition in Africa.

General discussions on the above-mentioned topic were led by Dr. A.K. Mosi and Dr. L.J. Lambourne, both from ILCA. After a very exhaustive deliberation it was unanimously agreed that as a matter of urgency a Research Network involving institutions, individual scientists and donor agencies interested in the promotion of the use of agricultural by-products should be set-up. Such a network should consider the following:

i) The taking of an inventory on existing agricultural waste products, their availability, the use to which they could be put, the amounts available and the classes of livestock such waste products could be fed to.

ii) The designing of a suitable format for the collection of data on the subject.

iii) Making available facilities for periodic meetings and exchange of visits to enable constant exchange of ideas on the abject by scientists in Africa.

iv) Training of young scientists in institutions where facilities existed.

v) The publication of a newsletter to highlight in simple terms research achievements in the utilization of agricultural waste products.

It was noted that FAO had already started a nucleus network and that this should be extendced to include all countries in Africa. It was also noted that up till now no attention had been paid to poultry and game animal production and that such areas should be included in the network's programme of activities in the future. Finally, it was noted that FAO has planned a workshop in Dakar in September 1981 on the subject and that ILCA and AAASA should liase with FAO with a view to jointly organizing such a workshop and to deciding on the proper timing after considering other already scheduled conferences/workshops or seminars involving the same participants.

VI. CLOSING SESSION. 3:00 p.m. - 5:00 p.m.

Chairman: Prof. R.O. Adegboye.
Rapporteurs: Dr. H.B. Obeng, Chief.
Prof. E.O. Asare, Papers in English.
Mr. Gora Beye, Papers in French.

Before the commencement of the Closing Session the chairman announced that Dr. Bede Okigbo who was scheduled to present his paper earlier on but could not do so because of unavoidable circumstances which prevented him from arriving in Douala on time, had now arrived and would read his paper entitled "Studies on Potential Uses of Crop Residues and Some Industrial By-products in Soil Management in the Humid Tropics".

Prof. Okigbo in his presentation intimated that an experiment was carried out at the International Institute of Tropical Agriculture to study the effect of 22 mulch treatments on the yields and general performance of maize, cassava, cowpea and soybeans. He then gave the results so far obtained as follows:

i) Differential effects of mulches were observed on soil chemical and physical properties, weed incidence and namatode distribution.

ii) Organic mulches controlled weeds differentially but favoured growth of annual broadleafed weeds while inorganic mulches supported growth of broadleafed weeds and grasses.

iii) Mulching differentially affected nematode population which tended to decrease with time although build up of plant parasitic nematodes were more influenced by the test crop rather than by the mulch.

iv) Inorganic mulches had higher nematode population than the bare or control plot.

v) In general, leguminous mulches had more beneficial effects on crop yield than straw mulches.

vi) Spectacular increases in cassava root yields amounting to about double that of the bare plot were observed in plastic mulches and rice husks.

vii) Straw mulches of Typha and paddy rice tended to cause nutrient imbalance while some mulches interacted with fertilizers to reduce soil pH. Finally, he concluded that where mulches were used less fertilizers would be required with leguminous mulches than with mulches of wide C:N ratios or of non-legumes.

After Dr. Okigbo's presentation the closing session began with the chairman, prof. Adegboye, noting that the workshop had been a tremendous success in spite of the initial set-backs. Fifty participants from fifteen countries and some international organizations attended the workshop and that the AAASA had gained twenty two members who joined the association during the course of the workshop. Also that one member had converted his membership status to that of a life member after the payment of the required dues. He thereupon urged all members to follow such a worthy example. At this juncture, he expressed AAASA's worm gratitude to the government of the Republic of the Cameroun for providing such excellent facilities and offering all participants such an unusual hospitality. He then offered the appreciation of all participants not only to the enterpreters but also to the technicians and all other who contributed in diverse ways to the success of the workshop. Finally, he thanked all participants for attending the workshop and wished them a safe return to their respective homes and countries.

The chairman after his brief closing speech invited Dr. Mosi and H.E. Prof. Abdel-Akher to address the participants on behalf of ILCA and AAASA, respectively. Dr. Mosi in his closing remarks, expressed on behalf of ILCA his sincerest appreciation to the Government of the Republic of the Cameroun for providing such excellent facilities which enabled the workshop to come to such a very successful end. He then directed the gratitude of ILCA to the AAASA for not only willingly agreeing to co-sponsor the workshop but also for the wonderful cooperation it offered to ILCA in efficiently organizing the workshop. Turning to the President of AAASA, Dr. Mosi expressed his sincerest thanks to him, especially, inspite of his age and several home duties to have found the time and energy to come in person to Douala to fully participate in the deliberations of the workshop. Finally, he thanked all those who were invited by ILCA for accepting the invitation at short notice to prepare relevant scientific papers on the subject and to be present to discuss them; FAO which had already translated ILCA's dream of a research network into reality and, last but not least, all participants for contributing immensely to the success of the workshop.

H.E. the President of AAASA in his closing remarks intimated that the workshop was a tremendous success and that he would rate it as one of the most successful he had attended in his lifetime. He then expressed his warmest gratitude: to the President, the Government and the people of the Republic of the Cameroun, especially, Madame Koloko, for making available such a magnificient Conference Hall as the venue of the workshop and for their immense hospitality, to ILCA not only for its close cooperation with AAASA in organizing the workshop but also for its scientific contributions and finally, to all participants for their worthy contributions and wished them bon voyage to their respective countries.

The Chairman of the closing session, Professor Adegboye, lastly called upon Madam Koloko to declare the workshop closed. In her brief address, Madame Koloko commended not only AAASA and ILCA but also all participants for four days of very useful laborious deliberations. Cameroun, she intimated, was happy to have hosted such a successful workshop which she was sure would contribute immensely to improving the living conditions of the people residing in rural areas of the Continent. Finally, after expressing her warm gratitude to all participants and wishing them a safe return to their respective countries, formally declare the workshop closed.

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LIST OF PARTICIPANTS

FAO

Dr. R. Sansoucy
FAO, Division de la Production et de la Sante Animale
via delle Terme de Caracalla
00100 - Rome, Italie.

I. E.M.V.T.

Dr. Peleton
I.E.M.V.T.
10, Rue Pierre-Curie
94700 Maisons Alfort
France.

BENIN

Dr. C. M. Nago
Faculte des Sciences Agronomiques/UNB
Boite Postale 526
Cotonou, Republic of Benin.

CAMEROUN

Dr. G. Agbede
Centre Universitaire de Dschang
ITA B. P. 110
Dschang, Cameroun.

Dr. N. Azefor-Njianjek
CELLUCAM, S.A.
B.P. 22
EDEA, Cameroun.

Mr. S. Batimba
Mission de Development de l'Embouche Bovine de Mbandjock (MIDEBOM)
Boite Postale 80
Mbandjock, Cameroun.

Mr. Mouzong Boyomo
University Centre of Dschang
P.O. Box 96
Dschang, Cameroun.

Mr. Doube
University Centre of Dschang
Boite Postale 110
Dschang, Cameroun.

Miss Petnga Esther
Institut de Recherches Agronomique (I.R.A.)
Boite Postale 2067
Yaounde, Cameroun.

Mr. M. Foyet
I.R.A.
B.P. 13
Nyombe, Cameroun.

Mr. E. Hamika
CENEEMA, BIOGAZ Programme
P.O. Box 1040
Yaounde, Cameroun.

Mr. T. Mauger
Ministere de l'Economie et du Plan
Yaounde, Cameroun.

Mr. N. Mbangowrh
CELLUCAM
B.P. 22
EDEA, Cameroun.

Dr. J. M. Menyonga
Agricultural Research Centre, Ekona
P. M. B. 25
Buea, Cameroun.

Mr. A. Moukam
I. R. A., Ekona
P. M. B. 25
Buea, Cameroun.

Mr. R. D. Ndumbe
Institue of Animal Research (IRZ)
B. P. 1457
Yaounde, Cameroun.

Mr. Z. Ndzie
CENEEMA (Project Biogaz)
B. P. 9172
Douala, Cameroun.

Mr. J. C. Njock
I. R. Z.
B. P. 1457
Yaounde, Cameroun.

Mr. G. Roche
I. R. A.
B. P. 2067
Yaounde, Cameroun.

Mr. J. Soun-Soun
Societe Camerounaise des Tabacs
B. P. 9
Bertoua, Cameroun.

Dr. J. R. Tang-Bonga
Institut de Recherche Agronomique (I.R.A.)
Boite Postale 13
Nyombo, Cameroun.

Mr. S. B. C. Wanki
U. N. V. D. A.
P. O. Box 25, NDOP
N. W. Province, Cameroun.

Mr. R. Wesenberg
CENEEMA - Programme Biogas
B. P. 9172
Douala I Ruc, Cameroun.

EGYPT

H.E. Prof. M. Abdel-Akher
Faculty of Agriculture
Cairo University
Giza, Egypt.

ETHIOPIA

Mr. Beyene Megersa
Ministry of Agriculture
Arsi Rural Development Peroject
P. O. Box 3376
Addis Ababa, Ethiopia.

Dr. D. de Haan
I. L. C. A.
P. O. Box 5689
Addis Ababa, Ethiopia.

Dr. L. J. Lambourne
I. L. C. A.
P. O. Box 5689
Addis Ababa, Ethiopia.

Dr. A. Mosi
I. L. C. A.
P. O. Box 5689
Addis Ababa, Ethiopia.

Dr. Samu-Negus Haile Mariam
Horticulture Development Department
P. O. Box 5558
Addis Ababa, Ethiopia.

GHANA

Prof. E. V. Doku
University of Ghana
Crop Science Department
P. O. Box 44
Legon, Ghana.

Dr. H. B. Obeng
Soil Research Institute, C.S.I.R.
Academy Post Office
Kwadase-Kumasi, Ghana.

KENYA

Prof. C. N. Karue
University of Nairobi
P. O. Box 29053
Nairobi, Kenya.

Prof. C.P.M. Khamala
Kenya National Academy for Advancement
of Arts and Sciences (KNAAAS)
P.O. Box 47288
Nairobi, Kenya.

Miss Eileen Opoti
Department of Village Polytechnics
P.O. Box 53881
Nairobi, Kenya.

MALI

Dr. (Mrs.) M. Dicko-Toure
I. L. C. A.
CIPEA
B. P. 60
Bamako, Mali.

MAURITIUS

Mr. J. A. Claude Delaitre
Food Allied Industries
Gentilly
Moka, Mauritius.

NIGERIA

Dr. A. Abidogun
National Cereals Research Institute
P. M. B. 5042
Ibadan, Nigeria.

Prof. R. O. Adegboye
Agricultural Economics Dept.
University of Ibadan
Ibadan, Nigeria.

Prof. M. O. Adeniji
Dept. of Agric. Biology
University of Ibadan
Ibadan, Nigeria.

Prof. A. A. Ademosun
Dept. of Animal Science
University of Ife
Ile-Ife, Nigeria.

Prof. J. A. Alao
University of Ife
Dept. of Ext. Educ. &
Rural Sociology
Faculty of Agriculture
Ile-Ife, Nigeria.

Prof. E. O. Asare
Ahmadu Bello University
NAPRI, ABU P.M.B. 1096
Zaria, Nigeria.

Dr. E.A. Atayi
I. I. T. A.
P.M.B. 5320
Oyo Road, Ibadan
Nigeria.

Mr. S. Ayodele
Oyo State College of Education
P. O. Box 586
Ilesa, Nigeria.

Prof. A. Faniran
Department of Geography
University of Ibadan
Ibadan, Nigeria.

Dr. S. A. Oje
Faculty of Vet. Medicine
Ahmadu Bello University
Zaria, Nigeria.

Dr. B. H. Okigbo
I. I. T. A.
P. M. B. 5320
Oyo Road, Ibadan
Nigeria.

Dr. F. O. Olubajo
University of Ibadan
Dept. of Animal Science
Ibadan, Nigeria.

Dr. E. O. Otchere
I. L. C. A.
P.M.B. 2248
Kaduna, Nigeria.

Prof. A. Singh
University of Sokoto
P.M.B. 2346
Sokoto, Nigeria.

Dr. O. Smith
Dept. of Animal Science
University of Ife
Ile-Ife, Nigeria.

SENEGAL

Dr. N. Mbaye
Institut Senegalai de Recherches Agricole
Boite Postale 2057
Dakar, Senegal.

Prof. Ah-Lamine Ndiaye
E.I.S.M.V.
P. O. Box 5077
Dakar, Senegal.

Mr. M. Sarr
B. P. 486
Dakar, Senegal.

SUDAN

Prof. A. H. El-Nadi
Dean, Faculty of Agriculture
University of Khartoum
Shambat, Sudan.

Prof. A. G. H. Khattab
Faculty of Agriculture
University of Khartoum
Shambat, Sudan.

TANZANIA

Prof. J. A. Kategile
University of Dar-es-Salaam
Animal Science Department
P. O. Box 643
Morogoro, Tanzania.

UPPER VOLTA

Dr. Gora Beye
S/C UNDP
B. O. 575
Ouagadougou, Upper Volta.

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FAO ACTIVITIES ON AGRICULTURE AND AGRO-INDUSTRIES RESIDUE UTILIZATION

BY

T.E. Jakubozyk

FAO Regional Office For Africa
Accra, Ghana

INTRODUCTION

The world will add at least a billion people in the next fifteen years and is expected to double its present population after the end of the century. World food and feed production barely keep pace with population growth and reserve stooks have declined. Most developing countries are falling behind in per caput food production and cannot afford to import the additional food they require.

While large scale efforts are being directed towards improving primary food production, there is also an urgent need to consider all other means of achieving increased food supplies. The utilization of agricultural residues for human benefit is one area where strong emphasis should be placed. In recent years, the problems of agricultural and agro-industrial waste management have drawn increasing attention.

A residue is an excess produced together with the growing or processing of a target product. A residue becomes a co-product or a by-product when profitable use is made of it. If this is not the case the residue becomes a waste, which is defined as a material with no apparent market, social or environmental value-and at times a negative one-which the holder no longer wants in a given place at a given time. With these definitions in hand and with the growing concern and necessity in the world of making more out less, our task will then be to turn wastes into by-products.

In keeping with its mandate, FAO is concerned with all residues derived from biomass, direct or indirect. These residues can be classified in different ways as is shown in Table I.

Table 1: Classification of organic residues.

By:

Orgin	
Agriculture	- crop and animal wastes.
Fisheries	- shrimp heads, fish trimmings, trash fish etc.
Forestry	- bark, shavings, sawdust, logging wastes etc.
Related industries	- bagasse, hulls, oakes, pulps, bran etc.
Home/Community/Municipality	- garbage, sewage
Commodity or commodity groups	- animals, bavarage industries, cereals, fibres, fruits and vegetables, milk and dairy products, oilseeds and nuts, rubber, spices and essential oils, starchy roots and tubers, sugars.
Geographical distribution	- regional, national, rural etc.
Physical state	- solid, slurry, liquid, gaseous
Type	
- common properties	- meals and press cakes, straws, fruits pulps etc.
- common main component	- sugary, starchy, cellulosic residues etc.

Subject to the characteristics of the residues, the economic feasibility, the technical viability and the social and environmental acceptability, potential end-uses of residues are summarized as follows:

Table 2: Potential end-uses of organic residues.

For:

Food	- microbial biomass	
	- fermented foods	
	- beverages	
	- mushrooms	
	- oils	
	- proteins	
Feed	- direct use	
	- upgrading	physical
		chemical
		microbial
	- ensilage	
	- microbial biomass	
Fertilizer	- direct use	
	- compost	
	- residue of biogas	
Energy	- biogas	
	- alcohol	
	- producer gas	
	- direct use (combustion)	
Construction materials	- boards, panels, bricks	
Paper pulp	- paper, paperboard, packaging materials	
Chemicals	- furfural	
	- xylitol	
	- alcohol	
	- organic acids	
	- polysacceharides	
Pharmaceuticals	- hycogenin	
	- antibiotics	
	- vitamins	

PRACTICAL UTILIZATION OF SOME AGRO-INDUSTRIAL RESIDUES

Fermentation Alcohol Programme:

The Workshop on Fermentation Alcohol held in Vienna in March 1979 called upon UNIDO to assist develping countries in the production of fermentation alcohol for use as fuel and chemical feedstock and to seek the cooperation of FAO with regard to the agricultural aspects of fermentation alcohol production. The overal programme will consist mainly of (i) general studies on the economies of fermentation alcohol production from different raw materials e.g. cane juice, molasses, cassava, (ii) fuel alcohol test programmes and (iii) planning and establishment of new and additional capacities for production of fermentation alcohol in suitable interested developing countries.

The FAO's main contribution in this programme will be in the activities relating to assessment of
- current cane output and potential yield increases obtainable;
- competitive market outlets for sugar cane products;
- potential utilization of by-products and wastes for animal feed and fertilizers.

FAO will be involved in all aspects of planning and implementing new agricultural development required for the programme.

Utilization of Rice Husks:

In view of the crucial need to introduce modernized processes that will permit the utilization of rice husks as an energy source especially in the developing countries, FAO undertook a survey of available processes and equipment for burning rice husks to produce energy, leading to high-grade ash production. One of the major uses of rice husts is fuel to provide energy for rice mill operation. But the ever-increasing number of diesel and electrically-driven rice mills has largely eliminated such use except in certain areas. Consequently, large quantities of rice husks remain as unused waste material and create a significant disposal problem. The common practice has been to dump the rice husks in the open ground or into marshy river or creek. The husks are also burned to facilitate removal of husk stacks from the mill site.

As the result of this survey, FAO was able to publish a paper on "Rice Husks-Conversion to Energy". This publication is available in FAO.

FAO is monitoring and promoting an initiative of a private Italian rice miller to produce producer gas from rice husk and rice husk ash for industrial purpose (mainly metallurgy). A pilot unit of new design is under construction and will be combined with converted existing combustion engines for electricity generation.

Recycling of Organic Wastes in Agriculture.

A study tour was conducted in the People's Republic of China in 1977 to acquaint senior staff from developing countries with practices in the recycling of organic wastes in agriculture and to exchange experience. The study group organized under the FAO/UNDP Programme consisted of 20 participants of which 17 were from cuntries in Asia. The study placed special emphasis on the practical aspects and applicability of the methods observed in China.

This study was followed by another study tour on azolla propagation and small-scale biogas technology in China. The study took place in 1978 under FAO/UNDP programme in cooperation with the Government of the People's Republic of China.

Utilization of waste organic materials to produce biogas and manure is not a new concept and its technology is not only confined to China. But the national approach leading to widespread proliferation of the technology; the relative cheapness of biogas units through the use of locally available materials and communal labour; and the unique basic desic design of the units wherein the digester acts also a gas holder are valuable points which the developing countries could learn from China.

There are FAO publications on Organic Recycling in Asia and on the Roports of the above study tours to China. FAO is presently preparing a manual or handbook detailing all practical aspects of small-scale biogas technology in China.

Molasses Utilization:

The publication on molasses utilization is primarily intended for policy-makers, planners, development corporations and potential investors to help them decide on the most appropriate use of this valuable by-product. Molasses is one of the mostly widely used agro-industrial by-products but in several areas and countries it is one of the most under-utilized resources. The paper gives a condensed presentation of the different possiblities of molasses utilization. It also deals with fermentation processes.

Treating Straw for Animal Feeding:

A study was undertaken in selected countries in Asia, the Middle East and Europe to assess the physical, chemical and biological methods of treatment of straws for improvement of their feeding value. As the result of the study, recommendations were made on the practical application of various methods and for further research. The report of this study is available in FAO.

In producing cereal crops, the quantity of straw that is produced is equal to or greater than the quantity of edible grain. Its utilization is, therefore, of great importance.

New Feed Resources:

A variety of agro-industrial by-products are available in Africa for use as:

(a) Primary by-products: major ingredients forming the base of a feeding system.

(b) Secondary by-products: minor ingredients supplementing the diet.

An FAO publication on New Feed Resources is available. It provides information on the various physical, chemical and biological methods by which the value of poor-quality roughages can be improved, how such improved materials can be made to pay. The studies include utilization of various agricultural products in the feeding systems.

Although in several instances effective use is already made of residues, and some by-products have become main products in their own right, such as molasses or soy flour, in many cases residues are still under-utilized or completely wasted. A number of possible reasons why this apparent wastage is at times occurring, should however be recognized: Remoteness or scattered production can raise collection costs out of proportion to the value of the product. Straws and other field crop residues tend to have this handicap. A strong seasonal character puts an extra burden on investment for processing or storage. Fruit and vegetable residues are an example. Dilution of the residue by process water or incorporation of harmful substances are also factors that can make the residue economically inaccessible. Lack of know-how adjusted to local conditions in scale and simplicity and, on occasion, restrictions of a social nature further play a role in determining residue utilization possiblities. Insufficient credit facilities, especially in rural areas, may block an otherwise promising residue utilization scheme.

All these possible constraints make it necessary to act prudently when considering residue utilization. Apart from the quantitative and qualitative aspects of the residue and the appropriate technologies, local infrastructure and conditions should therefore be closely studied. It should not be forgotten either that the incentive for profitable residue utilization is quite often linked with, or dependent on, political decisions.This is already shown in some industrialized countries where penalties imposed on environmental pollution have shiften the economic feasibility of residue utilization practices in its favour.

FAO PROGRAMME IN RESIDUE UTILIZATION:

FAO's activities in residue utilization are decentralized in the Organization because of the magnitude and diversity of the subject matter involved.

Most FAO activities are either commodity or end-use oriented. Of the potential end-uses listed in Table 2, most emphasis is placed on residue utilization for animal feed, organic fertilizer and renewable energy. The activities focus on the publication of manuals, holding of meetings, workshops, and training courses, collection and dissemination of information and field projects. Typical examples of field projects are the Regional Training Project on Organic Recycling in the Far East, and the use and adaptation of indigenous material for animal feeds, including onsilage of fisheries' residues. Basides biogas projects, activities on producer gas and fuel alcohol have been initiated. Weed fuel, which is partially based on residues, also forms an important aspect of the search for more and improved use of renewable energy sources.

Residue utilization as a concept was extensively discussed in a UNDP/FAO Seminar in 1977. As a follow-up FAO has issued four publications on residues, i.e. the Directory of Institutions, the Compendium of Technologies, a Bibliography and the results of a Quantitative Survey. These publications which are widely distributed aim at facilitating communication and exchange of information between similarly orientated Institutions and individuals.

Residue utilizatio covers a wide field both by commodity and by discipline, yet there are many similarities in the technological approach and the required mental attitude towards achieving the goal of making fuller use of the world's nautral resources.

In this context international co-operation is not only desirable but a costsaving necessity, at least up to the point where the cost of co-operation does not exceed the savings expected. Although the need for co-operation is recognized, effective co-operation is not easily accomplished even assuming the good intentions of everybody concerned. In biogas production one could name at least eight Agencies in the UN alone that, over the last few years, have become engaged in this subject. In addition there are numerous Non-Governmental Organizations, Institutes, bilateral aid agencies and national programmes, that are involved . Small wonder than that it becomes complicated and time consuming to keep tract of, or benefit from, all on-going work. A pragmatic approach should therefore be adopted. Efficient co-operation will not be fostered by organizing costly meetings which yield little factual results but should rather aim at pursuing and adhering to the principle of division of labour, by which wasteful duplication of activities will be avoided, or reduced to the minimum.

On the international level organizations will have to exercise restraint in staying within the terms of reference for which they were created. The establishment of networks of Institutions on a regional or global level dealing with selected topics in residue utilization should be encouraged. A system of Newsletters is useful if continued publication and distribution over a prolonged period can be ensured.

FAO's contribution to improved communication and information exchange will be the continued publication at three-year intervals of the Directory of Institutions and the Compendium of Technologies. Apart from this general service it will continue to provide technical assistance in selected subject areas, and where possible and feasible generate funding for field project developments.

A good example of international cooperation in this field in Africa could be FAO supported collaboration between University of Ife in Nigeria (Prof. A. Adegbola) Institute of Zootechnical Research in Bamanda, Cameroun(Dr. R.Ndumbe)and Ecole Intertates des Science et Médecines Vétérinaires, Dakar, Sénégal (Prof. Ndiaye).

The objective of this cooperation is to disseminate at the small farm level methods of fattening beef cattle based on the optimal utilization of cocoa husks, rice milling, byproducts, maize crop residues, groundnut hulls and molasses.

These Institutions, i.e. University of Ife, (cocoa husks), IRZ Bamenda (rice by-products and maize crop residues) and EIS Dakr (groundnut hulls and molasses) are now carrying out feasibility pilot experiments on the use of these agro-industrial by-products by means of funds attributed through letters of agreement.

The results anticipated will be (i) increased rate of adoption of these techniques by small farmers, which eventually would lead to a stratification of beef production based on a wider use of by-products from agriculture and its allied industries, (ii) establishing linkages between groups in developing countries and between developing and developed countries.

In order to reach the level of a real "network" other countries should also be involved. The mission which took place between 15 and 26 September (1980) and in which all three mentioned above representatives of Cameroun, Nigeria and Senegal took part have reviewed the work already carried out in these centres and discussed the future experiments in this field.

It is also expected that a sub-regional Workshop of West African states on the utilization of by-products in animal feeding will be organized in Dakar, Senegal on September 21-25, (1981).

ANNEX

A LIST OF FAO PUBLICATIONS ON AGRICULTURAL AND AGRO-INDUSTRIAL RESIDUE UTILIZATION

1. Agricultural Residues: World Directory of Institutions.
2. Agricultural Residues: Compendium of Technologies.
3. Bibliography of Agricultural Residues.
4. Agricultural Residues: Quantitative Survey.
5. Residue utilization: Management of agricultural and agro-industrial wastes.
6. Les residus agricoles et leur utilisation dans certains pays due sud et due sud-est de l'aise.
7. China: Recycling of Organic Wastes in Agriculture.
8. China: Azolla Propagation and Small-Scale Biogas Technology.
9. Organic Recycling in Asia.
10. Rice Husks-Coversion to Energy.
11. Tsreating Straw for Animal Feeding.
12. Molasses Utilization.
13. New Feed Resources.
14. Fish Silage Productioninin theIndo-Pacific Region-A Feasibility Study.
15. Prospects for Fish Silage in Malaysia, Sri Lanka, Bangladesh and the Philippines.
16. Prospects for the Production and Utilization of Fish Silage in Thailand.

PART II

INTEGRATED USE OF AGRICULTURAL BY-PRODUCTS AND ANIMAL WASTES AT HOME, VILLAGE AND COMMUNITY LEVELS

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p. 51-62.

UTILIZATION OF AGRICULTURAL WASTES

BY

M.O. Adeniji

Department of Agricultural Biology
University of Ibadan, Ibadan, Nigeria.

INTRODUCTION

The production of many food products inevitable involves the discarding of parts of the raw materials from which they are made. In most cases therefore, a large part of the original harvested material is lost. The ideal solution to this problem will be to convert such discarded parts into commodities which can be sold at a profit.

This paper will consider the utilisation of local agricultural wastes commonly found in most parts of Africa.

COCOA WASTES

In the production of chocolate and many cocoa-based beverages from the harvested cocoa pods, a large part of the original harvested fruit, namely, pod husks, mucilage and bean shell is discarded as waste materials. Such valuable waste by-products are, therefore, lost.

COCOA POD HUSK

In Nigeria, the annual production of dry cocoa beans for export is estimated at 250,000 tons. Atanda and Jacob (1973) have shown that, depending on the type of variety, about 9-18 gms of pod husk material are required to produce 1 gm. of dry coca beans. It means, therefore, that about 4 million tons of wet pod husk are produced in Nigeria annually. The moisture content of the wet pod husk is 80-85%, thus leaving a total of 800,000 tons of dry pod husk a year. The disposal of cocoa pod husk is a problem because if it is left in the cocoa plantation it can serve as source of inoculum of *Phytophthora palmivora*, the causal agent of the black-pod disease of cocoa.

Extraction of Potash from Cocoa Pod Husk and Possible Utilisation as Saponifying agent for Making Soap with Low Grade Cocoa Butter:

For every ton of dry cocoa bean produced, about 9.8 tons of pods are discarded as wastes. This is an important by-product for which an important marketable outlet must be found. The chemical composition of the cocoa pod husk is as follows:

	Dry matter %
Crude protein	6.5
Crude fiber	30.3
Pectins	2.8
Nitrogen free extract	4.0
Ash	13.4

Detailed analysis of the ash component of the pod husk is as follows:

CaO	0.22-0.59
MgO	0.40-0.52
K_2O	2.85-5.27
P_2O_5	0.30-0.49
SiO_2	0.06-0.14

K_2O is the principal component of the ash and it is the only readily soluble oxide present. Extraction had been done by the leaching process, thus, converting the oxide into soluble potassium hydroxide. The potash thus extracted had been used in soap making and if properly refined can be used in the laboratory for other purposes. In addition to its use as a supplier of potash, the ash from cocoa pods can also be used as a fertilizer.

Use of Cocoa Pod Husk as Part of Animal Feeding Stuff:

Cocoa pod husk had been suggested for use as a roughage in livestock feed (Greenwood-Barton 1965 and Adeyanju, et al., 1974). The husk was substituted for maize in a dry season ration particularly the digestable dry matter, crude protein and nitrogen free extract.

Utilisation of Cocoa Pulp Juice for the Production of Jam and Wine:

The cocoa pulp juice is the sugary viscous liquid that drains from the beans during extraction prior to fermentation. Apart from the limited use of the juice as a fresh drink, no other use is known in Nigeria. Analysis of the juice (Fajade, 1972) shows that it is made up of mainly water and glucose as shown below:

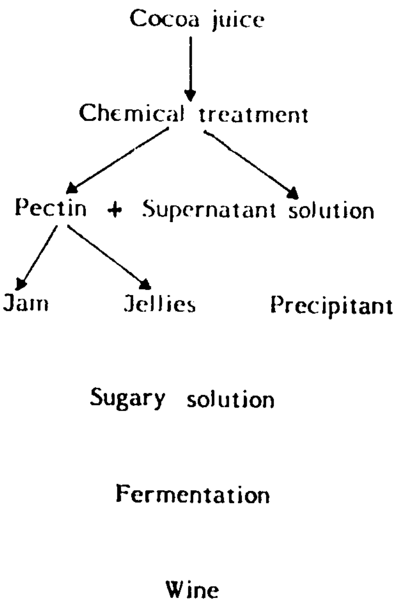
Composition of Cocoa Juice

	%
Water	79.2-84.2
Dry substance	15.8-20.8
Non volatible acids	0.77-1.52
Glucose	11.60-15.32
Sucrose	0.11-0.90
Pectin	5.00-6.90
Ash	0.40-0.50

The cocoa pod juice is also rich in pectin, which is regarded as a long chain of polygalacturonic acid molecules with the carboxyl groups partially esterified with methyl-alcohol. The most important use of pectin which has the abilityto form gels is in the manufacture of jams, jellies, marmalades and preserves. The pectin in cocoa juice has been precipitated and utilised for this purpose. In the presence of a dehydrating substance, suitable pH and heat, pectin forms a suitable jelly-like substance which can be used as jams.

In addition to the pectin, the juice is very rich in glucose and undergoes natural fermentation to produce a liquid rich in both alcohol and acetic acid. This uncontrolled natural fermentation is undesirable. Potassium metabisulphate which, in solution, produces the H_2SO_3 ion is used to check this type of fermentation. In addition to the juice this prevents the wild yeasts naturally present therein to ferment it. The treated juice can be later fermented using wine yeasts, to produce a wine of good quality (Falade, 1972). A wine, golden yellow in colour and having an alcohol content of 12% has been produced.

Possible by-products of cocoa juice



CASHEW NUTS

Utilisation of Cashew Nut Meal as a Suitable Source of Plant Protein:

Various food formulations were carried out using cashew nut meal and its derivatives as suitable sources of protein (Falade, 1972). The meal was obtained by the removal of the oil from cashew nut, and later grinding and sieving the defatted cake. Analysis of the meal is shown as follows:

Composition of Cashew nut meal

	%
Moisture	6.85
Ash	4.75
Crude protein	42.10
Nitrogen free extract	47.30

Cashew nut protein can be obtained from the protein-rich meal using water as the extracting solvent.Dilute Hcl is used to adjust the pH of the aqueous extract to 4.1-4.5 (Proteins are precipitated out from solution at this pH range-Isoelectric point). Caustic soda is added to adjust the pH back to neutral (6.7-7.0) in order to obtain a good dispersible final product. The extracted protein is then dried at low temperature to avoid denaturation.

Two high protein food products were formulated primarily as baby foods. In both recipes, cashew meal was used as the principal basic ingredient and other nutritional factors necessary for the growth and development of children were added in appropriate proportions.

CROP RESIDUES

Utilisation of Crop REsidues as Fertilizers:

Crop residues are very important sources of organic matter. In many countries crop residues such as cereal straw and legume haulm are not, or to a limited extent only, available for fertilisers but are used as fuel or as domestic materials. This is especially true of arid and semi-arid zones but can also apply to some degree, to other regions. Reliable information of farmers' practices is scarce, but it seems that legume haulm is generally removed for animal fodder and cereal stover is often grazed by nomadic cattle particularly in more arid areas. Unused residues are burned or allowed to decay in the fields. Ploughing in cereal residues has been found to improve soil structure in Senegal (Charreau and Nicou, 1971).

In the sandy dune soils of Niger, annual incorporation of millet stover increased soil pH and the content of organic matter and exchangeable cations resulting in improvement of crop yields.

In Northern Nigeria, Jones (1976) found that residues from a continuous maize-millet rotation, burned and the ash incorporated or chopped and incorporated unburned, produced significant fertiliser effect. It aided applied superphosphate in increasing exchangeable Ca and thereby lessening the fall in soil pH. The top soil exchangeable K and Mg were also conserved.

There are many areas in the humid tropics where the vegetative parts of maize and cotton may be used for mulching.

In Japan, the typical organic material most popularly used as fertilisers are compost and stable manure produced from cereal crop residues, particularly rice straw. The practice of ploughing-under of fresh rice straw has become popular in the rice-producing areas. Since rice straw is applied to the soil in an undecomposed condition and immediately ploughed under, the decomposition which subsequently takes place in the soil has an important influence on the growth of the following rice crop. The decomposition process is influenced by the temperature and moisture content of the soil. In this first stages of the decomposition process, the soluble carbohydrates in rice straw are decomposed rapidly (within 30 to 40 days after application) if weather conditions are warm. The cellulose and ligning are more slowly decomposed. It has been shown that decomposition of rice straw progressed more rapidly under higher soil moisture conditions and that the addition of nitrogen considerably accelerated the decomposition during the early stages.

It is difficult to evolve a general rule for agricultural utilisation of crop residues. For example, in some cases, the composting of straw may be recommended whereas in others its direct incorporation into the soil may be economically, and from the agronomic point of view, better justified.

Utilisation of Plant Residues for the Control of Plant Parasitic Nematodes:

The use of nematicidal chemicals is perhaps the most reliable method for a quick control of nematodes infecting crops. However, in most developing countries of the world, it is unrealistic to recommend such chemicals to farmers because most nematicides are toxic to humans and require skilled labour for a successful application. They are also too costly and the increases in yields obtained by their use may not be sufficient to cover costs (Caveness, 1967). Other methods must, therefore, be found which can ensure crop yields by killing or reducing nematode pests.

The use of crop residues as soil amendments have been reported to offer such a possibility. Soil population of Pratylenchus brachyurus, the root lesion nematode of maize, had been reduced as follows: 35% by farm yard manure (rotted cow dung + 5% elephant grass straw) 58% by cocoa pod husk and 75% by cassava peelings (Egunjobi and Larinde, 1975). Corresponding improvement in yield of maize was as follows: 85% increase with farm yard manure, 124% with cocoa pod husks, and 22% with cassava peelings. Some earlier workers Hutchinson *et al.* (1958), found that decayed pumpkins were capable of suppressing soil populations of some phytophagous nematodes. Tomerlin *et al.* (1969) associated alfalfa meal, cotton seed meal, and rice straw amendments with notable depression in populations of *Belonolaimus longicaudatus*.

The specific nature of the nematicidal properties in these soil amendments is unknown. These, however, may be the result of some chemicals produced from microbial degradation of the organic amendments; toxic intermediate breakdown products such as ammonia; and increase in soil microfauna inimical to nematodes or even other competitive nematodes.

Utilisation of Crop Residues as Animal Feeds:

In the developing countries, two types of by-products can be distinguished. The first are those found all over the world and that have been used for several decades, e.g., groundnut cake and cotton seed cake. While difficulties are still being encountered in the use of these by-products in feeds because of their highly variable proximate composition and protein quality, it is generally agreed that the utilisation value of such feeds is well understood (Fetuga and Tewe, 1979). The second are the lesser known by-products which in most instances are peculiar to and originate in the tropics, *e.g.* cocoa pods, coffee hulls and palm kernel cake. Despite their availability in great quantities and potential as substantial feed resources, there is little or no literature regarding their properties or their potential as feeds.

Utilisation of Cow Dung and Poultry Droppings:

Cow dung when processed through a gas plant yields enough gas for cooking and lighting and produces in addition a good quality manure, thus being of multiple benefit. It is worth noting that the heat efficiency of cowdung burnt in the trac nal way is not more than 11% of the inherent caloric content of the raw material, while cowdung gas burnt in properly designed burners reaches about 60%.

Cattle dung is used in India and Pakistan as fuel. Dung cakes are made, dried and burnt for cooking purposes. As a result of research work carried out at the Indian Agricultural Research Institute, New Delhi, a design was perfected to produce methane gas from animal wastes. The process reduces loss of organic matter through decomposition and stops nitrogen losses and provides cooking gas (Ambika singh, 1974).

Composition of Cow Dung:

Moisture content	74-82
Total soild	18-26
Volatile solids as % of total solids	70-80
Total nitrogen as N % on dry basis	1.4-1.8
Total phosphorus as P_2O_5	1.1-2.0
Potassium as K_2O % on dry basis	0.8-1.2

Poultry droppings form a good source of nitrogen fertiliser on decomposition. The fresh chicken droppings have also been of great benefit when applied to fish ponds by the production of planktons which constitute a rich source of food for fishes.

Wheat by-products:

Wastes and by-products of wheat processing include wheat bran, wheat middlings and wheat shorts. A sizeable quantity of this is currently available from the flour mills located in Nigeria.The local demand for this product is, however, low. Only about 20% of the current output finds its way into livestock feeds. A considerable portion of the total by-products is exported. The various milling by-products are, however, of great importance in the formulation of diets for highly productive animals. Wheat bran is one of the most popular ingredients in dairy feeds all over the world. It has been included in dairy rations at levels between 30 to 50% of the mixture. Up to a level of 15 to 25% can also be effectively used for fattening lamb and beef cattle. It can also be utilised as swine and poultry feed but in a limited proportion (10-15%) due to its fairly high crude fibre content. The lysine content of wheat middling is about 0.9%. Perhaps the greatest hope for the utilisation of this feed lies in its being ground and pelleted to be used as cattle feed particularly in the dry season in areas where fodder becomes scarce (Fetuga and Tewe, 1979).

Rice by-products:

By-products from rice-milling include rice bran, rice polishings and rice flour middlings. Rice bran is already in use in compound live-stock feeds. Its present role is essentially as a source of bulk in diets for non-ruminant animals to facilitate intestinal mobility. The levels used do not exceed 20% even with finishing pigs. More liberal amounts may however, be used for ruminant animals. Rice flour middlings also has a fairly high oil level (14.5-16.8%).Extraction of the oil will produce valuable concentrated vitamin and carbohydrate source for pigs and poultry. The oil can also be used in feed mixtures (Branckaert et al., 1976).

Oil-seeds by-products:

A large variety of oil seed crops are grown in Africa. The cakes produced from the process of oil extraction constitute an excellent protein source for livestock feeding. Groundnut cake is the most commonly used in compound livestock feed. The presence of aflatoxin requires some care in its use especially for pigs and poultry. Cotton seed is consumed by cattle as supplementary feed in the dry season in Northern Nigeria. A large portion (about 60%) of total production is, however, exported. Cotton seed cake has always been suspect because of the toxicity attributed to gossypol but it seems that the effects of this substances have been exagerated. It is to a great extent destroyed during the extraction of oil through the expeller process (Brackeart and Vallerand, 1968).

Palm kernel meal contains approximately 20% crude protein and appreciable quantities of essential amino acids. It's fibrous nature has, however, made it unacceptable in monogastric rations.

Sugarcane by-products:

In the manufacture of sugar, two major by-products, molasses and baggase are produced. There is also the sugarcane tops which, with proper processing, can constitute valuable additional fodder.

Cane molasses contains very little nitrogenous :terial. It is, however, good source of all the major and minor mineral elements with the exception of phosphorous. It is also a good source of the readily available carbohydrates. This feed has considerable potential as an energy source in rations for pigs, sheep and cattle (Fetuga and Tewe, 1979). Sugar molasses is also utilised on a large scale in the distillation of alcohol).

Bagasse is usually burnt as fuel in sugar factories. It has however, been processed in some tropical countries (Puerto Rico and Peru) for animal feed through mechanical and chemical treatments (Preston 1972 and 1975).

Maize cobs:

These are currentlyburnt and their ashes employed as a fertilizer in many farms. Corn cob has a feeding value approaching that of poor millet or guinea corn straw. Its nutritive value can, however, be considerably improved by treatment with alkali. Such treated corn has been used at levels between 20-30% in dairy rations with some success.

Cotton seed hulls:

This represents about 25% of whole cotton seed. Very little has been made of this waste product as at now probably because of a lack of understanding of the mode of effectively utilising it. This highly fibrous feed can, however, be combined with cake and fed to livestock. The product is usually ground to a fine texture,a procedure believed to increase the availability of the crude protein 1.7 times and the fat about two fold.

Cassava tuber peels and leaves:

Tubers and root crops provide a good portion of the energy requirements of many Africans. Some of these products in order of importance are: Cassava, yam, sweet potato and cocoyam. A considerable protion of the cassava tuber is discarded during gari production. These include the small-sized tubers which are difficult to process, the peel which accounts for between 10 and 13% of the tuber by weight and the shaft obtained from the pulp after shredding (Tewe et al., 1975). In addition to these, cassava leaves that are discarded after harvesting, can be used as a source of protein. Goats and sheep are known to relish cassava peels. They can, therefore, find considerable use in ruminant feeding. Considerable information is available in literature indicating that leaves of cassava, especially in the dried forms, can be incorporated into rations for pigs, poultry and dairycattle. The use of cassava and its by-products is, however, handicapped by its high hydrocyanic acid (HCN) content.

Studies by Tewe et al., (1975) also indicated that oven-dried cassava peels contain up to 1,000 ppm HCN after milling into powder. This places some extra demand on requirement of animals for sulphur amino acids to detoxify the hydrocyanic acid. Moreover, cassava is very lcw in protein and hence the requirement for protein supplementation is much higher than cereals. The high crude fibre content of the roots limits the level of its inclusion in monogastric rations. The leaves have a high protein content (17-40%) although they are deficient in methionine.

Apart from the amino acid imbalance, the physical form and palatability of cassava are important. Henry (1971) indicated that the powdered starch is ulcerogenic to the gastric mucosa. Cassava based rations given as a marsh usually result in diarrhoea in pigs and consumption is reduced in most instances. However, when pelleted, they are preferred to maize based diets.

CONCLUSION

It appears from this presentation that crop by-products and wates have tremendous potentials in alleviating the teething problems of shortage of energy, fertiliser and protein components of livestock feeds in Africa. The problems that have to be faced for efficient utilisation of thes wastes are as follows:

- The need for public awareness of the potentialities of available agro-by-products and wates. This can be facilitiated through training, extension, demonstration, factual publicity and where possible pilot production and utilisation.

  There is need to encourage the use of such products in localities where they are produced or where possible prepare them into forms in which they can be easily transported to larger commercial feed mills.

- It is also important to develop processing facilities for those by-products that require rendering and processing before use.

There is a clear need for efficient wastes management to enable maximum exploitation of the available by-product resources and those considered wastes to meet the rising demand for power, fertilizer, livestock feeds and other useful products.

Table 1: Chemical composition and nutritive value of crop residues and crop by-products.

	Item	Dry matter %	Crude protein	Crude fibre	Precent dry matter			Ca	P	TDN %
					Ether Extract	Nitrogen free extract	ASH %			
1	Wheat bran	87.6	16.9	11.3	3.8	61.6	6.4	0.1	0.9	5858
2	Wheat Middling	90.4	19.4	6.8	3.3	66.5	4.0	0.14	0.16	62
3	Wheat short	92.7	16.1	4.6	4.2	60.1	15.0	0.38	3.14	74
4	Sugarcane molasses	74.0	3.2	0.4	0.1	86.8	9.5	0.7	0.07	53
5	Sugarcane bagasse	90.3	1.0	45.0	1.0	44.1	8.0	-	-	-
6	Sugarcane tops	25.6	6.5	35.0	2.2	50.3	6.0	-	-	-
7	Cocoa pods	88.4	6.5	30.3	1.1	48.7	13.4	-	-	-
8	Discarded cocoa beans	47.2	14.3	9.0	42.8	29.3	4.6	-	-	-
9	Cashewnut hulls	80.6	20.0	4.5	37.5	33.2	4.8	0.05	0.45	75
10	Cotton seed hulls	94.5	7.1	52.0	0.6	34.6	5.6	1.2	1.0	-
11	Maize cobs	95.5	2.5	32.6	0.9	60.1	3.9	0.16	0.06	-
12	Rice bran	89.1	8.3	23.8	3.6	37.7	15.7	0.2	0.4	-
13	Rice husk	89.6	5.2	34.8	0.8	37.5	11.3	0.04	0.08	-
14	Rice polishing	86.6	12.4	5.2	13.5	68.9	4.8	0.06	1.38	-
15	Ricestraw	89.2	10.3	38.0	1.7	46.6	3.4	2.15	0.75	-
16	Cassava peels	27.9	5.3	20.9	1.2	66.6	5.9	-	-	-
17	Groundnut cake	90.4	49.9	4.6	5.5	26.6	6.0	0.18	0.70	-
18	Palm kernel cake	93.8	18.7	10.3	6.7	49.7	4.2	0.28	0.74	-
19	Cotton seed cake	92.7	46.8	10.2	8.6	30.4	6.3	-	-	-

Source: Fetuga and Tewe (1979).

Table 2: Some important nutrient levels in crop by-products.

	Lysine %	Methionine %	Cystine %	TDN %	ME Kcal/kg
Wheat middlings	0.9	0.25	0.19	62	1870
Rice bran	0.5	0.24	0.11	72	2860
Discarded cashewnuts	0.9	0.30	0.38	75	2860
Molasses	-	-	-	53	1950
Groundnut cake	1.6	0.48	0.85	30	2640
Palm kernel cake	0.64	0.39			2178

source: Fatuga and Tewe (1979).

REFERENCES

Adeyanju, S.A., Ogutuga D.B.A., Ilori J.O., and Adegbola A.A. (1974) ' Cocoa Husk: Has it any feeding value in livestock feeds ? Proceedings Nigerian Society of Animal Production, Kano, Nigeria.

Ambika Singh (1974) Use of organic manures and green manures as fertilisers in developing countries. Report of the FAO/SIDA Experts' Consultation. Rome, 1975.

Branckaert, R. and Vallerand, F. (1968) Utilisation du tourteau de coton en alimentation animale. Zootechnia 17, 73.

Branckaert, R., Tessema S., and Temple R.S. (1976) The use of local by-products for formulating diets in Tropical African Countries. Proceedings First International Symposium Feed Composition. Animal Nutrient Requirements and Computerisation of Diets. p. 676-684. July 11-16, 1976. Utah State University, U.S.A.

Caveness, F.E. (1967) Nematology Studies: End of Tour progress report on Nematology Project 620-11-110-050, pp. 15.

Charreau and Nicou (1971) L'amelioration du profil cultural dan les sols sableux et sablo-argileux de la zone tropicale seche ouestaftricaine et ses incidences agronomiques. Agronomie Tropicale Paris 26:209-255, 565-631, 903-978, 1183-1237.

Egunjobi, O.A. and Larinde, M.A. (1975) Nematodes and maize growth in Nigeria (ii) Effects of some amendments on populations of Pratylenchus brachvurus and on the growth and production of maize in Nigeria. Nematologia Mediterranea 3:65-73.

Fade, A. (1972) In 1972 Report of the Cocoa Research Institute of Nigeria.

Fetuga, B.L. and Tewe, O.O. (1979) Potentials of Agro-Industrial by-products and Crop residues as animal feeds. Proceeding of the Third Conference of the Nigerian Institute of Food Science and Technology.

Greenwood-Barton (1965) Utilisation of Cocoa by-products FdMf. 40, 52-56.

Henry, Y. (1971) Effects nutritionels de lincorporation de cellulose punfice dans le gregime due porc en croissance. Ann. Zootech. 19, 117-121.

Hutchinson, M.T., Reed, J.P. and Pramer, D. (1958): Observations on efects of decaying vegetable matter on nematode populations. Plant Dis. Reptr. 44, 400-401.

Jones, M.J. (1976) The significance of crop residues to the maintenance of soil fertility under continuous cultivation at Samaru, Nigeria. J. Agric. Sci. Camb. 86, 117-125.

Preston, T.R. (1972) Lengraissment des bovins de boucherier a la mellasse dan les regions tropicales. Rev. Mond. Zootech. 1, 24.

Preston, T.R. (1975) Sugarcane as the basis for intensive production in the tropics. Animal feeds. Tropical Products Inst., London, pp. 68-83.

Tewe, O.O., Job, T.A.,Loosli, J.K. and Oyenuga,V.A. (1975) Composition of two local cassava varieties and the effects of processing on their hydrocyanic acid content and nutrient digestibility by Rat. Nigerian J. Anim. Prod. F 3(2), 60-66.

Tomerlin, A.H. Jr., Arthur, H. and Smart, G.C. Jr. (1969) The influence of organic soil amendments on nematodes and other soil organisms. J. Nematol. 1, 29 -30 (Abst.).

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-12 Nov. 1980, Douala, Cameroun, p.63-95.

STUDIES ON POTENTIAL USES OF CROP RESIDUES AND SOME INDUSTRIAL BY-PRODUCTS IN SOIL MANAGEMENT IN THE HUMID TROPICS

BY

B.N. Okigbo, B.T.Kang, R.Lal, O. Akobundu and F.E. Caveness

Institute of Tropical Agriculture, Ibadan, Nigeria

INTRODUCTION

Sources, availability, potentials, effects, limitations and problems of organic residues in the maintenance of soil fertility and crop production in various parts of the world have been reviewed by various authors (FAO/SIDA, 1975 and 1978). The beneficial effects of organic matter in crop production in the tropics have been emphasized by Greenland (1972) and Charreau (1974). Of relevance to the topic of this paper are Ayanaba and Okigbo (1975) and Lal (1975 and 1979) who reviewed the practice of mulching and noted its potential in maintenance of soil fertility and crop production. They reported that mulching produced different effects which were (I) physical in that it conserves soil moisture, improves infiltration rate, controls run-off and erosion, reduces weed and weed competition, lowers soil temperature and its fluctuation and improves soil structure, (ii) biological in increasing the activity of soil micro-organisms, animals such as earthworms, effects of phytopathological nematodes and fungi and phytotoxic effects and (iii) chemical, involving increases in humus and cation exchange capacity as well as mobilization or immobilization of plant nutrients, depending on the prevailing conditions which determine whether nutrient deficiencies or toxicities result. The overall effects of all these changes or effects of mulching is improved soil fertility which results in significantly increased yields of cereals, grain legumes and root and tuber crops. It was noted that where the organic mulches used (e.g. leguminous plant residues) supplied sufficient amount of nutrients such as nitrogen to the crop, no addition of inorganic fertilizers was found necessary. Moreover, it is now well known that productivity from soils in the tropics under continuous cultivation can be sustained economically provided soil erosion is controlled, and soil physical and nutritional characteristics are maintained at a favourable level. In addition to the above various workers have confirmed that no-till farming with crop residue mulch at 4 to 6 t/ha can effectively control soil erosion and maintain soil physical conditions at favourable levels for soils in the humid and sub-humid regions (Jurion and Henry, 1969; kannegieter, 1967 and 1969; Lal, 1975-1976 and Seubert et al., 1977). Soil fertility can be maintained through balanced fertilizer application, crop rotation with leguminous crop covers (Lal et al., 1978), strip cropping of cereals with perennial legumes, and the use of crop residue mulch (Lal, 1979).

At IITA studies have been conducted on Zero-tillage in which it was demonstrated that erosion was controlled and overall beneficial effects on soils and crops were achieved where 5 t/ha of crop or plant residues were available (Lal, 1976). These studies clearly demonstrated that mulching produced multiferous effects on soils as indicated above. In the no-tillage studies at IITA, it was decided to study effects and potentials of different cover crops in zero-tillage, management of various plant residues in zero tillage and the potentials of living or 'live mulch'. This paper is devoted to studies on potentials of crop residues and some industrial wastes in soil management and crop production in the humid tropics. The objectives of the experiments started at IITA, Ibadan, Nigeria in 1975 were to

i) evaluate the various chemical, physical and biological effects of crop residue, crop and industrial wastes and by-products on soil, and

ii) to determine the potentials, management problems and effects of different mulches on yield and general performance on four test crops-maize, cowpea, soybean and cassava.

MATERIALS AND METHODS

The experiment was started in 1975 at the International Institute of Tropical Agriculture, Ibadan, Nigeria. Environmental characteristics of Ibadan are presented in Table 1. The design of experiment was a split block design of 22 mulch treatments, (18 of which are shown in Table 2 in addition to black polythene, translucent polythene, fine gravel mulch, and bare soil) as main treatments with four test crops (maize, cassava, cowpea and soybean) as subtreatments. The experiment was planned for 5 years but after 1975, a sub-subtreatment was superimposed to facilitate determination of the nutritional value of the different mulch treatments. This was accomplished by dividing each plot into two and applying fertilizers at the rates specified below on only one half of the plot. The fertilizer applications in kg/ha of actual nutrients were as follows:

	Crop	N+	P+	K+	Time of application
1.	Maize	120	90	60	at planting and 4 WAP++
2.	Cowpea	30	20	20	at planting
3.	Soybean	30	30	20	at planting
4.	Cassava	40	20	40	at 3 WAP

\+ Forms of fertilizers; N as Urea, P as single superphosphate and K as muriate of potash.

++ Weeks after planting.

During the first year organic residues applied varied with mulching materials since enough of each mulch was applied to reach 5cm thick. This amounted to 15 tons/ha for corn cobs, rice straw, rice husks, cassava stems, pigeon pea stems, mixed twigs, saw dust and legume husks. With the exception of fine gravel to which 25 t/ha was applied the rest received 10 t/ha during the first year. All treatments received half the weight of mulch during subsequent years. No additional mulch was applied to the corn cobs and fine gravel as from 1978. Data presented are only for 1975 and 1977 for maize, 1975 for soybean, cowpea and cassava.

The chemical composition of the organic residue mulch materials were determined as presented in Table 2. The non-organic crop/plant residue mulches (black polythene, transuscent polythene, fine gravel and bare soil check) were not analyzed because this was unnecessary.

The variety of maize used was TZB two crops (early and late) of which were grown each year with the early planting in 1975 done on March 23rd, harvested on July 12th and late planting followed onAugust 22nd and harvested on January 5th, 1976. In 1977, early maize was planted on April 20th and harvested on August 8th followed by late maize planting on August 31st and harvesting on 19th December. Two crops of each of cowpea and soybean were grown each year but only one crop of cassava was possible. In 1975, early soybean (Bossier) was planted on March 21st followed by early cowpea (Ife brown) on March 24th with harvesting on 18th June and 2nd June, respectively. Late crop of cowpea was planted on August 26th and that of soybean was on August 28th followed by harvesting on January 7th and 9th, 1976, respectively. Cassava (variety Isunikankiyan) was planted on May 11th, 1975 and harvested in 101/2 months on February 27th, 1976. Spacings for the different crops were maize 25 x 75 cm, cowpea 25 x 75 cm, soybean 10 x 75 cm and cassava 1 x 1 m. Plot size was 4 x 6 m with 1 m guard rows round each plot. There were three replications. Weedings were carried out at 2, 6 and 10 WAP. In 1975 Azodrin at 0.5 kg/ha and in 1977 Nuvacron 40 at 1 kg/ha were used to spray cowpeas first at the flowering stage and subsequently at 15 days intervals.

Table I: Environmental Characteristics of Ibadan.

Location:	(a) Latitude	7°.30'N	
	(b) Altitude	220m	
Soil:	Alfisol (Oxic Paleustalf)		
	pH	6.3	
	Effective CEC (me/100g)	6.2	
Mean Annual Rainfall		1250mm (bimodal)	
Mean Annual Evapotranspiration		<u>1975</u> 1428	<u>1976</u> 1655
Temperature (1975/76) Monthly means 1975		24.8°C	29.0°C
" " " 1976		23.7°C	28.1°C
		<u>1975</u>	<u>1976</u>
Mean Relative Humidity		75%	77%

Radiation (daily range) 330.6 - 469 g.cal/em^2/day.

Table 2: Chemical composition of mulch material used in trial.

Mulch material	N	P	K	Ca	Mg	Na	Mn	Fe	Zn	Si$_2$
	%						ppm			%
Maize	0.73	0.16	2.00	0.39	0.16	0.01	86	344	30	-
Maize cobs	0.66	0.16	0.66	0.13	0.06	<0.01	43	917	13	-
Oil palm leaves	1.48	0.19	0.57	0.67	0.77	0.01	252	378	25	3.78
Rice Straw	0.77	0.18	0.90	0.34	0.19	0.22	727	556	34	8.22
Rice musks	0.89	0.45	0.58	0.13	0.20	<0.01	256	599	51	10.4
Pennisetum polystachyon	0.39	0.14	1.16	0.30	0.16	0.02	42	171	42	-
Elephant grass	0.62	0.14	1.17	0.43	0.25	<0.01	130	216	52	3.68
Panicum maximum	0.31	0.42	1.26	0.42	0.15	0.02	41	545	62	6.59
Andropogon	0.23	0.16	0.32	0.34	0.08	<0.01	215	215	38	-
Typha straw	0.89	0.14	0.91	1.22	0.18	0.23	1305	217	30	-
Cassava stem	0.70	0.20	1.42	0.77	0.26	<0.01	42	128	25	-
Pigeon pea tops	2.57	0.21	1.37	0.66	0.16	0.02	207	207a	33	1.20
Pigeon pea stem	0.99	0.18	1.50	0.37	0.08	0.01	-	41	24	-
Cowpea/lima bean/pigeon pea husks	1.70	0.20	1.57	0.52	0.26	0.03	87	393	30	-
Soybean tops	1.16	0.18	2.66	0.93	0.53	0.02	126	506	21	-
Eupatorium tops	1.01	0.16	1.38	0.61	0.21	0.02	43	174	17	-
Mixed twigs	1.25	0.16	1.04	1.38	0.31	0.02	475	519	47	-
Saw dust	0.44	0.12	0.28	0.95	0.06	0.01	-	172	17	-

In maize, observations were made on tasseling, ear emergence, silking lodging, height and plant population at harvest, yields of stover and grain of which only yield will be presented here. Similarly, observations on flowering, plant population and yields were made in cowpea and soybeans but only yield data are presented. In cassava, data is presented on plant height, root number and yield. Chemical analyses were performed on both mulches and soils under various treatments. Observations were made on nematodes for which soil samples were collected at crop maturity in July for the first season and in November for the second season. Each crop-treatment combination had three replications and nine soil samples were taken from each replication. Soil samples were vertically taken with a soil tube to a 20-cm depth. Sample size was 108 cm^3 of soil. Nematodes were isolated from the soil using the modified Baermann funnel technique (2) and were concentrated by the settling-siphon method (1). For each replication, nematodes were identified and counted in three composite samples at 30X. Observations were made on weeds as from 1976 onwards and this involved two 0.5 m^2 quadrats per subplot just close to harvesting. Samples of the weeds collected were dried to constant weight. Soil physical measurements were based on a separate replicate in which cultivation treatments were superimposed on the mulch treatment. Drums were buried in the soil collection of run-off water from different treatments but only maize was used as a test crop. The set of treatments on which the physical measurements were based are shown in Table 4.

Initial Chemical Composition of Mulches and Soils After Three Years Under Treatments

The initial chemical composition of various crop/plant residue mulches are presented in Table 2. High levels of N were observed in palm leaves, pigeon pea tops, legume (cowpea/lima gean/pigeon pea) husks, soybean tops, Eupatorium tops and mixed twigs. Low N levels were observed in Panicum straw, Andropogon straw and saw dust. High P levels were observed in rice husks and Panicum tops. All other materials had about the same level of P. High K levels were observed in maize stover, straws of Pennisetum, Panicum, and elephant grass, chipped cassava stems, pigeon pea tops and stem, legume husks, soybean tops, Eupatorium tops and mixed twigs. Rice husks and maize cobs had low K contents. High Ca levels were observed in oil palm leaves, Typha straw, cassava stems, pigeon pea tops, legume husks, soybean tops, Eupatorium tops, mixed twigs and saw dust. Low Ca levels were observed in maize cobs and rice husks. Except for soybean tops and mixed twigs all other materials have low Mg levels.

Data on soil chemical properties after three years of different mulch and fertilizer treatments are shown in Table 3. Application of fertilizer especially in the absence of organic residue caused marked decreases in pH. In the presence of crop residue mulch and particularly with addition of fertilizers organic C level increased. The increases observed under no-mulch, plastic and gravel mulch treatments may

Table 3: Effect of mulch and fertilizer treatments on some chemical properaties of surface soil.

Mulch material		pH- H_2O	Org. C	Total N	In Am. Acetate Extractable					Bray P-1
			%	%	K		Mg	Na	Mm	
					me/100g					ppm
No. mulch	a	5.9	0.83	0.21	0.21	3.89	1.29	0.07	nd	12.0
	b	5.8	1.14	0.16	0.19	3.35	0.86	0.08	0.01	9.9
	c	5.5	1.21	0.17	0.29	3.15	0.64	0.06	0.05	40.2
Maize stover tops	a	6.0	0.83	0.16	0.21	2.48	1.29	0.07	nd	17.0
	b	6.4	1.58	0.21	0.69	2.65	1.13	0.07	-	19.7
	c	5.4	1.55	0.21	0.67	2.83	1.04	0.07	0.10	42.1
Maize cob	a	6.1	0.79	0.18	0.15	2.15	1.21	0.07	nd	16.3
	b	5.8	1.59	0.19	0.65	2.65	0.90	0.07	0.05	25.0
	c	5.3	1.54	0.21	0.51	2.13	0.72	0.06	0.14	38.6
Oil palm	a	6.3	0.79	0.27	0.13	2.44	1.23	0.07	nd	16.8
	b	5.3	1.34	0.18	0.22	2.28	0.74	0.05	0.06	27.5
	c	5.3	1.35	0.18	0.20	2.20	0.78	0.06	0.09	27.4
Rice straw	a	6.1	0.82	0.22	0.22	2.98	1.20	0.08	nd	18.3
	b	5.7	1.43	0.18	0.51	2.48	0.86	0.07	0.05	15.0
	c	5.5	1.58	0.19	0.59	2.50	0.89	0.07	0.08	33.0
Rice husk	a	6.1	0.86	0.21	0.21	2.90	1.23	0.07	nd	12.4
	b	5.5	1.35	0.15	0.11	2.65	0.84	0.07	0.01	12.3
	c	5.3	1.29	0.17	0.19	2.83	0.93	0.07	0.07	16.6
Pennisetum	a	5.8	0.82	0.19	0.09	2.49	1.09	0.07	nd	13.5
	b	6.4	1.24	0.19	0.58	2.68	1.13	0.07	-	14.0
	c	5.4	1.38	0.23	0.46	2.45	1.06	0.06	0.05	19.0
Elephant grass	a	6.0	0.85	0.17	0.21	3.10	1.26	0.06	nd	15.8
	b	6.5	1.32	0.18	0.56	2.98	1.22	0.07	-	10.2
	c	5.4	1.29	0.18	0.42	2.58	0.81	0.06	0.10	37.3
Panicum maximum	a	6.3	0.86	0.18	0.20	2.07	1.43	0.06	nd	13.6
	b	6.4	1.44	0.20	0.72	2.90	1.31	0.07	-	21.2
	c	5.4	1.42	0.18	0.68	2.80	1.09	0.07	0.03	19.7
Andropogon	a	5.9	0.83	0.18	0.20	2.07	1.43	0.06	nd	18.6
	b	6.1	1.35	0.20	0.72	2.90	1.31	0.07	-	21.0
	c	5.6	1.73	0.18	0.68	2.80	1.09	0.07	0.03	28.0
Typha	a	5.9	0.93	0.22	0.20	2.71	1.41	0.07	nd	16.4
	b	6.0	1.28	0.18	0.72	2.65	0.79	0.09	0.02	36.1
	c	5.1	1.34	0.18	0.68	2.18	0.54	0.07	0.07	47.8

Table 3: (Continued).

Mulch material		pH-H_2O	Org. C %	Total N %	In Am. Acetate Extractable K	Ca	Mg	Na	Mm	Bray P-1
					me/100g					ppm
Cassava stem	a	6.3	0.90	0.21	0.20	3.93	1.26	0.06	nd	23.6
	b	6.4	1.65	0.22	0.55	3.65	1.45	0.07	0.01	49.4
	c	5.6	1.94	0.26	0.54	3.59	1.38	0.07	0.04	54.6
Pigeon pea	a	6.3	0.98	0.20	0.19	3.98	1.30	0.05	nd	19.3
	b	5.7	1.37	0.20	0.45	3.73	1.06	0.07	-	20.6
	c	5.0	1.50	0.21	0.41	3.28	0.83	0.07	0.10	44.7
Pigeon pea stem	a	6.2	0.92	0.22	0.19	2.90	1.86	0.06	nd	14.5
	b	5.7	1.34	0.18	0.31	2.30	0.70	0.06	0.01	19.6
	c	4.9	1.47	0.17	0.31	1.95	0.63	0.06	0.09	25.0
Cowpea husk	a	6.1	0.86	0.23	0.19	3.51	1.16	0.07	nd	11.9
	b	5.6	1.69	0.25	0.51	2.75	1.30	0.07	0.05	30.0
	c	5.7	1.46	0.21	0.47	2.83	1.27	0.07	0.05	31.0
Soybean tops	a	5.9	0.80	0.20	0.21	3.43	1.38	0.07	nd	14.6
	b	6.5	1.50	0.20	0.67	3.75	1.81	0.06	-	40.6
	c	6.0	1.61	0.23	0.54	3.05	1.45	0.06	0.01	42.9
Eupatorium tops	a	6.1	0.89	0.17	0.24	3.14	1.37	0.07	nd	12.5
	b	6.3	1.21	0.16	0.44	2.88	1.07	0.06	0.01	14.1
	c	5.2	1.23	0.16	0.44	2.65	0.73	0.06	0.12	41.6
Mixed twigs	a	6.3	0.96	0.20	0.21	3.52	1.34	0.06	nd	13.9
	b	5.8	1.53	0.20	0.30	3.63	0.93	0.06	0.02	23.9
	c	5.7	1.59	0.21	0.38	3.43	0.90	0.06	0.08	44.4
Saw dust	a	6.2	0.88	0.19	0.21	3.40	1.07	0.06	nd	14.8
	b	6.8	1.64	0.19	0.30	4.13	1.15	0.06	-	11.9
	c	5.9	1.77	0.19	0.36	4.20	1.04	0.06	0.05	15.3
Black plastic	a	6.0	1.04	0.16	0.18	3.28	1.05	0.06	nd	15.1
	b	5.9	1.20	0.16	0.18	3.20	0.86	0.06	-	6.1
	c	5.7	1.15	0.17	0.31	3.08	0.69	0.06	0.01	14.8
White plastic	a	6.3	0.86	0.17	0.19	3.87	1.11	0.05	nd	16.5
	b	5.9	1.09	0.19	0.18	3.75	1.04	0.08	0.04	10.1
	c	4.9	1.20	0.21	0.37	2.63	0.67	0.07	0.21	22.1
Gravel	a	6.0	0.95	0.20	0.23	3.41	1.42	0.08	nd	19.2
	b	5.8	1.14	0.16	0.12	3.02	0.82	0.06	0.02	9.7
	c	5.4	1.22	0.16	0.26	2.50	0.67	0.06	0.02	26.1

a) Sample collected at start of experiment in 1975
b) No fertilizer treatment, sample collected beginning 1978
c) No fertilizer treatment, sample collected beginning 1978

be due to analytical problems, since, soil samples from 1975 and 1978 were not analyzed at the same time. Saw dust mulch gave the highest organic levels. Mulching also resulted in a higher percentage N level and also increased the K and Ca status of the soils. In some of the treatments there was a sharp decline in Mg status. Applied Fertilizer lowered Ca and Mg levels. In the presence of mulch, fertilization increased extractable P level.

Soil Physical Properties

The effects of different types of crop residue mulch and seedbed preparation on runoff and soil erosion for plots of 10 x 4 m^2 on 7% slope are shown in Table 4. For rainfall of 23 mm, runoff under maize was effectively controlled by all mulch treatments. The maximum runoff of 63% was observed on unmulched ridges running up and down the slope. Unmulched mounds, a traditional practice of growing crops on hillocks constructed by scraping the surface soil, decrease runoff to 9%. The soil loss was negligible on all mulched plots and 3.3, 2.1, 1.3, and 0.9 t/ha for unmulched ridges, plowed and unmulched flat, unplowed and unmulched flat, and traditional mounds, respectively. Soil erosions from mulched-mounds treatment was also negligible, e.g. 5 kg/h.

Some of the crop residues (such as typha) may cause nutrient imbalance or toxicity through excessive release of Mn and Al. Nitrogen immobilization can be particularly serious for residue with high C:N ratio. Synthetic materials, such as transparent and translucent polythene mulches, do not decompose fast or at all to add plant nutrients to the soil. However, through modification of hydro-thermal regimes, these materials hasten the rate of mineralization of soil nitrogen and render it readily available for plant growth. These conclusions are supported by the data in Table 5 that depicts the effects of different mulch materials on maize grain yield without supplementary fertilizer application. Grain yields in excess of 3 t/ha was obtained with a mulch of water lettuce and pigeon pea tops, and inexcess of 2 t/ha with legume husks, soybean tops, and oil palm leaves. Grain yield at 1 to 1.5 t/ha was obtained with crop residue mulch such as Panicum straw, maize stover, Typha, Pennisetum, rice husk, chipped cassava stems. The lowest yield of 0.1 t/ha was obtained from unmulched mounds.

Nematode Distribution

Aggregate plant-parasitic nematode soil population on all crops and under all mulch treatments increased in numbers from a preplanting mean of 234 nematodes to a mean of 1,984 the first year and 3,485 nematodes per liter of soil the second year (Table 6). By the end of the first and second years plant-parasitic nematode population means had increased the least under organic mulches (Table 7). Plant-parasitic nematode population means under non-organic mulches were

Table 4: Effects of different mulch materials on runoff and soil loss. Rainfal = 23 mm.

Plot	Treatment	Runoff mm	Runoff % of Rain-fall	Soil erosion (kg/he)
1	Mounds with guinea grass mulch	3.3	14.3	5
2	Ridges unmulched	14.5	63.0	3,300
3	Flat unmulched	10.3	44.8	1,250
4	Flat with chipped Pigeon pea stem mulch	3.9	17.0	T
5	Flat with water lettuce mulch	2.0	8.7	T
6	Flat with eupatorium mulch	2.0	8.7	T
7	Flat with maize cobs mulch	0.4	1.7	T
8	Flat with elephant grass mulch	1.0	4.3	T
9	Ridges with guinea grass mulch	5.3	23.0	T
10	Flat with maize stover mulch	5.3	23.0	T
11	Flat with pennisetum mulch	4.3	18.7	T
12	Flat with pigeon pea branches mulch	5.3	23.0	T
13	Flat with transparent polythene mulch(white)	0.7	3.0	T
14	Flat with gravel mulch	3.3	14.3	T
15	Flat with soybean straw mulch	3.3	14.3	T
16	Flat with oil palm leaves mulch	3.3	14.3	T
17	Flat with typha straw mulch	3.3	14.3	T
18	Flat with rice husk mulch	1.3	5.7	T
19	Flat with pigeon pea/cowpea husk mulch	2.6	11.3	T
20	Flat with saw dust mulch	1.3	5.7	T
21	Flat with cassava stem chipped	0.3	1.3	T
22	Flat with guinea grass mulch	1.0	4.3	T
23	Flat with Andropogan mulch	2.0	8.6	T
24	Flat with mixed twigs and branches mulch	3.9	17.0	T
25	Flat unmulched and plowed	0.7	3.0	2,210
26	Mound,unmulched	2.0	8.6	860
27	Flat, rice straw mulch	0.7	3.0	T
28	Flat, translucent polythene mulch (black)	2.6	11.3	T
29	Flat, plowed with guinea grass mulch	0.7	3.0	T

T = $<$ 5 kg/ha.

Table 5: Effects of mulch material and seedbed preparation on maize grain yield without supplementary fertilizer application. (Second Season, 1978).

Plot	Treatment	Grain yield (t/ha)
1	Mounds with guinea grass mulch	1.5
2	Ridges unmulched	0.6
3	Flat unmulched	0.3
4	Flat with chipped pigeon pea stem	0.5
5	Flat with water lettuce mulch	3.3
6	Flat with eupatorium mulch	1.1
7	Flat with maize cobs mulch	0.7
8	Flat with elephant grass mulch	0.8
9	Ridges with guinea grass mulch	1.2
10	Flat with maize stover mulch	1.7
11	Flat with Pennisetum mulch	1.4
12	Flat with pigeon pea branches mulch	3.1
13	Flat with transparent polythene mulch (white)	0.7
14	Flat with gravel mulch	0.1
15	Flat with soybean straw mulch	2.7
16	Flat with oil palm leaves mulch	2.3
17	Flat with typha straw mulch	1.5
18	Flat with rice husk mulch	1.8
19	Flat with pigeon pea/cowpea busk mulch	2.9
20	Flat with sawdust mulch	0.7
21	Flat with cassava stem chipped mulch	1.4
22	Flat with guinee grass mulch	1.0
23	Flat with Andropogen mulch	0.8
24	Flat with mixed twigs and branches mulch	0.8
25	Flat, unmulched and plowed	0.7
26	Mounds, unmulched	0.1
27	Flat, rice straw mulch	1.6
28	Flat, transparent polythene mulch (black)	0.8
29	Flat, plowed, with guinea grass mulch	1.0

well above the no mulch control plot mean. The ranking of all treatments by soil population means is given in Table 6.

The plant-parasitic nematode soil populations responded more to cropping influences than to mulch treatments (Fig. 1-4). The root lesion nematodes (Pratylenchus sefaensis, P. brachyurus) became the most numerous on maize. The root lesion nematode population mean rose from a preplanting mean of 2 nematodes to 9,230 per liter of soil by the end of four seasons under continuous maize (Fig.2). The spiral nematodes (Helicotylenchus pseudorobustus, H. erythrinae, H. cavenessi) increased most on soybean, cassava and maize (Fig.3). Spiral nematode preplanting population mean was 126 and increased to 1,404 nematodes per liter of soil by the end of four seasons of continuous soybean. Root-knot nematode (Meloidogyne incognita) increased most on cowpea from a preplanting mean of 73 to 1,251 juveniles per liter of soil after four seasons (Fig.4).

The population levels of non plant-parasitic nematodes (saprozoic, predatory, fungivorous and browser forms) were monitored as a general indicator of biological activity in the soil. The mean non parasitic nematode soil population prior to beginning the trial was 19,412 nematodes per liter of soil. The mean populations for all treatments were reduced to 50 percent or less of the preplanting mean under the treatments of the mulching trial (Table 8). Population means of 11 organic mulches were about the same or greater than the unmulched control plots (Tables 8 & 9). Population means under the non-organic mulches were consistently less than population means of the control plots (Table 9).

Weed Populations

Data on the effect of mulch treatments on weed population are presented in Table 10 and Figure 5. Significant differences in weed distribution were observed among the test crops of maize (cv. TZB), cowpea (cv. Ife Brown), soybeans (cv, Bossier) and cassava (cv. Isunikankiyan). Subtreatment plots were divided into one meter grids and weed counts were taken from two randomly selected grids using $0.5m^2$ metal frames. Weed population density was highest in soybean and least inmaize with regard to the various types of mulches. Also differences among weed population means of the various mulching materials were highly significant (Table 10). Quantities of mulching materials varied between 10 tons and 15 tons/ha and all provided good coverage of the soil surface. The most effective mulching material for suppressing weeds were oil palm leaves, maize stover, Andropogon straws and rice husks. Mixed twig and chipped maize cobs were the least effective. Among the inorganic mulches black plastic effectively suppressed weeds while fine gravel gave the poorest weed control. All mulches suppressed weeds more effectively than bare soil. Generally, mulching materials of organic origin caused a shift in weed flora in favour of annual broadleaf weeds (Fig. 5). Periodic weed removal during

Table 6: Ranking of all plant-parasitic nematodes with mulch treatments on all crops for the two growing seasons for the years 1975 and 1976a

Percentage of no-mulch plot			Treatment	Plant-parasitic nematodes[d]	
1975	1976b	1976c		1975	1976
44	138	79	Sawdust	948	2,964
61	94	55	Panicum straw	1,307	2,026
64	249	144	Maize stover	1,387	5,352
66	150	87	Maize cobs	1,409	3,232
68	180	105	Andropogon straw	1,473	3,878
69	123	71	Typha straw	1,474	2,639
69	99	57	Pennisetum straw	1,482	2,122
70	101	59	Cassava stems	1,510	2,172
73	218	126	Pigeon pea stems	1,562	4,686
76	124	72	Rice straw	1,645	2,677
80	221	128	Elephant grass	1,711	4,751
87	130	75	Pigeon pea tops	1,869	2,792
97	149	86	Bean husks	2,078	3,199
100	172	100	Control (no mulch)	2,151	3,708
107	108	62	Soybean tops	2,308	2,325
107	114	66	Mixed twigs	2,338	2,443
111	150	87	Clear plastic	2,385	3,277
115	149	86	Eupatorium tops	2,470	3,199
123	329	191	Black plastic	2,655	7,068
132	194	113	Oil palm leaves	2,835	4,173
139	190	110	Rice husks	2,980	4,096
170	183	106	Fine gravel	3,660	3,944
92	162	94	Mean	1,984	3,485

a) Mean numbers of nematodes per liter of soil based on 528 samples for each treatment.
b) Between year comparisons.
c) Within year comparisons.
d) Principal nematodes were root-knot, root lesion and spiral nematodes.

Table 7: Mean numbers of plant-parasitic nematodes per liter of soil under organic and non organic mulches.

Percentage of no-mulch plot			Treatment	Plant-parasitic nematodes[c]	
1975	1976a	1976b		1975	1976
100	172	100	Control (no mulch)	2,151	3,708
85	152	88	Organic mulches	1,821	3,263
135	221	129	Non organic mulches	2,900	4,746

a)Between year comparisons.

b)Within year comparisons.

c)Principal nematodes were root-knot, root lesion and spiral nematodes.

Table 8. Ranking of non plant-parasitic nematodes with mulch treatments on all crops for the two growing seasons for the years 1975 and 1976a.

Percentage of no-mulch plot 1975	1976b	1976c	Treatment	Non plant-parasitic nematodes[d] 1975	1976
87	127	88	Panicum straw	6,046	8,777
88	122	85	Clear plastic	6,079	8,456
90	100	70	Fine gravel	6,224	6,931
95	120	84	Pennisetum straw	6,564	8,335
95	106	74	Black plastic	6,588	7,326
100	144	100	Control (no mulch)	6,921	9,948
103	149	104	Andropogon straw	7,119	10,332
103	98	68	Rice husks	7,139	6,790
104	128	89	Typha straw	7,231	8,835
105	164	114	Rice straw	7,280	11,367
107	127	89	Oil palm leaves	7,382	8,804
108	148	103	Eupatorium tops	7,468	10,210
108	145	101	Maize stover	7,480	10,030
114	128	89	Elephant grass	7,908	8,855
116	138	96	Pigeon pea tops	8,008	9,541
120	125	87	Cassava stems	8,320	8,631
127	159	111	Pigeon pea stems	8,782	11,004
130	175	121	Maize cobs	9,005	12,080
134	148	103	Mixed twigs	9,296	10,228
140	175	122	Bean husks	9,684	12,103
156	140	98	Soybean tops	10,783	9,712
175	195	135	Sawdust	12,140	13,468
114	139	97	Mean	7,884	9,626

a) Mean numbers of nematodes per liter of soil based on 528 samples for each treatment.
b) Between year comparisons.
c) Within year comparisons.
d) Saprozoic, predatory and browser nematodes.

Table 9: Mean numbers of non plant-parasitic nematodes per liter of soil under organic and non organic mulches.

Percentage of no-mulch plot 1975	1976 a	1976b	Treatment	Non plant-parasitic nematodes[c] 1975	1976
100	144	100	Control (no mulch)	6,921	9,948
117	144	100	Organic mulches	8,202	9,950
91	109	76	Non organic mulches	6,297	7,571

a) Between year comparisons.

b) Within year comparisons.

c) Saprozoic, predatory and browser nematodes.

Table 10: Effect of mulching and crop type on weed distribution in different test crop 1976.

Mulch	Weed distribution (Weed/m^2)				
	Maize	Cowpea	Soybean	Cassava	Mean
1. Bare - No mulch	49	68	67	51	59 a
2. Maize stover	2	3	13	8	7 jklm
3. Maize cobs (chipped)	13	18	23	26	20 cd
4. Oil palm leaves	0	3	5	9	4 m
5. Rice straw	7	8	34	7	14 fg
6. Rice Husks	3	4	11	15	8 ijk
7. *Pennisetum* straw	4	3	23	14	11 hi
8. Elephant Grass Straw	9	1	23	8	10 ij
9. *Panicum maximum*	14	23	13	17	17 def
10. *Andropogon* straw	0	1	16	8	6 jklm
11. *Typha* straw	1	3	19	13	9 ijk
12. Cassava stems (chipped)	10	5	10	6	8 ijk
13. Pigeon pea tops	19	16	21	17	18 de
14. Pigeon pea stem (chipped)	2	3	28	9	11 hi
15. Legume husks	6	9	26	29	18 de
16. Soybean tops (chipped)	4	9	9	21	11 hi
17. *Eupatorium* tops	10	11	16	24	15 efg
18. Mixed twigs (chipped)	19	12	29	35	24 c
19. Saw dust	8	9	26	17	15 efg
20. Black plastic	3	7	13	7	8 ijkl
21. Translucent plastic	14	8	17	15	14 fgh
22. Fing gravel	15	55	46	21	34 l
Mean	10c	13bc	22a	17ab	

Means followed by the same letter in the same column or row are not significantly different at the 5% level using Duncan's multiple range test.

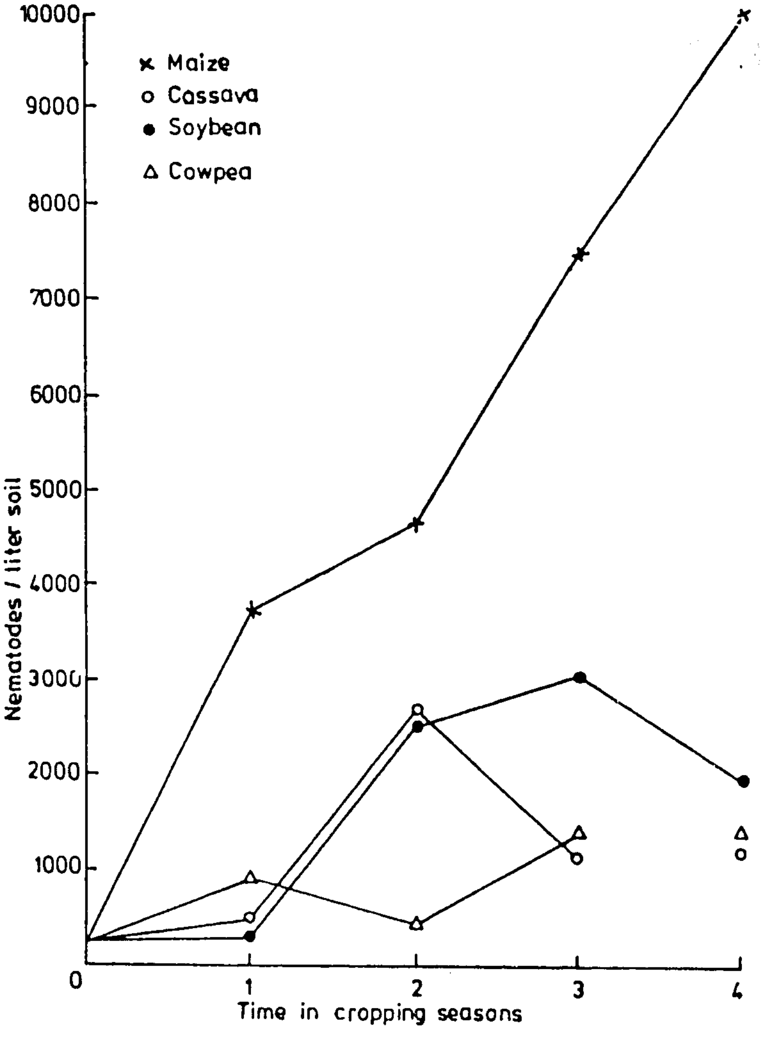


Fig.1. Summary all plant-parasitic nematodes.

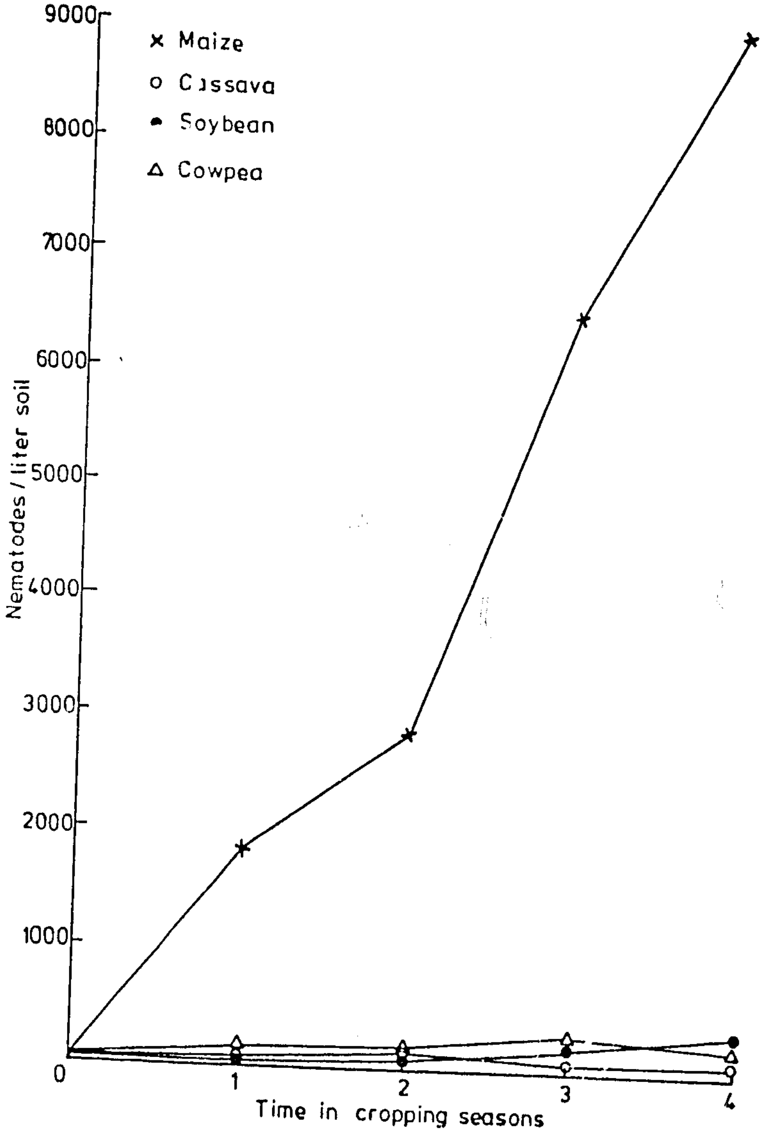


Fig.2. The root lesion nematodes.

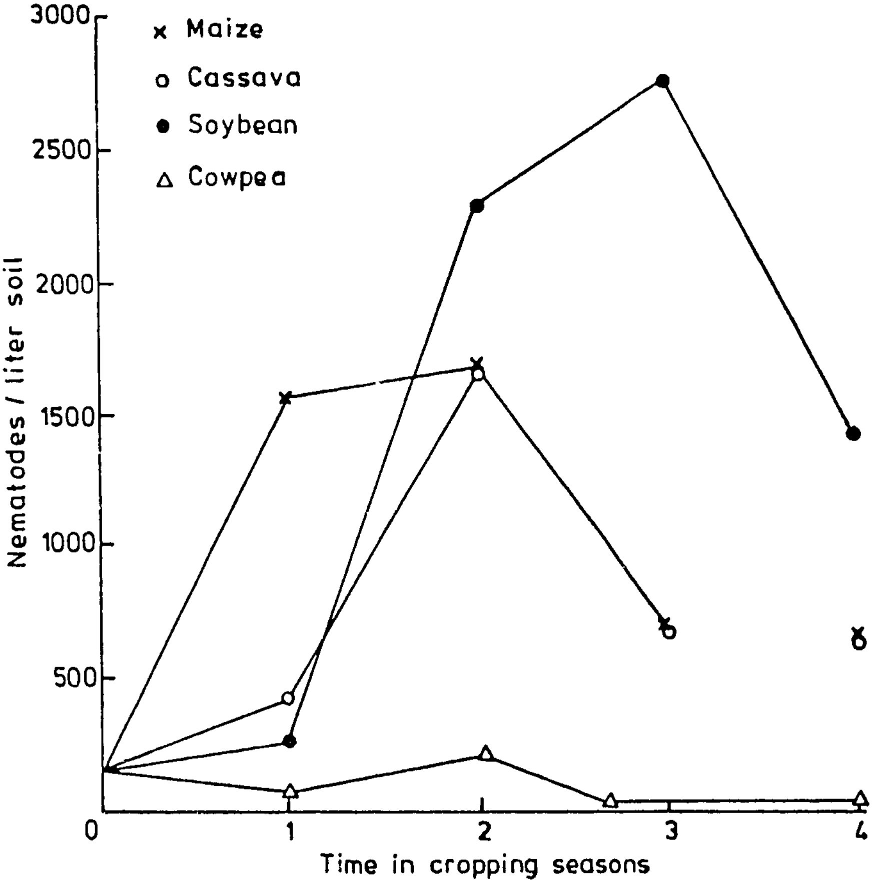


Fig.3. The spiral nematodes.

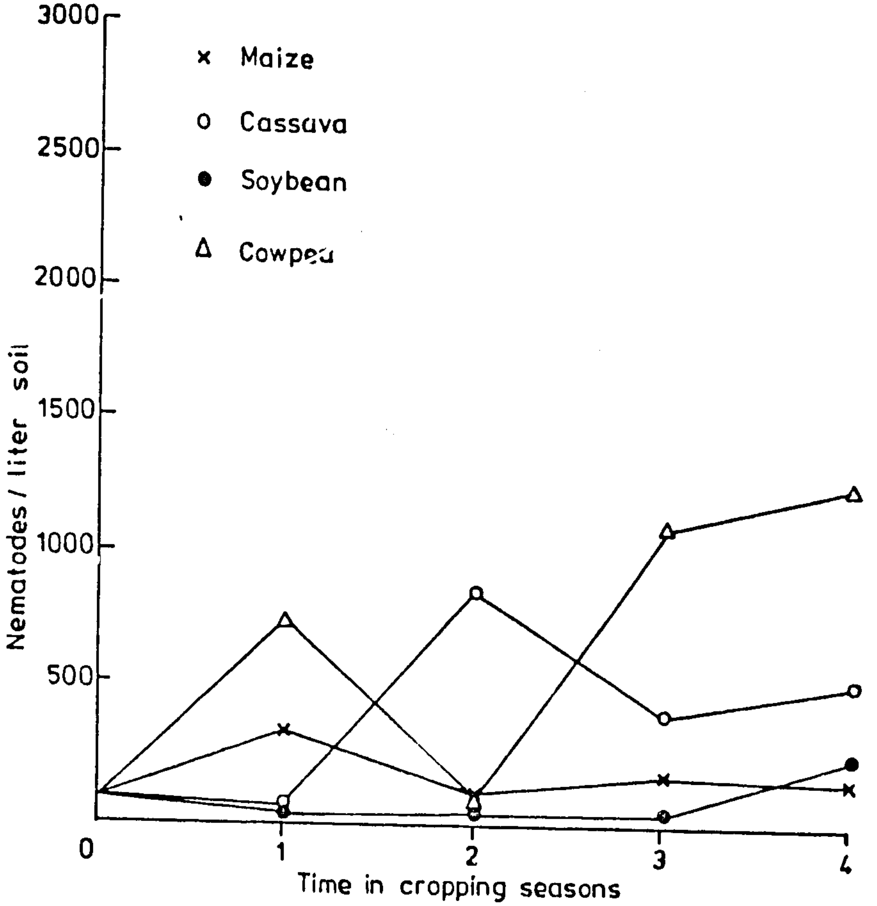


Fig.4 . The root-knot nematodes.

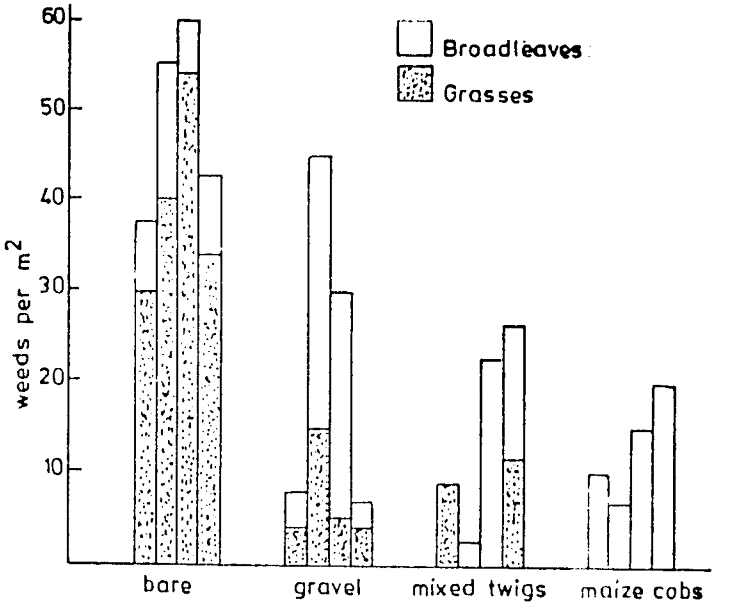


Fig.5a. Effect of mulch on weed flora and population.

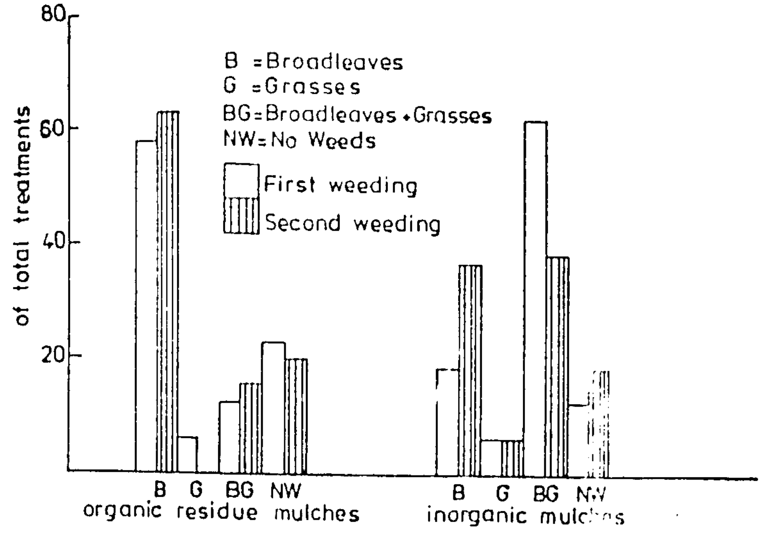


Fig.5b. Effect of mulching on weed flora.

the growing season appeared to favour the predominance of annual broadleaf weeds in all mulch treatments (Figure. 5). Mixed population of annual grasses and broadleaf weeds dominated the inorganic mulches while weeds in organic mulch materials were mainly annual broadleaf weeds.

Crop Performance and Yields

The data on maize dry grain yields in 1975 are presented in Table11. No significant differences in grain yields among mulch treatments were observed in early maize but significant differences were obse-ved in late maize. Although no significant differences were observed in the early maize the legume mulches, fine gravel and plastic mulches gave higher dry grain yields than the non-legume mulches and bare treatments. In the late maize, lowest grain yields were observed on the elephant grass straw, Typha straw, translucent plastic, Eupatorium tops, Andropogon straw, Rice straw and bare plots. Highest dry grain yields were observed in the chipped cassava stems, sawdust, soybean tops and rice husks. No significant differences were observed among legume, non-legume, gravel and plastic mulch groups all of which gave high but insignficant yields than the bare plot.

In 1977 mean dry weight stover and grain yields observed in the different mulch treatments in early and late maize crops are presented in Table 12. Highly significant differences among treatments were observed in both stover and grain yields. All other mulch treatments gave significantly higher stover yields than the bare and fine gravel treatments in the early maize. The highest stover yields in the early maize were observed in the Elephant grass, Panicum straw, Typha straw, rice husks and soybean tops. Significantly lower dry grain yields were observed in the bare and translucent plastic than in all the other muich treatments with the exception of the fine gravel, black plastic, mixed twigs and the Pennisetum straw. Highest grain yields were observed in the soybean tops followed by Typha straw, rice husks and rice straw. In the late maize, significant differences were observed among treatments in both dry weight of stover and dry grain yield (Table 12). The highest stover yield occurred in the cassava stems mulch followed by pigeon pea tops, maize stover and soybean tops while stover yields in the translucent plastic followed by fine gravel and bare treatments were (except for the bare plot) significantly lower. As in the early maize crop, mulch treatments which gave the highest stover yields did not necessarily give the highest grain yield. In general dry grain yields were about half or less than half of the corresponding late crop yields. Significantly lower yields were observed in the translucent plastic and maize cobs mulches followed (but not significantly so) by the bare, fine gravel and mixed twigs treatments. The dry grain yield in the legume husks treatment was significantly the highest.

Table 11: Mean Maize grain yields (t/ha) as affected by different mulch treatments in 1975/76.

Treatments	1975 Early	1975 Late
1 Bare - no mulch	4.0a	2.5bcde
2 maize stover	4.0a	2.9abcd
3 Maize cobs (chipped)	3.7a	2.8abcd
4 Oil palm leaves	4.3a	2.7abcd
5 Rice straw	4.8a	2.5bcde
6 Rice husks	5.0a	3.0abc
7 Pennisstum straw	4.2a	2.8abcd
8 Elephant grass	4.9a	1.7e
9 Panicum straw	4.3a	2.8abcd
10 Andropogon straw	4.6a	2.5bcde
11 Typha straw	4.5a	2.1de
12 Cassava stems	3.9a	3.3a
13 Pigeon pea tops	4.8a	2.9abcd
14 Pigeon pea stems	4.1a	3.0abc
15 Legume husks	4.5a	2.8abcd
16 Soybean tops (chipped)	5.0a	3.0abc
17 Eupatorium tops	4.5a	2.5bcde
18 Mixed twigs (chipped)	3.9a	2.7abcd
19 Sawdust	3.8a	3.1ab
20 Black plastic	4.8a	2.7abcd
21 Translucent plastic	4.6a	2.4cde
22 Tine gravel	4.7a	2.9abcd
Mulch Groups		
1 Bare	4.0a	2.5bcde
2 Legumes	4.7a	2.9abcd
3 Non-Legumes	4.2a	2.9abcd
4 Gravel	4.7a	2.9abcd
5 Plastic	4.7a	2.6bcd

Table 12: Mean maize stover dry weight yields (t/ha) and mean maize dry grain yields (t/ha) observed for the early and late crops in relation to mulch treatments at Ibadan in 1977.

Treatments	EARLY MAIZE 1977 Dry weight of stover (V2)		EARLY MAIZE 1977 Dry weight of grain (V3)		LATE MAIZE 1977 Dry weight of stover (V2)		LATE MAIZE 1977 Dry weight of grain (V3)	
1. Bare - no mulch	1704	i	1217	g	940	bcd	430	de
2. Maize stover	3279	abcde	2058	abcde	1400	a	665	abcd
3. Maize cobs	2892	cdefg	1939	abcde	1013	abcd	351	e
4. Oil palm leaves	3129	bcde	2051	abcde	1119	abcd	550	bcde
5. Rice straw	2924	cdefg	2342	ab	1137	abcd	631	abcd
6. Rice husks	3602	abc	2338	ab	1251	abc	547	bcde
7. Pennisetum straw	2192	ghi	1763	cdef	1170	abc	595	abcde
8. Elephant grass	[illegible]009	a	2276	ab	1086	abcd	524	bcde
9. Panicum straw	3812	ab	1875	bcde	1353	ab	594	abcde
10. Andropogon straw	2983	cdef	2106	abc	1143	abcd	672	abcd
11. Typha straw	3600	abc	2328	ab	1335	ab	697	abc
12. Cassava stems	3353	abcd	2041	abcde	1449	a	759	ab
13. Pigeon pea tops	3131	bcde	2024	abcde	1401	a	769	ab
14. Pigeon pea stems	2759	defg	1953	abcde	1134	abcd	550	bcde
15. Legume husks	3319	abcde	2079	abcd	1289	abc	812	a
16. Soybean tops	3511	abc	2408	a	1384	ab	713	abc
17. Eupatorium tops	2581	efgh	1876	bcde	1108	abcd	565	abcde
18. Mixed twigs	2757	defg	1760	cdef	1247	abc	505	cde
19. Sawdust	3010	cdef	2211	abc	1161	abc	626	abcd
20. Black plastic	2276	fghi	1591	defg	1068	abcd	549	bcde
21. Translucent plastic	1945	hi	1294	fg	703	d	378	e
22. Fine gravel	1603	i	1569	efg	858	cd	467	cde

Means opposite the same letter (S) are not significantly different according to Fishers Protected Means Square Test.

The general effect of the different kinds of mulches and especially in relation to response of test crops to fertilizer are shown in Figures 6 and 7 for early and late maize, respectively. Mean stover yields of bare and mulch treatments and in fertilized and unfertilized halves of the plots of both treatments were lower than corresponding values in the legume, non-legume and plastic mulch treatments. But mean grain yields in bare plots including fertilized and unfertilized halves were lower than corresponding legume, non-legume, gravel and plastic mulches. In both stover and grain yields, fertilized and unfertilized plots were least pronounced on the legume group of mulches with the difference being much less pronounced for the grain as compared to the stover.

Cassava

Data on plant height, root number and fresh weight of roots observed in 1975/76 are presented in Table 13. Significant differences were observed among mulch treatments. Plant height was lowest in bare plots followed by elephant grass straw, Panicum straw and oil palm leaves treatments all of which were significantly lower than the highest value observed in the black plastic followed by legume husks, pigeon pea tops and rice husks. Highest number of roots per plant were observed in the black plastic followed by rice husks, legume husks, and translucent plastic all of which gave significantly higher root numbers than in the Pennisetum straw, Typha straw, oil plam leaves and bare treatments. Spectacularly high root yield of 30.5 t/ha was observed in the black plastic followed by over 26 t/ha on the rice husks, translucent plastic and legume husks all of which were significantly higher than on the Pennisetum straw with 14.15 t/ha Panicum straw with 15.5 t/ha and the bare and maize stover mulches with 16.3 t/ha. This would appear to be partly due to high nitrogen flushes that appear to build up under the plastic mulched plots, high potassium content and weed suppressing effect of rice husks and high nutrient content of legume husks. A comparison of effects of the different groups of gravel on cassava performance indicates that in height, root number per plant and root yield, the general trend (except for slight difference in root number) followed the trend Plastic mulch>legume mulch>gravel>non-legume mulches>bare. The significantly higher root yield of 27.8 t/ha observed on the fine gravel as compared to 16 t/ha on the bare suggests that other factors such as moisture and perhaps temperature may also be interacting with other effects in a complex manner.

Cowpea and Soybean

Data on yield of early and late cowpea and soybeans in 1975/76 are presented in Table 14. No significant differences were observed in both late cowpea and soybean crops in 1975. Early cowpea and soybean yields were higher than the early crops of 1976. Highest cowpea seed yields were observed in cassava stems, soybean tops, Panicum straw, pigion pea, legume husks, maize cobs, oil palm leaves

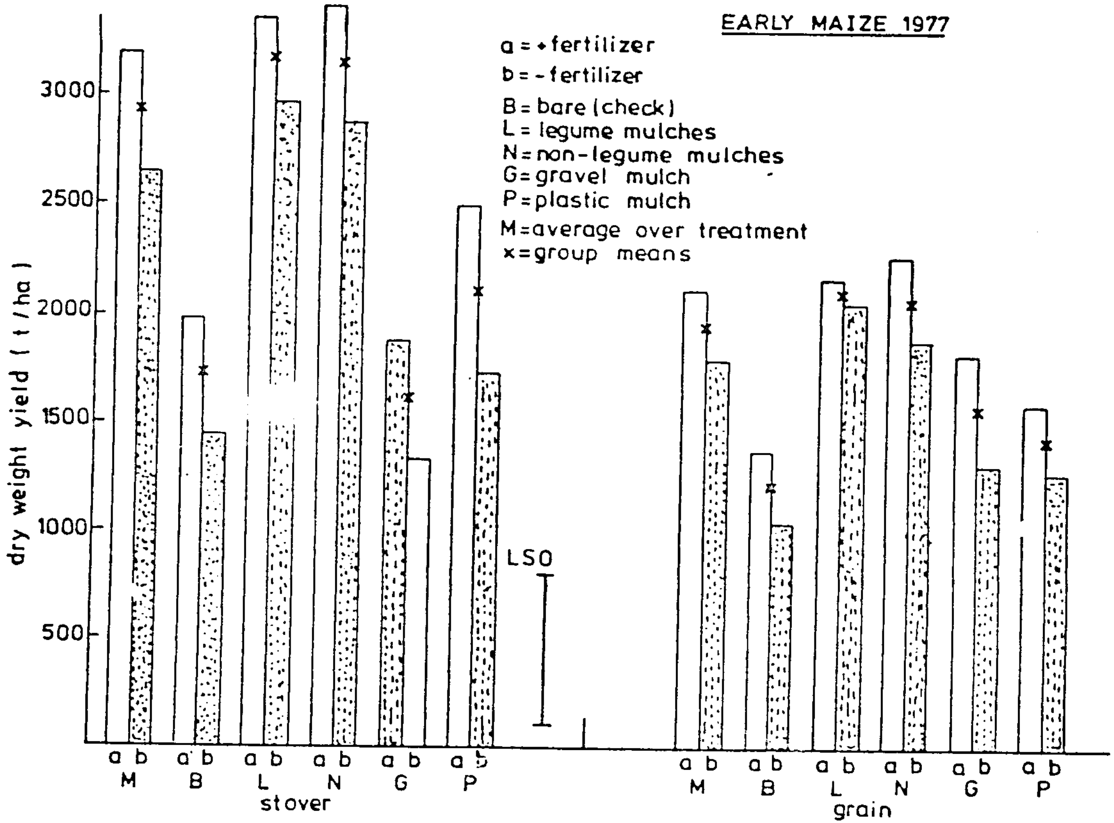


Fig.6. Mean stover and grain dry weight yields in early maize in different groups of mulches with and without fertilizer at IITA in 1977.

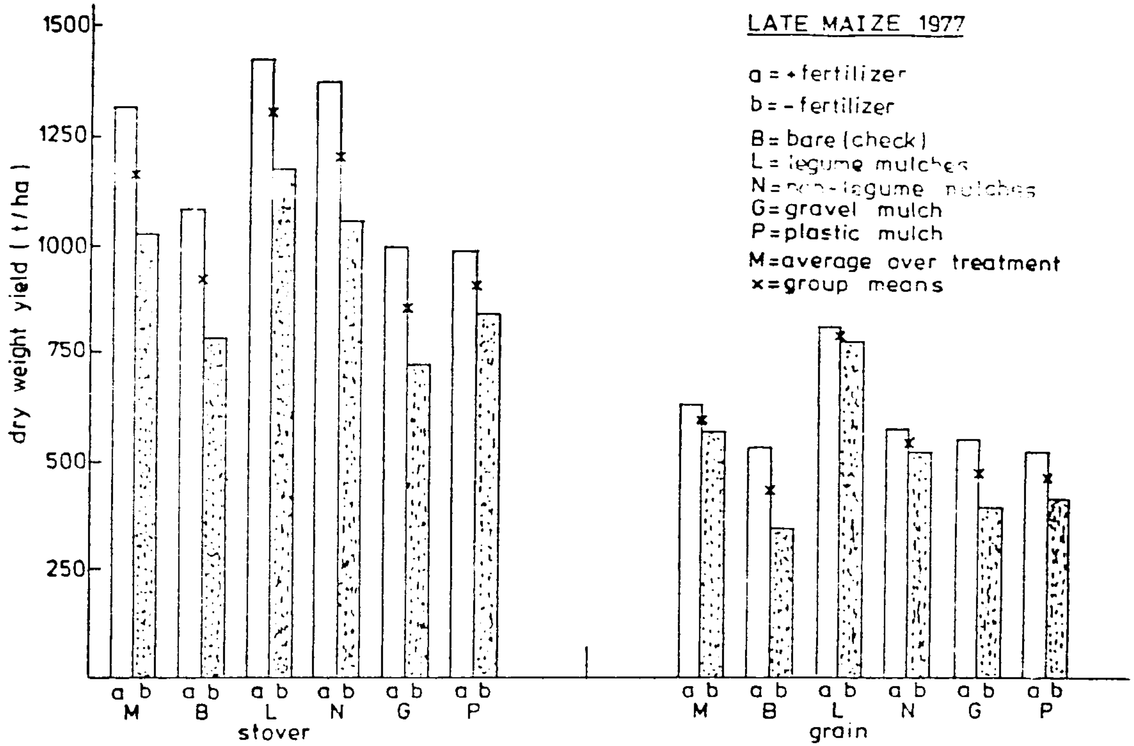


Fig.7. Mean stover and grain dry weight yields in late maize in different groups of mulches without fertilizer in 1977.

Table 13: Observations on cassava grown in different mulches in 1975/76.

Treatments	Plant height at harvest (cm)	Roots No/stand	Fresh wt. of roots t/ha
Bare no mulch................	254.60g	4.9ghi	16.38def
Maize stover.....................	330.63bcdef	5.6fghi	16.36def
Maize cobs (chipped)..........	330.27cdef	5.1ghi	17.82edef
Oil palm leaves................	310.20ef	4.8hi	17.08def
Rice straw........................	316.03	5.0ghi	17.93cdef
Rice husks.........................	352.27abcd	7.3ab	28.32a
Pennisetum straw.............	314.60def	4.6i	14.15ef
Elephant grass..................	303.27f	5.0ghi	16.57def
Panicum straw..................	309.87ef	5.1ghi	15.50f
Andropogon straw.............	330.77bcdef	5.4fghi	18.47cdef
Typha straw	319.37cdef	4.8i	16.72def
Cassava stems (chipped).....	335.37bcdef	5.8defgh	20.90cd
Pigeon pea tops................	353.47abc	6.4cd	22.92bc
Pigeon pea stems (chipped)	333.27bcdef	6.3cdef	19.92cde
Cowpea lima p,pea husks...	356.70ab	7.0bc	26.40ab
Soybean tops.....................	348.37abde	6.3cde	22.90bc
Eupatorium........................	338.33bcdef	5.1ghi	18.83cdef
Mixed twigs (chipped)........	325.03bcdef	5.9defg	18.50cdef
Sawdust.............................	343.87abcdef	5.3fghi	20.45cde
Black plastic.....................	374.97a	8.0a	30.51a
Translucent plastic...........	337.53bcdef	7.0bc	27.68ab
Fine gravel........................	343.70abcdef	6.6bcd	22.85bc
Mulch groups			
1. Bare	254.6	4.9	16.4
2. Legumes	347.9	6.5	23.0
3. Non-legumes	325.7	5.3	18.4(17.6)
4. Plastic	356.3	7.5	29.1
5. Gravel	343.7	6.6	22.9

Means opposite the same letter (S) are not significantly different at the 5% level.

Table 14: Mean Cowpea and soybean yields (t/ha) as affected by different mulch treatments in 1975-76 at IITA.Ibadan.

Treatments	Cowpea		Soybean	
	Late 1975	Early 1976	Late 1975	Early 1976
1. Bare-no mulch	0.67a	0.59a	0.43a	0.58de
2. Maize stover..............	0.99a	1.11a	0.88a	1.49abc
3. Maize cobs (chipped)...	1.03a	1.07a	0.64a	1.35abcd
4. Oil palm leaves..........	1.03a	1.20a	0.65a	0.91bcde
5. Rice straw................	0.98a	1.02a	0.74a	1.50abc
6. Rice husks................	0.82a	1.14a	0.48a	0.79de
7. Pennisetum straw........	1.01a	1.22a	0.81a	1.35abcd
8. Elephant grass............	0.92a	0.94a	0.58	1.29bcd
9. Panicum straw...........	1.08a	2.09b	0.87a	1.53ab
10. Andropogon straw........	0.69a	0.98a	0.42a	1.19bcde
11. Typha straw...............	0.95a	0.97a	0.72	1.08bcde
12. Cassava stems............	1.23a	0.77a	0.59a	1.38abcd
13. Pigeon pea tops..........	0.99a	1.08a	0.66a	0.90cde
14. Pigeon pea stems........	1.08a	0.97a	0.63a	1.29bcd
15. Legume husks.............	1.05a	1.01a	0.82a	1.50abc
16. Soybean tops (chipped).	1.10a	0.97a	0.62a	1.05acde
17. Eupatorium tops..........	0.90a	1.01a	0.69a	1.23bcde
18. Mixed twigs (chipped).	0.98a	1.02	0.78a	1.21bcde
19. Sawdust.....................	0.95a	0.93a	0.73a	1.91a
20. Black plastic..............	0.85a	0.94a	0.60a	1.08bcde
21. Translucent plastic......	0.94a	0.96a	0.49a	1.13bcde
22. Fine gravel................	0.79a	0.98a	0.70a	1.00bcde
Mulch groups				
1. Bare......	0.67a	0.59a	0.43a	0.58de
2. Legumes.....................	1.08a	1.02a	0.73a	1.24bcde
3. Non-legumes..............	0.99a	1.02a	0.67a	1.37abcd
4. Gravel........................	0.79a	0.98a	0.70a	1.00bcde
5. Plastic.......................	.90a	0.95a	0.55a	1.11bcde

Means opposite the same letter (S) are not significatly different at the 5% level.

and Pennisetum straw while the lowest occurred on the bare followed by Andropogon straw treatment in the late 1975 crop. However, in the early 1976 crop highest cowpea yields occurred in the Panicum straw, followed by Pennisetum straw, oil palm leaves, rice husks ano maize stover but the lowest were observed on the bare and cassava stem treatments. Yields of soybean followed the same trend as those of cowpeas. In the 1975 late crop, highest yields were observed ir the Panicum straw, followed by legume husks, maize stover, and Penni setum straw but the lowest values occurred on the bare, Andropogon straw and rice husks. In the early crop of 1976 highest yields were observed in saw dust, Panicum straw legume husks and rice straw: with lowest yields in the bare and rice husks. It would appear that in general yields of both soybean and cowpea and soybean were better in the legume mulches in the late crop of 1975 than the other treatments while in the early crop the reverse was true. It was observed in the field that both crops flowered earliest and also matured earliest in the plastic mulch treatments perhaps due to higher temperatures under these treatments.

CONCLUSIONS

Organic residues such as agricultural waste from crops, by-products of forest industries such as sawmilling and even plastic materials have some potential in soil management such as in erosion control, soil fertility maintenance or both. When used as mulches their effects on the soil and on the crop varies with plant species, the part of the plant involved and the nutrient composition. It is also known that the amount of mulch used has considerable influence on its effectiveness. Although mulches can add considerable amounts of nutrients to the soil, their use cannot effectively eliminate fertilizer use but may considerably reduce it. Some mulches interact with fertilizer to reduce soil pH. Some straw mulches such as Typha and addyrice straw may cause nutrient inbalance and toxicities due to the high amounts of Mn and Al they may release during decomposition. The beneficial effects of leguminous ones appear to be due to their narrower C:N ratio. In general, leguminous mulches which are not very woody gave on the average higher yields of all the test crops.

Spectacular effects of polythene and rice husk mulches oncassava were observed due perhaps to the nitrogen build-up in the former as Confirmed by the dark green colour of the cassava plants growing in the plastic mulch. The effects of the latter may be due to its effectiveness in suppressing weeds and adding some nutrients to the soil. In any case both mulches create favourable environment for cassava and may prove to be of some commercial potential. Graminaceous residues appear to be less suitable for mulching than leguminous ones except that legumes perform reasonably well in them perhaps due to stimulation of rhizobial activity. Of all the crop residue mulches used, it would appear that only pigeon pea and maize stover can be easily obtained by including them in a rotation which would be more economical than carrying them from elsewhere. Sawdust and rice husks promise to be the only by-product mulches that may be locally abundant in some areas but large quantities may be difficult to come by for large scale farms.

It should not be generalized that mulching increases nematode populations. After about two years of cropping plant parasitic nematode populations on the average increased least under organic mulches and under non-organic mulches they were higher than in the control. It would appear that the crop associated with the mulch had a greater role to play in the incidence of a specific nematode than the organic residue per se.

Mulching effectively suppressed weeds with the most efficient being black plastic which does not permit any weeds to grow under it due to lack of light. In addition it does not disintegrate in sunlight as the translucent one. Mulching materials had differential effects on annual broad-leafed weeds as compared to grasses. But of all the organic mulches palm leaves, maize stover, rice husks and Andropogon straw were very effective in suppressing weeds.

With the results of this experiment it would be possible to plan a cropping sequence or system not only to combat erosion, increase soil organic matter and achieve other heneficial effects but also ensure sufficient crop residues for zero-tillage and minimize damage by nematodes and weeds on certain crops. Thus a rotation or cropping sequence can be designed to achieve any objective of interest. A lot of work remains to be done on the study of decomposition process in different mulches in relation to the amount of mulch required within the humid tropics.

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REFERENCES

Ayanaba, A. and Okigbo, B.N. (1975) Mulching for improved soil fertility and crop production. Report of the FAO/SIDA Expert Consultation 1975, FAO, Rome pp. 97-120.

Charreau, C. (1974) Systems of cropping in Dry Tropical Zone of West Africa. Seminar on Farming Systems of Tropical Africa. Ibadan. Lectures on Soil Management in dry tropical zone of Africa. Cornell Univ. Ithaca, USA.

FAO/SIDA (1975) Report of the FAO/SIDA Expert Consultation on Organic material Fertilizers, FAO, Rome.

FAO/SIDA (1978) Organic recycling in Asia, FAO Rome.

Greenland, D.J. (1972) Biological and organic aspects of plant nutrition in relation to needed research on tropical soils. Com. Sem. on Tropical Soils. IITA (Ibadan, May, 1972).

Jurion, F., and Henry, J. (1969) Can primitive Farming Be modernized? Horn Series, Belgium.

Kannegieter, A. (1967) Zero cultivation and other methods of reclaiming Pueraria fallowed land for food crop cultivation in the forest zone of Ghana. Trop. Agriculturist 73.

Kannegieter, A. (1969) The combination of short-term pueraria fallow zero cultivation and fertilizer application: its effects or a following maize crop. Trop Agriculturist 75.

Lal, R. (1975) Role of mulching techniques in tropical soil and water management. IITA Technical Bulletin I, 38 pp.

Lal, R. (1976) Soil erosion problems on an Alfisol in western Nigeria and their control. IITA Monograph 1,208 pp.

Lal, R., G.F. Wilson, and B.M. Okigbo. (1978). No-till farming after various grasses and leguminous crop covers. I. Crop performance. Field Crops Research 1, 71-84.

Lal, R. (1979) Influence of within and between-row mulching on soil temperature, soil moisture, root development and yield of maize (Zea mays L.) in a tropical soil. Field Crops Research 1, 127-139.

Seubert, C.E., Sanchez, P.A. and Valverde. C. (1977) Effects of land clearing methods on soil properties of an Ultisol and crop performance in the Amazon jungle of Peru. Trop. Agric. (Trinidad) 54, 347-361.

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Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p. 97-109.

PRELIMINARY STUDIES ON THE USE OF WOOD-ASH SOLUTIONS AND DRY WOOD-ASH POWDER IN THE CONTROL OF POSTHARVEST FUNGAL WET ROT OF TOMATO

BY

M.S. Ayodele*

Biological Sciences Department, University of Ilorin, Nigeria

INTRODUCTION

Tomato [Lycopersicon esculentum (L) Karst.] is a widely cultivated vegetable crop in Kwara, Oyo and Kano States of Nigeria. In Ilorin (Kwara State) the variety which is mainly used for local consumption is grown by the farmers. Tomato fruit is used primarily as condiment for stew (Opeola, 1975). Vegetable fruits play an important role in the diet of many people in the tropics, providing essential mineral and vitamins and adding flavour, colour and variety to what would otherwise be a monotonous diet.They also contribute proteins and calories (N.A.S., 1978). Production of fruit and vegetables in developing countries in 1976 represented nearly 20% of total food crop production (FAO, 1977).

Several pathogens are reported to cause post-harvest rot and decay of tomato fruits. Bailey (1966) listed Phytophthora sp., Curvularia lunata (Wakk) Boedijn and Fusarium solani (Mart) Sacc. as fungal pathogenes causing fruit rot in tomatoes in Nigeria. Ladipo and Amosun (1975), reported a watery rot disease on green tomato fruits caused by Geotrichum sp. In Ile-Ife, Oyo State of Nigeria.

In Nigeria, although one notices considerable damage to tomato fruits brought for sale, there are no records to show the magnitude of the losses. Even the loss figures that have been obtained for perishables in developing countries bydirect measurements are of limited value because they cover the loss for one specific commodity, in one location and for one specific set of conditions (N.A.S., 1978).

While most other cash and grain crops are receiving more attention in disease control, no effective attempts are made to control tomato fruit rot diseases in the areas presently under study. However, fungicides and other chemical washes have been successfully used to control fruit rot in other countries. Porte (1934) had controlled storage and transit decay by dipping tomato fruits in 11% solution of Borax in formalin. Felix (1959) in Tennesse, U.S.A. using copper fungicides obtained

* Present address: Oyo state College of Education, Agricultural Education Department, Ilesa, Nigeria.

80-90% reduction in Phytophthora spp. buckeye rot.Batson (1973) using Benomyl, reduced rot caused by Rhizoctonia spp. by 28%.

Many of the substances used for crop protection are toxic to mammals (Wheeler, 1972). Their long term effects on human beings are, at present, not known (Tarr, 197.). Currently in Nigeria, emphasis is placed on chemical pesticides as the only means of controlling crop pests by manufacturers' agents and extension staff. This, therefore, constitutes a great threat to future human health especially if the use of chemicals is extended to vegetables and fruits by the mass of illiterate farmers in the villages. This thus necessitates alternative control substances of less toxicity to mammals, that will not taint fruits or reduce their palatability or nutritive value (Tarr, 1972 and Tomkins, 1934). Some unorthodox control substances have been tried in the control of fungal pathogens. Aulakh and Grover (1968-1969) in India, reported the differential toxicity of various oils to conidial germination of several fruit-rotting fungi. They used vegetable and mineral oils for controlling Phoma and Curvularia rot of tomato fruits.

Although there are few undocumented reports obtained from discussions of dry-ash powder being used by indegenous farmers for protecting seeds and preventing rot on surfaces of cut yam, there are no records of the use for controlling tomato fruit rot in Nigeria.The aim of this study is to conduct preliminary investigations on the effect of wood-ash solutions and dry powder on fungal propagules and on wet rot disease development in tomato fruits. This is with a view to using these substances directly or other products from them as emulsions in controlling fungal wet rot of tomato fruits.

MATERIALS AND METHODS

Effect of Ash solution on conidia germination:

The wood of Khaya senegalensis, a common timber tree in the savannah and commonly used around as firewood, was burnt to produce ash for the experiment. To remove charcoal and other trash, the ash was sieved twice through 50 mesh/sq cm and 180 mesh/sq cm sieves, respectively. The sieved ash powder was stored in a 12-litre Nipol plastic bucket for use throughout the studies. An aluminium tray (30 x 24 cm) was filled with ash powder, covered with aluminium foil and sterilized in the oven at 160°C for 12 hr.

Different concentrations of ash solutions were prepared by dissolving 1,3 and 5 g of ash in 100 ml of distilled water to give, 1, 3 or 5%. The ash in the water was rapidly stirred with an electric stirrer for 5 minutes. The supernatant solution was decanted after 20 min. The pH of the ash solutions was taken with a Phillips pH meter. A drop from each ash solution was put on a glass slide. Dry conidia were transferred to ash solutions with a sterile mounted needle from 7 day-old cultures of four previously isolated fungal organisms from diseased tomato fruits viz: Verticillium albo-atrum, Fusarium solani, Geotrichum sp. and Rhizoctonia solani; maintained on PDA. The glass slide was put in a sterile Petri-dish lined with moist filter paper and incubated at 30°C. Five glass slides were prepared for each concentration of ash solution. Distilled water was used as control. Microscopic observations were taken at 0, 12, 24 and 36 hours, respectively, by always focusing on a particular conidium or aggregates of conidia using the vernier scale readings. Other conidia or aggregates of conidia from at least five different fields of view were also observed to ascertain that the results obtained from the test aggregates were representative of all conidia on the slide.

Effect of Ash solution on mycelia growth:

Ten ml of 1,3 and 5% ash solution were dispensed into a sterile Petridish. A 5mm diametermycelium disc was cut out with a sterile cork-borer from a 7 day-old culture maintained on PDA.

This was asceptically transferred into the centre of the ash solution medium. Distilled water was used as control. The dishes were incubated at 30°C and visually observed for 5 days. Microscopic examinationwas carried out on each inoculum on the 5th day.

Effect of dry Ash powder on the development of fruit rot symptoms on inoculated fruits:

Sterile Nipol plastic box was filled with Khaya ash powder to a level of 25 mm from the base. Sterilized healthy ripe tomato fruits were inoculated by injuring by means of a sterile pin used to pick conidia from 7-day-old cultures.

The inoculated fruits were put on the ash layer in the box. More ash powder was added until the fuits were covered upto 25 mm above the fruits. The plastic box was covered and incubated at 30°C for five days. Ten fruits were used for each organism and the experiment repeated three times. Visual observations were made for 5 days on control fruits not covered with ash. Microscopic examination was carried out on the 5 th day on all fruits.

RESULTS

Effect of ash solution on conidia germination:

Conidia from Verticillium, Fusarium and Geotrichum cultures were germinated in 1, 3 and 5% concentration of ash solution as previously described. In all the concentrations of ash solution tested there was no germination of conidia surrounded by ash solution but there was germination of conidia at or close to the edges of the cover-slip where there was as solution/air interface. The % germination (5-20%) of conidia in the ash solution/air interface considerable lower than the germination in distilled water (80-95%) even at 36 hours. The rate of growth of the developed hyphae, indicated by the formation of hyphal mesh, was slower in the solution at 36 hr.

Effect of ash solution on growth of mycelia:

Mycelial discs obtained from Verticillium, Fusarium, Geotrichum and Rhizoctonia cultures were tested for further growth in the three concentrations of ash soltuiosn as described earlier.

There was a recorded growth of 2 to 6 mm diameter of mycelia originating from the inoculum for Verticillium albo-atrum. Fusarium solani and Geotrichum sp. The mycelium for each organism developed in the ash solutions compared with that in distilled water, was composed of sparse strands of hyphae floating on the ash solution. The mycelia in distilled water grew up to 3 to 6 mm diameter and they were composed of denser strands of hyphae at 5 days.

There was no growth of mycelium of Rhizoctonia solani. But the mycelium on the inoculum surface turned brown. When examined microscopically, abundant sclerotial cells were observed. There was no noticaeable effect on or change in the morphology of the hyphae or the sclerotial cells.

Effect of dry Ash powder on the development of fruit rot symptoms on inoculated fruits:

With each of the fungal organisms-Verticillium albo-atrum, Fusarium Solani and Geotrichum sp., ten ripe tomato fruits were inoculated. Ten unripe tomato fruits were also inoculated with Rhizoctonia solani. Unripe fruits were used owing to the previously observed faster rate of deterioration of unripe than ripe fruits by Rhizoctonia solani.

For each of the organisms, 5 of the incoulated fruits were buried in dry ash powder as previously described, while the remaining 5 were left in the sterile plastic box without ash as control.

Five other healthy uninoculated ripe fripe fruits were buried in ash powder while 5 were left as control. Similarly, 5 healthy uninoculated unripe fruits were buried in ash powder while 5 were left as control.

Fruits inoculated but unprotected with ash powder-control: Fruits inoculated with Verticillium developed a brown watery lesion 1 to 3 mm diamter around the point of inoculation 1 day after inoculation. The lesion extended to 15-18 mm diamter after 3 days. A white mycelium mat which developed from the inoculum trailed behind the lesion 8-12 mm diamter. At 5 days, about 75-100% rot on fruits was recorded. Some fruits had collapsed pericarp, with the fruit pulp totally disintegrated. A pungent odour persisted from the messy pulp. Conidia and hyphae of Verticillium were identified in wet mounts of diseased tissues.

Fuits inoculated with Fusarium developed a brown to dark-brown watery rot on all fruits 5 days after inoculation. A white fluffy mycelial mat covered the point of inoculation. About 50-100% rot on fruits was recorded. A persistent pungent odour was emitted from the rotten pulp. Fusarium conidia and hyphae were identified in wet mounts.

Fruits inoculated with Geotrichum sp, developed a pale-brown watery soft rot t5 days after inoculation. In some fruits, the pericarp appeared firm while the underlying tissue had been completely disintegrated. 75-100% rot was observed on the fruits. A bad odour was emitted from the rotten pulp. Geotrichum conidia and hyphae were identified in wet mounts.

Unripe fruits inoculated with Rhizoctonia developed a brown to black watery soft rot 24 hours after inoculation. Amount of rot on some fruits was up to 100% by 2-4 days after inoculation. Rhizoctonia sclerotial cells and hyphae were identified in wet mounts of diseased tissue bits.

Fruits inoculated and protected with ash powder: At 5 days after inoculation, an ash mound 8-10 mm diamter formed on the point of inoculation with Verticillium. A ring of soft brown lesion (1-2 mm diameter) surrounded the ash mound. On washing off the ash mound a mat of white mycelia was observed. The extent of rot on the fruits was limited to the area of the ash mound formed. The infected tissue formed a compact entity with mycelial mat. This was easily thawed off the unaffected portion of the fruits, leaving behind a clean hole 6-8 mm diamter and 5-7 mm depth. The unaffected tissue around this hole remained fresh, emitting a persistent aroma of fresh tomato fruit.

Fruits inoculated with Fusarium developed a fairly dry brown lesion around the point of inoculation. The mesocarp of the inoculated point on the fruits formed a distinct black demarcation from the red pulp of the unaffected portion of the fruit. This was also easily scooped out along with the mycelium leaving a shallow hole 1-2 mm deep.

Fruits inoculated with Geotrichum developed a ring of dark-brown to black soft rot clesion 1-2 mm diamter around the point of inoculation. This lesion was easily scooped off leaving a fresh unaffected pulp tissue around the hole.

Unripe fruits inoculated with Rhizoctonia developed a brown to black watery rot. Except for those fruits which started ripening on some parts, the amount of rot on other fruits was up to 100%. The pulp tissues of such rotten fruits and their seeds turned black.

Uninoculated ripe and unripe fruits: Both the uninoculated ripe fruits buried in ash and their control, remained healthy after five days. The pericarp of the fruits buried in ash were, however, toughened. Their fruit pulp appeared congealed and were less succulent than those of the fruits not buried in ash. Some of the unripe fruits buried in ash started ripening.

DISCUSSION

The effect of wood ash solutions of varying strength (1,3 and 5%) on the fungal propagules viz: conidia and mycelia; varied for the two propagules tested in four fungal organisms-Verticillium albo-atrum. Reinke and Berth, Fusarium solani (Mart.) Sacc, Geotrichum sp. and Rhizoctonia solani, Kuehn. In three of the fungal organisms-Verticillium, Fusarium and Geotrichum; whereas the conidia at the ash solution/air interface of the mounted slides germinated, those surrounded by ash solution did not germinate. The mean % germination range obtained from 5 mounted slides, each slide examined at five different fields of view, for the ash solution (5 to 20%) was, however, considerably lower than that of the conidia germination observed in the control-distilled water (80-95%) after 36 hr.

The differential germination performance of conidia at the outer and inner portions of the slide mounts cannot be readily explained.In many cases, all that is required to stimulate the germination of a spore or propagule are conditions suitable for vegetative growth (Whitney, 1976). These include moisture, temperature, light, pH, O_2 and CO_2, and biological factors (Tarr, 1972). Almost all these factors could be accounted for in this study except the pH of the ash solution medium. Generally, fungal organisms require a pH range of 3 to 8. A slightly acid condition with optimum pH of 5.0 to 6.5 (C.M.I., 1968 and Cochrane, 1958) is prefered by fungal pathogens. For spore germination in culture medium, Walker (1969) work in which two pH maxima of 4.5 and 7.0 were reported for Fusarium oxysporum f. lycopersici (Sacc) Synder and Hausen. The pH values of the ash solutions were 8.45, 8.85 and 8.98 for 1,3 and 5%, respectively. The ash solutions being more on the alkaline side of the pH scale was probably unfavourable for germination and possible induced a sporostatic effect (Allen, 1966) on those conidia completely surrounded by ash solution and did not germinate. Conchrane (1958) reported that under given conditions, a fungus will grown maximally over a certain range of initial pH values of the medium and will fail to grow at high and low extremes. He, however, warns that the pH is not a unitary factor; the mechanism of its action differs in different concentrations of hydrogen ion. The principal effects of external pH are probably on permeability and other surface phenomena (Cochrane, 1958). Further confirmatory experiments may be necessary to deduce the effect of the alkalinity of the medium on the fungi.

Although there was a recorded growth of mycelia of Verticillium, Fusarium and Geotrichum from the inoculi discs (range 2 to 6 mm radial growth) in the ash solutions, this growth was mainly the elongation of a few strands of hyphae compared with growth from the inoculi in distilled water (the control). This had denser strands of hyphae. The rate or amount of growth or both of fungi are affected by separate factors comprising the internal and external environment. The external environment, however, acts by modifying the internal environment (Lilly and Barnett, 1951). The inoculation of ash solutions of varying concentrations with the fungal organisms in this study is analogous to culturing the organisms using Ash solutions as a basal synthetic medium. The analysed constituents of this "medium" compared with those of some recommended media (Appendix A) for fungal propagation shows excess. absence or difficiency of some essential elements for fungi (Lilly and Barnett, 1951). The composition of a medium is one of the four factors listed by Lilly and Barnett (1951) as the external factors controlling the experession of the genetic potentialities of a fungus. Bulter (1957) working with Merulius lacrymans observed that altering the size of food base (medium) for the fungus affected the density of mycelium and strands more than it affected the growth rate of individual hyphae of the mycelial margin. In a process such as growth, a suboptimal amount of an essential metal element will stop growth because the apoenzymes or coenzymes synthesized will lack the necessary activating metal (Lilly and Barnett, 1951). Garret (1946) also reported that the increase in concentration of nutrients in agar (medium) also increase the production and growth of strands.

Of the four fungal inoculi sources tested in ash solution, only the mycelial discs of Rhizoctonia did not show any growth of mycelium or hyphae. The inoculum surface instead, contained abundant sclerotia cells more than that on the inoculum in distilled water. A sclerotium is a hard resting body resistant to unfavourable conditions. It may remain dormant for long periods of time and germinate upon return of favourable condition (Alexopoulus, 1962). Sclerotia are normally produced towards the end of parasitic activity and constitute the resting stage of the fungus Rhizoctonia (Garret, 1946). The fungus, therefore, probably reacted more to the unfavourable 'medium' environment of ash solution than the other 3 fungi by the abudnant production of sclerotia cells. This is evident from the fact that whereas the minimum, optimum and maximum pH values of Rhizoctonia growth are 2.7, 4.2-7.4 and 8.3, respectively, (Anon, 1969), the pH values of the Ash solutions (1,3 and 5%) were 8.45, 8.85 and 8.98, respectively. Blair (1943) reported also that good growth of 2 isolates of Rhizoctonia solani were made over the range of pH 5.8-8.1. In his experiments, a neutral reaction was optimum for growth of the organism.

Dry wood-ash powder curtailed infection on fruits inoculated with Verticillium, Fusarium and Geotrichum but did not on those inoculated with Rhizoctonia. The factors involved in the susceptibility of matured fruits include high moisture content, high nutrient, lack of protection by intrinsic factors which confered resistance during fruit development on the plant and the easy vulnerability of fruits at maturity (Eckert, 1975). Of these factors, the role of moisture is important. Pearson (1976) reported that 93.4% of the tomato fruit is water. Moisture influences the initiation and development of infectious plant diseases (Agrios, 1969). The most important influence of moisture being the germination of fungal spores and the penetration of host by germ tube. Moisture also increases the succulence of host plants (Agrios, 1969). A possible explanation, therefore, for the role of the dry wood-ash in curtailing fruit rot in the fruits inoculated with Verticillium, Fusarium and Geotrichum might be that the dry wood-ash first absorbed moisture from the fruit through the point of inoculation. A further moisture absorption possibly continued after the ash layer adjacent to the fruit surface inoculated dissolved in the moisture causing more moisture extraction from the fruit, possibly by osmosis, leading to the formation of ash mound over the point of inoculation. The observation of the development of a toughened pericarp and a less succulent fruit pulp (mesocarp) in uninoculated healthy ripe fruits buried in ash, as opposed to that of similar control fruits not buried in ash, suggests a possible moisture withdrawal from the fruits buried in ash. This moisture movement gradient from fruit to ash probably limited the mycelia growth activity only to the inoculated measocarp tissue underlying the point of inoculation. Other thorough investigations would confirm the actual mode of action. But it was observed that a thick mycelia mat underlied the ash mound and formed a compact entity with the infected tissue. The entity was easily thawed off, leaving behind a clean fruit pulp of the uninfected tissue emitting the aroma of a fresh tomato fruit. It was observed that apart from limiting the vegetative spread of the fungi in the fruits, the as powder also modified the type of rot caused in inoculated fruits. Whereas a watery, messy rot was developed in unprotected (with ash) fruits, fruits buried in ash developed soft rot limited only to the area covered by the ash mound.

The story is different with unripe fruits inoculated with Rhizoctonia and buried in ash. Except on portions of fruits that had started ripening, there was no control of fruit rot caused by Rhizoctonia by the wood-ash powder. This observation is difficult to explain on the same premise as the observation made in ripe fruits incoulated with, for example, Verticillium, above. A possible explanation, however, is based on the observed fast rate of growth of Rhizoctonia in unripe fruits. The amount of rot in some control fruits inoculated was up to 100% within 48 hours after inoculation. This fast rate of growth possibly encouraged a quicker invasion of the fruit pulp (mesocarp) at a shorter time than required for effective water absorption by the ash powder, such as would limit the mycelia growth progress. Batson (1973) also reported the characteristic rapid growth of Rhizoctonia in culture. Blair (1943) also observed in an experiment that Rhizoctonia was capable of a most rapid growth even at the lowest soil moisture content he tested-30% saturation.

The present study is a preliminary work on the possiblity of using ash as a tomato fruit-rot control substance which will equally give effective control of fruit rot as chemicals and fungicides without any effect on the tast, colour, food constituents of the fruits and without any effect on the tast, colour, food constituents of the fruits and without any mammalian toxicity. The effect anticipated in the use of ash is to provide an unsuitable surface (environment) for fungal development on fruits after harvest. The idea is based on Stevens' (1960) suggestion on identifying the environmental factors which most profoundly affect a disease and developing techniques which can be employed to ameliorate these factors.

There is no documented record of the use of ash in the control of plant diseases in Nigeria. It is, however, a common practice by farmers to use ash in storing grains and legumes. They also rub ash on injured yam tuber surface to prevent rot. It is stated that ash from oil-palm female inflorescence is most efficient for this purpose (Wilson, Pers. Comm.). The explanation for the efficiency of oil-plam ash is, however, not known. Further work is necessary on ash from various other Agricultural and Forestry waste products. It will also be necessary to carry out various experiments on the storage of tomato fruits in dry ash powder on a larger scale. The control effected by ash if elaborated, would give an alternative and cheaper method of fruit storage than refrigeration at home level. The ash would preserve healthy ripe fruits and limit the rotten area on fruits already infected before storage. At village community level, a larger storage requirement will be necessary for fruits in transit to markets both in the villages and urban areas. There will thus be the problem of bulkiness in transportation of the fruits plus ash powder. It is, therefore, necessary to carry out further studies on developing the preparation of ash emulsions which could be used for coating the surfaces of the fruits after harvest. Such emulsions could be sprayed on fruits or applied by dipping fruits in them before storage or transit to the markets. The emulsions must be such that could be persistent during the period of storage, be readily and easily washed off the fruits before they are displayed for sales.

The regular source of ash to use at home level or for emulsion preparation would not constitute a problem. Most cooking in the village is done with firewood as a source of fuel. For a large scale requirement of ash powder, other sources include the several Bread bakeries where firewood is the source of fuel for the ovens.In most of these places, the disposal of ash residue was observed as a cumbersome problem. Another source of large scale ash production is through burning of wood-shavings and sawdust from numerous sawmills and plank-making industries where these materials are observed to constitute a big nuisance.

APPENDIX A

COMPARISON OF CONSTITUENTS OF SOME MEDIA FOR FUNGAL PROPAGATION WITH THAT OF WOOD ASH

Basal Semisynthetic medium (Lilly and Barnett,1951)		Czapek (Cox) Agar (C.M.I.,1968)		Analysed Dry-wood ash	
Carbon source	10g	Sodium Nitrate ($NaNO_3$)	2.0g	Total N (%)	0.125
Asparagine	2g	Potassium dihydrogen-phosphate		Total P (%)	1.11
KH_2PO_4	1g	(KH_2PO_4)	1.0g	Ca (%)	22.63
$MgSO_4 \cdot 7H_2O$	0.5g	Magnesium sulphate ($MgSO_4 \cdot 7H_2O$)	0.5g	Mg (%)	1.55
Fe^{+++}	0.2mg	Potassium Chloride (Kcl)	0.5g	K (%)	1.34
Zn^{++}	0.2mg	Ferrous Sulphate ($FeSO_4 \cdot 7H_2O$)	0.01g	Na (ppm)	16376
Mn^{++}	0.1mg			Mn (ppm)	387
Biotin	5ug	Sucrose	30.0g	Cu (ppm)	45
Thiamine	100ug	Agar	20.0g	Zn (ppm)	252
Distilled water to make 1 litre		Distilled water	1.0 litre		

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REFERENCES

Agrios, G.N. (1969) Effect of environment on development of infectious plant diseases in "Plant Pathology" 7: 165-166. Academic Press, New York, London.

Allen, P.J. (1966) "Control of spore germination and infection structure formation in the fungi in Sussman and Halvorson's "Spore: Their Dormancy and Germination" pp. 51-70. Harper and Row, New York, London.

Alexopoulos, C.J. (1962) "The Fungi" in Introductory Mycology 1, 3-39. John Wiley and Sons Inc. New York, London.

Anon (1969) Review of applied mycology 15, 521.

Kulakh, K.S. and R.K. Grover (1968) Ripe fruit rots of tomato and their control by oils. Plant Dis. Reptr. 52(7), 555-559.

Kulakh, K.S. and R.K. Grover (1969) Use of oils for controlling ripe fruit rots of tomatoes caused by *phoma destructiva* and *Curvularia lycopersici*. F.A.O. Plant Protection Bulletin. 17, 90-91.

Balley, A.G. (1966) A check list of plant diseases in Nigeria Federal Department of Agricultural Resources, Ibadan, Memo No. 96.

Batson, W.E. Jr. (1973) Characterization and control of tomato fruit rots. Plant Dis. Reptr. 57, 453-456.

Blair, I.D. (1943) Behaviour of the fungus *Rhizoctonia solani* Kuehn in the soil. Ann. Appl. Biol. 30, 118-127.

Butler, G.M. (1957) The development and behaviour of mycelial strands in *Merulius lacrymans* (Wulf.) Fr. I. Strand development during growth from a food-base through a non-nutrient medium. Ann. Bot. 21, 523-537.

Cochrane, V.W. (1958) Cultivation and growth-pH and Growth in "Physiology of Fungi". 1, 1-34 John Wiley and Sons Inc., New York, London.

The Commonwalth Mycological Institute (1968) Mycological culture media in "Plant Pathologist's Pocket book". pp. 235-242. Commonwealth Mycological Institute, Kew, Surrey, England.

Eckert, J.W. (1975) Postharvest diseases of fresh fruits and vegetables-Etiology and control in "Postharvest Biology and Handling of Fruits and Vegetables". 9, 81-117. The Avi Publishing Coy. Inc. Westpost Connecticut, U.S.A.

FAO, (1977) 1976 FAO Production Yearbook Vol. 30, Food and Agriculture Organization of the United Nations, Rome.

Felix, E.L. (1950) Control of buckeye rot by Copper fungicides. Phytopathology 40, 9 (Abst.).

Garrett, S.D. (1946) A study of violet rootrot. Factors affecting production and growth of mycelial strands in "Helicobasidium purpureum Pat. Trans. Br. Mycol. Soc. 29, 114-127.

Ladipo, J.L. and Amosun, J.O. (1975) Studies on a fruit rot disease of tomato in the Western State of Nigeria. Nigerian Journal of Science 9(2), 271-279.

Lilly, V.G. and Barnett H.L. (1951) (a) Culture meida, (b) Factors affecting growth (c) Essential metallic elements. in "Physiology of fungi"2, 8-23, 3, 32-44; 5, 65-86, Mc Graw-Hill Book Company, New York, London.

NAS, (1978) Perishables in "Postharvest Foor Losses in Developing Countries" 5:110-139. National Academy of Sciences, Washington, D.C., U.S.A.

Opeola, S.M. (1975) Tomato Bread. Journal of Science Teachers Association of Nigeria. 6(2), 9-12.

Pearson, D. (1976) Fruit and vegetable products-general composition of fruits and vegetables in "The Chemical Analysis of Foods". 5, 153-156, Churchill Livingstone Press, 7th Edition, Endiburgh, London, and New York.

Porte, W.S. (1934) Notes on the control of transit and storage decay of tomatoes by the use of Chemical washes. Phytopathology 24, 1304-1312.

Stevens, R.B. (1960) Cultural practices in disease control, in "An Advance Treatise Plant Pathology", Edit. Horsfall and Dimmond. 10, 360-370. Academic Press, New York, Lonon.

Tarr, S.A.J. (1972) (a) The entry of pathogens into plants-prepenetration, (b) Physical and Chemical methods of disease control (1), in "The principles of Plant Pathology", 10, 138-169; 26, 506-599.

Tomkins, R.G. (1934) Iodized wraps for the prevention of rotting of fruit. J.Pomol 12, 311-329 H.A. Vol. 5, Abst. 147.

Walker, J.C. (1969) Diseases incited by fungi imperfecti-fusarium wilt of tomato, in "Plant Pathology". 7, 298-308, Mc Graw-Hill Book Compay, 3rd Edition, New York, London.

Wheeler, B.E.J. (1972) Plant disease control: protection in "An Introduction to plant Diseases". 20, 335-336, John Wiley and Sons Ltd., London.

Whitney, P.J. (1976) Infection: Germination in "Microbial Plant Pathology", 4, 55-77. Hutchinson of London.

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UTILIZATION OF PLANTAIN/BANANA PEELS AND PALM OIL/PALM KERNEL OIL FOR SOAP MAKING

BY

E.V. Doku

Corps Science Department, University of Ghana, Legon, Ghana.

Among the several industries operated by Africans long before the arrival of Europeans in the early 15th century was the manufacture of soap, a by-product of a production chain complex, namely, the production of palm oil and palm kernel oil as well as blacksmiths' furnance fuel obtained from the borken shells of the palm kernel. The burnt shells from the furnances are sometimes used as charcoal by house-wives.

This production chain complex of which native soap manufacture is a part still thrives in Africa to date despite five centuries of severe competition from soap produced in Europe and elsewhere, and since independence, from locally manufactured soap based on imported caustic soda. This resilience of nature soap is no doubt due to its special qualities including good lather and good skin-oiling characteristics, the latter quality is because the glycerol is not removed by salting out as is the case with "European" soap.

To my knowledge, no government in West Africa has studied the various materials used and the processes and organizations involved in the production of the "native" soap which is a good example of the utilization of agricultural and industrial waste products developed by indigenous Africans. The alkali is derived mainly from plantain peels and the fat (or oil) from palm oil or palm kernel oil.

The plantain peels are collected, dried over a period, burnt in a heap and the ash (alkali) collected. No fuel is used as the dry peels by themselves burn very well. The ashing may be done over a period until enough alkali is accumulated. The oils used are second or third grade palm oil or palm kernel oil left over after the marketable grade oils have been removed.

The processes involved as given to me by my dear mother, aged 87, and which I have faithfully followed to produce my own sort are as follows:

1. Dissolve the ash in a minimum amount of water streining off insoluble carbon particles (Solution largely Potassium hydroxide -is $K_2O + H_2O \rightarrow 2KOH$).

2. Gently boil mixture of one part "crude" palm oil or palm kernel oil and two parts of the alkaline solution until the mixture becomes semi-dry, i.e. until almost all the water has evaporated.

3. Add one more part of the alkaline solution and gradually increase the heat. Frothing will occur at this stage.

4. Continue adding small quantities of the alkali until frothing is followed by thickening of the mixture.

5. Continue heating with stirring until the mixture assumes the desired consistency of native soap.

6. Leave to cool and mould into balls or whatever shape is desired.

The fuel for heating is usually the shells of the palm kernel, at least partly, if not wholly.

All the input are, therefore, waste products which could have been thrown away to pollute the environment. In the rural areas, plantain peels are fed to sheep and goats in addition to cassava, yam and cocoyam peels. However, in the cities and urban centres, it is usual to find several tons of plantain peels in the dust bins and public incinerators. We throw away several tons of our own sources of alkali only to import the same thing from other countries. A lot of education is needed to conserve and utilize this vital natural source of alkali as was done during the war years of 1939-1945.

In an attempt to estimate our potential for native soap production, I tried without success to obtain up-to-date production figures for palm oil, palm kernel oil and plantain. The only "reliable" figures I obtained are for plantains in Ghana which I shall use to illustrate our capacity for native soap production without a single imported component.

The acreage under plantains is approximately 1,500,000 (1 1/2 million acres). A conservative production estimate of 3.3 tons per acre will be around 5 million tons per acre per annum. Yields are indeed much higher.

The composition of the fruit is approximately as follows:

Fruit to peel	K_2O of peel	NaO_2 of peel
15-20%	6-10%	0.3-0.4% (Negligible)

Therefore, K_2O production from peel will range between:

$$\frac{15}{100} \times \frac{6}{100} \text{ i.e., } \quad 0.009\%$$

to

$$\frac{20}{100} \times \frac{10}{100} \text{ i.e., } \quad 0.02\%$$

For KOH production, the figure will be double: 0.018% to 0.04%.
(ie. $K_2O + H_2O \longrightarrow 2KOH$)

Therefore, the potential for caustic potash production from plantain peels for Ghana will range between 90,000 tons and 200,000 tons per annum.

Large countries like Nigeria, Ivory Coast, Cameroun, tec. have huge resources of palm oil, palm kernel oil and plantain as well as several other unexploited plant sources of alkali and oil which can also be used for soap manufacture. Research is needed to find out the most desirable species within the continent for large-scale production of soap.

I would like to close by urging AAASA to urgently commission detail studies of African resources for soap manufacture utilizing 'waste' products.

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LES SOUS-PRODUITS AGRO-INDUSTRIELS AU MALI PRODUCTION-DESTINATION-CONTRAINTES A LEUR UTILISATION PAR LE BETALL

Par

Maimouna Salah Dicko* et Jean Bourama Oulare**

INTRODUCTION

Durant ces vingt derniéres années, on a assisté au Mali à la création d'unités industrielles parmi lesquelles des usines d'égrenage de coton, huileries, sucreries et rizeries dont les productions de matiéres qui font l'objet de leurs installations sont accompagnées de celles de sous produits susceptibles d'être valorisés par le bétail.

Les Centres de Recherches Zootechniques ont par conséquent multiplié les essais d'introduction de ces divers ingrédients dands les rations des animaux afin de quantifier leurs effets sur les performances et la productivité (Rapports d'activités C.N.R.Z. Sotuba 1973-1975-1976 SERZ/S Niono 1971-1972-1974, Doumbia 1974, Sangaré 1974, Traoré 1971-1973). Les résultats enregistrés ont été à l'origine de la création des feedlots de l'Office du Niger*** d'une capacité annuelle de 4500 bovins et à la pratique de l'embouche bovine par quelque éleveurs pilotes.

Dans le milieu rural des zones où les complexes agro-industriels sont implantés, les agents de vulgarisation agricole conseillent la distribution de la graine de coton et de la farine basse de riz aux animaux notamment aux boeufs de labour pendant la période de soudure. L'E.C.I.B.E.B. (Etablissement de Crédit et d'Investissement pour le Bétail et la Viande) encourage et subventionne l'embouche paysanne. Quelques essais d'introduction ont été entrepris dans les zones sahéliennes, loin des centres de production (Sylla 1978-Activités de l'OMBEVI à Dilly).

Toutes ces actions ont contribué à élever la demande de sous produits par les éleveurs. L'offre sur le plan national, n'arrive par contre pas à satisfaire cette demende. Parallélement les prix de vente des sous produits augmentent au point de n'être plus en rapport aves leur valeur alimentaire. Un malaise se créee. Où en sont les sous produits agro-industriels au Mali ? Tel est le propos de cette communication.

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* Nutritionnniste CIPEA, Programme du Sahel, Bamako, Mali.
** Ingénieur des Sciences Appliquées, IPR, Katigougou, Mali.
*** Office du Niger = Organisme de Développement des cultures irriguées dans le delta central du fleuve Niger.

Tableau 1: Productions et Valeurs alimentaires réelles (1979) et potentialles des sous produits agro-industriels au mali.

Sous produits	1979			Potentielles		
	MS (T)	UF (000)	MAD (T)	MS (T)	UF (000)	MAD (T)
RIZ						
Son + balles	2323	627	77	8043	2172	260
Farines basse	3405	3405	319	8256	8256	776
Conne à sucre						
Bouts blance	23700	13035	497	26958	14827	566
Mélasse	6225	6474	56	7080	7364	64
Graines oléagineuses						
Graines de coton	60888	63932	5845	109504	114979	10512
Tourteaux de coton	3000*	2526	1152	6918	5811	2650
Tourteaux d'archide	15974	15175	5925	33084	31429	12274
Sous produits des Abattoirs(*)						
Farine de viande	23	26	12	56	62	29
Farine de sang	0,8	0,9	0,6	70	78	57
Poudre d'os	20	-	-	295	-	-
Total	115556,8	105200,9	13883,6	200264	184978	27124

(*) Il s'agit des productions de 1978. Celles de 79 nétaient pas disponibles au moment de l'enquête.

L'évolution des productions de 1974 à 1979 n'a pas toujours été conforme aux prévisions qui avaient un taux annuel de croissance de 10% (Traoré 1973). Leurs fluctuations durant cette période rapportées au tableau 2 montrent que les productions de graines de coton et de mélasse ont connu une certaine stabilité et même quelquefois un léger accroissement. Celles des issues de riz et tourteaux d'arachide se présentent en dents de scie et lea quantités de tourteaux de coton et des sous produits des abattoirs ont diminué d'année en année.

Tableau 2:

Sous produits	1974	1975	1976	1977	1978	1979
Graines de coton	100	60	105	116	115	126
Issues de riz	-	100	83	115	93	113
Sous produits des abattoirs	-	100	97	86	83	-
Mélasse de canne	-	-	100	145	157	144
Tourteaux d'arachide	-	-	100	129	78	115
Tourteaux coton	-	-	100	85	45	-

Les raisons essentielles de ces fluctuations demblent étre:

1. la variation des quantités de matiéres premiéres traitées qui sont liées aux aléas climatiques et à l'existence d'un marché paralléle plus rémunérateur pour le paysan,
2. les difficultés de fonctionnement de certaines usines.

Compte tenu de ce passé, toute planification à long terme de la production de sous produits s'avére difficile. Des inventaires réguliers qui tiennent compte de tous les sous produits disponibles et des spéculations autres qu'alimentaires vers lesquelles ils pourraient être orientés (exportation, fabrication d'alcool et de vinaigre, utilisation d'alcool et de vinaigre, utilisation comme combustible etc...) deviennent indispensables. Ainsi seulement des programmes sûrs de leur utilisation dans les entreprises d'élevage pourraient être établis.

DESTINATION

Trois formes de destination se présentent actuellement:
- utilisation par le bétail
- exportation
- spéculation autres qu'alimentaires

Les issues de riz:

Les productions de l'Office du Niger qui représentent 80 à 90% de la production total sont entiérement cédées aux colons* pour la mise en forme des boeufs de labour avant la période des cultures.

Le reste de la production localisée au niveau de Mopti est acheté par des éleveurs de la région et par certains organismes d'Etat (C.N.R.Z., ECIBEV, C.A.S.) qui pour la plupart sont basés à Bamako soit à 650 km du centre de production.

La production actuelle d'issues de riz ne couvre pas la demande intérieure et son acquisition devient par conséquent difficile.

Les sous produits de la canne:

Les bouts blancs de canne et la mélasse étaient jusqu'en 1977 consommés par les bovins mis en embouche dans des ateliers construits

* Colons = Exploitants des terres irriguées de l'Office du Niger.

prés des unités de production. Ces ateliers d'une capacité annuelle de 4500 tétes ont cessé de fonctionner à cause d'une organisation inadéquate au niveau de l'écoulement du bétail embouché. Il s'ensuit que les bouts blancs sont brûlés pour faciliter la récolte des connes et que plus de 90% de la mélasse produite est versée dans les canaux d'irrigation. Le manque de lieux de stockage et la faible commercialisation de ce produit due aux difficultés de conditionnement et de transport expliquent cette conduite.

La transformation de la mélasse en alcool dont la capacité potentielle des unités est de 2500000 litres est réduite actuellement à 150000 litres en raison des difficultés rencontrées par le placement d" l'alcool à l'extérieur.

Les graines de coton:

Le tableau 3 relatif à la commercialisation de la graine de coton produite lors de la campagne 1978-79 montre que la quasi totalité de la production est écoulée ce qui sous entend une non satisfaction de la demande.

Tableau 3: Commercialisation de la graine de coton (Campagne 1978-79)

Localisation des clients / Qualité des clients	2éme Région (Bamako) (T)	3éme Région (Sikasso) (T)	4éme Région (Ségou) (T)	Total Quantité (T)	Total %
Société Malienne d'Import d'Import-Export et Société d'Exploitation des Produits Oléagineux	36861			36861	59
Services nationaux s'occupant de l'agriculture et de l'élevage	3252	2086	9781	14119	23
Particuliers	7039	2590	1574	11203	18
Quantité (T)	47152	4676	10355	62183	100
%	76	7	17	-	100

Les acquisitions de la SOMIEX et de la SEPOM soit 59% de la production totale sont destinées à l'exportation vers des pays développés et à l'extraction de l'huile. Lex exportations des graines de coton qui représentaient 13% de la production en 1975 sont passées à 48% en 1978. A ce quota doit s'ajouter une grande part des graines (soit 18% de la production) cédées aux particuliers qui sont le plus souvent des commerçants qui exportent ce sous produit vers des pays limitrophes comme la côte d'Ivoire et la Haute Volta.

Les quantités de graines de coton utilisées au niveau national seraient donc de l'ordre de 23% de la production qui se répartissent entre le bétail et les semences. Les zones d'utilisation sont les Régions Economique surportant 70% du cheptel bovin ne sont pas concernées par cette vente.

Les tourteaux:

Les tourteaux d'arachide et de coton sont produits au niveau de deux huileries qui sont la SEPOM et la SEPAMA.

La SEPOM, société nationale commercialise ses tourteaux tant à l'intérieur qu'à l'extérieur du pays. Mais des difficultés de fonctionnement de cette unité ont réduit considérablement les productions qui ne représentent plus en 1978 que 45% de la production du tourteau de coton de 1976 et 29% du tourteau d'arachide de la même année.

La SEPAMA, société mixte Mali-République Fédérale d'Allemagne, exporte la totalité de son tourteau suite à une autorisation découlant de la Convention d'Etablissement.

La baisse des activités de la SEPOM risque d'être un frein à l'utilisation des tourteaux si une modification de la convention de la SEPAMA n'intervient pas.

Les sous produits des abattoirs:

Ils sont introduits dans les concentrés pour volailles. La diminution d'année en année des quantités produites fait que la demande qui augmente à cause de l'essor de l'aviculture dans les grandes agglomérations n''est pas satisfaite.

Il existe done un véritable déséqui libre entre l'OFFRE et la DEMANDE, désequilibre accentué par les exportations des graines de coton et des tourteaux qui sont les sous produits les plus importants quantitativement et qualitativement puisque riches en azote.

CONTRAINTES

La transformatio des sous produits en proteines animales a été en Afrique, durant ces dernières années, objet de nombreux essais dont les résultats ont été rapportés au niveau de divers séminaires (Colloques IEMVT Farcha 1969, Dakar 1973, Bouaké 1977, Journées techniques de la production animale IEMVT 1977 etc...). Cette transformation techniquement réalisable avec un taux de 10 UF/kg de poids vif pour le zébu et 14 pour le taurin notamment la N'Dama (CIPEA 1979) ne saurait être appliquée à grande échelle que si elle se revéle économiquement rentable. Présentement au Mali, plusieurs contraintes limitent le développement de structures modernes de productions animales:

1. L'absence d'une politique de planification et d'utilisation des sours produits, ce qui favorise une restriction de leur disponibilité intérieure.

2. La non intervention de l'Etat dans la fixation et la stabilisation des prix de vente des sous produits.

Lex prix sont fixés par les unités de production et différent d'un endroit à l'autre. Par exemple la farine basse de riz est à 17 FM* le kilogramme à l'Office du Niger et 25 FM à la rizerie de Mopti. La montée des prix qui se fait sans tenir compte de la valeur alimentaire des ingrédients semble être liée à la demande. Les prix des farines de sang et d'os ont doublé en 1974 et celui de la farine basse de riz de Mopti a quintuplé en 1977. Les augmentations de prix sont arrivées au point où le kilogramme de sous produit est proposé à l'éleveur ou au paysan plus cher que ce dernier n'est vendu la matiére premiére dont cet ingrédient est issu (cas de l'arachide et de son tourteau).

3. Les frais occasionnés par les transports sont élevés à cause des grandes distances entre les lieux de production et des lieux d'utilisation. La montee du prix des hydrocarbures ne fait qu'aggraver le phénoméne.

4. Les prix de la viande constituent unfrein non moins important. Ces prix fixés par l'Etat sont à Bamako de 1000 FM pour le kilogramme de viande avec os et 1200 FM pour la viande sans os.

Avec les frais induits de transformation le marché intérieur ne peut pas actuellement valoriser les animaux engraissés. Une solution pourrait être la qualité. En attendant, tout le bétail embouché est vendu hors des frontiéres (Côte d'Ivoire notamment).

CONCLUSION

Cette situation des sous produits agro-indistriels se retrouve dans beaucoup de pays en développement notamment ceux sahéliens dont les productions agricoles sont à la merci des aléas climatiques. L'inflation galopante augmente de jour en jour les coûts induits de transformation de ces infrédients en proteines animales cequirend inespéré le développement des entreprises modernes d'élevage.

Deux principales voies restent à la destination des sous produits.

1. L'esportation qui assure une rentrée de devises.

2. L'utilisation par le bétail qui, dans les pays sahéliens connait un déficit alimentaire durant le longue période séche (9 mois par an), se traduisant par une perte de poids, une baisse de la productivité et de la fertilité des animaux, une diminution de la resistance face aux maladies infectieuses et parasitaires.

L'importance qu'il faudrait accorder à chacune des voies est un choix politique.

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* 1 france malien = 0,50 Franc C.F.A.

La volonté politique du Mali dans ce domaine a été définiepar la création (Avril 1979) d'une commission nationale chargée de l'étude de planification et d'utilisation des sous produits. Les recommandations de cette commission sont entre autres:

"-proposer la réservation d'un quota annuel de sous produits agro industriels, région par région selon la répartition géographique des principales sources d'approvisionnement afin de diminuer les couûts exorbitants de transport.

- fixer des prix intérieurs des aliments du bétail sur une proposition d'une commission "ad hoc" du Ministère du Développement Rural.

- envisager une solution pour les Centres de Recherches et Opérations de développement de l'élevage pour l'acquisition des sous produits agro-industriels à des conditions acceptables (problémes de sacherie à résoudre, subvention de prix par le Gouvernement cession gratuite pour des fins de recherches".

LEXIQUE DES ABREVIATIONS UTILISEES DANS LE TEXTE

C.A.S.	Centre Avicole Sotuba.
C.I.P.E.A.	Centre International pour L'Elevage en Afrique
C.N.R.Z.	Centre National de Recherches Zootechniques.
E.C.I.B.E.V.	Etablissement de Crédit et d'Investissement pour le Bétail et la Viande
I.E.M.V.T.	Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux.
O.M.B.E.V.I.	Office Malien du Betaic et de la Viande.
S.E.P.A.M.A.	Société d'exploitation des Produits Arachidiers au Mali.
S.E.P.O.M.	Société d'Exploitation des Produits Oléagineux du Mali.
S.E.R.Z/S	Station d'Elevage et de Recherches Zootechniques du Sahel.
S.O.M.I.E.X.	Société Malienne d'Importations et d'Exportations.

BIBLIOGRAPHIE

C.I.P.E.A. (1979) Le potentiel de l'Afrique Tropicale en sous produits utilisables pour l'alimentation du bétail. Tendances Economiques bull. No. 6.

Doumbia, M. (1974) Essai d'engraissement intensif de trois races locales de moutons. C.N.R.Z.-I.P.R. Katibougou.

Rapports D'Activites C.N.R.Z. (1973) Formules de concentrés pour volailles, veaux et caches laitiéres.

Rapports D'Activites C.N.R.S. (1975) Mise au point d'un aliment de remplacement pour veau et effects sur la croissance.

Rapports D'Activites C.N.R.Z. (1976) Extériorisation des potentialités laitiéres des metisses N'Dama-Jersey.

Rapports D'Activites S.E.R.Z./S. (1971) Résultats des Essais d'engraissement des zébus sahéliens à Dougabougou et au Ranch de Niono par l'utilisation de sous produits agro-industriels de l'Office du Niger.

Rapports D'Activites S.E.R.Z./S. (1972) Synthése des résultats d'essais d'embouche bovine. SERZ/S. IEP-DRZ.

Rapports D'Activites S.E.R.Z./S. (1974). Embouche bovine à base de fanes de légumineuses et sous produits agro-industriels.

Sangare, A. (1974) Utilisation de la sciure de bois et de la melasse dans la ration d'entretien des bovins-C.N.R.Z. IPR Katibougou.

Sylla, D. (1978) Essai de complémentation alimentaire du bétail en transhumance sud dans la région de Didiéni. O.M.B.E.V.I. 1978.

Traore, N.G. et T.A. Tamboura (1971). Résultats des expériences d'engraissement de zébu à la sucrerie de Dougabougou: Utilisation d'une ration à base d'urée-SERZ/Z.

Traore, N.G. et T.A. Tamboura (1973) Résultats d'embouche intensive de zébus peuls et maures au Mali. Colloque IEMVT. 4-8 Dec. 1973 Dakar.

Traore, N.G. et T.A. Tamboura (1973). Les sous produits agro-industriels disponibles au Mali. Perspectives de leur utilisation dans les productions animales. Colloque IEMVT. 4-8 Dec. Dakar.

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p. 123-125.

UTILIZATION OF AGRICULTURAL WASTE PRODUCTS IN THE CONTEXT OF RURAL DEVELOPMENT: SOME IMPLICATIONS FOR RESEARCH POLICY

BY

Ayo Abidogun
National Cereals Research Institute, Ibadan, Nigeria.

INTRODUCTION

The energy crisis has brought sharply into focus the need to reexamine development objectives and strategies in the face of the alarming rate of exhastion of natural resource reserves, many of them nonrenewable. Intensification in the use of current stock of such resources is one way of meeting this challenge. The exploitation of what has hiterto been regarded as agricultural waste products is in effect an intensification in the use of agricultural resources.

In many African countries utilization of agricultural waste products is a releatively new area of research, and is yet to be integrated into mainstream agricultural research programmes. Consequently no coherent research policy in this area has been evolved. In view of its growing urgency, utilization of agricultural waste products promises to attract increasing attention in the coming years. It may therefore be necessary to articulate relevant research policy in this direction, firstly because of the need to avoid a haphazard development in this area of research, and secondly because as an area for public investment it will have to relate to national policy objectives.

For most developing countries rural development remains the fulcrum of developmental policy. The utilization of agricultural waste products should therefore be seen in the context of its impact on the rural economy. Against this background the objective of this paper is to examine the issues involved in rural development and to discuss their implications for research policy in the area of agricultural wasteproducts utilization.

SOME ISSUES OF RURAL DEVELOPMENT

The theories of economic development, notably the two-sector model (Lewis, 1954 and Ekcaus, 1955), have undoubtedly had some influence on the thinking of policy makers in developing countries. Emphasising, as the two-sector model does, the need to transfer supposedly surplus labour from the rural sector to the urban sector, such tranfer has today been achieved in many of these countries with a vengeance. Past efforts aimed at stemming the rural-urban exodus, for example, state farms in Ghana and farm settlements in Nigeria, have failed to achieve their objectives (Dadson, 1971).

Among the factors usually listed in post mortems as contributing to the failure of these schemes are high capital cost, lack of spare parts for farm machinery, low farm output, and settlers unwillingness or inability to adapt to the rural way of life. Underlying the strategy reflected by these factors is what Lipton (1968) has called urban bias in rural planning, an attempt to transplant the urban setting into the rural millieu in form of capital-intensive projects, high-energy machines, sophisticated farm designs and lay-out, and even urbanized inhabitants. Thus the social needs of the rural inhabitants are seen as an extrapolation of urban requirements (Abubakar, 19[illegible]).

Given the need for a new approach to the whole question of rural planning and development, agricultural research as an area that has the most bearing on rural welfare has a leading role to play. Indeed the urban-biased approach to rural development in the past can be traced to the orientation of agricultural research policies and programmes. For example, emphasis has always been placed on sole cropping with its implication of specialization and therefore large-scale production and its attendant need for heavy mechanization. The result has been that agricultural researchers have been working at cross purposes to real farm problems that are rooted essentially in mixed cropping and small-scale production. Yet it has been shown that there were valid reasons of a technological, sociological and economic nature for farmers' reluctance to change to sole cropping system (Norman, 1971). Significantly there now seems to be a dawning awareness in research and governmental circles of the need to base research on indigenous farming systems with a view to improving them.

While agriculture occupies a special position in the rural set-up in terms of employment, it is by no means the only occupation. Others include handicrafts, smithery, dyeing, etc.Thus rural development embraces the physical, economic and social development of the entire rural environment, rather than agricultural development alone with which it is often regarded as synonymous. In particular rural development strategies in most African countries would have to be directed to stemming the rural exodus since this threatens to lead to serious depopulation, thus the vicious circle: lack of necessary infrastructure because it is uneconomic relative to the population, further migration because of lack of amenities and necessary infrastructures.

No doubt secular overall economic development requires that because of structural changes in the economy, agriculture would supply resources, especially labour, to the expanding secondary and tertiary sectors. But this would have to be predicated upon increased productivity of the primary sector itself. At present available evidence suggests that in the West African sub-region, for example, agricultural productivity has failed to keep pace with demand for food.

It could be said then that in the short-run at least, rural development would need to stabilize the rural population and in some cases even provide incentives for a back-to-the-land movement. This can be done within the framework of certain basic objectives of rural development which include the generation of increased agricultural productivity, higher rural income, increased employment and equity in income distribution.

IMPLICATIONS FOR RESEARCH POLICY IN UTILIZATION OF AGRICULTURAL WASTE PRODUCTS:

What are the implications of the foregoing analysis for research policy in the utilization of agricultural waste products ? Essentially research policy in this area should be directed at those waste products that have the greatest potential for rural development; in particular those that could be expected to lead to the attainment of basic rural development objectives like increased rural (agricultural and non-agricultural) productivity, higher income, employment generation, and equity in income distribution.

Detailed articulation of such policies would of course need to be based on specific information regarding the particular rural economy:for example production techniques; linkages between the various subsectors of the rural economy; linkages between the rural sector and the urban sector; items of agricultural products that are currently regarded as waste products, and their possible uses within the rural economy: etc. But regardless of the detailed specifications, any policy guidelines must incorporate a hierarchy of priorities. It is suggested that in the context of rural development, the hierarchy of priorities should have the following order:

1. research in waste products that can be utilized as inputs in agricultural production;
2. research in waste products as inputs outside agricultural production but within existing (traditional) rural occupational sub-sectors;
3. research in waste products as inputs for small-scale industrial processes; and
4. research in waste products as inputs for large-scale industrial processes.

Waste products that can be utilized in agricultural production have potential for stimulating rural development. It can generate additional income with virtually no additional costs. Such products could be substitutes for previously purchased inputs, for example the use of cocoa husks as fertilizers (Egunjobi, 1975). Furthermore, because the supply source of such substitutes is within the farm or in the vicinity of the rural area itself, delavs or non-availability in supply of chemical fertilizers is eliminated, thus leading effectively to increased productivity. Moreover, the utilization of wast products that supplement livestock feed, for example, again cocoa husks (Adeyanju, _et al._, 1975) could lead to greater effective food supply for both rural and urban populations.

In terms of income distribution, the utilization of waste products within agriculture also has very great potential. For example, through increased real productivity it could lead to lowering of unit production costs and hence cheaper food thus increasing real income. So also does it have a stimulating effect on employment generation. Greater effective output means increased labour in such area as harvesting, processing and marketing generally.

For waste products that cen be utilized outside agriculture but within the rural system, the effect on rural development is almost as favourable. Millet stalks for example could be used for such diverse purposes as building materials and fuel (Dalton, 1971). Again the effect of this is a real increase in farm productivity. It could also generate increased employment particularly at the farm level through increased labour for harvesting and post harvest handling. Because utilization is occuring within the rural system, there is a generation of Hirschman-type backward linkages, thus stimulating increased farm production through the demand in the other sub-sectors of the rural economy. By and large, the effects have direct and immediate impact on the rural economy.

The next in the line of policy priority is the utilization of waste products that constitute inputs in small-scale industries. Since the waste products are of agricultural origin their demand as industrial inputs would lead to increased real productivity with its associated generation of increased labour requirements for harvesting and handling. Moreover, it would generate further employment in the form of labour required to work in the industries. Since small-scale industries tend to be labour-intensive such employment generation is the greater. The impact of such effects tends to have direct impact on the rural economy to the extent that small-scale industries may also be located in rural areas.

Finally, there are the waste products that serve as input into large-scale industrial processes. Such industries are usually capital-intensive and are likely to be located in the urban centres.Consequently their effects on rural development can be expected to be weak. Nevertheless since its inputs are of agricultural origin, such industries do stimulate increased agricultural output, higher real productivity and possibly increased level of employment.

SUMMARY AND CONCLUSION

The utilization of agricultural waste products is a relatively new area of research in African countries. However, in view of its growing urgency in the face of threatening global exhaustion of natural resource reserves, it promises to attract increasing attention. Hence there is need for coherent policy formulation to avoid a haphazard development.

As an area of public investment research in utilization of agricultural waste products would need to fulfil social policy objectives. For most developing countries, rural development remains the pivot of developmental policy. Research in utilization of agricultural waste products in African countries should thus be seen in the context of rural development.

Some issues of rural development in Africa are discussed and the reasons for failures of past attempts at rural development highlighted. Their implications for research policy in utilization of waste products are then discussed in terms of a heirarchy of priorities. These include research in waste products as inputs in agricultural production; researchd in waste products as inputs outside agricultural production but within existing rural occupational sub-sectors; research in waste products as inputs for small-scale industrial processes; and research in waste products as inputs in large-scale industries.

REFERENCES

Abubakar, Y. (1975) Rural poverty: Some non-agricultural issues. Proceedings of the 1975 annual conference of the Nigerian Economic Society, Ibadan, Nigeria.

Adeyanju, S.A. et al. (1975) Potentialities of cocoa husks in Livestock Feed. Proceedings of 5th International cocoa research converence, Ibadan, Nigeria.

Dadson, J.A. (1971) Farm size and the mechanization of agriculture in Ghana. Proceedings of International Conference on factors of economic growth in West Africa, ISSER, Legon, Ghana.

Dalton, G.E. (1971) Adaptation of farm management theory to the problems of small-scale farmer in West Africa. Proceedings of Conference on factors of agricultural growth in West Africa, ISSER, egon, April (1971).

Ekcaus, R.S. (1955) The factor proportion problem in underdeveloped areas. American Economic Review, September (1955).

Egunjobi, O.A. (1975) On the possible utilization of discarded cocoa (Theobroma cacao L) pod. Proceddings of 5th international cocoal research conference, Ibadan, Nigerai.

Hirschman, A.O. (1958) The Strategy of Economic Development, New York.

Lewis, A.W. (1954) Development with unlimited supplies of labour. Manchester School of Economics and Social Studies Vol., 22.

Lipton, M. (1968) Urban bias in rural planning in India. O.U.P.

Norman, D.W. (1971) Crop mixtures under indigenous conditions in northern Nigeria. Proceedings of conference on factors of economic growth in West Africa. ISSER, Legon, Ghana.

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p. 129-149.

INTRODUCTION AND POPULARIZATION OF BIO-GAS TECHNOLOGY (THE ETHIOPIAN ATTEMPT AND EXPERIENCE)

BY

B. Megersa
Arsi Rural Development Project (A.R.D.P.)
Agricultural Engineering Section P.O.Box 3376, Addis Ababa

ABSTRACT

There are pressing fuel problems in the country and this has been aggraviated by the fact that the rate of planting does not cope up with the ratè of depletion of the forest in the country. The current trend indicates that the country will run short of its forest within the next two decades, if intensive afforestation programme isn's under-taken soon.

The infrastructure facilities in the rural area has not yet reached scattered home-steads. This implies that even if it is wanted to substitute fuel-wood with kerosene, at subsidized prices, it may not entertain the whole rural masses because the road infrastructure is not yet well developed. Even if such systems are adapted, its supply is not guaranteed because the oil exporters have been constantly increasing the price of fuel and decreasing the supply.

On the other hand, in some parts of the country, there seems to exist an-other substitute for the fire-wood: ie the introduction and popularization of bio-gas technology. Introduction of bio-gas technology not only partly solves the fuel problem, but also that of fertilizer as well. It also improves environmental health conditions.

The raw-materials needed for the production of bio-gas are found scattered as most of the people . This fact assures the availability of raw-material that may be fed into the digesters that may be owned by the rural residents. In fact in Ethiopia, an average family has enough number of animals whose manure, if collected and fed into bio-gas plants, can produce that amount of gas a family needs per day for cooking and lighting.

One of the major constraints that hinder popularization of bio-gas technology is the initial investment needed to construct bio-gas generators. Some efforts are being made to come up with simpler and less expensive designs. The results achieved, with them are so far encouraging. But there must still be some sort of national credit policy that assist in financing the initial cost of the digesters. The national credit policy will give the people a chance of getting some % of the money needed to construct and install bio-gas plants. The owners of bio-gas plants, as may be stated in the credit policy, will gradually pay the money rowed after the digesters start producing bio-gas.

Another bottleneck that has limited populariza- tion of bio-gas technology is the lack of proper coordination and directives on a national level. The Ethiopian National Energy Committee working Group was formed to widen the above mentioned bottlenecks and is better (than ever before) har- monizing the activities related to the development of rural energy.

The Current Conditions of Energy in the Rural Community

Ethiopia has probably the largest number of livestock population in African and 8th in the whole world (1). The 1979 estimate shows that the country has 27 million heads of cattle, 41 million sheep and goats, 7 million horses and mules, 1 million camels, 50 million poultry (2) and 3.8 million donkeys (3).

A great proportion of the human population are ural residents, whose home-steads are scattered all over the country. The farmers need power for cultivating their small fragmented farms. The sources of such power are very often, animals and oxen in most cases. cows are mostly owned for milk purposes. A family of five members has an average of 5 cattle, 7 sheep and goats, 1 horse or mule and 8 poultry (4).

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(1) Sinet Vol. 2, No. 1 pp. 4;

(2) National Development strategy for the animal resources of Ethiopia (1980-1990).

(3) Central Statistical Office-1967 and 1968 pp. 48. It is the estimate of 1967 and 1968 and does notrefer to that of 1979.

(4) This has been based on the assumption that the population of Ethiopia is 30 million.

As has been indicated above 89% (5) of people are rural residents and are mostly farmers (81%) (6); this by far involves the majority of the population and any healthy development program must be designed with these rural residents in mind.

The rural homesteads are scattered and the electric lines do reach only some (parts areas of it)future plane of electrifying the rural homesteads maytake a longtime. This leaves us with firewood and Kerosene to be the current source of already tapped fuel in the rural communities.

Kerosene, which is an imported commodity, is not a dependable source of fuel for the rural resiedents for two reasons: first, the road infrastructure is not yet well developed and this in turn will mean that Kerosene can not reach most of the rural residents in large volumes: and second, its price is increasing continuously. It may soon reach a point beyond which the people may not be able to buy but in some other countries, where road infrastructure is already well developed, majority of the people depend on kerosen as a major source of fuel. The governments also subsidize the price of kerosen to keep it locally available at a reasonable price (7).

This approach, directed towards solving energy shortage is debatable since the producers and exporters of Kerosene do not maintain the supply and they have been constantly increasing the price hence this trend, if addapted, could lead one to rely on an unde-pendable energy supply.

This system, which can not be adapted (as the only source of feul energy) and introduced to the rural parts of the country, leaves us with fire wood. Recent studies indicate that the present rate of depeletion of fuel-wood is 700,000 hectares of wood land per year (8) and there is only 88,000 km^2 of forest land remaining in the country (8). These figures indicate that, at the present rate of depeletion, the country will be compeletly running out of its forest within the next to decades (10).

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(5) A paper by the Ethiopian National Energy Committee on: Desertification caused by the uncontrolled consumption of non-commercial energy, (Undated).

(6) From Revolutionary Victory Through Struggle Expo in 1979.

(7) Inerciencia, Vol. 5, No. 1, Sep. 1980, pp. 58.

(8) ENEC-report pp. 2.

(9) Livestock strategy.

(10) The seedlings to be planted in the coming years are not included.

Hence use of fuel wood from forests, which covers less than 8% of total land area of the contry (11) should be discouraged but there must be alternative solutions to the need of fuel-wood.

Here, it seems logical to start developing improved stoves to reduce consumption of fire wood. The Faculty of Technology and A.R.D.U, in co-operation with the Energyy Sub-Council of the Ethiopian Science and Technology Commission, has already started conducting such a research.

In some instants, dried cow manure is used as a source of fuel but in most cases, the humas and valuable nitrogen contents are destroyed and only the mineral contents of the ash remains. The lost manure is then not available for use as fertilizer.

The previous reports (12) indicate that the domestic price of fertilizer has increased by 93.2% within the last six years (13). The actual price of a quintal of fertilizer was 135 birr in 1977 (14). The imported fuel and fertilizer thus are not dependable sources of inputs for the scattered homesteads in the rural parts of the country: Fire wood has been depelected rapidly thus bio-gas has been considered as one alternative.

This point can be further confirmed by the fact that the from the total animal population owned by an average family, in Ethiopia, can produce that amount of bio-gas needed for cooking and lighting a rural homestead.

Bio-Gas Digestes Built Some Years Ago

Some organizations and individuals have built bio-gas generating units. Many of these units have been out of operation at one time or another.

These bio-gas digesters were made as simple demonstration trials that are not, as such, geared to the daily needs of the people around the site.

There has also been frequent interruption of the bio-gas projects due to staff shift from the site. The remaining staffs did not have the same initiative for continuing the bio-gas projects already in operation.

This problem has been usually localized to specific sites other sites were having relatively richer experience than the rest. There

(11) From Revolutionary Victory Through Struggle, EXPO-1978.
(12) A.R.D.U. Publications-Annual Report (1974/1975).
(13) Domestic price of imported fertilizer was 44 Birr/quintal in 1974 and is 85 Birr in 1980.
(14) I.A.R. Proceedings - Fifth Annual Research Seminar 30 Oct. Nov. 1974 pp. 1975-A.A.

has not been any kind of co-ordination between the various centres dealing with activities related to bio-gas. This un-co-ordinated action has later been realized by the government and it has resulted in the birth of the Ethiopian National Energy Committee Working Group.

The Establishment of a Working Group that Co-ordinates Activities Related to Development of Bio-Mass Technology (in Ethiopia)

In order to properly plan and implement activities related to bio-gas, a working group was established in 1978.

The working group has been established when the conditions were purely disorganized and were with-out national applicability in mind. Summary of the past experiences in the country have guided the groups as to what measures are to be taken in order to properly bring the bio-gas activities under one umberlla. The most serious constraint was lack of proper know-how. The group is hence used for consultancy purposes as well.

Some Major Activities of the Working Group

A tentative job description of the working group may be stated as follows:

In consultation with the Office of the Executive Secretary of the Ethiopian National Energy Committee: (ENEC): the Working group:

- Prepare and distribute details of research proposals to various collaborating bodies.
- Prepare work schdule and budget that may be needed to conduct a particular project and finance as may be agreed with the respective organizations.
- Supervise and assure proper implementation of the proposed project.
- Collect and document all research results, and after proper consultation with the appropriate organs of ENEC interprates and publishes papers.
- Issues directives (in local languages) on how to construct the digester and how to use the gas and the sludge.
- Give technical sercices (designs and advices) to those who want to Construct bio-gas generators of their own.
- Take all possible actions in order properly distribute more biogas plants all over the potential areas in the country.
- Correspond with other bodies on related matters.

- Present monthly, quarterly and annual progress reports (15).
- Prepare directives and conditions under which the ownership of the digestors that are built for demonstration purposes will be handed over to local residents.

The working group organizes meetings regularily. The actual progresses and problems that have been made and encountered at each center, are discussed. Future work programmes are set by the group and each center is assigned to handle particular assignements.

The role of the Ethiopian science and technology commission in promoting rural energy (The Establishment of the Energy Sub-Council):

A summary of the (past) pressing fuel problem and its effect on the country's future development programme, the analysis of the country's annual budget allocation for the purchase of fossil fuel in the last years, and many other problems related to development have been recognized by the government. To this end, in order to properly handle the energy aspect of development, Energy Sub-Council has been established and is exclusively a component of the Ethiopian Science and Technology Commission. The Sub-Council is authourized to set policies that would encourage the search for new technologies suitable to local conditions.

Policy that has been set by the Energy Sub-Council of the Ethiopian Science and Technology Commission

The objective of this energy research and development policy of Ethiopia which is set by the Ethiopian Science and Technology Commission, is to develop applied and adaptive research for the building of a national scientific and technological capability, commonsurate with the socio-economic level and the development pattern of the country, which enables to,

a) Identify, assess and develop all possible energy sources of the country.

b) Utilize all energy sources rationally and efficiently.

c) Maximize the use of renewable energy sources.

d) Reduce the dependence on petroleum and natural gas to the extent possible.

e) Develop new and alternative sources of energy.

f) Take due and timely measures for environmental protection and the protection of the public and the working population from hazards arising from the production and use of energy.

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(15) Reports include developments, problems, deviations etc and proposed solutions as the case may be.

g) Develop the country's indigineous technological capability in manufacturing of parts or whole system components in the field of energy.

The Ethiopian Science and Technology Commission has hence set out the following policy guide-lines for further research and development in the field of energy:

A. Research on methodology to collect, analyse and evaluate data on energy demand, consumption pattern and use.

B. Research on rational utilization of all forms of energy.

C. Research on energy conservation possibilities at all levels of energy production, conversion, transportation and utilization.

D. Research on substitution possibilities of certain forms of energy with other more convenient, undertaking into account technological, social, economical and political considerations.

E. Research on the relationship between energy and socio-economic pattern of development.

F. Research on general technological developments and transfer possibilities in the field of energy.

Source: Energy Sub-Council of the Ethiopian Science and Technology Commission.

Current research activities on bio-gas:

There are about five active research centers (16) that are currently involved in conducting various trials on matters related to bio-gas. The trials consist of developing various burners (17). There are also some attempts of making parts of a lamp and a MITAD (18). There are also some successful attempts of developing a pre-mixer (19) which mixes cow-manure and water before feeding the mixture into the digester. Performance test of the mixer indicates that it is, at least, five times as fast as the traditional way of mixing two raw-materials.

It may be argued, at this stage, that the introduction of a pre-mixer may also mean additional cost to the farmer who thinks that the digesters are already very expensive: but it must be realized that, any one who buys a bio-gas plant is not obliged to purchase

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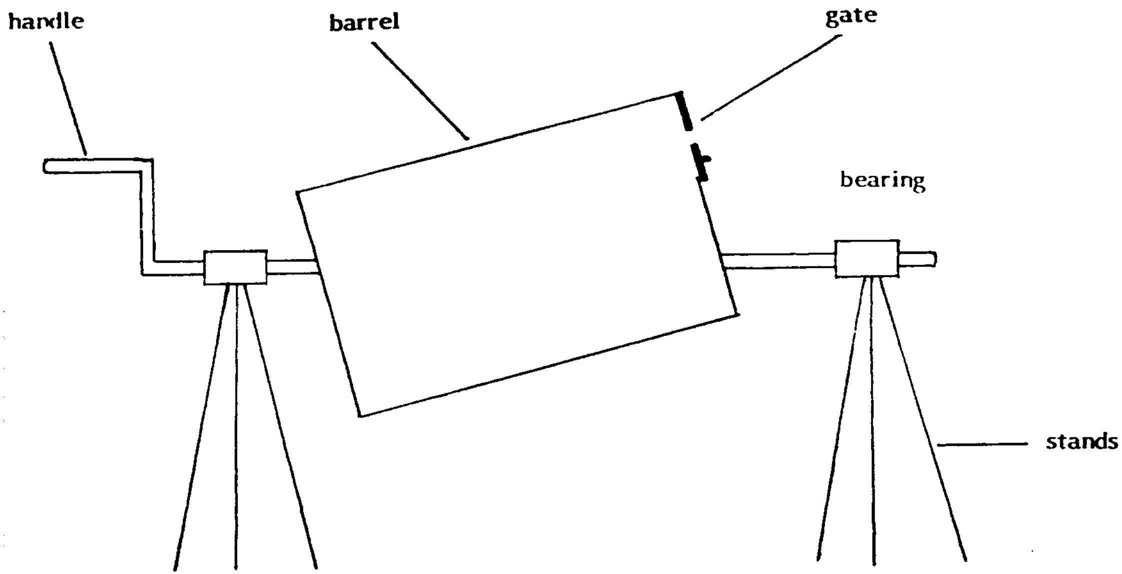
(16) These centers include A.R.D.U, Awasa, Melkawerer, Nazereth and WADU.

(17) Some are made up of metals and some others are make up of clay soils.

(18) A mitad is a clay tray, which can be placed on fire and is used to make the traditional food called injera.

(19) See the next page.



PRE-MIXER (FOR FRESH MANURE & WATER)

a pre-mixer. He can select only those items that he needs and leaves those he can not affored to buy.

An other successful attempt was the development of a cheap portable bio-gas plant (20) whose cost is only 1/5 of a concrete bio-gas plant and 1/2 of a masonary plant. The break-downs of the costs of the various bio-gas units have been indicated.

Table 1: Materials cost of a 5.7 cubic meter fixed top cheap digester that has been installed at Dhera.
(with 2mm sheet-metal for the dome).

S.N.	Materials	Quantity	Rate Birr	Total Cost Birr
1	Sheet-metal (2mm) for the dome	5 pcs	54.8	274.15
2	Angle-iron (4cm x 4cm 3mm) for stands	1 pcs	18.2	18.20
3	Angle-iron (3.5cm x 3.5cm x 3mm) for circular frames			
4	Sheet-metal (base part of the digester	3 pcs	11.90	35.70
5	Inlet structure (P.V.c4)	2 pcs	33.0	66.00
6	Sack and coal-tar	1/2 pcs	84.0	42.00
7	Electrodes, antirusts elbow paints etc. are assumed to be 10% of the above material costs 466.05 x 0.1 = 46.61	6 mts²	5.0	30.00
				46.61
8	Total material cost			512.61

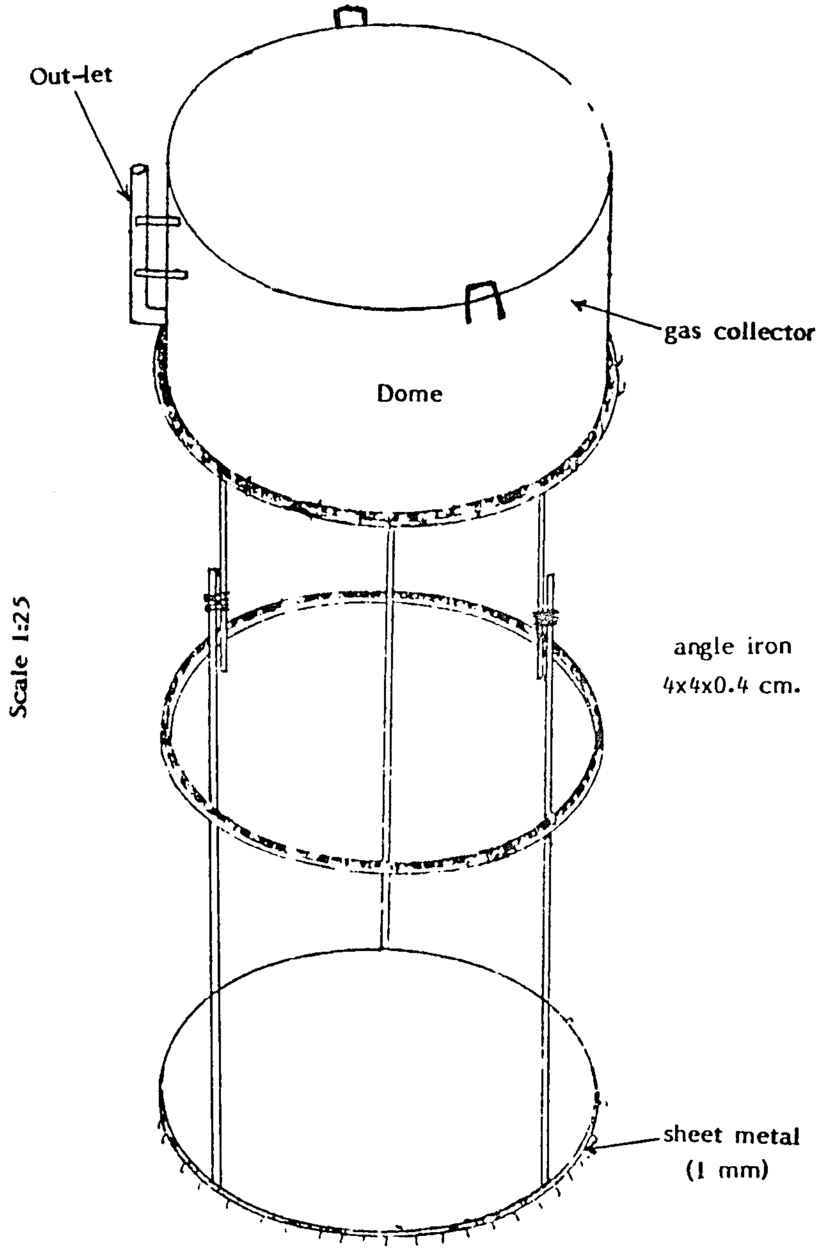
Cost per-cubic meter of the slurry is,
a) 89.52 birr if h 200 cm. The total volume is = 5.73 mts³.
b) 48.92 birr if h = 400m. (30.00 + 18.20 + 512.655) = 560.85).
the total volue is 11,45 mts³.
c) 44.42 birr if h = 450 cm (560.85 + (4.5-4) (0.5) (48.2) = 566.9 birr total volume is 12.76 mts³ (21).

Table 2: Cost of one cubic meter of mass concrete:

S.N.	Materials	Quantity	Rate Birr	total Cost Birr
1	Gravel	0.65 mts³	45/mts³	29.25
2	Cement	300 kgs	0.22/kgs.	66
3	Sand	0.65 mts³	33 mts³	21.45
4	Labour cost-20% of the above cost			23.34
5	Total material and lacing cost			140.04
	Trand total (approximate)			280.08

Source: ARDU-Building and Maintenance Section.

(20) It is only A.R.D.U. which is conducting such a research.
(21) It is the size of portable standard cheap bio-gas digester of ARDU.



CHEAP DIGESTER: DESIGNED BY BEYENE MEGERSA

As can be deduced from the above figurs, a concrete walled-digester (without the dome and the partition wall costs about 3000 birr/digester (22).

If masonary work is to be made, (with out the dome and the partition wall) it will cost about 1,000 birr/digester of 12.76 mts³(23) capacity.

As may be deduced from tables 1 and 2, the cost per cubic meter of slurry to be contained in the digester may be summerized in the following table.

Table 3:

S.N.	Types of digester	Material of construction	Cost of each digester	Cost of the dome*	Average cost per cubic meter
1	Mass concrets (floating top)	Cement, sand and gravel	3000	464.762**	271.55
2	Masonary work (floating top)	Cement, sand and stone	1000	464.76	114.80
3	Cheap-portable ARDU-digester (fixed top)	Sheet-metal, Sack coaltar, angle iron	768.92***	464.76	60.25

Note: Volume of the digester is 12.76 mts.

* The price of five sheet metals (of 2mm) and three pieces of angle iron (25 mm x 3 mm - by 600 cm) have been included. it has also been assumed that the construction cost is equal to half the material cost.

** As has been shown on table 1. (274.15 + 35.70) + 0.5 (274.15 + 35.70) = = 464.76 birr.

*** The data on table 1 (512.61 birr) has been adapted [0.5(512.61+512] = 768.92.

As may be deduced from table 3, more cheap-portable bio-gas plants may be constructed with the cost that may be needed to construct one digester with the mass concrete or with masonary work.

One possible ground for comparing the digesters mentioned above is the duration of the service years. It looks as if the digesters with either concrete or masonary wall would last longer than the cheap-portable one; but a close comparison indicates that there is no any convincing logic if the limiting factors are considered.

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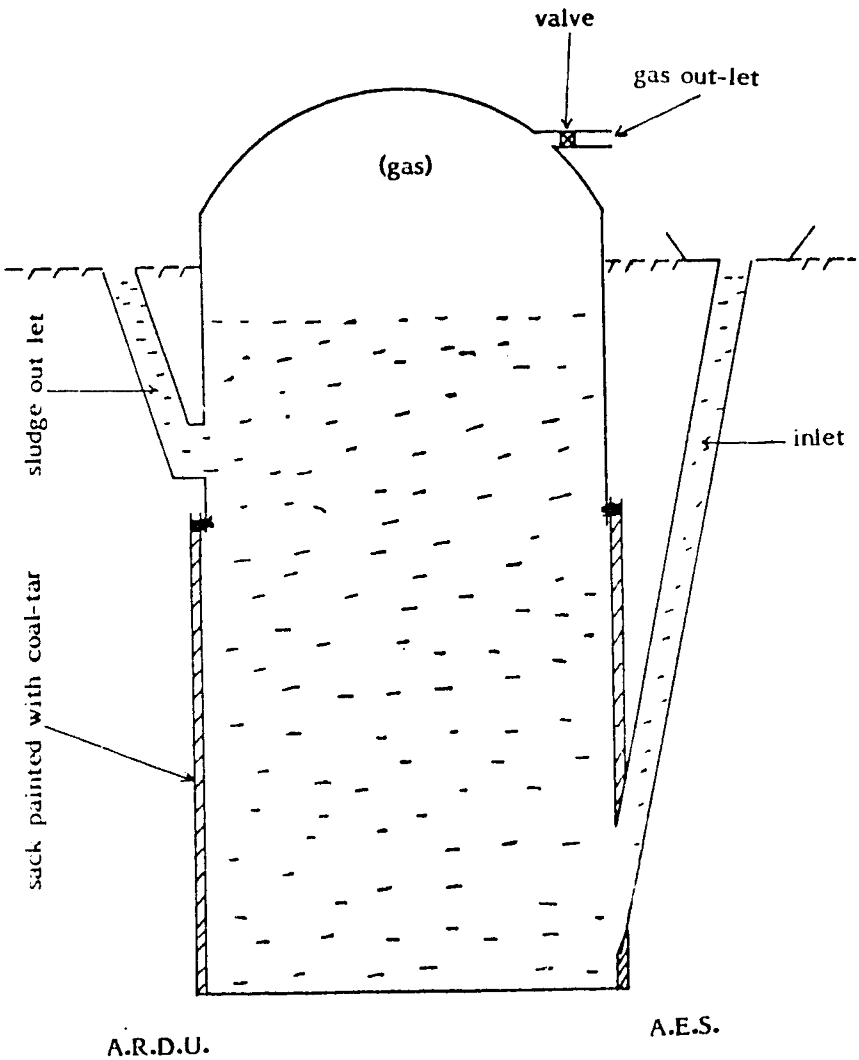
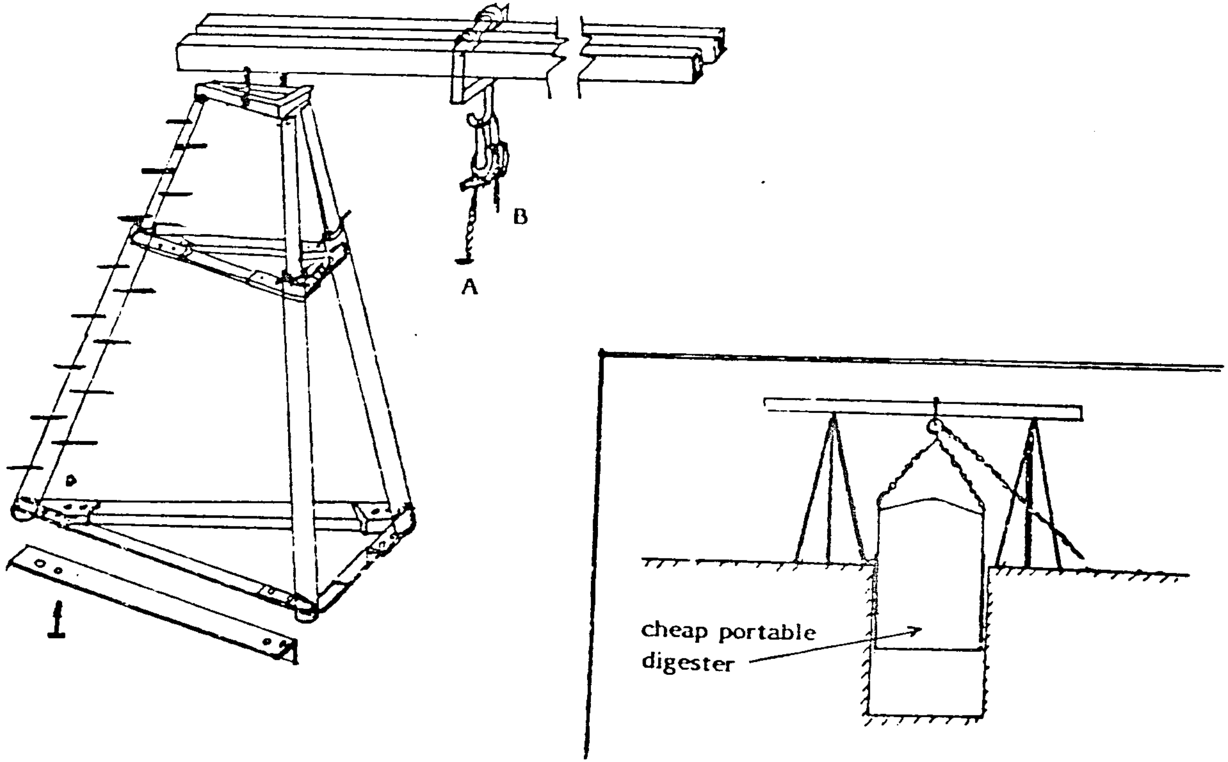
(22) The wall-thickness is 50 cm. The internal diamter of the wall is 200 cm and the height is 450 cm. The cost of the dome is not included.

(23) The diamter of the dome is 190 cm.



CHEAP PORTABLE BIO-GAS PLANT
(fixed top)

SIMPLIFIED



PORTABLE CRANE: TO LIFT & PLACE DIGESTERS IN PIT

In all the cases using metalcollecters it is the dome that causes the problem: but the corrosion equally affects all metal domes. All (domes) are made up of the same material and all are painted with anti-rust. Hence the service years of all digesters are expected (24) to be about the same.

Dissemination of bio-gas at Dhera and its prospects:

The project (ARDP) has started the first bio-gas test and demonstration center at Dhera (elev 1980 mts a.s.l.) because it has its own livestock research on the site to be used as source of raw material for the bio-gas plant. Residents, on the closest, are about 200 meters away from where the animals are kept and their houses were not electrified. These residents which consist of five families live in different rooms of the same house (see the next drawing).

The project has installed two digesters and has conveyed the gas to the rooms of the residents with the help of a 1/2 P.V.C. pipe burried to a depth of 60 cm.

At the beginning, there were only four stoves that have been taken to Dhera and hence gas has been made available to only four rooms. A few days atter making the first bio-gas installations the researching team was in-formed that the one who lives in the fifth room without bio-gas began to reserve his communication with those neighbours whose rooms have bio-gas stoves. This was an indication of dissatisfaction. He was jalous of his neighbours, who benefit from the bio-gas produced.

In order to avoid the misunderstandings that has been created between the neighbours due to the bio-gas project at Dhera, the researching team has given a stove for the one who has not had it at the beginning. The team was later told that the neighbours have resumed their sweet friendship.

This friendship did not last long. Another problem arose when one lamp (that operates with bio-gas) was installed in such away that it could be used by the people living in the four different rooms. All of the people do not sleep at the same time; and if he who has access to the switch of the lamp pats of the light when the others are still awake and in need of light, the others get dissappointed. This problem has been aggraviated when the ones who have recently fed the cow-manure into the digester, did not feel like sleeping.

Finally to put an end of this problem, the project has installed some more lamps, ie. one for each family and there is no problem reported since then.

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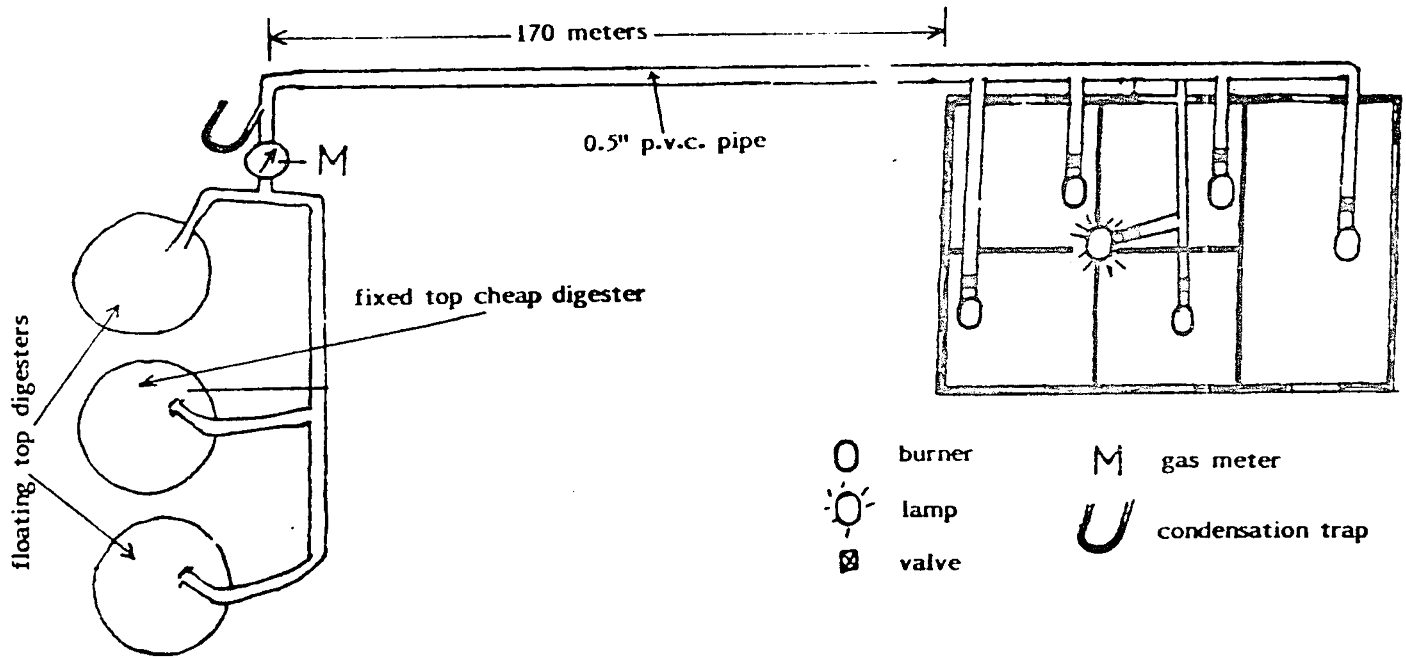
(24) "Expected" we have not yet actually tested the cheapportable bio-gas plant over a long period of time.



DHERA BIO-GAS INSTALLATION , SIMPLIFIED -not to scale-

In order to avoid further minor problems that may arise, a committee has been formed and the adminstration has been handed over to the committee.

Production of bio-gas under cold conditions:

Temperature is one among the various variables that affect the rate of bio-gas production. In some cold areas bio-gas production trials have been conducted under various conditions of the digesters. In one instant such a trial was conducted at Kulumsa, which is at an elevation of 2200 m (a.s.l.)

Artificial environmental condition has been created by placing the digester in the aerobically decomposing manure and in this case the temperature of 27.5°C has been maintained when the ambient temperature was only 20.5°C.

The rise in temperature will of course increase the rate of bio-gas production and will also decrease the cycle of fermentation in the digester.

Caloric Value of Bio-Gas

Bio-gas is a colourless, and inflamable gas with a calorific value of about 600 B.T.U. per cubic feet. It is a mixture of methane (60%), carbondioxide (32%), water-vapour and other traces (25). To increase the caloric value of bio-gas, there are two possible ways that may be practised. The first possible means is to remove the non-flammable gases in the mixture there by incrasing the concentration of methan which is the most active ingredient in bio-gas (26).

The second alternative is to enrich bio-gas with fuels of higher calorific value. This has been actually done by ARDU. The diagram on the next page describes how such test has been conducted. The result of this test has considerably increased the intensity of the light from the gas lamps.

There are two fuels, benzine and petrol that have been used. The vapour from the liquid fuel will be used as an enricher of bio-gas: both the heating and lighting qualities have been tested. The data that have been recorded for the heating trial have been summarized on the following table.

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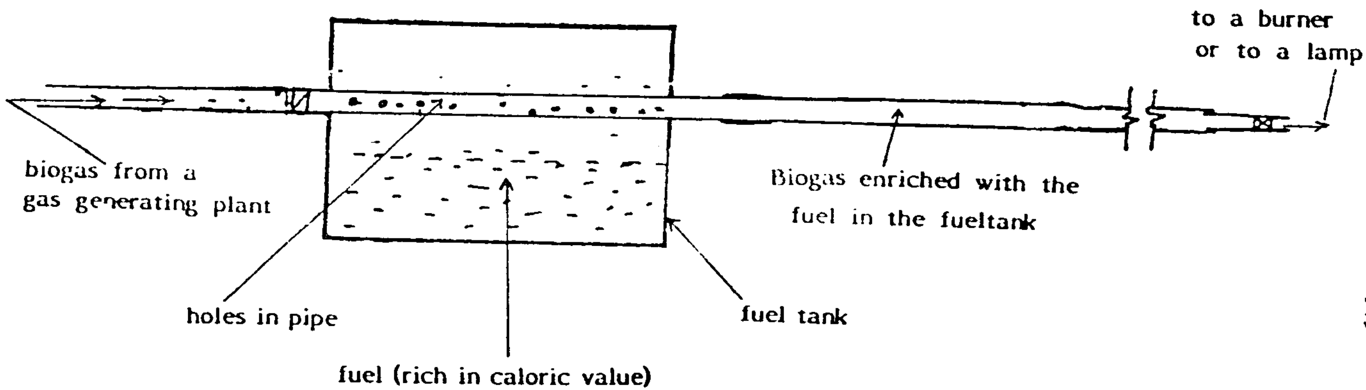
(25) Mather Earth news-Hand Book of Home Made Power, pp. 283.
(26) The only attempt done is the removal of condensed moisture with the help of a condensation trap. Removal of other impurities is not practised as yet.



ENRICHING BIOGAS WITH (MORE) CALORIC VALUE

S.N.	Bio-gas enriching fuel	ambient temp. (°C) Of the air	Of the water	Time taken:to raise the temp.of one liter of water to 90°C (minutes)
1	benzine and bio-gas	29	23	8.63
2	Nafta and bio-gas	31.5	24.5	11.60
3	Benzine+Nafta+bio-gas(27)	32.3	24	9.40
4	bio-gas	24	22	10.16

Note: In all the cases, the gas inlet and outlet are above the level of the enriching fuel in the container.

As may be deduced from the above figures, compared with bio-gas alone, the mixture of benzine and bio-gas has decreased the time of heating by 15%, whereas, that of nafta and bio-gas has increased it by 14%.

There has not been any light-meter to record the intensities that have been observed. However, it was obvious to observe the clear contrast of (higher intensity) light when benzine vapour mixed with bio-gas is used as fuel. The intensity was much heigher, when benzine vapour mixed with bio-gas is used, than those when neither nafta nor nafta and benzine vapour mixed with bio-gas is used.

The possibility of using un-lined pit as a digesting unit:

The experience we have had with the desposed sludge at Dhera indicates that there is very little mix between the sludge and the soil. This has been observed while feeding the digester with fresh raw material, when the raw material was fed on the inlet side, there was a discharge of an equal amount of sludge on the out-let side. The sludge so desposed was discovered not to mix with the soil (28) in the canal conveying the desposed sludge into a sludge collection pit.

The above observation leads one to conclude that there is a possibility of using open and un-protected pit as a digesting pit (29). It has hence been proposed to construct and test one such digester (30).

In order to enable one know the rate at which a digester sludge passes through sieves of different meshes, permeability tests have been conducted and the following results have been recorded.

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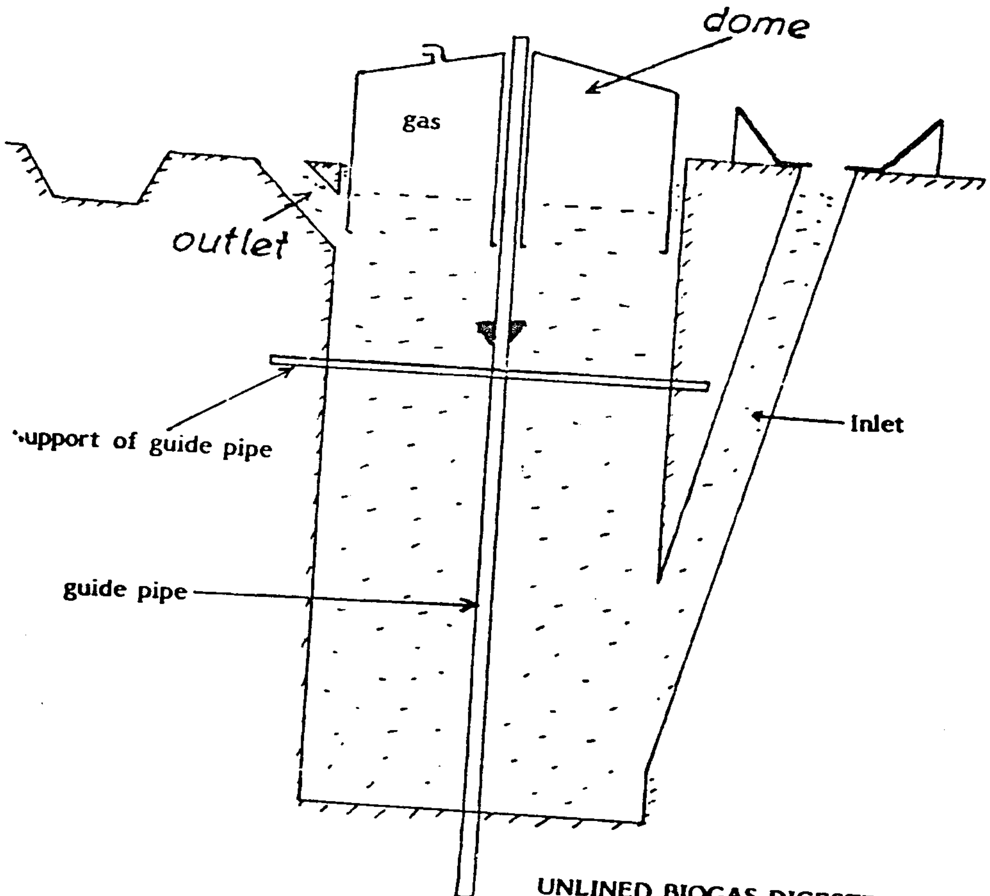
(27) Equal volume has been combined.
(28) It was during the dry season that such observations were made.
(29) The proposed digester is to be constructed and installed in the future.
(30) The proposed design of bio-gas generating plant may be seen on the next page.



UNLINED BIOGAS DIGESTER

Permeability Test of Slurry (31) through sieves of various Meshes:

S.N.	Sieve size-diamter of each hole (mm)	Rate of permeability mm/3 days
1	0.165	3
2	0.40	4
3	0.600	4
4	0.787	9

The largest size of a grain of soil is 2mm (32). Assuming the permeability of slurry through the soil whose texture is 2mm, to be 4mm/3 days (33), the distance that will be covered by the liquid matter, within a period of 60 days will only be 8 cm (34). Assuming the dimension of the digester to be the same as that of ARDU's cheap bio-gas digester (with the diameter of 190 cm and a height of 450 cm) it is expected that there will only be 2377 liters (35) of liquid that may permeate into the soil but maximum ratio at the end of the 60 days is expected to be 26%(36).

The daily feed is about 213 liters (37) and it seems possible to add an additional (40 liters)(38) liquid to maintain the final solid-liquid ratio in the digester at 8%.

One other possible chance to occur will be the effects that may be caused by the fibers in the manure. The fibers may seal some of the holes in the soil there by preventing the liquid matter from permeating into the soil.

The type of raw material to be fed into the digester:

One of the fear of those concerned is the type of raw-material that must be fed into the digester: and it is generally agreed, by

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(31) The slurry has been in the digester for 50 days. It was initially cow-manure mixed with an equal volume of water to form the original slurry.

(32) The soil particle with the largest size is sand which has a maximum diamter of 2mm.

(33) See the peremeability of slurry through a sieve whose hole is 0.24 mm from the table.

(34) This has been calculated as follows. (60 + 3) (4mm)= 80mm/60days

(35) Surface area of contact of slurry with the soil = $2\Pi Rh + \Pi R^2$ ie. $2\Pi(95)(450)+\Pi(95)^2$ = 297078.6 cm^2. volume= (297078.6 x 8)cm^3 = 2377 liters/60 days. ie 40 liters/day.

(36) The original ratio is 8% and concentration may tend to increase the ratio by 18% hence the total concentration may be 26%.

(37) 12760 liters/60 days = 213 liters/day.

(38) 2377 liters/60 days = 40 liters/day.

the bio-mass working group in Ethiopia, that it must not consist of human refuses, at least (now) at the beginning because it may increase the farmers resistance to accept the bio-gas innovations.

It is assumed that, with the acceptance of this power source and its popularization, the raw material now in use, animal manure, could step by step be partly or wholey substituted by human wastes minimizing the dependence on cattle wast.

Social bases in the rural communities:

The directives that have recently been declared are designed to encourage the establishment of villages in the rural communities and is hoped to be a potential social base for the rapid dessimination of any new innovation, among which bio-gas technology is nothing but one. The reasons are that, in the first place, lots of people can be taught within a time and secondly they can affored to buy a bio-gas generating unit in groups and this in turn will decrase the share per head and hence more people may be encouraged to start the Project.

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p. 151-157.

CONSTRUCTION ET ESSAIS DES DIEGESTEURS A BIOGAZ AU CAMEROUN

Par
Emmanuel Hamika

Le Centre National d'Etudes et d'Expérimentation du Machinisme Agricole (CENEEMA), Programme Biogaz, B.P. 1040, Youndé, Cameroun.

PRESENTATION

La politique de l'énergie dans le monde est caractérisée par une situation de crise. Crise encore plus durement ressentie par les pays en développement aux ressources limitées tels aque le Cameroun. Consciente de cette situation, la République Unie du Cameroun en coopération avec la République Fédérale d'Allemagne, a demandé au CENEEMA d'initier un programme BIOGAZ.

Le but du programme:

1. Construire et expérimenter des prototypes (PT) de digesteur dans différentes zones écologiaues du pays.
2. Tester l'efficacité des matériaux de construction disponibles.

Disponibilité:

La présence des déchets organiques des élevages, des cultures, de la transformation des produits agricoles, des déjections humaines (hôpitaux, internats d'écoles...), ainsi que des conditions climatiques favorables, facilite l'organisation d'essais pour la production du biogaz. La matiére décomposée (le sapropéle), un sous-produit de ce procédé peut être utilisée comme amendement pour l'amélioration de la fertilité des terres cultivées encore relativement jeunes.

Conditions:

Les méthodes de génération du biogaz décrites dans les études et rapports provenant de l'Inde, de la Chine Populaire et de nombreux Etats Européens ne peuvent s'appliquer directement aux conditions combien différentes qui prédominent au Cameroun. L'élevage de bovins* qui fournit le plus d'informations dans ce domaine, n'est pas présent partout; l'utilisation adequate d'autres déchets organiques disponibles est indispensable.

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* Absent dans les zones forestiéres des régions équatoriales. Causes: absence de pâturages et surtout présence de la mouch tsé-tsé.

DONNEES DE BASE

Elles concernent les divers prototypes de digesteur à étudier et la région à retenir au Cameroun pour l'implantation du Programme BIOGAZ.

Les expériences connues proviennent d'autres pays; elles doivent être adaptées aux conditions locales, afin de pouvoir développer et perfectionner de PT en vue de leur reproduction en serie.

La région retenue jusqu'à présent pour les essais pratiques est aussi représentative que possible tant du Cameroun que des pays limitrophes. Elle comprend 3 Provinces: Littoral; Nord-Ouest; Ouest dont les caractéristiques sont définies dans le tableau suivant:

	Popul. Hab.	Super. km²	Dens. Hab/km²	Routes km
Littoral	935166	20222	46.2	2.172
Nord-Ouest	980531	17300	56.7	3.407
Ouest	1035597	13890	74.5	3.385
Total	2951294	51412	---	8.964

Sources: 1) Recensement Général de la population et habitat 1976
2) Direction des Routes Yaoundé.

L'excellent état de la route Douala-Bamenda facilite des inspections régulières; le siége du Programme Biogaz étant à Douala.

Les activités du Programme se sont complétées par des essais à Yaoundé, Garoua puis à Bertoua.

REALISATIONS

Les prototypes prévus:

les 7 PT prévus ont été installés à des endroits différents pour tester l'efficacité de divers matériaux soumis à des traitements différents.

Ce sont:
- Douala 2,50 m³ pour déchets ménagers.
- Douala 12,00 m³ pour déchets ménagers volaille sans litiére
- Douala 9,00 m³ pour déchets ménagers volaille avec litiére
- Nkongsamba 9,00 m³ pour déchets ménagers porcins
- Bandjoun 9,00 m³ pour déchets ménagers porcins
- Bandjoun 9,00 m³ pour déchets déjections humaines
- Bamenda 12,00 m³ pour déchets bovins

Les prototypes supplémentaires:

Avec les moyens excédentaires des PT supplémentaires ont été construits:

Youndé: 1 P.T au CENEEMA, qui sert pour les démonstrations et qui décompose les déjections bovines.

1 P.T se trouve dans une porcherie privée (100 têtes) où le sapropéle sert à la production d'algues dans un étang; le propriétaire entend utiliser ces algues pour l'alimentation des porcs.

Garoua: 2 P.T ont été implantés à Pitoa chez des particuliers et décomposent les déjections de l'abattoir de cette ville.

Bamenda - Bafoussam: 4 P.T ont été installés dans les environs de ces deux villes.

Bertoua: 1 P.T a été iplanté dans la ferme prévue pour les démostrations lors du Comice Agro-Pastoral.

Le Programme BIOGAZ compte actuellement 16 digesteurs ou fermenteurs à Biogaz déjà opérationnels dans tout le pays.

PROTOTYPES (P.T)

Formes ou Modéles:

Plusierus formes ont été installées en un ou plusieurs exemplaires (selon les coûts) pour étudier leur efficacité.

La forme Indienne dite Gobar-Gas-Plant: Un seul fermenteur, implanté dans une ferme avicole à Douala - Bassa. Un enterrement de 4,00 m ne facilite pas la vidange pratique de ce modéle.

La Forme Chinoise: Un P.T a été construit sur ce modéle avec les matériaux de construction disponible; mais les coûts de réalisation furent aussi élevés que ceux de la Forme Indienne citée ci-dessus.

La forme Darmstadt - Horizontal dite Modéle CENEEMA: Un grand nombre de P.T construits, suit ce Modéle qui se caractérise par la présence d'un gazométre flottant dans la matiére.

Principe de fonctionnement:

La taille d'un digesteur se définit en fonction de la matiére organique disponible (MOD).

La génération successive de Biogaz est assurée par un systéme continu; chaque jour on verse dans le canal d'entrée (cuve d'entrée) la quantité de MOD, à ce moment il se déverse par le côté opposé (canal de sortie ou cuve de sortie) le trop-plein de la quantité équivalente de sapropéle.

En général la matiére à décomposer doit séjourner 45 jours dans le fermenteur. Pour cela le volume du digesteur doit être 45 fois plus grand que la quantité de MOD par jour.

Exemple:

- Elevage porcin de 80 têtes de poids vif 50 kg
  80 x 2,25 kg M.O.D/j = 180 kg M.O.D/j.
- Elevage de volaille de 1000 pondeuses
  1000 x 0,18 kg M.O.D/j = 180 kg M.O.D/j.
- Elevage bovin de 12 têtes de poids vif 400 kg
  12 x 15,00 kg M.O.D/j = 180 kg M.O.D/j
- Hôpital de 450 personnes
  450 x 0,40 kg M.O.D/j = 180 kg M.O.D/j.

Le volume du digesteur à implanter dans le cadre de cet exemple est de: 180 kg M.O.D/j x 45 j = 8,10 m³ (digesteur).

La température intérieure du digesteur doit être de 30°C environ

Description:

Pour assurer le passage continu de la matiére à l'intérieur du digesteur (cuve de digestion), nous imiterons autant que possible l'appareil digostif d'un être vivant.

Le fermentour comprend, une cuve parallélépipédique de 4,00 m de longueur, de largeur et hauteur variables, composée de trois parties principales:

- une cuve d'entrée
- une cuve de digestion
- une cuve de sortie.

Une manivelle qui traverse le digesteur (dans le sens de la longueur) permet de remuer la matiére en décomposition.

Dans la cuve de digestion un gazométre de forme également parallélepédique flotte dans la matiére, qu'elle couvre créant un milieu anaérobie favorable au processus de décomposition.

Les gaz qui se rassemblent sous le gazométre, le soulévent de maniére qu'il flotte sur une couche mince de gaz à laquelle il donne une pression d'environ 80 mm d'eau (20 millibar) qui permet d'envoyer les gaz vers leur lieu d'utilisation (ou de stockage).

CONSTRUCTION

Coûts:

Ils sont variables et tiennent compte des coûts des matériaux de construction et de la main-d'oeuvre. Selon les expériences du programme, un digesteur Modéle CENEEMA d'une taille de 8,00 m³ a un coût variant de 28000 à 35000 F CFA par m³.

Matériaux:

Selon la taille de l'appareil on utilise:

300 parpaings de 15.
50 parpaings de 10.
20 sacs de ciment
3 m³ de sable.
1 manivelle.
1 gazométre en tôle galvanisée de 2 à 3 mm
1 tuyauterie selon la distance (du lieu de production au lieu au lieu de consommation).

Durée:

Prés de 9,0 Hommes jour (9.0.H.J) dans les conditions expéri-mentales du Programme BIOGAZ.

PRODUCTION ET UTILISATION DE BIOGAZ

Production:

Les facteurs qui influencent la production de Biogaz sont:

- La nature de la matiére organique.
- La température dans le digesteur
- le pH de la matiére

Au Cameroun les conditions climatiques quoique variées restent favorables au processus. Même en construisant le fermenteur dans le sol, on lui assurele sol, on lui assure une température constante en le recouvrant avec un gazométre peint en noir.

Les chiffres de production du biogaz obtenus avoisinent ceux des autres pays, il est à remarquer qu'en Europe on ne peut arriver à ces chiffres qu'en utilisant 30 à 35% de l'énergie produite pour rechauffer le digesteur.

Un fermenteur de 8,10 m³ approvisionné par:

- 80 porcs produit 13000 l/j.
- 1000 pondeuses - 10000 l/j
- 12 boeufs - 6000 l/j.
- 450 personnes - 12000 l/j.

Utilisation:

Les appareils suivants: - gaziniéres
- lampes à mancnon
- engins.

permettent d'utiliser le biogaz produit.

L'utilisation du biogaz doit être fonction de la M.O.D. Si les besoins sont élevés ou augmentent la production du biogaz en ajoutant d'autres matiéres organiques. L'utilisation du biogaz connaît des résultats trés encourageants dans le monde: mais dans le cadre du Programme, il n'a été effectué que des [illegible] à la gazinière.

La comparaison tient compte uniquement du pouvoir calorifique, des deux sources d'énergie dans la cuisson des aliments.

Exemple de calcul: (Source: Rapport du Programme).

Dimension de la chambre de fermentation = 7 m^3.
Production journalière de biogaz = 10 m^3
Valeur calorifique du biogaz.
4700 Kcal/m^3 = 19646 kj/m^3.
Rendement d'une gazinière = 0.60.
Energie utilisable par m^3 de biogaz :
19646 x 0.60 = 11,787 kj.
Valeur calorifique d'un kg de bois séché à l'air
3800 Kcal/kg = 15800 kj/kg
Rendement de l'utilisation de la chaleur d'un feu (ouvert) de bois pour la cuisine: 0,17.
Energie utilisable par kg de bois:
15 800 x 0.17 = 2686 kj
Ansi 1 m^3 de biogaz remplace:
11787 : 2686 = 4,4 kg de bois
10 m^3 de biogaz remplacent 44 kg de bois.
Energie utilisée dans une cuisimére à bois fermée avec un rendement de: 0.60
15800 x 0,60 = 9480 kj/kg de bois
Ansi 1 m^3 de biogaz remplace
11787: 9480 = 1,4 kg de bois
10 m^3 de biogaz remplacent 14 kg de bois.
Le rendement économique
Durée de vie de la chambre
de fermentation en maçonnerie : 10 ans
Durée de vie de la cloche en tôle : 5 ans
Les frais de la cloche représentent
environ 50% de l'ensemble des frais:
Frais de construction de l'installation de 7 m^3: 300000 FCFA
On considére une durée moyenne de vie de: 7 ans

Amortissement:	14%	
Entretien, réparation:	2%	
Intérêts	3%	
	19%	soit 57000 FCFA/and

L'installation produit 10 m^3 de biogaz par jour:
soit 3600 m^3/an
Dans le cas d'un feu de bois ouvert:
3600 x 4,4 kg: 15840 kg de bois/an
1 kg de bois ne devrait pas coûter plus de:
57000 : 15840 = 3,6 FCFA

Dans le cas d'une ouisiniére à bois fermée:
3600 x 1,4 = 5040 kg de bois/an
1 kg de bois ne devrait pas coûter plus de:
57000 : 5040 = 11 F CFA

A douala le prix minimum qu'on paie pour le bois de chauffage est de 25 F CFA.

En admettant que ce prix corresponde à environ 2 à 4 kg de bois, on paierait donc annuellement:

- Pour un feu de bois ouvert de 99000 à 198000 F CFA
Pour une cuisinière à bois fermée de 31500 à 63000 F CFA

Naturellement dans les villages de la forêt vierge, le bois que les femmes ramassent et rapportent à la maison est gratuit; on ne compte ici que le temps nécessaire à la recherche, coupe et transport du dit bois.

CONCLUSION

Compte tenu de l'importance des essais mis en place, on est en droit de dire que le Programme Biogaz est une enjambée dans la politique de l'énergie (surtout énergie non conventionnelle) au Cameroun.

En étendant ses activités dans le pays, le Programme précisera dans nos conditions, les besoins quotidiens en Biogaz pour la cuisine, l'éclairage et les engins.

Les problémes de formation du personnel et de stockage de Biogaz doivent faire l'objet d'une attention particuliére.

La cuisson à bois exige une alternative pour éviter les déboisements excessifs. La cuisson traditionnelle exige dans certains cas un feu plus fort que le feu de bois pour faire face à une longue période chaque jour.

Le biogaz produit par 80 porcs est suffisant pour faire tous les repas pour 20 personnes par jour.

Selon Wienecke on remplace ainsi prés de 50 kg de bois dce chauffage par jour.

L'association élevage-cultures trouve un puissant support dans le systéme biogaz qui rendra la vie en famille plus agréable (utilisation de biogaz) et assurera une amélioration des sols cultivés (utilisation du sapropéle) pour des récoltes plus abondantes, ceci pour le bien-être de nos populations tant des zones rurales que des villes.

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SMALL-SCALE TECHNOLOGIES OF UTILIZATION OF ROUGHAGES SUITABLE FOR SMALL HOLDERS IN AFRICA

BY

J.A. Kategile

Department of Animal Science, University of Dar-es-Salaam, P.O. Box 643, Morogoro, Tanzania.

INTRODUCTION

Different agricultural systems have evolved in various areas as dictated by soil, climate and socio-economic factors. Arable cropping is primarily aimed at producing human food and livestock production has a similar aim but the two are interdependent, the former supplying man with mainly energy and bulk and the latter supplying protein of high quality.

Systems of livestock production based on cultivated herbage and cereal grains have evolved in developed countries but with the current increases in global human population one cannot overlook the need for abating competition for food between livestock and man. As the costs of machinery, fertilizer and energy have increased the cost of producing cereals and cultivated herbage have consequently increased and the need for rational utilization of resources arises.

The situation is, unfortunately, more serious in developing countries where a large majority of the population is poor and engaged in agri-gulture. Lack of know how, capital and appropriate technology are serious bottlenecks to development in these countries is unrealistic as human food production is presently inadequate due to the constraints cited above. Consequently efforts towards solving the immediate problems of food production implies devoting relatively more land and capital to arable cropping resulting in less resources for livestock production. However, as arable cropping results in the production of field crop residues, the use of these as ruminant feed can go a long way in combining crop and livestock production.

In spite of the fact that these materials are of low nutritive value. i.e. low digestibility and voluntary feed intake (Rexen et al., 1975) they are still important livestock feeds, especially, out of necessity. History tells us that resource scarcity, during the first world war, forced European scientists to conduct intensive and extensive research for alternative sources of livestock feedstuffs. A lot of work was done in Germany and Britain (Godden, 1920). The major objective of their work was to improve the feeding value of field crop residues of wheat straw and barley straw which was plentiful and in the absence of imported concentrates. We may not be in such a desperate situation but definitely the constraints of shortage of capital for developing our livestock industry are over prevalent.

As mentioned, earlier, from a socio-economic and practical point of view, the use of field crop residues is necessitated by scarcity of relatively high quality roughages (for high levels of productivity) which is brought about by: intensive arable cropping occupying land at the expense of grazing; high population density in rural areas with accompanying resource scarcity; inadequate inputs for the production of high quality forages and absence of adequate fodder conservation. In addition, the awareness that these residues are useful is a major factor.

The densely populated mountain areas of Tanzania are heavily cultivated and ruminants are fed on leaves, pseudostems and peels of banana and various weeds from the shambas while fodder production is limited by scarcity of land. The stall feeding of maiz stover and standing hay to ruminants during the dry season is a matter of necessity. In fact feed availability has been a major limiting factor in the development of the dairy cattle industry in these areas. In the Miombo woodland and Savana areas where arable cropping is important for annual food and cash crops and livestock keeping is traditional, the field crop residues are valuable feeds in the dry seasons as the pastures are, during those periods inadequate, qualitatively and quantitatively.

The large scale wheat and rice farms produce large quantities of field crop residues which are largely wasted by burning.

Under various situations we realise that livestock feed supply is an important constraint and a rational utilization of field crop residues can assist in partly solving this problem. With this objective in mind the following aspects have to be considered in planning the utilization of crop residues:

1. Quantities of the available field crop residues.
2. Methods of prodcurement.
3. Storage.
4. Processing of the material to improve nutritive value.
5. Feeding.

Quantities of Field Crop Residues:

Annually, a tototal of more than 2 million of cereal field crop are produced in Tanzania (Table 1). Field crop residues of pulses have not been included in the table. This amount is adequate for feeding 5, 169, 511 cattle for a dry season of five months at 3-kg dry matter per animal per day. If only half of it is available to livestock, then this is enough for more than 2 million cattle for that period of time. The potential is there.

Another important crop residue is sisal waste with a capacity of 600,000 tons of dry matter, annually. This waste is currently dumped as a semisolid waste into streams causing pollution. The cycling of this waste into animal feed may not only avoid pollution but render it into productive use. To date, the experiments which have been conducted at Morogoro (Kroonen and Kategile, 1978; Bamuhiga, 1979; Ngobei, 1979 and Majani, 1980) indicate that it is a good feed.

Table 1: Estimated quantities of field crop residue in Tanzania based on Msuya and Maro grain production estimates. Field crop residue production based on straw grain ratio 2:1 for maize, sorghum and millet and 1:1 for rice and wheat.

Crop.	Production 1973	
	Grain (tons)	Field crop residue (tons)
Maize	603,196	1,206,392
Rice	204,085	204,085
Wheat	77,735	77,735
Sorghum	247,624	495,248
Millet	171,410	342,820
Total		2,326,280

Source: Msuya and Maro (1977) Survey of the status quo and prospects of developments in agro- industry in Tanzania, University of Dar-es-Salaam Mimeograph.

Methods of procurement:

It is desirable to collect the straws, stalks and stover in the fields as grazing in situ which, traditionally, is associated with inefficiencies and wastage as a result of trampling. Materials which have been trampled on an soiled with urinary and faecal excreta is usually rejected and not consumed. Up to 50% of the whole can be rendered useless. In Europe and other developed countries, chopping and baling in the field with machinery is common but unfortunately such machines are too expensive for the small indigenous farmers. Manual collection using folks seems to be the only method at small scale. After collection it is adeal to compress the material so as to reduce bulkiness thereby making it easy to be handled. Chopping reduces the volume to a small extent, on the other hand, it is difficult to handle and to transport the loose chopped straws. At our station, attempts have been made to make small bales of straw in weld mesh baskets, mannually, with little success. The real problems have been inadequate pressure to compress the material and that the thick stemmed maize could not be handled by this method. This still remains a challenge.

With sisal waste the problem is that of too much water. As the waste comes out of the factory the water content is at 90% and as such the material becomes difficult and expensive to handle. A squeezer to reduce the moisture content to 50% was being developed but was not completed due to personnel shortages.

Storage:

As the need of feeding straws is very important in the dry season, storage is desirable to offset unplanned usage and burning. Traditionally, where collection is done, stooking in the field is common. This is satisfactory when the material does not have to be carried for some distance. In localities where stall feeding is done, the material has to be protected against rains and this is where storage problems arise. As cited earlier, as the residues are not compacted, bulkiness is of major concern. Tying bundles is so far the only common method of compaction. It is probably desirable in the future to design small housing units for cattle with a provision of storage space under the roof.

In the case of sisal waste, sillage making is the most convenient and the cheapest method (Ngobei, 1979). Others have suggested sun-drying of sisal waste but it is laborious and justified only where it has to be transported for feeding.

Processing of the materials:

Numerous research findings have indicated that physical processing of roughages increase feed intake, feed utilization efficiency and animal performance as reported by Moore (1964), Beardsley (1964), Pigden and Heaney (1969), Pigden (1971) and Pigden and Bender (1972). However, fine grinding has a simultaneous effect of reducing the digestibility of dry matter, organic matter, cellulose and crude fibre and nitrogen free extracts. For small-scale operations, chopping is the only relevant method which needs attention. Chopping of straws improves voluntary feed intake of roughages and also enhances feed utilization efficiency and animal performance (Greenhalgh and Wainman, 1972). Any decreases in digestibility is associated with high levels of intake and actually is less important than the benefits accrued (Kategile, 1978). Chopping of thick stemmed maize stover, sorghum stalk and bullrush millet stalk has a marked improvement on voluntary feed intake as long stems cannot be readily eaten in the native form. Small hand choppers are available in some countries for chopping these. Where these do not exist long big knives can be used. Of course, it has to be appreciated that these methods are applicable on a small-scale basis only and hence not practical for large-scale.

The use of chemicals and in particular alkalis in treating straws with an objective of improving the digestibility and voluntary feed intake of these low quality roughages has been extensively investigated. Recent research and development in improving the feed value of roughages had led to industrial alkali treatment of straw in Denmark (Rexen et al., 1975) and the United Kingdom (Wilson, 1974) and production of large-scale farm machines for treatingstraw. Such technologies cannot be directly used in developing countries where capital is scarce and infrastructure is poor. At Morogoro, attempts have been made to modify the traditional Backmann method (1922) to suit the small-scale farmer. This method is described as follows:

The straw is packed in baskets and soaked overnight for 18hr. in 0.67 to 1.00% w/v NaOH solution. The ratio of weight of dry matter to volume of solution is 1:15. The treated straw is allowed to drain and then washed with a volume of water which is slightly less the volume of solution taken up. The draining effluent is led into the container of treatment solution. After washing, the treated straw retains an equivalent of 40-60 kg NaOH/t DM of straw and is ready for feeding. Such treated straw is superior in nutritive value when compared to untreated straw. The used solution which is an effluent, is replenished by adding an amount of NaOH equivalent to the amount of NaOH taken up by straw and made to volume. With successive replenishments, NaOH treatment solutions can be re-used for at least twenty times without developing an undesirable smell.

The basic equipment consists of a plastic or steel (round or rectangular) container and 5.2 cm stell weld mesh basket which fits into the treatment container. In our experiments cut oil drums were ideal. A water can for spraying during washing is useful.

The amount of NaOH used for replenishment of 49-60 kg/t DM of roughage coincides with the optimum treatment rates for the dry methods (Rexen et al., 1975 and Kategile & Frederiksen, 1979), and is less than the amount of NaOH used in the Beckmann method (1922). With the soaking method, it is not necessary to chop rice or wheat straw and mechanical mixing is also eliminated. These are advantages over the dry method. Further, the modification of the Beckmann method which has been used in these experiments has the added advantages of reducing water consumption and effluent output which is a major objection of the Beckmann method (Homb et al., 1976) and also reducing alkali utilization as about 150 kg NaOH/t DM is used up in the traditional Beckmann method in comparison to 40-60 kg NaOH/t DM in this method. In addition, the new method eliminates extensive washing which is labour intensive. Some data obtained from the method is given in Table 2. Improvements in digestibility and voluntary feed intake are quite substantial. The factors which have held back the adoption of this method by farmers are; the costs of NaOH which has increased substantially; the unavailability of NaOH; and the fear by some people that NaOH is too corrosive and farmers will not be able to handle it. Actually, farmers do handle chemicals which are even more hazardous than NaOH.

Feeding:

Wastage during feeding cancontribute to large losses espe[illegible]ly when there are no proper feeding trouhgs or racks and when [illegible] are givenfar in excess of requirements. of particular importance, is the use of hay racks for straws and troughs which can reduce wastage considerably. It is a matter of convincing livestock keepers to adopt their use as there are many designs.

Table 2: The chemical composition of maize stover and means of in vivo DM, OM and CWC digestibility of maize stover based diets. (Kategile, unpublished data).

Treatments			Daily intake of roughage	Digestibility (%)			Chemical composition of roughage(%)		
	$Ca(OH)_2$ (kg/100kg DM	NaOH (kg/100kg DM	(kg)**	DM	OM	CWC	DM	OM	CWC
1	0	0	0.497	53.2[a]	57.2[a]	52.6[a]	85.0	90.9	73.9
2	0	10 (4.2)*	0.681	68.2[d]	71.8[c]	71.5[c]	22.7	88.4	68.4
3	0	15 (6.0)*	0.651	70.3[d]	75.1[d]	72.1[c]	21.6	84.2	63.3
4	2.5(2.2)	10 (4.2)*	0.563	60.9[b]	65.1[b]	62.7[b]	21.6	84.5	63.9
SE of means and significance difference				1.46 ***	1.52 ***	2.01			

* Replenishment rates.

** Each sheep was also given 0.100 kg of simsim meal.

*** $P < 0.01$, means within a column with different superscripts are significantly different.

SUMMARY

From the foregoing, it is obvious that field crop residues can be used to feed livestock in the dry season. In order to exploit the potential fully, simple technologies involving collection, handling, storage, processing and feeding have to be developed and advocated for.

REFERENCES

Bamuhiga, E.B. (1979) Nutritive value of formaldehyde stabilized sisal waste, B.Sc. (Agric.) Special Project, Faculty of Agriculture, Forestry and Veterinary Science, University of Dar-es-Salaam.

Beardsley, D.W. (1964) Symposium on forage utilization. Nutritive value of forages as affected by physical forms Part II. Beef cattle and sheep studies. J. Anim. Sci. **23**, 239-245.

Beckmann, E. (1922) Conversion of grain straw and lupins into feeds of high nutritive value. Chemical Abstr. **16**, **765**.

Godden, W. (1920) The digestibility of straw after treatment with soda. J. Agric. Sci. **10**, 437-456.

Greenhalgh, J.F.D. and Wainman, F.W. (1972) The nutritive value of processed roughages for fattening cattle and sheep. Proc. Br. Soc. Prod. 61-72.

Homb, T., Sundstl , F. and Arnason, J. (1976) Chemical treatment of straw at commeriial and farm levels. In: "New Feed Resources". FAO Animal Production and Health Paper No. 4, FAO, Rome.

Kategile, J.A. (1978) Improvement of the nutritive value of maize cob using sodium hydroxide, Ph.D. Thesis, University of Dar-es-Salaam (1978).

Kategile, J.A. and Frederiksen, J.H. (1979) Effect of level of sodium hydroxide treatment and volume of solution on the nutritive value of maize cobs. Anim. Feed Sci. Technol., **4**, 1-15.

Kroonen, J.G. and Kategile, J.A. (1978) Progress report on sisal waste stabilization (Unpublished report), University of Dar-es-Salaam.

Majani, A.S. (1980) A comparison of sorghum silage and sisal pulp silage as roughage feed for lactating dairy cattle (Unpublished report), University of Dar-es-Salaam.

Moore, L.A. (1964) Symposium on forage utilization. Nutritive value of forage as affected by physical form. art I. General principles involved with ruminants and effect of feeding pelleted or wafered forage to dairy cattle. J. Anim. Sci. 23, 230-238.

Ngobei, E.I.L. (1979) Evaluation of sisal waste as a feed for ruminants. B.Sc. (Agric.) Special Project, Faculty of Agriculture, Forestry and Veterinary Science, University of Dar-es-salaam.

Pigden, W.J. and Heaney, D.P. (1969) Lignocellulose in ruminant nutrition. Cellulose and their application, Advances in Chemistry series Number **95**, 245-261.

Pigden, W.J. (1971) Effect of physical and chemical processing and non-protein (NPN) supplementation on utilization of lignocellulose. Paper presented for the Meeting of FAO. Ad hoc Expert Committee on Animal Nutrition, Makerere University, pp. 17, Uganda (1971).

Pigden, W.J. and Bender, F. (1972). Utilization of lignocellulose by ruminants. World Animal Review. 4, 7-10.

Rexen, F., Stigsen P. and Kristensen, V.F. (1975) The effect of a new technique on the nutritive value of straws. Nineth Conference for Feed Manufacturers, University of Nottingham, 65-82.

Wilson, P.N. (1974) Possiblities of processing straw for animal feed. In Report on Straw Utilization Conference held at Oxford on December 5, 1974. Agricultural Development and Advisory Service of Ministry of Agriculture, Fisheries and Food, Oxford, pp. 19-24.

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POSSIBILITES ET CONTRAINTES DANS L'UTILISATION DES SOUS-PRODUITS DE LA PECHE AU CAMEROUN

Par

J.C. Njock
I.R.Z., Yaoundé (Cameroun)

La pêche camerounaise qui se pratique aussi bien en eaux intérieures que marines fournit annuellement sur le marché, une production estimée à 100.000 tonnes. Il convient d'y ajouter des produits importés. Cette quantité correspond à une consommation annuelle par habitant de 12 kg. Ce chiffre jugé bas, est l'objet d'une préoccupation majeure de la part des autorités qui, par diverses interventions dans le secteur de la pêche cherchent à le relever, tant il est vrai qu'au Caeroun comme partout ailleurs en Afrique, le poisson constitue avant tout, au même titre que la viande, un aliment protéique.

EVALUATION DES RESIDUS DISPONIBLES

La production nationale est consommée sur place et dans les pays voisins sous for, e de produits frais, séchés ou fumés. Les produits frais qui pour leur quasi-totalité proviennent de la pêche maritime industrielle (18.000 tonnes), sont mareyés dans des atelier construits au port de pêche de DOUALA. Le tonnage des déchets issus de ce mareyage n'est pas connu, mais peut être considéré comme négligeable. Le fumage es le séchage ne concernent que les produits de la pêche qrtisanale maritime et continentale. Ces produits subissent ces traitements à état entier. C'est dire qu'il n'existe à l'heure actuellement au Cameroun, aucune industrie de transformation de poissons. Dans ces conditions, les déchets succeptibles d'alimenter une éventuelle industrie des sous-produits de la pêche pour la fabrication d'engrais, de farines, d'hydrolysats et autres huiles ne sont pas actuellement disponibles en quantités suffisantes, pas plus que les rebuts provenant des contrôles sanitaires (saisies). Les seuls sous-produits qui pourraient être utilisés par une usine de transformation sont des déchets laissés par l'étêtage des crevettes. Leur quantité évaluée à 650 tonnes en 1974 est reduite de moitié en 1978 par suite de la chute dces apports de crevettes.

IMPLICATION SUR L'ENVIRONNEMENT

Compte tenu de l'inexistence d'une industrie de sous-produits de la pêche, l'environnement Camerounais n'est pas encore soumis aux nuisances dues à ce genre d'activités.Toutefois, d'une façon générale, du fait du processus d'industrialisation entrepris depuis l'Indépendance, le milieu nautrel de notre pays et singuliérement le milieu aquatique commence à connaître ce fléau des temps modernes qu'est la pollution. Divers efforts ont été entrepris pour éviter le pire. C'est ainsi que les industries naissantes succeptibles de polluer sont tenues à obéir à certaines normes avant le rejet de leurs effluents.

FACTERUS SOCIO-ECONOMIQUES

Le Ive Plan Quinquennal de Développement Economique [illegible] et Culturel (1976-1981) a inscrit dans son chapitre sur l'" [illegible] du Possion", un project de conserverie de thons et de sar[illegible]. La réalisation de ce projet pourrait permettre l'approvisionne[illegible] une industrie de traitement des sous-produits de poisson en [illegible], premières, constituant ainsi un bon soutien aux grands pro[illegible] - pastoraux par la fabrication d'engrais minéraux azotés (p[illegible] et d'aliments pour bétail.

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Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-12 Nov. 1980, Douala, Cameroun, p.169-175.

TECHNOLOGIES AVAILABLE ON FISHERIES RESIDUES AND PROSPECTS OF THEIR UTILIZATION IN KENYA

BY

Canute P.M. Khamala

Associate Professor, Department of Zoology,
University of Nairobi, Kenya

INTRODUCTION

In Kenya, there are various sources of fisheries residues. The residues are normally those products of fish discarded after the principal use of the provision of food has been fulfilled. The common fisheries residues are fish offal from filleting and fish cleaning plants, fish skin from fish salting and drying depots, shells from oysters and other molluscs etc. In some countries, for example, the Soviet Union, Japan and Britain, these residues are of high economic importance, especially, in the manufacture of fertilizer.

The discussion which follows examines and provides information on the different ways in which various fisheries residues, which are readily available, have been used and/or can be utilized in a similar manner in Kenya.

FISH SCRAP FOR FERTILIZER AND FISH MEAL

Fish scrap is obtained after treatment of residue of filleting fish and cleaning fishing equipment and depots. It is normally composed of fish bones, scales, tails, skins and other fish offal. In Kenya the raw materials for fish scrap are obtained from filleting industries, including the fish processing plants at Lakes Bogoria, Turkana, Victoria and in the sea at Mombasa. The general method of processing fisheries residue into fish scrap includes steam cooking to render any fat in the material free. After the fat is separated the remaining solid material is pressed to ensure that all the fat oil is eliminated. The pressed scrap is then dried using steam or direct hot air. Alternatively, the pressed fish scrap, can be acidified with sulphuric or hydrochloric acid to prevent decomposition which takes place easily in the presence of moisture. Acidifiation is a cheaper process than drying but it has some disadvantages; a considerable qantity of moisture remains in the scrap making it bulky and cumbersome to transport. Furthermore, acidified scrap cannot easily be mixed with other material, when being used directly, especially, as fertilizer. Hot-air dried fish scrap is suitable as fertilizer and as animal feed.

The method for the preparation of fish scrap for fish meal is generally the same as for fish scrap fertilizer. In this case, however, whole fish is used. In Kenya, the freshwater fish Haplochromi (which is abundant in Lake Victoria)[2] and the small marine fish, e.g. Sardines and Anchovies can be utilized in fish meal manufacturing.

Fish meal is an excellent protein source for poultry and livestock. Its protein content is readily available and has a high percentage of calcium phosphate which is used in the formation of egg shells and bones. The high content of nitrogen and phosphates in the form of phosphoric acid in fish scrap and fish meal makes them useful as fertilizers, particularly when supplemented with inorganic fertilizers.

Fish Oil and Fish-liver Oil

Fish oil is generally obtained from all parts of the fish while fish-liver-oil is obtained from the liver only. Oils whether from vegetable or animal can be divided into three groups; non-drying, semi-drying and drying oils, according to their ability to absorb oxygen from the air and from insoluble solid compounds. Sardines and Anchovy give drying fish oils, while Carps (a common pond fish) give semi-drying oils. The fatty acids in fish and fish-liver oils are composed of glycerides of stearic and palmitic acids in varying proportions.

The drying oils contain a high proportion of glycerides of the highly unsaturated fatty acids which easily get hydrogenated to form solids. On the other hand, the semi-drying oils contain a lower proportion of the unsaturated fatty acid glycerides. It is also worth noting that liver oil contains a higher contraction of cholesteral than fish oil. These fish byproducts are of high economic value. In Kenya, potential sources of fish oil are Sardines and Anchovies which are both marine fish, while the Nile Perch and Haplochromis are the potential freshwater fish sources. Fish-oil can be made from generally any fish residues.

After fish oil has been removed through steam cooking and scrap pressing, the mixture of oil and water is made to flow through a series of containers which effect a physical separation of the oil and water. The water separated from oil is composed of fine particles of fish-scrap known as "gurry". The gurry, which contains a considerable amount of oil, is treated with dilute sulphuric acid to facilitate the separation of oil. It is cooked in steam and pressed in canvas bags to obtain an oil-acid-water mixture. The mixture is then washed with water to remove acid and the oil allowed to separate from the water. In some cases, like in the manufacture of Sardine and Merring oil (in Califonia)[1] gasoline can be used to extract oil from the pressed fish-scrap and then the gasoline recovered by evaporation and condensation.

The manufacture of liver oil is fundamentally similar to that used for fish oil. Fish-livers are cooked in steam to free the oil from fat cells. Oil which comes out is skimmed off. The cooked livers are transfered in canvas bags for pressing out oil. Alternatively, an electrolytic method for oil extraction can be used. In this case the livers are chopped, ground and treated with a warm sodium chloride (salt) solution or any other saline solution. Electrodes of opposite polarity are then used to pass an electric current. The process separates the fine liver tissues in suspension from the emulsion and also the water from the oil.

The final product will not form solid material on being left exposed to the atmosphere at low temperatures even at O°C. To solidify this crude oil must be further refined. This is easily achieved by allowing the crude oil to stand open in cold air (O°C.) until stearine, the solid component of fat, separates out. Alternatively, a chemical method is used where the oil is treated or washed with caustic soda solution which converts free fatty acids into soaps, which being soluble in water, are washed off the oil. The washed oil is then filtered and leached.

Fish and fish-liver oils are used commercially in the tanning and curing of leather. Leather tanning involves rubbing oil on prepared skin and subsequent oxidation of the oil. Washing the tanned skin in hot water or pressing it removes excess oil. Curing is the finishing process carried on tanned leather to render it pliable and water-proof. It involves stuffing the leather with oils and fats which lubricates to provide a waterproof surface. Other uses of fish and fish-liver oil are in the manufacture of oiled cloth, soap, etc. Refined shark-liver is used in medicine similar to cod-liver oil.

Fish Glue and Isinglass

The raw material for making fish glue are fish residues such as skin, scales or trimmings, heads and bones. Glue made from skin is considered superior to that made from head parts, bone and other trimming wastes.

The manufacture of fish glue from skins, heads and other fish waste is generally the same. The raw material is first washed thoroughly to remove all the salt. The freshened material is now cooked in a steam jacketed container. Acetic acid is normally added as a preservative during cooking depending on the type of raw material. Fish heads with larger proportion of bones require greater quantities of acetic acid compared to the skin or other tender trimmings. The acid also acts as catalyst and hastens the hydrolysis of the material into glue, reducing slime in the chum so that it is easily pressed and dried. The glue liquor after cooking is usually filtered out into evaporators where the liquor is concentrated to the required viscousity ready for use.

The residues left in the cookers consist of solid material with considerable proportion of glue liquor. This chum is placed in canvas bags and pressed to recover the extra glue mixed with the main bulk in evaporators. The pressed chum when dried is used as either poultry feed or fertilizer. As it has a high proportion of easily digestible protein and calcium phosphate necessary for egg devleopment, it provides good pultry feed. Fish glue is used for a variety of purposes: from labelling and stamping to use in furniture making and other general joinery work.

Fish isinglass is prepared directly from fish air-and swim bladders. In kenya, e.g., the Nile Perch, which is abundant in Lake Victoria, is a potential source of swim-bladders, a product normally wasted during cleaning of the fish for food. Catfish and Carps are the chief sources for swim-bladders used in the manufacture of isinglass. Isinglass is the carefully washed and dried fish air or swim-bladder mechanically made into the required shape. Isinglass is composed of collagen which does not dissolve but absorbs and swells in cold water. Heating Hydrolyses it into gelatin which easily dissolves. It forms a gel on cooling constituting glue of great adhesiveness. This glue is commonly used for preserving eggs by keeping out air. Isinglass was formally used in the Soviet Union and the U.S.A. in the filteration of wines and beer before modern methods of filteration were adopted. It was also sometimes used as a substitute for gelatin.

Sharkskin and Fishskin Leathers

The coastal Kenya water, being tropical, have considerable populations of sharks which are usually fished for food.(3) A number of markets and landing depots exist along the Kenya coast where they are processed, cleaned, salted and sun-dried for preservation. Normally, the shark skin is of little or no use to the local fishermen and thus it is usually disposed as a waste.

The skin, like that from land animals, can be utilised for leather of economic importance. However, unlike the latter, sharkskin has a calcereous deposit known as shagreen on the outside which has to be removed during the processing. Proper tanning and curing of the shark skin results in excellent leather which is of high commercial value.

There are other fish processing skins similar in character to that of the shark. Skates skins, for example, have a layer of shagreen requiring the same methods of tanning and curing treatments as for sharkskins. However, their potential for commercial use remains unexploited.

Fishery Shells

Oysters and other molluscs are commercially important in the world. However, the mollusc and oyster industry is still to be developed in Kenya. Apart from the principal use of the flesh of some of these animals as food, their shells which are usually discarded, can be dried, crushed and ground to form grit. Grit is used as a supplement for poultry feed due to its high content of calcium which is essential for the formation of egg shells. The shells can also be dried in a heated rotary drier or "burned" and crushed to obtain lime which is used in fertilizer manufacture. The lime is also used to counteract acidity in soil. Shells removed from fishing equipments and depots during cleaning could be put to this valuable agricultural use. Some oyster shells are very ornamental and are thus used to make pearl.

Crustacea

Lobsters, crabs, shrimps and prawns are commercially important fishery products and they have a high market value per unit. Residues consisting of the hard shells and other wastes after the flesh has been removed for food from these animals are normally discarded. However, these residues can also be utilised in fertilizer manufacture in a similar process to mollusc and oyster shells.

Commercial Importance of Seaweeds

The Kenya inter-tidal shore and the deep water region exhibit a natural abundance of seaweeds which have so far not been exploited for possible commercial use. Seaweed is the common name for marine algae, while other names like 'Kelp' are sometimes used specifically when referring to the larger brown seaweed found along the Pacific Coasts of the United States and the United Kingdom.

In a number of countries of the orient, e.g., Japan and Philippines, some algae are used for food(3).

The most significant commercial value of seaweeds relates to iodine, bromide and potash manufacturing. The seaweed burning industry is an ancient one in European countries, e.g. Britain, Germany and Sweden. The processing method involves harvesting of the seaweeds and drying in the sun. The dry seaweed is then burned in kilns to ash which is then made to cake by melting and fusion. The ash or kelp cake is the raw material used in the manufacture of iodine, bromine and potassium salts. Some disadvantages exist in the making of seaweed ash in this manner. About half the iodine is lost due to the high temperature applied in fusion. Additionally, a considerable amount of potash is vaporized.

An alternative but more expensive method of manufacturing these items from seaweeds involves distructive distillation of dried seaweed in closed retorts. This process (which was applied in Califonia)(1) prevents quantity losses in iodine and potash.

Other different methods of iodine production from seaweed are employed in countries like France and Japan. The Devillers process used in France does not involve incineration or fusion. Here the seaweeds are washed and iodine solution obtained by precipitation as cuprous iodine (CU_2I_2).

Potassium hydroxide can be used in soap making while iodine is an important commercial product in medicine. Due to its high potash and nitrogen content the dry raw seaweed, e.g. dry kelp, has been used directly as a fertilizer.

The Agar-Agar Industry

Agar or agar-agar is the dried partially bleached gelatinous extract of certain species of red algae. Agar has been of commercial importance mostly in Japan, China, Ceylon, Australia and the United States. Agar contains approximately 70% of a "vegetable jelly" generally known as gelose.

In Japan, agar is obtained from dried harvested seaweeds. The algae are washed, re-dried and then bleached by alternatively wetting and drying in the sun. The bleached seaweeds are boiled for five to six hours in about 50 times its weight of water, otherwise direct steam is used to cook the raw material. A small amount of either acetic or sulphuric acid is added during boiling. The mixture is then filtered to remove undissolved matter in order to obtain a solution which when cooled down forms a jelly. Thawed and dried agar-jelly produces pure agar.

Agar is similar to gelatin in some of its properties. It absorbs and swells in cold or lukewarm water, forming a stiff gel. It dissolves in water boiling for some time and cools to form a stiff gel.

In the orient, agar-agar has long been used as food by Japanese and Chinese, as jellies, or additives for soup, sauces and gravies. It is also used in Europe and the United States mostly in preparations of ice cream and jellies. A dilute solution of agar forms a firm gel on cooling and this can be used for packing soft tinned fish and corn beef. Some agar is used in filtering wine as well as a culture media in bacteriology.

In the case of Kenya, apart from the marine seaweeds, there exists the notorious freshwater weed Salvinia. among others, growing rampantly in Lake Naivasha. It should be possible to find ways of utilising this weed in an economic way, for example, the possibility of provision for a fertilizer.

A close relative of Salvinia also inhabiting freshwater environments is the water hyacinth (Eichhornia crassipes) found mainly in the River Congo and the Nile. The World Bank has taken a keen interest in this weed because of its implications for agriculture, fisheries, public health and energy. Under favourable conditions 10 plants with their attractive lavender flowers and swollen pear-shaped leaves can multiply to 600.000 and carpet an acre of water within eight months. The mechanics of its rapid spread are very simple. Its leaves act as sails and the plant can even travel upstream against the current. Because of this, the water hyacinth is one of the pernicious weeds in the world. It shelters disease-carrying organisms, causes floods, disrupts hydro-electricity installations and restricts fishing activities and traffic on major waterways such as the Congo and the Nile. The Sudan spends 2.5 U.S. million dollars annually on the control of this weed and a number of affected African countries is rapidly increasing; they include Egypt, Zaire, Uganda, Kenya, Congo, Burudi, Rwanda and many others.

There is a scheme leading to the developing of new technologies for the conversion of this rich plant material into bio-gas and fertilizers as a concentrated scientific effort for the control of the weed pest. Water hyacinth can be converted into bio-gas when the plant is decomposed in an oxygen-free atmosphere. The gas contains about 60% methane. It is possible to use small fermentation units to produce gas for cooking and lighting. Such equipment is now being tested in the Sudan. Large central fermentation units might also be practical but, because of the difficulties and expense of storing large volume of gas, it would probably have to be converted immediately into electricity. The residual organic matter from this process has a nitrogen content of about 1.6% dryweight and may also be useful as a fertilizer.

Another process on the water hyacinth that has been tried in the Sudan is pyrolysis, or the decomposition of the plant material as high temperatures and under airtight conditions for the production of charcoal. The first experiments have been quite promising. Sixty percent of the pyrolysis was charcoal and the other end-products included gas and oil.

Water hyacinth can also be used as fodder. In China, for example, it is grown extensively in village communes and used to feed pigs. The plant can also be used as an ideal biological filter for domestic and industrial wastes because of its ability to absorb and condense heavy metals such as lead, cadmium, mercury and nickel.

REFERENCES

1.BIRKETT, L IOP/TECH/79/26,Western Indian Ocean Fishery Resources Survey. Report on the Cruises of R/V/PROFESSOR MESAIETSEY December 1975-June 1976/July 1977-December 1977,99p.

2.JANSEN, E.G. (1973) Report to the East African Freshwater Research Organization on the Fishing Population in the Kenyan Part of Lake Victoria, 135p.

3.TRESSLER, O.K. (1940) Marine Products of Commerce New York, Reinhold Pullishing Corporation, 762p.

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p.177-190.

LA FABRICATION DE L'ALCOOL: SOUPAPE DE SURETE DE L'AGRICULTURE

Par
J.R. Tang Bonga
Ingénieur Agronome, Docteur en Sciences Alimentaires, I.R.A.,
B.P.13, Njombe, Cameround.

INTRODUCTION

La fabrication de l'alcool par des distilations date de longtemps- Tout ou grande partie de ce qu'on connaît maintenant au sujet du matériel et de l'appelation des produits de distillation a pris naissance dans les temps anciens sous des noms plus ou moins différents que ceux que nous connaissons à l'heure actuelle. Ainsi au IIIé siécle l'alambic fut créé par les Egyptiens et décrit sous le nom de "trivique" le vrai mot alambic n'apparaîtra qu'au Xé siécle dans les écrits arabes. Le nom eau-de-vie attribué à l'alcool encore appelé eau permanente ou eau d'or, voulait tout simplement dire que l'&alcool était une eau précieuse qui prolongeait la vie. La nécessité de la production de l'alcool par voie biologique sitôt ressentie par les premiers hommes n'était pas sans intérêt à leur temps et elle no l'est pas moins au nôtre.

Par alcool nous entendons alcool éthylique ou éthanol dont la formule est C_2H_5OH.

Nous orienterons notre exposé suivant les deux aspects qui sont proposés dans le sujet.

D'abord nous parlerons de la fabrication de l'alcool-Au cours de ce développement, nous présenterons la biochimie de la fermentation alcoolique et le procédé de distillation aprés avoir signalé rapidement d'autres procédés d'obtention d'alcool. Ensuite nous expliquerons ce que nous entendons par: "Soupape de sûreté de l'agriculture en dégageant l'importance de l'alcool".

AUTRES ORIGINES DE L'ALCOOL

Nous ne sommes pas sans savoir que signaler simplement que la fabrication de l'alcool est une soupape de sûreté de l'agriculture sans autre explications risquerait de laisser une bonne partie de l'auditoire en suspens. Ce suspense étant bien justifié par le fait qu'il existe des procédés de fabrication de l'alcool qui n"empruntent pas la voie de l'Agriculture. Cette variante de production de l'alcool est dite synthétique, par opposition au procédé biologique ou biochimique signalé ci-dessus et dont nous parlerons plus bas.

L'alccol synthétique peut être obtenu à partir des carbures suivant trois possibilités:

- Synthése à partir des carbures saturés.
- Synthése à partir des carbures insaturés.

La fabrication de l'alcool xsynthétique n'est pas sans soulever des problémes. Les matiéres de base de la synthése à savoir les carbures, saturés ou insaturés ne sont pas à proprement parler des matiéres premiéres dans le vrai sens du mot, mais elles proviennent du traitement des autres produits. Ainsi la chaîne de la production de l'alcool par synthése s'avére s'avére trés longue. Pour arriver à des résultats souhaités, il faut disposer de la houikile du pétrole qui sont les deux plus grandes sources des matiéres premiéres pour l'industrie chimique organique, puis des installations appropriées.

A l'opposé de cette richesse difficilement offerte à tous les pays se trouve l'agriculture qui constitue le premier trésor pour la plupart des pays en voie de développement sinon la totalité.

PRODUCTION DE L'ALCOOL PAR FERMENTATION

Lr riche trésor qui nous est gratuitement offert par la nature et qui est constitué par les matiéres premiéres produites en agriculture comparend:

Les matiéres sucrées contenant des sucres fermentescibles (glucose, fructose, maltose...) ou aboutissant par hydrolyse à des sucres fermentescibles. Ce sont les fruits, certaines racines (betterave à sucre...) les tiges (canne à sucre, sorgho, mais...), la mélasse de canne à sucre, le miel, le lait par exemple.

Les matiéres amylacées, contenant de l'amidon, qui, sous l'action des solutions acides ou des diastases, peut être hydrolysé et transformé en blucose et maltose. Ce sont les céréales, les tubercules (la pomme de terre, le manioc).

Les matiéres cellulosiques, contenant des celluloses qui par hydrolise, conduisent également à la formation du glucose. Ce sont surtout: le bois; les tiges annuelles et les résidus végétaux.

Dans ce procédé de fabrication de l'alcool non synthétique on s'appuie sur les produits agricoles qui sont soumis à l'action des microorganismes et notamment des levures. Ainsi l'obtention de l'alcool nécessite une étape intermédiaire qui est appelée la fermentation alcoolique pour la distinguer des autres types de fermentations aboutissant à des produits autres que l'éthanol. L'extraction de l'alcool formé au cours de la fermentation alcoolique fera appel à la distillation.

La fermentation alcoolique:

La matiére premiére peut entrer en fermentation sous forme liquide, pulpeuse ou mélange liquide-solide par exemple. Sans entrer dans les détails particuliers à chaque classe de matiére premiére concernant la saccharification de l'amidon ou de la cellulose, nous ne considererons ici que la tranformation du sucre fermentescible en alcool.

La transformation du moût ou liquid sucré, en vin ou liquide alcoolique, se produit par le phénoméne biologique connu sous le nom de fermentation alcoolique. Ainsi les sucres du moût sont transformés en alcool et en gaz carbonique, sous l'action de certains produits élaborés par les levures qui se sont multipliées dans le milieu. Ces produits sont appelés les enzymes. Au cours de ce processus on constate:

- dun bouillonnement,
- une augmentation de la température au sein de la masse qui fermente,
- un changèment de saveur du liquide mis en fermentation,
- une diminution de sa densité, qui s'approche de celle de l'eau, puis lui devient inférieure.
- une augmentation de sa couleur pour les jus mis en fermentation avec les particules solides.

La fermentation alcoolique est un phénoméne aéro-anaérobie c'est-à-dire que l'oxygéne de l'air nécessaire seulement au démarrage du processus pour permettre l'accroissement et la multiplication des levures, doit être supprimé par la suite pour permettre la bonne réalisation de la fermentation, faute de quoi s'installe l'effet pasteur et par conséquent le but ne sera pas atteint.

D'une façcon générale la formation de l'alcool au cours de la fermentation alcoolique passe par deux étapes qui sont:

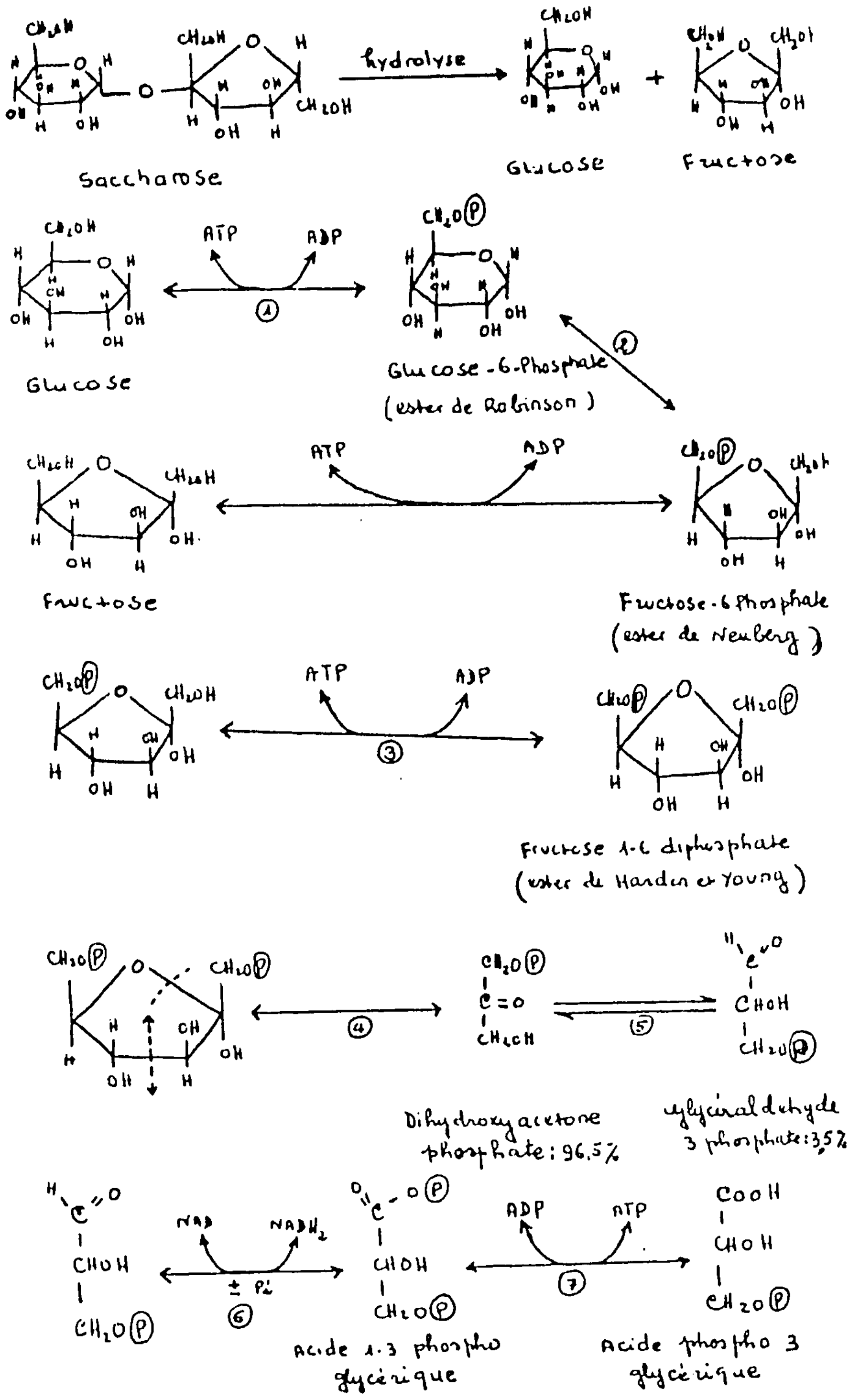
- la glycolyse qui aboutit à la formation de l'acide pyruvique.
- la transformation anaérobie de l'acide pyruvique.

Chacune des réactions de transformation au cours de la glycolyse et de la transformation de l'acide pyruvique est sous le contrôle d'un enzyme.

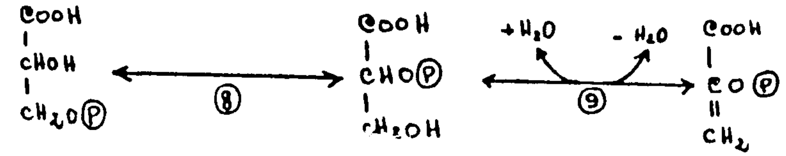
L'équation globale de la fermentation alcoolique d'aprés Gay-Lussac s'écrit:

$$C_6H_{12}O_6 \longrightarrow 2\ CH_3CH_2OH + 2\ CO_2$$

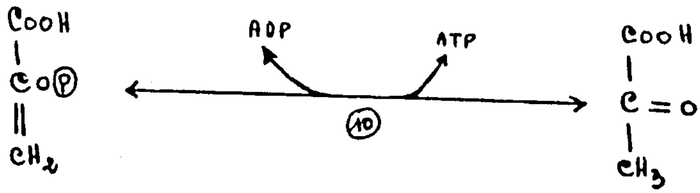
La Glycolyse: est le tronc commun de la dégradation du sucre en C_6, glycose ou fructose, tant en aérobiose (respiration) qu'en anaérobiose (fermentation alcoolique et fermentation lactique) en acide pyruvique. Elle se résume sous forme d'équations ci-dessous:



hydrolyse
Saccharose
Glucose
Fructose
ATP
ADP
Glucose
Glucose-6-Phosphate
(ester de Robinson)
Fructose
Fructose-6-Phosphate
(ester de Neuberg)
Fructose 1-6 diphosphate
(ester de Harden et Young)
Dihydroxyacetone phosphate : 96,5 %
Glycéraldehyde 3 phosphate : 3,5 %
NAD
NADH2
± Pi
Acide 1.3 phospho glycérique
Acide phospho 3 glycérique



Acide phospho 3 glycérique — Acide phospho 2 glycérique — Acide phospho enol pyruvique.

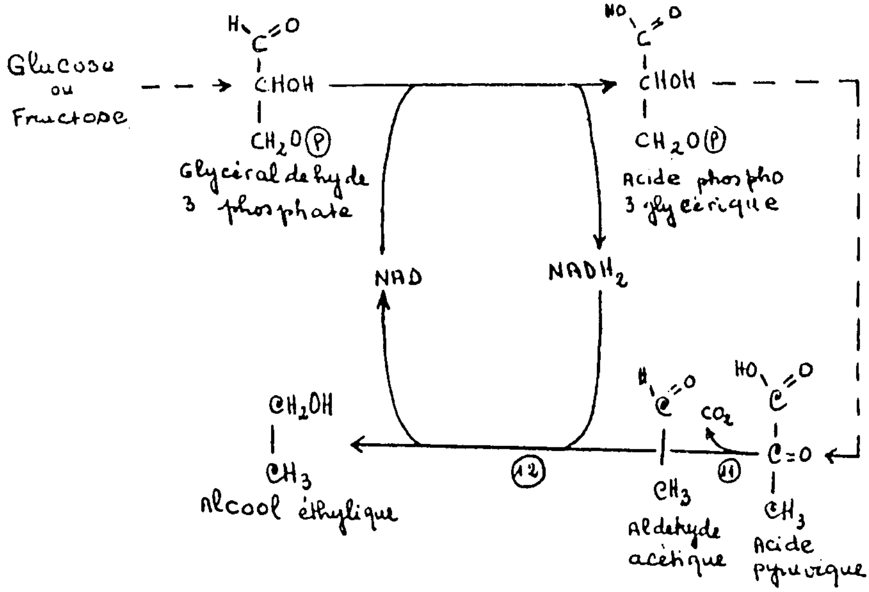


Acide phospho enol pyruvique — Acide pyruvique

Les différents enzymes intervenant au cours de ces réactions et numérotés de ① à ⑩ sont les suivants :

① gluco-kinase
② Phospho-hexose isomérase
③ Fructose 6 P kinase
④ Aldolase
⑤ Triose-P-isomérase
⑥ Triose-P-déshydrogenase
⑦ Transphosphorylase (3 glycérate-kinase)
⑧ Phospho-glycero-mutase
⑨ Enolase
⑩ Pyruvate kinase

Glycolyse



(11) Décarboxylase

(12) Alcool déshydrogenase

L'alcool ainsi formé au cours de la fermentation alcoolique est extrait du milieu par distillation.

Fermentation alcoolique

La transformation anaérobie de l'acide pyruvique: Alors que l'acide est oxdé en aérobiose par l'intermédiaire des réactions du cycle de Krebs selon l'équation:

$$CH_3\text{-}CO\text{-}COOH + \frac{5}{2}\ O_2 \longrightarrow 3CO_2 + 2H_2O$$

Il ne l'est pas en anaérobiose et sert plutôt d'accepteur d'hydrogéne (électron) qui apparaît au cours de la glycolyse sous forme de $NAD/\!/H_2$. Il est ensuite décarboxylé en éthranal ou aldehyde acétique ou acétaldéhyde-L'aldéhyde acétique est à son tour réduit en alcool éthylique. Cette réaction se fait sous forme réduite NAD. C'est à ce niveau que la réoxydation de $NADH_2$ est nécessaire, faute de quoi la glycolyse s'arrêterait dés que tout le NAD présent dans la cellule aurait été réduit. Ci-aprés le schémas de la fermentation alcoolique.

La distillation de l'alcool.

La distillation est l'opération qui consiste à extraire vins fermentés, tout l'alcool contenu dans le liquide en même temps que tous les prodùits volatils.

La distillation peut être réalisée soit dans un alambic, soit dans une colonne. L'alambic est constitué d'une chaudiére où le produit fermenté est mis en ébullition et d'un réfrigérant où les vapeurs sont condensées au cours de leur passage pour être récoltées sous forme liquide dans un récipient. Cet appareil est utilisé pour la production des eaux-de-vie et pour les petites installations industrielles. Quant à la colonne qui est appliquée aujourd'hui dans l'industrie, la vapeur s'éléve et traverse successivement les plateaux dans lesquels elle est mise en contact avec le liquide qui, de ce fait, s'épuise alors que la vapeur s'enrichit en alcool.

La différence fondamentale entre les alcools de bouche et les alcools industriels se situe au niveau de leur origine, leur composition et leur titre alcoométrique.

- L'origine des alcools. Les alcools de bouche sont produits à partir des vins, cidres et fruits alors que les alcools industriels sont produits par les matiéres amylacées, les betteraves et les melasses.

- La composition des alcools et leur titre alcoométrique.

Quant à la composition, les alcools de bouche doivent nécessairement contenir un peu d'impuretés. Ces derniéres ayant pour rôle de contribuer à l'arôme de la boisson. Par contre les alcools industriels doivent être débarrassés de toutes impuretés; cet aboutissement nécessite l'opération qui s'appelle la rectification. Un exemple à ce sujet: Pour mériter l'appelation d'eau-de-vie l'alcool doit contenir au moins 280 g. d'impuretés par hectolitre de pur.

Ces impuretés, représentés par un peu de "têtes" et un peu de "queue" sont constituées par les acides organiques et minéraux, les aldéhyles, les esters, les alcools supérieurs, les bases (ammoniac et amines) sous forme de combinaison avec les acides.

Due point de vue titre alcoométrique ou degré alcoolique, les alcools de bouche titrent "43° alors que les alcools industriels titrent plus: 90-95°.

Au cours de la distillation des alcools de bouche on distingue deux phases:

La premiére phase ou chauffe de vin permet de récupérer un liquide ne méritant pas le nom d'alcool et qui est appelé "brouillis" dans le cas de la fabrication du Cognac. Ce brouillis qui titre environ 30° est séparé des "tfes" et des "queues" qui représentent respectivement les premiéres et les derniéres fractions du liquide.

C'est au cours de la deuxiéme phase applée bonne chauffe ou chauffe des brouillis, que les brouillis mis en chaudiére et portés à "bullition donnent naissance à de l'alcool qui évoluera au cours du vieillissement pour devenir la boisson voulue. Cet alcool appeelé "Coeur" titre environ environ 70°. Tout comme dans la chauffe du vin, ici aussi, on sépare le "coeur" des "têtes" qui passent avant et des "secondes" qui passent aprés.

Pourtant du fait que la distillation ne se fait pas d'aprés les tensions de vapeur, mais en fonction de celles qui résultent de la solubilité réciproque de divers produits, on comprend pourquoi il est difficle d'obtenir les eaux-de-vie constituées uniquement de "Coeur".

Tout comme la distillation, la rectification peut être réalisée en discontinu ou en continu dans de colonnês à haut degré.

SOUPAPE DE SURETE DE L'AGRICULTURE

Nous venons de voir plus haut:

- Que pour la fabrication de l'alcool, un riche trésor nous est gratuitement offert par la nature.

- Que ce trésor est constitué par les produits agricoles qui peuvent être:
  1. Des matiéres sucrées.
  2. des matiéres amylacées
  3. des matiéres cellulosiques.

Si à certains mements les produits sont utilisés en distillerie de façon voulue, en général, leur utilisation dans ce domaine comme excédents ou comme écarts de triage ou déchets est le plus à retenir.

La théorie selon laquelle la babrication de l'alcool est une soupape de sureté de l'agriculture a été vérifiée dans le passé; elle l'est aujourd'hui et le sera probablement dans l'avenir.Elle a été, elle est et elle sera la solution de liquidation des excédents. Ce sont les cas par exemple:

- des betteraves et céréales notamment le blé en France
- de la carne à sucre au brésil et autres pays tropicaux
- des pommes de terre en Allemagne
- du mais en Amérique
- etc.

Cette situation devrait d'autant plus prendre de l'importance à l'heure actuelle que les gens sont à la recherche de solution à la crise de l'énergie qui est une conséquence directe de la crise du pétrole.

La fabrication de l'alcool dans son qualificatif soupape de sûreté de l'agriculture, peut être vue sous plusierus angles:

- d'abord comme technologie appropriée à la tranformation de produits agricoles glucidiques.
- ensuite comme valorisation des déchets ou sous-produits agricoles,
- puis comme liquidation des excédents;
- enfin comme solutions à des problémes tels que les problémes de l'énergie ou du carburant.

En prenant un exemple portant sur la valorisation des déchets ou encore l'écarts de triage, probléme qui rejoint en derniére analyse la liquidation des excédents, nous nous rendons immédiatement compte du rôle de la fabrication de l'alcool. Quelques chiffres relevés sur la banane et l'ananas du Cameroun sont encore plus explicites à ce sujet.

Quelques données recueillies auprés du Centre des Cultures Vivriéres et Fruitiérs de NJOMBE, de l'Institut de la Recherche Agronomique (IRA), et de l'Organisation Camerounaise de la Banane (OCB) sont groupées ci-dessous:

a) **I.A.R.**

1. Ananas:

- Production moyenne annuelle: 300 Tonnes.
- Ecarts de triage correspondant à un an (2° Semestre 1979-1er Semestre 1980): 36,643 Tonnes.
- Rapport $\frac{\text{écarts de triage:}}{\text{Production totale}}$ $\frac{1}{8}$
- Poids du jus attendu à raison de 50% de rendement: 18,322 Tonnes.
- Soit en litres avec une masse volumique de 1,04 ug/ml

17.617 litres disponibles pour la fermentation et par conséquent à la production de l'alcool.

2. Banane:

Bonnées types de la récolte de bananes à l'hectare au cours de premier cycle en 1979.

- Rendement à l'hectare: 48,504 Tonnes
- Poids moyen du régime: 25,4 Kg.
- Poids total exporté: 35,542 Tonnes
- Poids non exporté: 6,080 Tonnes
- Poids de hampes: 2,693 Tonnes
- Poids moyen de la hampe: 2 Kg.
- Poids total non exporté: 8,046
- Rapport $\frac{\text{écarts de triage}}{\text{Production}}$: $\frac{1}{6}$

Le poids total non exporté est égal à la some de 6.080 tonnes plus le poids des régimes refusés, auquel on soustrait le poids correspondant des hampes. Ces écarts peuvent servir dans la production de l'alcool.

B) O.C.B.

Données relatives à la récolte annuelles de la banane pour l'ensemble de l'OCB entre Avril 1979 et Mars 1980.

- Récolte totale: 1.921.005 régimes
- Refus = 384.201 régimes
- Poids de refus à 25 kg 9.605.025 Kg
- Rapport $\frac{\text{écarts de triage}}{\text{Production}} = \frac{1}{5}$
- la qualité de jus correspondant, avec 72% de rendement:6.915.018Kg de jus.
- Soit en litre de la masse volumique étant 1,08 g/ml = 0.403.331,5 l.
- Pour un extrait sec de 20% on s'attendrait à = 192 g/l de sucre.
- Tenant compte du fait que la formation de 1° d'alcool nécessite en moyenne la dégradation de 17 grammes de sucre par la levure, on est en droit d'attendre, à partir de ce cas précis, des vins de = 11°3.
- Ainsi la fabrication de 1 l. d'alcool à 90° qu'on aimerait avoir, tenant compte de 1% de perte au cours des manipulations nécessite 8,05 l l de vin à 11°3.
- Le nombre de litres d'alcool à 90° à extraire de 6.403.331,5 l est donc = 795,407,7 l.

Il est à noter que si nous avons raisonné ici en jus il ne faut pas croire que c'est la seule possiblité de réaliser la fermentation. Ces produits peuvent être fermentés sous forme de mélange jus et particules solides, comme il a été déjà signalé plus haut.

En considérant les exemples mentionnés ci-dessus, nous notons pour l'ananas et la banane que les rapports $\frac{\text{écarts de triage}}{\text{Production totale}}$ sont respectivement $\frac{1}{8}$, $\frac{1}{6}$, $\frac{1}{5}$ - Ces écarts qui ne sont pas négligeables méritent d'attirer notre attention et nous devons chercher à les utiliser à des fils utiles, d'autant plus que ces produits disposent d'un bon potentiel alcoolique. La fabrication de l'alcool à partir de ces sous-produits est un débouché louable.

Nous constatons que par le canal de la fabrication de l'aclool, nous tendons à utiliser nos produits à 100% alors que l'utilisation des fruits en frais telle l'exportation ne résorberait qu'un pourcentage moins important. Cela est d'autant plus vrai qu'on sait que les écarts de triage représentent prés de 20% de la production bananiére nationale.

Quelques essais entamés au laboratoire de la Section Technologie Alimentaire IRA NJOMBE sur la production de l'alcool à partir de ces mêmes fruits nous permettent d'être optimistes. Cette confiance nous est donnée par l'importance de l'extrait de ces fruits, traduisant ainsi leur teneur en sucre ? Ainsi l'extrait sec de l'anannas peut atteindre 17% en saison séche alors que la banane atteint 22%. Autrement dit en tenant compte que 17 g. de sucre fermentescible sont nécessaires dans la formation d'' un degré d'alcool (1°), on peut s'attendre à unevin de 9° à 10° pour l'ananas dans les périodes les plus favorables et de 12° à 13° pour la banane.

D'une façon générale nous savons qu'en tenant compte de 1% de perte au cours des manipulations X litres de vin à 9° donent $\frac{8,91}{90}$ x l. d'alcool à 90°.

Ces essais de fermentation et de distillation déjà réalisés avec les jus d'ananas et de banane nous ont permis d'obtenir des alcools pouvant avoir un titre alcoométrique jusqu'à 90°. Il ne nous reste plus qu'à améliorer le rendement qui reste encore faible faute de matériel adéquat de fermentation et de distillation.

Nous pensons que l'amélioration du matériel entreprise par nos responsables nous permettra d'améliorer nos résultats.

POURQUOI FABRIQUER DE L'ALCOOL

Nous l'avons déjà que l'aclool obtenu à l'issue des processus de fermentation et de distillation peut être utile à les fins multiples, que ce soit dans le domaine menager, ou comme carburant, aliment, boisson ou stimulant:

- l'alcool à l'éclairage est un remplacant satisfaisant du courant électrique,
- le chauffage à l'alcool évite les dangers d'explosion des réchauds à essence et l'inconvénient de la carbone des hydrocarbures,
- l'alcool solidifié est utilisé comme combustible; il est obtenu:

. soit par fusion des savons dans l'alcool à une température voisine de l'ébullition suivie d'un refroidissement qui détermine une prise en masse.

. soit par dissolution d'acide gras dans l'alcool suivie d'une addition de soude provoquant la saponification, donc la formation de savon.

- l'alcool est également utilisé comme carburant. A ce niveau d'importants travaux avaient été effectués par des nombreux savantes pour démontrer l'importance de l'alcool comme carburant des moteurs à explosion, l'importance de l'utilisation de l'alcool comme carburant, mise en évidence avant la guerre dans de nombreux pays tels que la France, l'Italie, la Tchécoslovaquie, la Hongrie, l'Allemagne, l'URSS, la Yougoslavie, la Suède, la Pologne, les Philippines, la Chine, l'Inde, le Brésil, l'Argentine... etc étudiée même dans les pays pétroliers comme les Etats-Unis d'Amérique, tient également à l'heure actuelle une place de choix pour résoudre la crise de l'énergie.

enfin l'alcool est utilisé par l'homme comme aliment, boisson ou stimulant.

Vu tous les aspects ci-dessus mentionnés, il n''est d'aucun doute que l'écool rend des services trés importants dans la vie de l'homme. Son rôle se ressent à presque tous les niveaux:

- niveau alimentaire: comme aliment ou boisson,
- niveau soical: comme source de lumiére (éclairage) et de chaleur (chauffage et combustible) et comme carburant,
- niveau économique: partout où il y a des dxséexéédents de récolte l'alcool carburant peut venir au sécours de l'économie agricole et de l'économie générale.

Nous ne sommes pas sans savoir, chacun en ce qui nous concerne dans nos pays respectifs, combien de devises sortent pour l'achat de l'alcool de bouche et tous autres alcools à toutes fins: nous connaissons également le prix que nous exûte le carburant pétrolier. La production locale de notre propre alcool à partier de nos produits agricoles nous permettrait de faire une économie partielle de nos devises. Un aspect qui se rattache égalemment à cette fabrication locale de l'aclool est l'extension de la culture des produits de base intéressés et par conséquent de l'agriculture toutes entiére.

Un autre point qui compléte le précédent dans cet essor économique est la création sur place des distilleries. Une telle réalisation permettrait de résoudre d'autres situations; ce sont par exemple:

- la diminution des chômeurs par leur recrutement dans lesdites distilleries,
- la rentrée de devises étrangéres par le développement de l'exportation de l'alcool produit.

Ainsi, compte tenu de son importance, l'alcool, au lieu d'être siplement considéré comme toxique en tant que boisson, doit être vu comme un des facteurs de l'essor économique.

CONCLUSION

Pour clôre cette étude, il conivient de signaler toutefois que la fabrication de l'alcool ne constitue pas à elle seule l'unique phase d'utilisation des sous-produits de l'agriculture. On peut citer d'autres possibilités d'utilisation de ces sous-produits; exemple:

- l'extraction de colorant à partir des marcs de raisins,
- l'extraction de l'huile de pépins: raisins et grenadille,
- l'alimentation du bétail: melasses de cannes à sucre, tourteaux d'arachides et de cotons etc,
- l'alimentation des chaudiéres: bagasse de canne à sucre,
- la fumure organique residus solides de vinaigrerie, marcs, autres déchets agricoles.

Par ce fait même l'agriculture doit être considérée comme une source inépuisable de richesses.

Nous venons de voir à travers ce qui vient d'être dit l'importance et le rôle de l'alcool vis-à-vis l'homme ent tant qu'individu et vis-à-vis de la Société quant à son évolution économique.

Cet essor économique qui n'est rien d'autre qu'une conséquence de l'existence de l'agriculture se trouve être également une bonne occasion pour résorber les excédents ou les déchets de cette agriculture.

Notre économie étant basée sur l'agriculture, nous pays Africains, devons profiter de cette occasion pour tirer le maximum de bénéfice de l'apport de cette agriculture en générale et à travers ses sous-produits en particulier. Un des aspects les plus rassurants de ce bénéfice est la fabrication de l'alcool.

Ainsi la fabrication de l'alcool qualifiée de "Soupape de sûreté de l'agriculture" mérite bien cet attribut et bien au delà, elle est même un gage à l'économie du pays.

BIBLIOGRAPHIE

Guymon, J.F. (1974). Chemical aspects of distilling wines into brandy (In "Chemistry of wine making" American Chemical Society).

I.R.A. Centre de Njombe 1980.
O.C.B. Cameroun 1980.

Lafon, J., P. Gouillaud, et F. Gaybellile (1973). Le Congnac. Sa Distillation (Edition J.B. Baillére Paris).

Mariller, C. (1951) Distillerie Agricole et Industrielle (Baillére, Paris).

Navarro, J.M. et G. Goma (1976). Fermentation théorie et applications à la préparation des boissons fermentées (Apria, Paris).

Strehaino, P., M. Moreno, et G. Goma (1978). Fermentation alcollique: influence de la Concentration en glucose sur le taux de production d'éthanol et le taux de Croissance (C.R. Acad. Sc. Paris 286).

Tang Bonga, J.R. (1979). Etude de l'influence de mode de conduite en continu sur la production de quelques sous-produits volatils de la fermentation alcoolique des jus de raisin. (Thése de Doctorat 3é Cycle, Université des Sciences et Techniques du Languedoc-U.S.T.L.- Montpellier).

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-21 Nov. 1980, Douala, Cameroun, p.191-204.

LES SOUS PRODUITS AGRO-INDUSTRIELS AU SENEGAL "APERCU SUR LES TRAVAUX DE L'INSTITUT SENGALAIS DE RECHERCHES AGRICOLES"

Par

Nadiaga Mbaye

Isra, Laboratoire National d'Elévage et de Recherches Veterinaires, Senegal.

INTRODUCTION

Les sous produits agro-industriels ont fait l'objet de nombreuses études aù Sénégal: déjà, en 1955. Letard et Al faisaient une revue des sous produits industriels utilisés en alimentation animale.

Depuis le Laboratoire Nationale de l'Elevage et de Recherches Vétérinaires de Hann et le Centre de Recherches Agronomique de Bambey ont intensifié les recherches sur les sous produits afin de préciser leur valeur nutritive et leur efficacité en alimentation animale.

Nous allons dans une premiére partie une revue des SOUS PRODUITS disponibles au Sénégal d'une part et d'autre part donner un aperçu sur les travaux effectués et les résultats obtenus.

LES SOUS PRODUITS DISPONIBLES

On distingue généralement les sous produits résultant des activités agricoles et ceux issus d'activités de transformation de produits végétaux ou animaux.

Les sous produits resultant des activités agricoles:

Ce groupe est constitué par les pailles: paille de céréales (riz, mil, sorgho, maîs) et pailles de légumineuses ou fane (arachide et nébé).

Tableau 1.

Produits	Disponibles Theoriques Actuels (x 1000 T)	Disponibles Horizon 1981-1982 (x 1000 T)
Riz	144	365,1
Mil		
Sorgho	3189	4874
Maîs	84	296
Fanes Arachides	1502	1899,1
Niebe	108	138,0
Total	4977	8772,0

Source: Mongadin et Tacher 1979.

Malgré ces tonnages importantes, les pailles sont encore peu utilisées. Hormis la fane d'Arachide qui est de plus en plus récoltée et stockée, les autres produits sont laissés sur pied ou quand ils sont récoltés ne font l'objet daucun soin d'où des pertes considérables de matiéres nutritives.

A ce premiére groupe on peut ajoindre des produits moins importants en volume; il s'agit: des ralles et cime de maîs, les talles de sorgho et de mil, les extrémités feuillues et vertes de la canne à sucre et les "bouts blancs".

Les sous produits industriels:!

Ce groupe de produits est sans conteste le plus important de part la diversité des substances disponibles et de leur valeur nutritive. On retrouve ansi des sous produits:

- de meuneries: son, remoulages et farines
- d'huileries: tourtaux, coques d'Arachide, graine de coton
- de rizerie: son, farine de cône et brisures
- de sucrerie: mélasse et bagasses.

Tableau 2:

Produits	Disponibles Theoriques Actuels (x 1000 T)	Disponibles Theorique Horizon 1981-1982(x1000T)
MEUNERIES:		
Grosson de blé	9,9	5,5
Son fin de blé	13,1	8,8
Remoulages	-	8,8
Son de mil	-	2,5
HUILERIES:		
Tourteaux d'arachide	339	356
Tourteaux de coton	8,7	14,2
Graine de coton	19,8	35,0
Coque d'arachide	53,2	52,2
Coque de coton	8	12,6
RIZERIE:		
Son de riz	1,2	1,4
Farine de cônes		4,6
BRASSERIES:		
Drêches	0,65	0,9
SUCRERIE:		
Mélasse	11,5	29
Bagasses	25,8	

Les sous produits d'origine animale:

Les sous produits des abattoirs et des ateliers d'écarissage ne sont pas encore exploités au Sénégal.

Il faut simplement signaler le démarrage par la SERAS d'une petite unité de production de poudre d'os, par contre, l'industrie des sous produits de la pêche est en plein essort et le principal sous produit est représenté par les farines de poissons.

Monogodin et Tacher (1979) rapportent que la production actuelle est de l'ordre de 14 900 tonnes réparties entre les trois usines

- AFRICAZOTE 6000 T
- SOPESINE 7700 T
- SENPROTEINE 1200 T

Si les projets de Mbour et Nikine sont réalisés, la production pourrait passer à 38000 tonnes à l'horizon de 1982-83.

Cet aperçu sur les produits disponibles au Sénégal pourrait à première vue faire entrevior un avenir prometteur à l'intensification de l'élevage s'il n'existait pas de problémes liés à la commercialisation et aux prix..

Ceci faisait d'ailleurs dire à MM I.S GUEYE et A. L. NDIAYE lors des journées médicales de Dakar (15,20 Février 1979), que trois mesures paraissent importantes.

2. Créer une structure chargée de la commercialisation des produits agricoles et sous produits agro-industriels pour enrayer l'anarchie dans ce secteur.

2. Mettre à la disposition de l'élevage local par le biais de cette structure des quotas suffisants d'aliments destinés au bétail.

3. Pratiquer une politique des prix aussi bien des aliments que des produits finis en tenant compte évidemment du pouvoir d'achat des masses locales premiéres destinataires des produits de l'élevage de leur pays.

Nous ajouterons que compte tenu des aléas climatiques, il est urgent d'organier la récolte et le stockage des pailles et fanes, que les ruminants sont capables de valoriser.

La deuxiéme partie de l'exposé rendra d'ailleurs compte des possibilités réelles d'utilisation de ces sous produits.

APERCUS SUR LES RESULTATS OBTENUS PAR LA RECHERCHE AGRICOLE

L'étude des sous produits agro-industriels a été abordée au Sénégal sous trois aspects:

- Etude de la digestibilité et de la valeur alimentaire
- Essais d'Amélioration de la valeur nutritive des pailles par des méthodes physiques, chimiques ou biologiques

- Essais alimentaires: Embouche bovine, ovine.

MATERIEL ET METHODES

Les sous produits étudiés:

Tous les sous produits cités dans la première partie ont fait l'objet d'expérimentations au Laboratoire Nationale d'Elevage de Hann et au Centre de Recherches Agronomique de Bambey comme en témoigne la bibliographie qui figure en annexe.

Les animaux:

a) Pour les études de digestibilité et de valeur alimentaire, les animaux sont généralement des moutons agés de 1 à 2 ans de race peulh-peulh et d'un poids moyen de 25 kg.

b) Pour les essais alimentaires. Sur bovins PUGLIESE et H. CALVET (1973), ont fait la synthése des résultats obtenus en embouche intensive au Sénégal et dégagé en ce qui concerne les performances techniques et économiques ce qui revient à l'espéce, à la race, à l'âge et au sexe.

Sur OVINS; HO DIALLO et AI (1976) ont dans un rapport fait la synthése des résultats obtenus.

En résumé, les différentes races rencontrées au Sénégal ont retenu l'attention des chercheurs ZEBU-GOBRA (ZEBU PEULH SENEGALAIS), maure, le métis Djakoré (zébuandama) le taurin ndama, le mouton peulh-peulh, le toubabire et le WARALE (métis peulh-peulh X toubabire).

Les methods:

a) Digestibilités et valeurs alimentaires. Digestibilité "IN VIVO"; il s'agit de mesurer correctement le coefficient d'utilisation digestive de la matiére séche (DIG MS) les autres coefficients étant obtenus par analyses des échantillons représentatifs de la matiére séche offerte (M S O), refusée (M S R) excrétée (M S F).

$$DIG\ ms = \frac{(MSO - MSR) - MSF\ S}{(MSO - MSR)} \times 100$$

MSO - MSR = L'ingérée.

L'analyse des échantillons consiste en la détermination par des méthodes chimiques de la teneur des aliments en matiére séche, matiére organique, matiére minérale, matiére cellulose, azotée totale extractif non azoté, matiére grasse, calcium, phosphone et oligoéléments.

La valeur fourragére étant déterminée par la formule:

$$\text{Valeur fourragére (V.F)} = \frac{MAD + MCD + ENAD + (MGD \times 2,25)3,65MS}{1883}$$

Digestibilité "IN VITRO"

La méthode est celle en deux temps de Tilley et Terry

b) **Essais alimentaire.** Il s'agit d'alimenter des animaux par des rations composées, et de mesurer leur comportement: évolution pondérale, croit quotidien moyen, indice de consommation et évaluation économiqe.

b) **Amélioration de la valeur alimentaire des FOURRAGES GROSSIERS:**

Méthodes Chimiques. Jusqu'à présent, seul le traitement à la soude a été tentée. On envisage dans les programmes futures des traitements al'ammoniac.

Méthodes Physiques: Fragmentation, broyage, pellétisation.

Méthodes Biologiques: Préfermentation ou utilisation de cellulases.

RESULTATS

Les travaux éffectués ont fait l'objet de nombreuses publication aussi nous ne donnerons ici que quelques résultats acquis ces derniéres années.

Valeur bromatologique et fourmagere des sous produits:

Tableau No. 3:	Pailles et Fanes
Tableau No. 4:	Tourteaux d'Arachide et Coton.
Tableau No. 5:	Graine de Coton, coque d'Arachideet coque de Graine de Coton Melasse et Farine de Poissons
Tableau No. 6:	Son de blé, Farine de Cône.

Tableau No. 3: Pailles et Fane.

	Fane d'Arachide	Pailled de Riz	Paille de Maïs	Paille de Sorgho	Paille de Mil
MS	870,7	977,8	959	774	850
MM	99,2	186,0	43	90	74
MO	900,7	814	957	910	926
MA	107,1	64,3	38	39	56
MG	15,8	14,6	8	16	27
MC	341,8	321,4	386	403	414
ENA	441,8	415,3	525	452	429
Ca	9,2	2,4	2	4,8	1,6
P	1,2	1,8	1,2	1,0	2,3
VF/kg ms	0,55	0,40	0,27	0,30	0,36
MAD/kg ms	64,9	26	14	0	19

Tableau No. 4: Tourteaux d'arachide et de coton.

	Tourteau Arachide expeller/Dakar	Rourteau extraction Solvants/Dakar	Tourteau Arachide Artisanala	Tourteau Coton expeller de graine entiere	Tourteau Coton expeller de graine délintée	Tourteau Coton pression graine décortiquer
MS	918,1	918,8	932,5	923,5	932,5	943,0
MM	41,8	45,8	37,6	57,7	65,5	80,9
MO	958,2	954,2	962,4	942,5	934,5	919,9
MG	46,1	8,0	232,0	118,7	97,3	178,7
MA	497,8	524,1	444,5	192,8	382,3	422,0
MC	91,0	73,5	50	306,2	110	31,0
ENA	323,3	348,6	235,9			
Ca	0,92	1,08	0,06	1,5	2,06	2,14
P	5,34	5,94	4,52	12,67	10,55	15,4
UF/kg ms	1,01	0,94	1,53		1,3	
MAD/kg ms	448	471,7	40		350	

Tableau No. 5: Graine de Coton-Coque d'Arachide et de Coton.

	Graine de coton Coton SODEC Sénégal	Coque d'Arachide	Coque de Graine de Coton	Melasse Richard-Toll 1978/1979	Graine de poisson (1976)
MS	866	924,0	932,5	811	943,6
MM	94	19	16,3	13,9	251,2
MO	906	981	983,7	986,1	748,8
MG	154	22	56,5		111,3
MA	206	6	70		652,0
MC	330	764	488,7		
ENA	207	225	301	647	
Ca		2	1,25	8,7	71,7
P		0,4	1,42	0,3	
VF/kg ms	1,17	0,08	0,3	1,0	0,55-0,70
MAD/kg ms	100	14	4	9	5550-460

	Gros son de blé G..D. de Dakar	Son de fin de blé G.M.D.	Remoulage de blé	Son de maïs	Farine de ônê
MS	882	870	886	865	897
MM	70	61	51	53	99
MO	930	939	949	947	901
MA	155	180	197	131	137
MG	38	36	48	101	173
MC	143	109	83	98	78
MNA	594	614	621	617	513
Ca	1,5	1,5	1,3	0,4	1,6
P	14,4	12,4	10,7	9	17,4
VF/kg ms	6,8	0,88	0,99	1,02	0,85
MAD/kg ms	118	140	162	86	89

Tableau 7: Quelques resultats d'embouche. Embouche bovine:

	Ration	Duree	Croit moyen journalier	Indice
1969	Coque d'arachide mélassée . Concentré farine sorgho (essai 1)	122 j	1.080	6,2
	. Concentré riz farine (essai 2)	122 j	585	10,3
1970	Coque d'arachide mélassée . Concentré farine de riz (essai 3)	147 j	850	7,3
	Paille de riz . Concentré farine de riz (essai 4)	126 j	672	9,1
1971	Lot 1: paille + concentré farine riz	111 j	698	8,6
	Lot 3: paille + concentré farine Sor	111 J	739	7,8
	Lot 4: Paille + Concentré farine riz	111 j	672	9,1
	Lot 5: paille de riz + tourteau	111 j	400	9,7
	Lot 6: paille de riz + tourteau urée	111 j	423	8,3
1972	Coque d'arachide mélassée + farine + son + graine de coton 18 à 24p, 100	112 j	1.059	7,4
1973	Lote A: coque d'arachide + farine et son + à 26p. 100 de graine de coton	84 j	948	6,64
	Lot B: coque d'arachide + farine + son + 12 à 15p. 100 de tourteau de coton	84 j	1.054	6,67

Embouche ovine: Les régimes expérimentés sont soit à base de fane d'arac base de coque; les taux d'incorporation variant entre 18 et 75% p et 20 à 50% pour la coque.

Ces deux sous produits sont complémentés par des concentrés fabriqués à partier du son de blé, du tourteau, de la graine de coton, de la farine de poisson, de la mélasse et des graines de céréales (sorgho ou blé).

Melioration de la digestiblité des pailles par le traitement a la soude:
Les résultats des digestibilités in vivo et in vitro du produit brut et du produit traité montrent une amélioration de la digestibilité et de la valeur alimentaire des pailles traitées comme il ressort des tableax suivants.

Tableau No. 8:

Régimes de base	Durée d'alimentat (j)	Moutons Utilisés Nbre	Poids initial	Race	Croissance Gain total kg	CQM Calculé(g/j)	Consommation Aliment(g/j)	MS/100 kg/pv	Indice de Consommat
	63	5	25	Peul-peul	8,5	129	1200	3,5	8,2
	42	5	24,9	Peul-peul	4,3	102	1100	3,4	7,0
Fane	90	8	26,6	Peul-peul	5,8	58	1071	3,2	11,2
	90	8	27,1	Peul-peul	4,9	51	1108	3,3	12,9
	90	8	24,4	Peul-peul	6,7	75	1118	3,2	9,0
	52	6	28,2	Peul-peul	5,9	115	1350	3,9	5,9
	98	9	25,8	Peul-peul	9,9	100	1403	4,0	10,5
	98	10	26,4	Peul-peul	11,9	120	1607	4,4	8,6
	98	8	26,0	Peul-peul	12,3	125	1722	4,7	7,8
Coque	133	6	28,6	touabire	13,2	99	1665	4,5	9,4
	133	6	29,4	touabire	12,8	96	1612	4,0	7,8
	133	6	29,1	toubire	10,0	75	1562	3,4	8,8
	70	10	36,1	Peul-peul	9,0	137	2276	5,1	8,4

Tableau No. 8:

Temps de contact	Teneur en soude			
	30	40	50	60
24 heures	52,6	56,1	58,6	62,5
Paille témoin		86,0		

Tableau No. 9:

	Paille temoin	Paille traitee 40 G soude/kg de paille
Matiéres Séches	52,1	59,1
Matiéres Organiques	52,7	60,3
Matiéres Grasses	39	39
Matiéres Cellulosiques	58	74,6
Matiéres Azotées	26,5	27,6
E.N.A.	51,4	54
UF/kg Ms	0,35	0,44
MAD/kg MS	13,5	19,8

CONCLUSION

Ce petit aperçu sur les sous-produits disponibles et les actions de recherches menées, montre que le Sénégal est doté d'une variété importante de produits tant d'origine agricole, qu'industrielle.

Cette situation est un atout exceptionnel pour la promotion de l'Elevage. Dés lors certaines actions peuvent démarrer en vue d'un meilleure exploitation de ce potentiel:

- développement d'une technologie simple en milieu paysan (broyage des pailles, mélassage, mélange à des concentrés)
- technologie plus élaborée (traitement des pailles, fabrication d'aliments complets).

La recherche continuera quand à elle de travailler:

- à la formulation de rations économiques
- aux traitements physico-chimiques et biologiqude des fourrages grossiers.
- l'étude de la valeur nutritive des aliments disponibles et à l'établissment de tables spécifiques.

Ces actions de recherches combinées à celles du développement devraient aboutir à la resorption du déficit en viande que connait actuellement le pays (8000 tonnes actuelles et 12000 prévues en 1982).

BIBLIGRAPHIE

Blancou, J. et H. calvet. Production de protéines unicellulaires à partir de coques d'Arachide. 197 (?). 12 p.

Bourdergues, R. et H. Calvet. Note sur la digestibilité des coques d'Arachide utilisées en alimentation animale. In: R.I.E.M.V.T.,1970, 23 (4): pp. 493-502.

Calvet, H. (1977). La coque d'arachide en alimentation animale.-Dakar: LNERV, 4p.

Calvet, H. (1978). Les sous produits agro-industriels disponibles au Sénégal et leur utilisation en embouche intensive. Dakar: LNERV. 52p.

Calvet, H. (1977). Traitement chimique des pailles: Compte-Rendu succinct des premiére essais. Dakar: LNERV. 10p (ronéo).

Calvet, H. et al. -Lapaille de riz dans l'alimentation au Sénégal.
Part 1: Analyses biomatologiques-Digestibilés in vivo et in vitro, bilans azotés et mineraux - In: R.I.E.M.V.T., 1974, 27(2):pp.207-221.
Part 2: Biochimie du rumeur-Embouche-conclusions In: R.I.E.M.V.T., 1974, 27(3).

Calvet, H. et al. Recherches sur le métabolisme du rumeur chez les bovins tropicaux.

Calvet, H. et al. Coques d'Arachides et alimentation du bétail. Communication présentée au colloque sur l'Elevage organisé par l'O.C.A.M., For Lamy, Decembre 1969.

Delafond, G. et P. Demus (1977). La récolte des foins au CNRA de Bambey, Bambey: CNRA. 621p. C 1677.

Doutre, M.P; (1959). Teneur en matiéres proteiques, en phosphore et en calcium d'échantillons de farine fabriqués à partier de 3 clupéidés du Sénégal. In: R.I.E.M.V.T., 12 (3): pp. 305-311.

Friot, D., et al. (1975). Tourteau d'Arachide détoxifie, expérimentation sur volailles. -Dakar: LNERV, 18p. xtabl. In: R.I.E.M.V.T., 28(3): pp. 419-425.

Gueye, I.S. et A.L. Ndiaye. L'utilisation des produits agricoles et sous-produits agro-industriels en Elevage aspects économiques. IX: Journées médicales de Dakar (15-20-Janvier 1979).

Letard, E. et al. (1955). Les sous-produits industriels dans l'alimentation animale. In: P.L.E.M.V.T., 8 (2-9). pp. [illegible].

Lhoste (1980). Recherche dDéveloppement sur l'arachide et de ses dérivés: utlisation de l'arachide et de ses sous-produits-Dakar: LNERV. 2 fiches techniques:
1. Mise au point d'l aliment d'allaitement à base d'arachide pour le sevrage précoce des veaux-3p.
2. Projet de création d'une unité mobile de fabrication d'aliments du Bétail à base de coque d'arachide. 4p.

Lnerv (1978). (Sec Physiologie). Dig. in vivo d'échantillons de paille de kolda du 20 mai au 15 Juin 1978. Dakar: LNERV. 8p.

Mbaye, N. (1979). Essai d'alimentation par la paille de mil traitée à la soude: Expérience/LNERV-CNRA., Dakar: LNERV. 7p. (ronéo).

Mbodji, M. (1973). L'utilisation des graines de coton dans l'alimentation des bovins. Bambey: CNRA, 14p. ill C 1392.

Mbodji, M. (1973). L'utilisation des graines de coton dans l'alimentation des bovins. Bembey: CNRA. 15p. C 1320.

Mbodji, M. (1977). Décomposition et humidification des résidus végétaux dans un agro-systéme tropical. I. Enfouissement pendant 4 années d'un camposi de paille de mil dans un sol sableux cultivé au Sénégal.
lére partie: Bilans du carbone et influence des doses d'engrais azotés/C. Feller, M.Cheval, F. Gaury. Dakar: ORSTOM, Bambey: CNRA. 22p.

Mbodji, M. (1977). Divers procédés de traitement des fourrages et des pailles en vue d'en accroître la digestibilité et la valeur nutritive. Bambey, CNRA. 17 p. Bibliog. C 1675.

Mongodin, B. et G. Tacher (1979). Sous-produits agro-industriels utilisables dans l'alimentation animale du Sénégal.

Publiese, P.L., et al. (1975). Rapport concernant l'éfficacité comparée du tourteau d'arachide et du tourteau de "béref". Résultat d'expérimentation sur volailles. Dakar: L.N.E.R.V., 38p.

Senegal, G. et al. (1954). Utilisation des farines de poisson dans l'alimentation de l'enfant.

Valenza, J., et al. Etude de la valeur biologique de rations alimentaires pour bovins à base de fanes d'Arachide. Colloque O.C.A.M., Fort Lamy, Décembre 1969.

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PART III

USE AND PONTENTIAL OF
RESIDUES AGRO-INDUSTERIAL BY-PRODUCTS
AND ANIMAL WASTES IN LIVESTOCK PRODUCTION

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UTILIZATION OF AGRO-INDUSTRIAL BY-PRODUCTS IN BEEF FATTENING RATIONS: PRELIMINARY RESULTS OF F A O SPONSORED PILOT PROJECT NET-WORK IN CENTRAL AND WEST AFRICA

BY

R. Dia Ndumbe

Institute of Animal Research (IRZ), P.B. 1457, Yaounde, Cameroun

SUMMARY

The traditional systems of animal husbandry and conventional animal feeding with scarce cereal grains and imported protein sources limited animal production in Africa. To promote increased animal production in order to combat the critical protein shortage in the diet of the people, recent stresses have been on the utilization of available but unused crop residues and agro-industrial by-products in animal feeding.

FAO with the cooperation of national institutions at Ife (Nigeria), Bambui (Cameroun) and Dakar (Senegal) have initiated a pilot co-ordinated research net-work project on the utilization of crop waste residues and agro-industrial by-production in animal feeding in central and West Africa. Encouraging preliminary results were obtained at Ife on the substitution of guinea corn with cocoa-pods, and at Bambui on the replacement of maize with rice bran, in beef cattle rations. Further experiments are in progress to confirm these results and there are hopes of testing other by-products in animal diets in the region for common benefits.

The cooperation and assistance of Governments, Institutions, Organizations and Industry in the regions are suggested in order to widen the scope of these studies and so stimulate rapid progress in animal production in Central and West Africa.

INTRODUCTION

The critical deficiency of animal protein in human diet and its attendant defects on the population in Africa have long been recognized. Over the decades the need to ameliorate this situation has been emphasized but without much progress. The rapidly increasing population of Africa (from 306.0 million in 1965 to 419.8 million in 1977 (FAO, 1977), and the relatively declining animal and crop production made worse in recent years by the tragedy of drought in the Sahelian region of West and Central Africa have brought the situation into sharper focus for urgent international and national concern.

The shortage of animal rotein has been attributed to the low productivity of livestock under the tropical environment (Chenost and Mayer 1977). By far the most important factor responsible for this low animal productivity is inadequate nutrition resulting from poor and/or inadequate pasturelands, the pressure on the available land for crop production and animal grazing and, worse still, the competition between man and animal for the available food supplies which are already inadequate for human food. A further consequence of this competition was increased food/feed prices which limited their use in animal production and, raised the price of meat prohibitively for the needy African masses.

In recent years xcientific thought has become rather critical of the use in livestock feeding of conventional feeds based on scarce cereal grains and imported concentrates. Consequently, in 1976 the Food and Agriculture Organization of the United Nation (FAO) in Rome Convened a Technical consultative meeting on New Feed Resources to study the situation and make proposals. An urgent need was stressed for the search, identification and development of new and cheaper animal feed resources which could be exploited for animal production and limit or eliminate the present competition between man and animals for scarce food resources. Preston (1972) earlier had stressed that the developing countries of the tropics and huge biomass resources for the promotion of animal production. The work of the Technical Consultation on New Feed Resources not only surveyed potential new feed resources but also decided on the activities which the FAO Animal Production and Health Division should put into operation for the expansion and utilization of unconventional feed resources for animal production, especially, in the developing tropical world.

CLASSIFICATION OF AGRO-INDUSTRIAL BY-PRODUCTS WITH POTENTIALS IN ANIMAL FEEDING:

Agro-industrial by-products and crop residues with potentials in animal feeding may be divided into four groups according to whether or not they are sources of energy, protein, energy and protein and miscelaneous diet ingredients (Chenost and Mayer, 1977 and Adegbola, 1977). Some of those with potentials in Africa are indicated below:

Energy Sources: Sugar cane molasses, bagasse, tops and leaves (from sugar processing industries) banana rejects, pineapple bran, coffee pulp and hulls, cassava and potato wastes, cocoa husks, cocoa bean shell and discarded bean. All of these may constitute the major parts of diets, especially, for ruminants and pigs.

Protein Sources: Groundnut cake, cotton seed cake, cotton seed cake and meals, soya bean cake and meal, palm kernel cake, fish meal, abattoir wastes (blood meal, meat and bone meals). To this group may be added the newer protein sources from cassava, sweet potato and leucaena forage (aerial parts), the utilization of which was receiving considerable emphasis in animal feeding, especially, in the Caribean and Central America regions in recent years (Buitrago, 1978; Preston, 1979) and Saucedo et al., 1980). These are valuable for supplementing protein in rations for ruminants and non-ruminant stock.

Protein/Energy Sources: By-products from cereal grain processing industries and, breweries-rice bran, wheat bran and middlings, brewers grains and maize meal. Nutritionally, the value of these lies between the first two groups.

Miscellaneous: This group includes wastes from fruit-juice processing-citrus pulp, tomato pulp, mango seed and also wastes from avocado pear and guava processing industries which are fast developing in parts of Africa.

In addition to these better-known by-products, Adegbola (1977) drew attention to the potential value in animal feeding of lesser recognized but valuable by-products such as rubber seed meal and poultry manure as protein sources, saw dust from saw mills as energy source. Poultry litter production form the growing deep litter and battery cage egg production, the author noted, was already threatening pollution problems in Nigeria, Kenya and Uganda. One might also add to these resources, huge residues from cereal crop harvests-rice straw, millet and sorghum stalks and maize stovers, all sources of energy which are largely either left to waste in the fields or burnt in much of West and Central Africa.

Table I gives estimates of production of some of the main by-products in Africa.

Table I: Estimated production of some agro-industrial by-products in Africa.

By-product	Production ('000 tons)	By-product	Production ('000 tons)
Energy-Sources:		**Energy/protein Sources:**	
Sugar-cane Molasses	1.7	Rice bran and polishings	1000
Sugar-cane tops and leaves	19.3	Maize meal	2676
Banana rejects	950.0	Wheat by-products	3700
Pineapple bran	77.5	Brewers grains	305
Coffee Pulp	1235.0		
Coffee hulls	175.0		
Citrus pulps	93.0	**Other Roughages: (Million Metric Tons)**	
		Maize straw	47.3
Protein Sources:		Millet straw	21.2
Oil cakes and meals	750	Sorghum straw	19.6
Blood meal	48	Wheat straw	10.8
Meat meal	191	Rice straw	8.0
Cassava forage	47600		
Sweet potato foliage	5167		

Sources: Chenost and Mayer(1977);Adegbola,A.A.(1977);Chenost,M.(1979).

The review by Adegbola (1977) on the utilization of agro-industrial by-products in Animal feeding in Africa, indicated that while the production and availability of these by-products were rapidly increasing with current developments and expansion of agro-industrial production in Africa, very little of some of the by-products found their way in animal feeding. Most others remained unused and wasted. These include sugarcane molasses and fodder, reject banana and coffee wastes which were already being fruitfully exploited in animal production in some other tropical and sub-tropical countries notably in Central America and the Caribbean.

The following have been identified as factors limiting increased use of agro-industrial by-products in animal feeding in Africa:

1. The traditional systems of animal production which would not allow modifications and establishment of stratified livestock production and permit introduction of effective utilization of agro-industrial by-products in animal feeding.

2. The voluminous or high moisture nature of some of the by-products which make their keeping and transportation to livestock locations difficult e.g. molasses, fruit-wastes, coffee pulp.

3. The unavailability of some of the by-products where they may be required. In cameroun, for example, the sugar factories producing molasses were over 400 Km from the animal producing regions of North and North-West Provinces.

4. Ignorance or unawareness of the possible utilization of these by-products in animal feeding.

It is on the last factor that the role of research was especially important and urgent in Africa for, while substantial information was becoming available on the nutrient values of these by-products (Göhl, 1975), serious applied research on methods of their use in animal feeding has to-date been scanty, particularly, in West and Central Africa where at present huge quantities of available by-products were little, or not used at all, in animal feeding. However, when it was realized that within this region food and animal production had been dangerously threatened by drought in the Sahel, the pressing need for sustained research on the utilization of the locally available agro-industrial by-products in animal feeding belatedly became apparent.

THE ROLE OF FAO

Consequently as a result of the 1976 Technical Consultative Meeting on New Feed Resources in Rome, the Animal Production and Health Division of FAO planned and provided funds for the development in West and Central Africa of a pilot project net-work of applied and co-ordinated research on the use of the available crop residues and agro-industrial by-products in less expensive animal feed rations for the benefit, especially, of the small holder. Priority attention was given to rations for beef fattening for understandable reasons-over 65% of the available mat is beef and cattle, like other ruminants, are the best converters of waste products to animal protein foods for man.

Initially, two national research institutions were involved in the Pilot Project-The Department of Animal Science of the University of Ife in Nigeria, and the Institute of Animal Science (IRZ) Bambui-Baemenda in Cameroun. Recently, the Inter-African Veterinary School in Dakar, Senegal, has been added to the project net-work. Ife activities are on the evaluation of cocoa husks as a feed ingredient for cattle while at Bambui studies are on the utilization of rice bran and maize stovers in rations for beef fattening. Work at Dakar would investigate the utilization of groundnut waste products-shells, hay etc. in rations for beef and sheep.

The first experiments at Ife and Bambui were completed in 1979/80. The second series of experiments are currently in progress at both centres. This report summarizes the results of the completed experiments.

EVALUATION OF DRY COCOA-PODS AS A FEED INGREDIENT FOR BEEF CATTLE

In their first experiment, Professor Adegbola and his team used cocoa husks to partially replace guinea corn in beef cattle diets. The three diets employed differed only in the levels of guinea corn and cocoa-pods (Table 2). Diet No. 1 (control) contained 62.3% guinea corn and no cocoa-pods while in diets No. 2 and 3 cocoa-pods replaced, respectively, 30% and 60% guinea corn in the control diet (No. 1).

Table 2: Ingredients and nutrient composition of experimental diets.

Ingredients	**Diets (% as fed)**		
	1	2	3
Corn	62.3	43.2	24.4
Cocoa pods	0.0	19.3	38.4
Brewers dried grains	19.5	19.4	19.3
Groudnut cake	4.7	4.7	4.7
Molasses *	11.7	11.6	11.5
Oyster shells	0.9	0.6	0.3
Dicalcium phosphate	0.4	0.7	0.9
Trace mineral salt	0.5	0.5	0.5
	100.0	100.0	100.0
Nutrients (%) calculated	**Diets (% as fed)**		
Dry matter	87.9	87.2	86.7
Crude protein	14.3	13.4	12.4
Crude fibre	-	-	-
Total digestable nutrients	80.4	74.9	69.4
Metabolisable energy (Mcal/kg DM)	2.8	2.7	2.5
Calcium	0.6	0.6	0.5
Phosphorus	0.44	0.44	0.44
Protein:Calorie	1:5.6	1:5.6	1:5.6

*** Courtesy of Professor A.A. Adegbola.**
Was afterall excluded fro diets.

Thirty-six local cattle breeds-Keteku, Ndama and Ndama X white Fulani crosses averaging 120 Kg initial liveweight were randomly alloted to the three diet treatments each of three replicates of 5 cattle based on initial liveweight. Thus there were 12 animals per treatment. The animals were pan-fed for an experimental period of 112 days.

The following results, detailed in Table 3, were obtained:

- Mean dry matter intake for the whole experimental period was similar on all diets irrespective of the levels of cocoa-pod in the diets.

- Mean daily gains at 112 days was significantly better on the control diet (No. 1) but did not differ between the cocoa-pod diets.

- The levels of cocoa-pods in diets did not appear to have affected acceptability of the cocoa-pod diets by the animals.

- Cocoa-pods had no deleterious effects on the health of the experimental animals.

- Replacement of guinea corn with cocoa-pods in the diets of beef cattle did not affect the taste (Organoleptic) and quality of beef as shown by consumer acceptance tests.

- Carcass data were similar in animals on all rations.

- The substitution of guinea corn with cocoa-pods resulted in good savings in feed costs and also saved substanbial quantities of corn for human food.

For the experiment now in progress, the levels of cocoa-pods in diets were increased up to 60%. The results at the end of the experiment should, it is hoped, provide further useful information on the utilization of cocoa-pods in beef fattening diets.

Table 3: Response of fedlot cattle to grain substitution with cocoa-pods-performance data*

Items	Diets 1	2	3	± SE 1
Number of cattle	12.0	12.0	12.0	
Initial liveweight (kg)	106.9	106.8	104.7	
Liveweight at 56 days (kg)	164.1	53.6	145.6	
Liveweight at 112 days (dg)	194.9	177.2	161.2	
Average daily gain (kg) 0-56 days	1.02a	0.84a	0.73a	0.14
Average daily gain (kg) 0-112 days	0.79	0.63a	0.51a	0.5
Feed dry matter intake (kg/day) 0-56 days	5.39a	5.74b	5.79b	0.09
Feed dry matter intake (kg/day) 0-112 days	5.23a	5.54a	5.59a	0.08
Efficiency of feed utilization (kg DM/kg gain) 0-56 days	5.28a	5.83ab	7.93b	0.56
Efficiency of feed utilization (kg DM/kg gain) 0-112 days	6.62a	8.79b	10.96c	0.39

1 Standard error of mean with N:12 observation/mean.
a,b Means on the same row with different letters are.
* urtesy of Professor A. A. Adegbola.

Table 4: Composition of experimental rations.

Ingredients	Ration Composition (% as Fed)		
	A	B	C
Maize	40	20	10
Rice bran	0.0	20	30
Maize stovers	10.0	10	10
Brewers grains	13.0	12.5	12.5
Wheat bran	14.0	14	14.5
Groundnut cake	6.0	2.5	1.0
Palm kernel cake	13.0	17.0	18.0
Mineral mixture*	3.75	3.75	3.75
Trace Minerals	0.05	0.05	0.05
Terramycine croissance**	0.20	0.20	0.20
	100.0	100.0	100.0

Nutrient (%) calculated	Bations (% as Fed)		
Dry matter	88.4	88.4	88.5
Crude protein	12.92	12.90	12.96
Crude fibre	11.4	13.8	14.8
Ether extract	0.9	6.9	7.9
N F E	52.3	46.3	43.5
Ash	6.5	8.1	8.8
Total digestable nutrients	69.6	65.8	62.3
Metabolisable Energy	2.9	2.6	2.4
Nutritive ration	1:5.8	1:5.8	1:5.7

* 50% bone meal and 50% salt.

** Pfizer: Contained antibodies and Vit. B. 12.

UTILIZATION OF RICE AND MAIZE BY-PRODUCTS IN BEEF FATTENING:

The experiment was on similar plan as the Ife experiment reported upon earlier on. It investigated the performance of intensively fed bulls on rations in which maize (the basal ration ingredient) was partially replaced by rice bran. Three rations were tested. Ration A (control) contained 40% maize. In rations B and C rice bran replaced, respectively, 50% and 75% maize in the control ration (A).

All rations (see Table 4) contained 10 maize stovers.

Forty-five bulls of two local breeds (Red Bororo and Ngaoundere Gudali) with average initial weight of 300 kg were ranked into three treatment groups each of 15 animal (5 per replication) on the basis of liveweight and breed and randomly assigned to experimental rations in a feedlot. Experimental feeding lasted 112 days.

Performance data are shown in Table 5.

In summary:

- Feed dry matter intake was similar on all rations regardless of the level of rice bran although somewhat higher on ration C. No differences were observed in the acceptability of the rations.
- Feed efficiency was also similar on all diets.
- Mean daily gain was significantly better on Ration C compared to Rations A and B but was similar on the latter rations. Significance between-breed differences in gains in favour of the Ngaoundere Gudali was recorded on all diets.
- Animals of All rations looked well finished.
- Carcase analyses showed that replacement of maize with rice bran did not significantly affect dressed carcase percentages which were 56.4, 57.1 and 54.5 on rations, A, B and C respectively. Fat colour and consistency were apparently not also affected by the diet.

The results also showed substantial economic benefits from the replacement of maize with rice bran in beef faffening diets. At 50% maize replacement (Ration B), returns increased by 12.8% while with 75% maize replacement (Ration C), a 16.3% increase in returns was realized.

Table 5: Effect of replacement of maize with rice bran in diets on performance of intensively fed bulls.

Item	Ration		
	A	B	C
Number of bulls*	14	15	14
Initial liveweight (kg)	279.7	272.2	285.6
Final liveweight (kg)	380.7	381.1	399.7
Mean daily gain (kg)	0.98a	0.98a	1.02b
Feed intake (kg DM/day)	6.78a	6.69a	7.38a
Efficiency of feed utilization (kg DM/kg gain)	6.92a	6.83a	7.24a

a,b, Mean values on the same row with different letters differ significantly (P 0.5).

The current experiment is on similar lines as the one just reported upon but it investigated the effect of complete replacement of maize with rice bran in beef fattening diets which also contained more maize stovers (20%) than the earlier experiment. The use of up to 40% rice bran in beef rations has been reported. Göhi (1975) and O'Donovan (1979) observed satisfactory gains in beef cattle with 30 and 50% maize stalks diets.

We await the result of the present experiment with interest. However, further work will be required to investigate optimal levels of maize stovers in rice bran based rations for beef cattle fattaning.

FUTURE OUTLOOK

Collaborative efforts on the utilization of agro-industrial by-products in animal feeding in West and Central Africa are just being initiated. The volume and variety of by-products available are increasing rapidly as a result of efforts of nations in the area to increase and diversify agricultural production. Also, agricultural products are fairly similar in the countries of the region and results of experimentation on the utilization of by-products in animal feeding in one country should find useful application in other coutries. For example cocoa is a major crop in the humid regions of West Africa. Results of the studies of feeding cocoa-pods on-going at Ife should be readily applicable in Ghana, Ivory Coast and Cameroun, all cocoa producers. Maieze and rice are stapples in West Africa. The results of work at Bambui on fattening cattle on these by-products should, therefore, find wide application in the region. The same should be true for the by-products of cotton, groundnuts, coffee, fruits, sugar cane, and other cereal crop by-products all of which await serious research in animal feeding.

FAO has stressed the urgent need to develop new and cheaper feed resources for livestock in the tropics in order to raise the production and availability of animal products for the protein undernourished populations of the tropics. The Pilot Project study net-work for West and Central Africa has beeninitiated and will hopefully expand its experimental activities to involve a wider range of by-products and livestock, besides cattle. While, however,FAO promises assistance in this field to countries requesting assistance (Annon, 1979) the cooperation and assistance of Governments, Institutions, Organizations and Industry in West and Central Africa will be necessary to promote a wider net-work of studies on the methods of treatment and utilization of crop residues and agro-industrial by-products in animal feeding in the region. Such cooperation should help bring about the desired effect in rapidly promoting increased animal production not only in Central and West Africa but also in Africa as a whole. The developing nations of the Caribbean and Latin American are doing so at present.

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REFERENCES

Adebola, A.A. (1977) Utilization of agro-industrial by-products in Africa. New Feed Resources: Proceedings of a Technical Consultation, FAO, Rome, 1976.

Alvarez, F.J. and Preston T.R. (1976) Dual purpose milk/weaned calf production with sugarcane, molasses, urea and Leucaena leucocephala. Tropical Animal Production 1, 27.

Alvarez, F.J. et al. (1977) Leucaena leucocephala as a combined source of protein and roughage for steers fattened on Moçlasses/urea. Tropical Animal Production 2, 288.

Annon (1979) Feedstuffs for Animals: Coment. Wld Anim. Rev. 32, Front Cover.

Buitrago, J. (1978) Personal communication.

Chenost, M. and Mayer, L. (1977) Potential contribution and use of agroindustrial by-products in animal feeding: Preceedings of a Technical Consultation, FAO, Rome, (1976).

Chenost, M. (1979) Personal communication.

FAO (1977). Production Yearbook, Vol. 31, FAO, Rome.

Cohl, Bo. (1975) Tropical Feeds, FAO, Rome.

Jones, R.J. (1979) Value of Leucaena leucocephala as a feed for ruminants in the tropics. Wld Anim. Rev. 31, 13.

O'Donovan, P.B. (1979) Fattening crossbred and zebu cattle on local feeds and by-products in Ethiopia. Wld Anim. Rev. 30, 23.

Preston, T.R. (1972) Prospects for Beef Production from sugarcane in Cameroun. Personal communication.

Preston, T.R. (1979) Personal communication.

Saucedo, G. et al (1980). Leucaena leucocephala as a supplement for milk production on tropical pastures with dual purpose cattle. Tropical animal Production 5, 38.

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-12 Nov. 1980, Douala, Cameroun, p. 219-224.

THE ROLE OF SUNFLOWER BY-PRODUCTS AS ANIMAL FEED

By
C. N. Karue and H. Kayongo-Male
University of Nairobi, Nairobi, Kenya .

INTRODUCTION

Kenya is a country lying in the Eastern part of Africa. It stretches between 5°N and 4°S and is transversed by the Equator. Geographically most of the country lies in the area that is easily classified as semi-arid to arid, comprising about 75% of landmass, with only about 20% of it considered is suitable for arable farming. Kenya has a total of approximately 580,000 sq. km of landmass. The landscape is transected from North to South by the Great Rift Valley within which are several lakes. It is bounded on the South by the slopes of Mt. Kilimanjaro, on the West by Mt. Elgon, within the centre by Mt. Kenya and on the East by the Indian Ocean.

The semi-arid and arid areas of Kenya experience seasonal rainfall and, therefore, demonstrate seasonal productivity of herbage. The herbage dries up and loses quality especially, during the dry seasons. The protein content of such herbage declines to such low levels that even maintenance needs of the grazing ruminant animals dependent on this herbage cannot be met, e.g. 3-4% CR. Animals usually fed on such herbage have not only shown negative digestion coefficients of the protein but also negative N. balances indicating a higher loss of N in faeces and urine of the animals than is suppiied from the herbage. It is these types of animals that need supplementation with a higher protein feed at certain times of the year to maintain their BW. This is usually referred to as strategic supplementation.

Of the 10 million cattle in Kenya, about 4.2 million are found in the rangelands and the rest within the agricultural areas. In the agricultural areas, dairy cattle accounts for about 1 million but the rest are beef animals that depend mainly on natural grazing. The range areas also support a majority of sheep and goats found in Kenya (8.5 million), camels 0.64 mil., and donkeys 0.187 mil. In addition, the area supports a wealth of grazing herbivores totalling nearly 2 million (1978, estimates). Of very great importance are some of the small ruminants like T. GAzelle, Impalla, Topi and G. Gazelle that account for about 1 mil. of the wild herbivores. All these wild herbivores are dependent on the seasonally available herbage in the range areas and directly compete with domestic livestock for the available herbage. The competition becomes more severe during the dry season when green herbage is scarce, and quantity and quality of natural grassland decline. This is then the time when extra feed is required in the range areas.

Often, supplementation of the grazing ruminants in the Tropics is not practised. This has largely been due to poor standards of feeding management and also to lack of sufficiently cheap feeds to be provided as supplements. A team of scientists, therefore, set out to evaluate some crop by-products as a possible source of relatively cheap feed for ruminants, especially, for the strategic supplementation.

The experiment was conducted using beef steers to evaluate the nutritive value of sunflower by-products as sources of protein and energy for cattle.

EXPERIMENTAL PROCEDURE

Three types of sunflower by-products - Sunflower Seedless Headmeal (SSH), Sunflower Waste Seed (SWS) and Sunflower Cake (SCK) were fed as the sole source of feed. The SCK was fed in a ration containing 4 parts of Sunflower Seedless Headmeal (SSH) and one part of SCK as offered.

Tye type of animals used were Zebu steers of the Boran breed of known age and known weight. They were standardized for weight for each ration. The rations were fed for a two-week adjustment period followed by a four-week experimental period during which time records for intake and digestibility of the feeds were collected.

Prior to placing the animals on the experiment, the animals were dewormed and their previous health record examined. Minerals were provided from a commercial mineral mixture at 50 g/day per animal. Injectable form of vitamins A, D and E were provided at a 1 million IU of A, 0.1 million IU of D and 200 IU of E, which was sufficient for the experimental period.

During the experimental period, collection of faeces and urine was done using standard digestibility stalls (1). The samples were subjected to chemical analyses (2) and the data subjected to statistical analyses (3).

RESULTS

The most important components of the three sunflower by-products were the protein content, and the fibrous components. The crude protein content of the sunflower seedless Head (SSH) was 4.42%. The SWS had considerably higher CP content, 16.24%. The SCK when mixed with SSH in the ratio SCK:SSH, 1 to 4 raised the protein content of the ration to 13.31% (Table 1).

The fibrous components, varied from 30-35% for ADF, 35-45% for CWC and 4.8 - 7.3% for ADL (Table 1). Although the ingestion of the fibrous components was high, their contribution as energy source in the ration was low due to poor digestibility of the fibrous components. The digestibility was lowest respect to the fibrous components in SWS because of the hard, almost indigestible seed coat. Although the SSH had much more available fibrous components than SWS, the low protein content in the SSH prevented better utilisation of the fibrous components. Addition of SCK at 20% enhanced significantly the digestibility of the ADF fibrous components although the overall effect on CWC was non significant. However, on the work compared with grasses of similar ADF content and N content (4) the digestibility of the sunflower ADF and CWC was lower than expected (Table 2). This may have been due to the high degree of lignification (7.31% for SWS and 5.99 for SSH) in the sunflower by products feeds.

The ingestion of dry matter from each ration varied from 3.774 ± 0.305 kg for SWS to 6.460 ± 0.636 kg for SCK:SSH ration (Table 2). The intakes ofSWS and SSH were not significantly different. The depression of DM intake in SWS despite its high protein content, was probably due to the hard seed coat of the waste sunflower seed. The inclusion of SCK in the SSH ration 1=4 ratio, respectively, significantly increased the DM intake. This indicates that the intake of the SSH ration was being limited by lack of adequate proteins in the ration and the fibrousness of the ration. The most important point to note is that in SWS digestibility of DM was much affected by the hard seed coat (29.01 ± 2.55) while compared to SSH with lower protein but still with a DM digestibility of 55.46 ± 2.93. Addition of SCK to SSH did not significantly increase the digestibility of DM although it was raised by 5.43 digestibility units to 60.89 ± 3.08.

Protein is the most important component contributed to animal feeds by sunflower waste seed and sunflower cake. The SWS, despite its low DM intakes provided 613 g of protein daily to the animal. The SWS protein was highly digestible showing a digestion coefficient of 71.03%. The SSH had negligible amounts of protein and the digestibility of the SSH protein was also considerably low 18.77%, this protein being mainly bound up in the fibrous mass as opposed to the SWS protein found in the endosperm of the seed.

Addition of SCK (20%)to SSH (80%) increased the protein intake to 860 g/day per animal. Since CP intake is closely related to digestible CP, there was a significant improvement in the digestibility of protein from 18.77 to 63.66 ± 3.05.

Normally, a grazing ruminant animal weighing between 200 kg and 250 kg BW should be allowed up to about 454 g of DCP per day. From this study, it is apparent that sunflower by-products, as the sole source of feed for cattle, were able to provide adequate DCP from SWS and SSH supplemented with SCK.

The sunflower by-products appeared to have an influence on the water metabolism of the animals wholly on these by products as the sole source of feed. The effect on urine output was most noticeable in the animals that were fed on the Sunflower Seedless Headmeal (SSH) more than on the ones feed on Sunflower Waste Seed (SWS) (Table 3). The animals purely on SSH, despite their normal water intake and DN intake comparable to animals on SWS, had a higher urinary excretion that animals on SWS. This high level of urinary excretion continued even after the prrotein level was increased.

DISCUSSION

It is apparent that sunflower crop by-products could be useful supplements for animal feeds during the dry season. The sunflower seedless head when ground was found to contain very small quantities of protein (4.42%). The digestibility of this protein was poor (18.77%) and therefore would contribute insignificantly to the improvement of dry herbage protein in the dry season. The fibre, which was high, was less signified than for the sunflower waste seeds, it was, therefore, possible to expect a high digestibility of the fibrous components of the SSH. This appeared to be so for the ADF. However, for CWC, the digestibility was low probably due to lack of N and available energy for stimulation of adequate microbial activity.

The sunflower waste seed (SWS) demonstrated a great potential as a protein supplement for grazing ruminants during strategic supplementation. The SWS refers to the light seeds whose endosperm contents are less than half of the normal heavy seed. The seeds have a hard, well formed seed coat. This seed coat is high in fibrous components as well as lignin. The seed coat has to be mechanically broken to release the contents of the seed to the digestive systems within the rumen. Any seeds not crushed may pass through the digestive system. Although a hard seed coat, there was a certain degree of degradation of the fibrous components, and especially that of the CWC components as a whole that was enhanced by improved digesta media that promoted microbial activity.

The protein content of SWS was 16.24% of which 71.03% was digested by the animal.

The possible improvement that can be imparted by a strategic protein supplement to grazing animals was demonstrated in this experiment. In the SSH, a small amount of sunflower cake (SCK) was added to evaluate the possible role of protein supplement in utilization of relatively otherwise poor roughage. As offered, the SSH was given in a ratio of 4 parts to one of the SCK. The two mixture provided a ration of 13.31% crude protein. The fibre component, however, still remained high, ADF 30.43 and was comparable to SWS ration - (ADF 30.35%). The most important points that were noted here were that:

(a) the protein digestibility was improved from 18.77% for headmeal alone to 63.66%. This was a three and half fold improvement in protein digestibility ;

(b) there was a slight improvement in the digestibility of the fibrous components, e.g. 25.90% to 40.75% for ADF.

One may conclude that where there is dry standing grass of poor quality in the natural grasslands, one of the most limiting components in utilization of that grass is N deficiency in the overall animal feed. Supplementation of this either directly from crop by-products or provision of higher protein fodder feeds would greatly enhance the performance of the animals and, therefore, the productivity of livestock in range areas. The animals in range areas attempt to supplement their poor quality dry grass by picking dry leaves, browsing some of the green trees and nibbling some of the drought tolerant leguminous plants commonly found in the range areas. The integration of arable crop farming with livestock enterprises in the use of crop by-products at certain times of the year will definitely go a long way to improving livestock production in the tropics, especially, in Africa.

TABLE 1. Chemical composition of sunflower by-products

	DM%	CP%	ADF%	ADL%	CWC%
Sunflower Waste Seed	86.64	16.24	30.35	7.31	44.78
Sunflower Seedless Headmeal	81.20	4.42	35.32	5.99	37.95
SSH (4) + SCK (1)	85.88	13.31	30.43	4.83	35.74

TABLE 2. Digestibility and nutrient intakes of various components of sunflower by-products

	Sunflower by-products		
	SWS	SSH	4SSH+1SCK
No. of Animals	6	8	6
Dry matter			
Intake, kg	3.774±0.305	4.029±0.635	6.460±0.636
Digestibility %	29.01±2.55	55.46±2.93	60.89±3.08
Digested, kg	1.094	2.186	3.931
Crude Proteins			
Intake, g	613	178	860
Digestibility, %	71.03±1.09	18.77±5.32	63.66±3.05
Digested, g	435	34	548
% Requirement	96.7	7.6	121.8
Acid Detergent Fibre (ADF)			
Intake, kg	1.145	1.646	1.966
Digestibility, %	20.13	25.90	40.75
Cell wall constituents (CWC)			
Intake, kg	1.748	1.769	2.309
Digestibility, %	24.30	32.93	34.28

* (Requirement from NRC estimates at 450 g DCP/day)

TABLE 3. Water intake and urine output under different rations of sunflower by-products

Feed	SWS	SSH	4SS + ISCK
Animals No.	6	8	6
DMI. kg/day	[illegible].774	[illegible].178	6.406
CPI, kg/day	0.613	0.178	0.860
Water intake L/day	5.895	4.260	14.030
Urine output L/day	7.179	15.313	22.625

REFERENCES

1. Karue, C.N., Evans, J.L. and Thilman, A.D. (1972). **J. of Animal Science** 35, 1025.

2. A O A C (1965). Official methods of Analysis (10th Ed.) Association of Official Agricultural Chemists, Washington, D.C.

3. Steel, G.D.R. and Torrie, J.H. (1960). **"Principles and Procedures of Statistics"**, McGraw Hill Book Co. Inc., New York.

4. Karue, C.N. (1975). Intake digestibility of **Themeda triandra** hay by age paired Boran and Hereford steers. **E. Afr. Agric. For. J.** 41, 35.

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Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-22 Nov. 1980, Douala, Cameroun, p.225-260.

THE UTILIZATION OF SUGARCANE PRODUCTS AND BY-PRODUCTS OF THE SUGAR INDUSTRY AND OF OTHER SECTORS AS ANIMAL FEED FOR THE PRODUCTION OF MILK AND MEAT IN MAURITIUS

BY

J.A. Claude Delaitre

Technical Director, Food and Allied Industries Ltd., Mauritius.

INTRODUCTION

Mauritius is a tropical island situated between latitudes 19° 50' and 20° 31' South and longitude 57° 18' and 57° 48' East. It covers an area of some 720 sq. miles and is populated by approximately 950,000 inhabitants. Mauritius became independent in 1968. The French are reported to have been the first to start the cultivation of sugarcane and other cash tree crops within the Island in 1715.

Mauritius falls within the humid and sub-humid tropics with a rainfall yearly average of 5,080 mm (200 inches) on the high plateau to as low as 635 mm (25 inches) within the coastal plains. The Island is subjected to cyclones during the summer months with gusts blowing up to 240 km (150 miles) per hour.

The island nation derives most of its foreign earnings from sugar, exporting an average of 550,000 metric tons yearly to European Economic community countries from where it receives a speciall negotiated price.

ANIMAL PRODUCTION IN MAURITIUS

Cattle:

Since the turn of the Century the total cattle population in Mauritius has oscillated around 48,000 heads. In the earlier years about 7/8 of the cattle were Zebu (Bos indicus) imported mainly from Madagascar, they were kept on the sugar estates to be used as source of power to pull the plough and the carts and from this lot came most of the beef production.

Another animal which has flourished on the Island is the Mauritian cow (Creole cow). It was introduced into the country about two centuries ago and is believed to be of North European origin.This animal(Bos taurus) has a good dairytemperament. It produces a calf yearly even under very stressful conditions. The same cow which would produce 900 litres/lactation under poor feeding conditions would produce 2,100 litres or more milk, when better fed. Having worked for 25 years with this cow I have always felt that the breed could be for the tropics what the JERSEY and the GUERNSEY have been for the temperate world.

Changes in the Cattle Population 1920-1960. Major socio-econmic changes took place in Mauritius around the [illegible]'s. Animal power was replaced by lorries and tractors on the sugar estates. This brought about major changes in the composition of the National Herd. The total number of cattle remained more or less constant at 48,000 with about 42,000 of this number being creole milch cattle owned by about 20,000 farmers. Presently, these animals are no more on the sugar estates but are kept in the villages in dark straw huts to keep away the biting fly belonging to the "Stomoxys" species. These milch cattle are zero grazed and are fed fodder growing on the road sides and on waste lands during 7 months of the year and for the remaining five months they receive cane tops which are available during the cane harvest season (July to November).

From an agricultural point of view these cows were playing an important role because they were utilising the produce of land with no alternative use producing milk and meat and returning this fertility in the form of manure for vegetables gardens.

The small nucleus of Zebu cattle were extensively grazed on the low rainfall, low fertility lands on the coastal plain and were used exclusively for beef production; the two breeds were never mixed probably due to the fact that since 1949 Mauritius has had its Animal Husbandry Services separate from its Animal Health Services. Mauritius is presently importing about 3,000 tons of meat yearly.

Other Classes of Livestock:

Pigs: The pig population remained fairly constant throughout the years with about 8,000 in Mauritius and about 6,000 in the island of Rodrigues; the majorityof the pigs being descendents of long nosed pigs introduced by the Dutch in 1598.

In the late 1950's Large White, Berkshire and Large Black pigs were introduced. Their introduction coincided with the formulation of rations for each class (age of livestock) manufactured by the Government owned feed factory (1958). The pigs on Rodrigues Island are exclusively fed on home grown maize, sweet potatoes and household waste.

Goats: Nearly every farmer who owns a cow would own about 5 goats. This would explain the goat population of about 95,000 heads. Goats are also zero grazed and fed with cane tops, roadside grasses and Leucoema leucocephala whenever available.

Sheep: Sheep never thrived in Mauritius. They numbered less than 1,000 head. Over the years a very interesting animal has developed in Rodrigues Island it is the result of the introduction of hairy sheep from East Africa, Dorsian sheep and Black head persian sheep. They are herded and grazed on waste lands and there is no tradition of shearing sheep in Mauritius.

Rabbits: There has been numerous attempts of raising rabbits as a backyard farming enterprise. Under normal conditions, this should have been a success but it has never been, mainly through not being able to control liver coccidiosis-the parasite being highly successful under our humid conditions. There must still be some 10,000 rabbits in Mauritius fed on fodder collected from waste lands.

Deer: The picture will not be complete if we did not mention the deer (Cervus timorensis russa) introduced around 1598. It thrived in the forest area of Maritius, increasing the revenue from these lands.

In the earlier days they were hunted for sporting purposes, but druing 1970-72 as part of an F.A.O.-funded project, the concept of deer farming was investigated and considered to be feasible. The deer population now numbers about 20,000; Government is encouraging deer farming by fair leasing rights and proper legislation. This is in turn bringing more revenue to forest lands and the feeding grounds are being improved.

Deer is also being raised in feed lots and intensively fed with molasses cum urea cum minerals cum protein-very encouraging results have been obtained so far. Current yearly production is estimated at 550 tons of meat.

Poultry: The poultry industry is a recent and successful one in Mauritius. Government created a Poultry Breeding Centre in 1955. This was the turning point from backyard farming to industrial farming. The concept of using hybrids for meat and egg production was introduced together with demonstrations of the control of coccidiosis by coccidiostats and the control of New Castle and Fowl Pox diseases through vaccination.

Presently, there are three firms producing broilers on an industrial scale they are producing about 75,000 broilers per week which is equivalent to about 100 tons poultry meat weekly.

Mauritius is self-sufficient in poultry meat and its technology of producing chicks under the prevailing tropical environment is so much "au point" that it is looking for export markets.

There are about 1,500 eggs producers in Mauritius. Mauritius has achieved self-sufficiency also in the production of eggs. The industrial producers produce about 50 million eggs yearly and the local farmers utilising the unimproved chicken running loose in the villages produce about 10 million eggs yearly.

Through its very efficient and concientious veterinary services, Mauritius has been kept free from most of the contagious and infectious diseases affecting livestock and poultry.

UTILIZATION OF SUGARCANE AND ITS BY-PRODUCTS AS ANIMAL FEED

General:

After Independence in 1968 it became evident that a new approach would be required so far as livestock production was concerned.

Many things happened at the same time:

1. The younger generations in the villages were no more prepared to harvest fodder from the road side to feed their cows;

2. Mauritius had for over a century relied on the importation of live cattle (about 15,000 heads yearly) from Madagascar. This supply stopped suddenly. Apart from importation of frozen beef, the Government decided to step up production;

3. at the same time the work of Preston in Cuba was producing results, a start had been made to valoriese the use of sugar cane and by-products for livestock production systems;

4. a team of ten F.A.O. zootechnicians and dairy technologists worked in Mauritius and from 1968 to 1972 their approach to the local problems were traditional and they produced the following working reports:

   a) Proposals on Milk Legislation.
   b) Field pasteurization at reduced costs.
   c) A pilot Milk Collector Scheme.
   d) Technical Background for Deer Management Legislation.
   e) Many other technical reports which proved most useful to build up the future development of livestock production.

However the technology being traditional not much innovation was in sight to develop meat and milk production in Mauritius.

One valuable contribution was that Sansoucy et al. devised a formula of a dairy ration made up to a large extent of locally available by-products. It had the advantage that although containing large amount of molasses it was a free flowing meal which could be made available to the thousands of cow keepers. The formula was the following and the feed became known as the Molasses/bagasse feed.

Molasses	74.0%
Dehydrated Bagasse pith*	14.0%
Ground Nut Cake	2.0%
Urea	2.0%
Dicalcium Phosphate	1.5%
Sodium Chloride	0.5%
	100.0%

* A by-product in the making of particle board from bagasse.

Results of research carried out with the molasses bagasse feed will be discussed under appropriate headings.

By 1972, the use of by-products of the sugar industry for milk and meat production based on the preliminary work of Preston in Cuba had made much head way throughout the sugarcane-producing world. The pioneer-work of Preston utilising molasses had been replicated in Mauritius with similar results. More or less at the same period, James and Miller working in the Carribean pioneered the work of utilising the sugarcane plant as livestock feed.

It became evident that Mauritius could not continue importing cereals as livestock feed wilst it was exporting most of its molasses and large quantities of by-products of the sugar industry was available. It was evident that due to lack of suitable lands, there was hardly any hope for traditional pastoral farming whilst valorising by-products of the sugar industry in devision appropriate livestock production systems appeared logical.

In Mauritius sugarcane fields are replanted every 10 years. Cereals, potatoes and vegetables are grown in the inter-rows of these newly planted fields. Roughly 200,000 acres of land are under sugarcane at any one time.

Research to further the efficiency of the sugar industry is carried out by the Mauritius Sugar Industry Research Institute. Research in the field of Animal Production has been entrusted to the Animal Production Division of the Ministry of Agriculture and Natural Resources and the Environment.

The following products and by-products of the sugar industry can be used in livestock production systems; fodder cane, white sugar, brown sugar, cane juice, sugarcane tops and trash, bagasse, molasses, and filter press cake scum.

Table 1: Yearly production of sugar and sugar by-products in Mauritius (M. Tons).

Item	1976	1977	1978
Sugarcane	6,402,277	6,022,287	6,260,483
Sugar	689,932	665,743	665,219
Sugarcane Tops*	2,134,092	2,007,429	2,986,828
Bagasse (30% humidity)*	993.273	937,801	956,310
Molasses	199,421	194,561	193,676
Scums (fresh)*	160,057	150,557	156,512

Source: Extension Services, Ministry of Agriculture & Natural Resources and the environment.

* Based on the assumption that the production of sugar cane tops bagasse and scums are 33%, 12% and 2.5% respectively of the amount of sugarcane harvested (Hardouin, 1973).

About 550,000 tons of the sugar produced, is exported to the European Economic Community Countries at a preferential price. Of the 2 million tons of cane tops available every year probably not more than 10% is being used as cattle feed-the remaining is left in the fields.

Until about a decade ago, about 95% of the molasses produced was exported and the remaining 5% was used either as a minor component of livestock feed or in the distilling industry for the manufacture of alcohol.

Every year 130,000 tons of bagasse are available over and above the amount utilised by sugar factories as fuel and to produce electrical energy. Filter cake scums have been mainly used as fertilizer and returned to the fields because it is difficult to handle. Bacterial decomposition takes place soon after its removal and a very objectionable smell renders it unpalatable to livestock. On standing, the product shows a relatively high nitrogenous content interpreted as being protein (N x 6.25) yet this protein is of low digestibility.

Table 2: Average composition of the by-products of sugar industry (%DM).

By-products	Dry matter	Crude protein	Crude fibre	Ether extract	References
Sugarcane tops	28.3	6.4	30.0	1.6	Sansoucy (unpublished)
Molasses	80.4	5.1	-	-	Preston and Willis (1974)
Bagasse (dry)	90.3	1.9	45.0	1.0	Gohl (1975)
Scum (rotary filter)	19.4	12.7	17.6	-	Miles (1971).

As shown in table 2 sugarcane tops have a high fibre content, low protein and a low fat content. In other words, a low energy feed. Molasses is high in minerals, low in protein and contains 30 to 50% sugar, in other words, an unorthodox feed. Bagase-nothing could be more fibrous and less nutritive. Scum contains also wax 14% of D.M what is referred to as Crude Protein is in fact (N x 6.25) experiments carried many years ago showed that this nitrogenous component was highly indigestible by monogastrics and 40% digestible by ruminants.

In order to make maximum use of these unorthodox feedstuffs so different in composition from the traditional feeds used in the temperate world, Mauritius has to develop our own technology, develop unorthodox managerial methods to rear her livestock. All these had to be backed by research carried out under local conditions by her people who must implement their findings and produce practical results. Mauritius was helped in this venture by the F.A.O/U.N.D.P and I should pay a special homage to Dr. Reginald Preston who for the last eight years has been guiding our efforts by visiting us twice yearly, thus keeping us in touch with others working in the same field throughout the world.

Hereunder, we have summarised some of the information we have concerning the utilisation of sugar and by-products of the sugar industry and other by-products in livestock feeding.

The Sugarcane Plant as Feed for Cattle:

Based on the results obtained at St. Kitts and in Barbados, a C-4 sugar cane derinding machine was imported from the Canadian Cane Equipment Ltd. The C-4 derinder consists basically of a sharp wedge which splits the cane longitudinally, the cane is then forced between a cane scraping drum which would wear off the interior of the cane to produce the comfith and the by-product was the cane rind.

The machine had to be constantly adjusted and breakdowns were numerous, in fact the machine worked best with straight clean canes, a condition not always obtainable under normal conditions. Subsequently a locally designed sugar cane chipper was used. It was 100 times less expensive than the C-4 derinder.

The basic experimental feeds were derined cane (comfith) chipped whole cane and chipped rind.

The supplement in every case was the following:
a molasses/urea solution (200 g urea dissolved in hot water and added to 720 g molasses/litre) at the rate of 50c.c per kg fresh cane product.
1 kg ground maize daily
300 g local fish meal (38% port).
Dicalcium Phosphate and salt.

In each of the treatments, average growth of over 800 gms/head/day was obtained during a 109-day trial using friesian xbred bulls

Average intake of fresh cane	kg/day	22.9
Average intake of molasses	kg/day	0.82
Average intake of Urea	kg/day	229
Average intake of Ground Maize	kg/day	1.0
Average intake of Fish Meal	g/day	300

Source: data Delaitre <u>et al</u>, (unpublished)

We investigated use of rind because we believed that in the future the cane could be derined and the derinded part could be used to manufacture sugar when a cleaner juice could be obtained and the rind could be used for cattle feeding.

Table 3: Composition of sugarcane as a percentage of fresh matter.

	Dry matter	Fibre	Prot.		Total Sugars	Ether Extr.	Ash	Sulphur
Derinded cane Stalk (av of 12 samples)	27.23	8.6	0.64	13.37	14.5	0.089	0.633	0.057
Chipped whole cane (av of 5 samples)	29.40	14.94	1.13	9.32	10.55	0.32	1.09	0.074
Cane tops (av of 2 samples)	26.8	17.1	1.16	4.43	5.49	0.30	1.43	0.096
Rind (av of 2 samples)	36.5	24.4	0.95	8.51	9.38	0.41	0.77	0.56

Source: Animal Production Division, Min. of Agr. and N.R & the E., Mauritius

To maximize the use of sugarcane and by-products and to reduce the requirements of imported cereals, an attempt was made to rear calves by the restricted suckling method (allowing the calf to suckle dam for 15 to 30 minutes after milking) and as from 15 days after birth provided the calves ad lib with a mixture of equal parts of fish meal and urea and 1 part of molasses.

The average daily gain of the calves from birth till weaning was 0.497 $\pm$ 0.27 kg for the restricted suckling group and 0.353 $\pm$ 0.043 kg for calves reared in the traditional method of bucket feeding. There was a highly significant difference ($P<0.01$) in favour of the performance of calves on the restricted suckling method in the average daily gain of the calves.

The observation reported in New Zealand that cows which suckled their calves had a lower incidence of mastitis was also confirmed in this trial (Source Gaya, Delaitre, Preston, Animal Production Division, Milk and Meat Project, 1974 report).

Even if we have no experimental data to present, it can be said that in practice it is as difficult to produce reasonable levels of milk on diets based on chipped cane as it is to produce milk on molasses diets. It should be pointed out that the processed sugar cane plant has a very limited "shelf life".

The Use of Molasses as Livestock Feed: Meat Production:

As early as 1893 Boname working at the station agronomique in Mauritius reported on the feeding of high levels of molasses to cattle and horses. However over the years molasses was exported rather than used as a feed until about 10 years ago when Preston brought molasses back into fashion.

It should be pointed out that in 1958 as a result of trials carried out at Curepipe Livestock Breeding Station, Delaitre formulated rations for pigs and cattle containing up to 35% molasses. These levels of molasses are being used up to now. Incorporation of high levels of molasses in rations became possible through a special mixer designed by LIM FAT. (Molasses was incorporated up to 2% in chicken feed and up to 5% in layers rations).

With the high molasses diets recommended by Preston the fact that ruminant could transform non protein nitrogen into protein assumed importance because this new approach made the ruminant a very important animal for the developing world when compared to pigs and poultry which required ready made protein of high biological value.

Every ruminant was doing what the most sophisticated laboratories could not do, convert N.P.N (convert organic fertilizer directly into protein). However, we should bear in mind that this unorthodox technology could well be God-sent for the developing world but yet it is still in its infancy.

Preston had pointed out that feeding high levels of molasses/urea to cattle was unorthodox because:

1. Molasses has no roughage characteristics.
2. it is deficient in Nitrogen (less than 1% in D.M).
3. The sugars present in the molasses are highly soluble.

Sansoucy et al. (1970) replicated in Mauritius the techniques Preston used in CUBA and obtained growth rates of 0.7 to 0.8 kg/dy with Zebu cattle. This earlier work also confirmed that restricting the fodder intake at 3% of live weight gave better results than feeding forage ad lib. Also the optimum level of urea in the molasses was 3%. It was found that the urea could only meet 60% of the Nitrogen requirement of cattle, the remaining had to come from natural protein sources, preferably, of low solubility so as to escape degradation in the rumen (by-pass protein postulated by LENG working in Australia).

A series or experiments were carried out in Mauritius with a view of finding the optimum combination of additions to suit high molasses/urea diets for beef production under local conditions. Details and Results of some of the trials are given hereunder. Supplementation of Molasses/Urea Diets with Protein Sources.

High molasses diets supplemented with protein sources such as fish meal or groundnut meal (either unprotected or protected by chemical treatment) have been investigated in terms of growth rates. Ma Poon, Delaitre and Preston (1975) found (Table 4 and 5) that there was no significant difference in growth rates of Creole heifers fed on a ration of molasses/urea supplemented with groundnut meal, formaldehydre treated groundnut meal, or fish meal.

Table 4: Performance of creole heifers fed molasses/urea and different protein supplement.

	Protein supplement		
	Groundnut Meal		Fish Meal
	Untreated	Treated	
No. of animals	8.	8	8
Initial Weight (kg)	212.7	214.1	227.8
Final Weight (kg)	297.4	297.2	307.8
Daily Gain (kg)	0.48±0.07	0.45±0.07	0.52±0.07
DM intake*(kg/dy)			
Forage (unspecified)	1.26	1.26	1.28
Molasses/urea	5.00	4.70	5.39
Protein Supplement	0.22	0.22	0.18
Maize Grain	0.84	0.84	0.84
Total	7.32	7.02	7.69
Molasses as % of total DM	68	67	70
Molasses as % total ME	71.1	69.8	73
Me intake (MJ/day)	80.21	76.79	84.22
Conversion of ME, MJ/Kg	167.1	170.6	162.0

Source: Ma Poon, Delaitre and Preston (1975).

* Forage was fed at 3% liveweight. Molasses containing 2.5% urea was fed ad libitum along with 1 kg maize grain/kg, minerals ad libitum and either 0.24 kg groundnut meal, or 0.2 kg fish meal/day. The animals were group-fed.

ME-Metabolizable Energy.

MJ-Megajoule.

DM and ME were estimated based on figures given in Table 5.

Table 5: Dry Matter (DM) and metabolizable energy (ME) content of feed ingredients used in Table 4.

Feeds	DM%	ME, MJ/kg DM
Forage	20	9.0
Molasses	78	11.4
Maize Grain	84	14.1
Fish Meal	90	10.2

Grazing time on acacia (Leucaena leucocephola), with or without supplementary groundnut meal, on performance of bulls fattened on molasses/urea (Hulman, Delaitre and Preston, 1975).

Preliminary observations indicated that cattle being fattened on molasses/ urea based rations grew faster when grazing acacia, than when given elephant grass forage. It was thought this was due to the protein component in the acacia, hence the present experiment which aimed to test two levels of intake of acacia (by varying the length of grazing time, as replacement for groundnut cake.

MATERIALS AND METHODS

A factorial design was used in which the factors were: a) grazing on acacia for 3 or 8 hrs daily; and b) presence or absence of supplementary groundnut cake (300 g daily). The rest of the ration was ad libitum molasses/urea (2%), and minerals. Groups of 8 bulls, made up mostly of Creole but with some Zebu, were allocated to each treatment combination. The experiment began on 16 August 1973 and lasted 336 days and was carried out on the estate of Mr. R. Osman, Belle Isle.

RESULTS AND DISCUSSION

Mean values for live weight gain and feed consumption are set out in Table 6; the analysis of variance for gain is in Table 7.

Table 6: Mean values for liveweight gain and feed consumption.

	3 hrs Grazing		8 hrs Grazing	
	Unsupplemented	300 g gr. nut cake	Unsupplemented	300 g gr. nut cake
Live Weight, kg				
Initial	175	175	175	175
Final	307	329	369	357
Daily Gain	0.393	0.458	0.577	0.542
Molasses/Urea/kg/d	5	5	5	5
Molasses/Urea conversion, kg/live weight gain				
Feed Cost/kg gain,	12.7	10.9	8.67	9.23
Rs[1]/	3.1	3.48	2.11	2.94

Table 7: Analysis of variance for effects of grazing time and groundnut supplement on daily liveweight gain (g).

Source of Variation	Degrees of Freedom	Mean square	F Value	Significance
Time	1	[illegible]	[illegible]	P 0.01
Groundnut	1	293		
Interaction	1	5473		
Error	27	3937		

Rate of live weight was significantly greater for 8 hrs compared th 3 hrs grazing time, but there was no response to groundnut cake, r any evidence of intercation. Apparently, there were no differences molasses/urea intake between the different groups, however, the curacy of these latter data is suspect. Feed conversion and costs gain data should also be treated with reserve.

The superior protein value of acacia forage in this trial, compared ith the groundnut supplement, confirms earlier observations on the ame estate when there were no differences in animal response to supplements of fish meal or groundnut cake, for cattle having access to acacia grazing (unpublished data, Ministry of Agriculture and Natural Resources and the Environment). There were no problems of molasses toxicity in any of the animals.

Different levels of meat meal as a supplement to molasses/urea for bull grazing on acacia (Hulman, Delaitre and Preston)

This experiment aimed to test the value of different levels of meat meal as a supplement to acacia grazing and molasses/urea.

Materials and Methods: The treatments in a 3 x 2 factorial design were a) meat meal at levels of Zero, 200 and 400 g/d; and b) average inital weights of 89.4 and 149 kg, respecitvely. There was one group of 7 or 8 Zebu bulls on each treatment combination. Feeding was molasses ad libitum, containing 2% urea, the appropriate level of meat meal and approximately 3 hrs grazing daily on acacia. The trial was carried out on St. Antoine S.E beginning 4 February and lasted 308 days.

Results and Discussion: Mean values for live weight gain and feed consumption are set out in Table 8; the analysis of variance for live weight gain is in Table 9.

Table 8: Mean values for change in live weight and molasses intake 308 days trial at St. Antoine S.E.).

	Daily Gain in LW, g	Molasses/urea Conversion
Initial Weight 89 kg		
No. suppl.	258	16.4
200 g meat meal	378	13.3
400 g meat meal	322	15.5
Initial Weight 149 kg		
No. suppl.	259	19.3
200 g meat meal	434	13.3
400 g meat meal	408	14.0

Table 9: Analysis of variance for effects of initial weight and supplementation with meal meat.

Source of variation	Degrees of freedom	Mean square	F test	Significance
Meat meal	2	58826	8.28	P 0.05
Initial weight	1	7753		
Interaction	2	10084		
Error	29	7107		

There was a significant response in live weight gain to supplementation with meat meal; however 200 g/day seemed to be as effective as 400 g. Initial weight did not affect live weight gain and there was no interaction. Daily intake of molasses averaged 5 kg with no apparent differences between treatments, however, the precision of these latter data is doubtful. The results differ slightly from those of the previous experiment at Belle Isle Estate, in that here there was a response to low levels of supplement in combination with 3 hrs grazing on acacia. It is possible this would not have occurred if grazing time had been extended to 8 hrs. Moreover, superiority of meat meal over groundnut is to be expected in view of the lower solubility of the former. Overall level of performance on the unsupplemented treatment was lower than at Belle Isle, despite identical diet composition. This would tend to indicate a lower genetic potential for growth in the cattle at St. Antoine; these were almost entirely Zebu while, at Belle Isle, the breed was mainly Creole. As at Belle Isle, there were no problems with molasses toxicity.

Acacia (Leucoena leucocephala) as sole forage and protein source for fattening bulls fed molasses/urea (Ma Boon, Delaitre, Preston 1975)

Previous trials with acacia forage have used grazing techniques, to control intake by time. Under these conditions, it is impossible to know the actual intake of acacia. This experiment was therefore carried out with acacia forage cut and fed to animals in complete confinement in order to determine more precisely the optimum daily intake.

Materials and Methods: A production function design was used to measure response to levels of freshly cut acacia forage of 0.5, 1.0, 2,0 and 3.0% of live weight. The rest of the ration was ad libitum molasses containing 2% urea and minerals; at the zero level of acacia, it was intended to use bagasse as a nutritionally inert forage, however, it was not consumed readily and was replaced by elephant grass at the level of 1% of live weight. Four individually fed Zebu bulls were allocated to each acacia level. The trial lasted 206 days and was carried out or Richelieu Agricultural Station.

Results and Discussion: Mean values for weight gain and feed intake are in Table 10. Figure 1 shows the relationship between acacia level and daily gain.

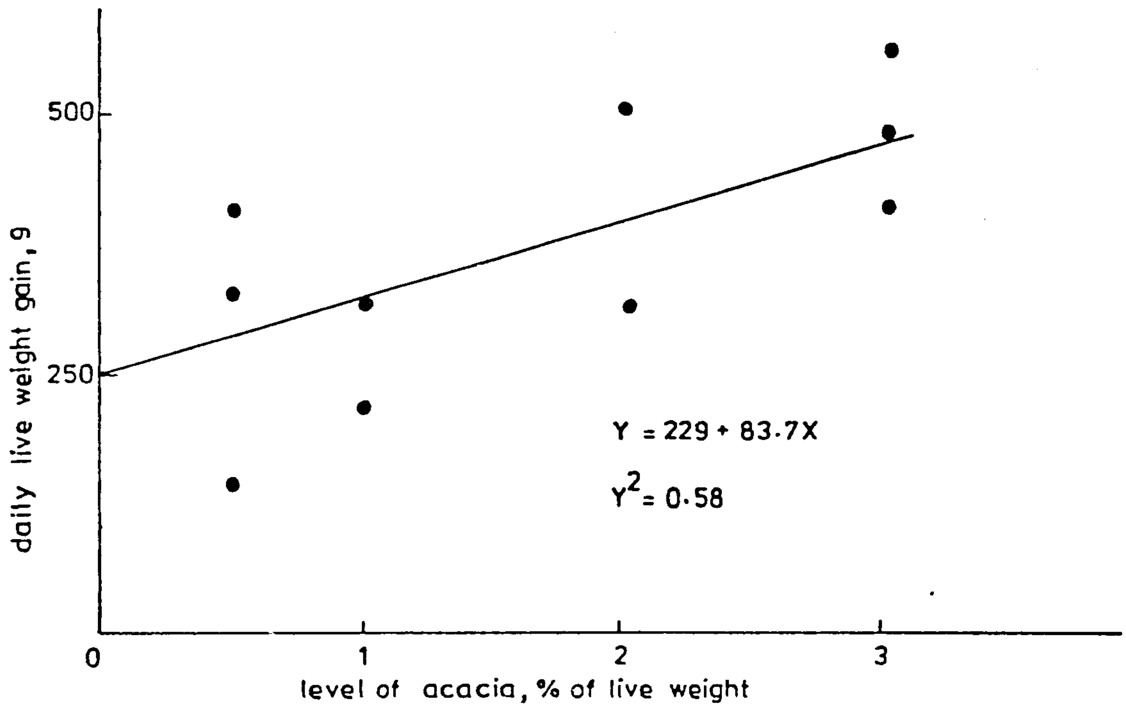

Fig. 1. Relation between daily live weight gain and level of acacia.

Table 10: **Mean values for live weight change and feed intake.**

	Level of acacia, % of live weight				
	0	0.50	1.0	2.0	3.0
Initial weight, kg	136	147	157	133	142
Final weight, kg	186	209	213	218	247
Daily gain, g	242	299	274	415	493
Feed intake, kg/d					
Molasses	3.83	4.41	4.08	4.25	4.36
Urea	0.077	0.088	0.082	0.085	0.087
Acacia	1.16	0.61*	1.28	2.54	3.98

* Elephant grass; this group also received trace elements and Vitamines A, D and E.

There was a linear response in live weight gain according to increasing level of acacia. The indication from the data is that the optimum level may lie beyond 3% of live weight; a similar inference can be drawn from the trial at Belle Isle, where 8 hrs grazing on acacia gave better growth that 3 hr. There was a suggestion that molasses intake increased slightly as between the various levels of acacia and the control treatment receiving elephant grass; but there were no differences within the different levels of acacia.

At the maximum level of acacia, the estimated intake of protein was some 150 g daily, which is comparable with that usually provided when supplements such as fish meal or groundnut meal are used.

Ensiled high moisture or dry maize as supplement to fattening rations based on ad libitum molasses/urea (Ma Poon, Delaitre, and Preston):

There is no strong evidence that molasses based rations are used with greater efficiency when supplemented with gluconeogenic material such as cereal grain. There are also suggestions that when grains, particularly, maize are ensiled at a high moisture content, this is associated with greater production of propionic acid in the rumen. This latter effect would be particularly beneficial on molasses rations. The following experiment was set up to test this hypothesis.

Materials and Methods: The two treatments in a random block design were a) dry ground maise fed at 1 kg daily; and b) the same maize, but ensiled for 21 days after raising the moisture content to approximately 30%. There were two groups of 6 bulls on each treatment. The rest of the ration was ad libitum molasses/urea, green forage at 3% of live weight, 300 g fish meal daily and minerals. The experiment was carried out at Palmar LBS and lasted 186 days.

Results and Dicussion: Mean values for live weight gain and feed intake are given in Table 11. The analysis of variance is in Table 12.

Table 11: Dry or ensiled maize, as a supplement for fattening rations based on molasses/urea.

	Ensiled Maize	Dry Maize
Initial weight, kg	165.2	177.5
Weight final, kg	254.5	252.3
Daily gain, g	480	400
Feed intake, kg/d		
Crass	8.44	861
Molasses	3.81	3.47
Urea	0.095	0.085
Maize	1.41	1.14
Fish Meal	0.2	0.2

At 30% moisture.

Table 12: Analysis of variance for weight gain.

Source of Variation	Degrees of freedom	Mean Square
Maize	1	840.75
Replicates	1	324
Interaction	1	6.3
Error	12	966

There was a slight indication towards growth rate on the ensiled maize treatment but the difference did not reach significance. At least it can be concluded that results will not be poorer with ensiled maize. This is of considerable practical value, since it is cheaper and affords protection against insects, to ensile maize at high moisture content. It also allows earlier harvesting, which is an advantage when maize is being grown in association with sugar cane and it is important to harvest it as early as possible. Harvesting at 30% moisture probably saves 20 to 30 days and ensiling avoids the need for expensive drying.

Use of Poultry Litter in a diet of molasses and bagasse for fattening bulls (Ma Poon, A. Boodoo, Hulman and Preston) Min of Agriculture, Reduit, Mauritius:

Eight bulls averaging 144 kg liveweight were fed a mixture which contained raw bagasse 20%, molasses 35%, poultry litter 37%, fish meal 3%, groundnut meal 4% and salt 1% for a period of 185 days. The daily liveweight gain over 185 d averaged 650 ± 55 g with a dry matter intake of 4.02% of liveweight.The overall feed conversion was 12.7 kg DM/kg gain. It appears that the feed has a low energy concentration with molasses constituting most of the utilizable energy.

Key words: Cattle, poultry litter, molasses, bagasse.

Use of poultry litter as a source of non-protein nitrogen in ruminant feeding is becoming increasingly popular in terms of utilization of waste products and in decreasing feed costs. This trial was undertaken to evaluate the use of poultry litter in a molasses based diet for growing bulls.

Materials and Methods: Animals and treatments. Eight bulls (six Friesian x Creole and 2 Simmental x Friesian) of about 140 kg liveweight were used to evaluate a diet consisting of poultry litter, molasses, bagasse and a protein supplement (Table 13). The bulls were housed in a slatted floor pen in the feedlot at Richelieu Livestock Breeding Station of the Ministry of Agriculture. The trial started in November 1978 and lasted for 185 days.

With regards to feeds and management, the different feed ingredients were mixed in a Gehl mixer and stored in bags. One ton of the mixture was made at one time sufficient to feed the animals for about 10 days. Poultry litter was obtained from the Poultry Breeding Centre of the Ministry of Agriculture. The refusals were weighed each morning before feeding the fresh mixture. Fresh water was available at all times. The poultry litter and the complete mixed feed mixture were analysed periodically. The animals were weighed every fortnight. The average daily liveweight gain was determined by regression of liveweight on time.

Results: The composition of the poultry litter and of the complete feed was fairly uniform during the trial (Table 13). The ash content of the mixture was quite high (15% of DM). For this reason, dicalcium phosphate was not included as it was assumed that the animals' requirements were met.

Table 13: Composition of diet and proximate analysis.

Composition, %		Analysis, %		
Ingredient			P. Litter	Complete Diet
Raw bagasse	20	Dry matter	88.6 ± 1.22	76.4 ± 1.0
Molasses	35	N x 6.25[1]	18.7 ± 0.9	14.9 ± 0.48
Poultry Litter	37	Crude fibre[1]	18.9 ± 0.3	18.0 ± 0.43
Local Fish Meal	3	Ether extract[1]	0.71 ± 0.09	0.55 ± 0.03
Groundnut Meal	4	Ash[1]	19.7 ± 1.46	15.0 ± 0.56
Salt	1			

1) Dry matter basis.

The animals were in good health throughout the trials and there were no apparent digestive troubles. At one stage, the animals had distended abdomens such as in the case of bloat, but this did not persist.

The intake of the poultry litter mixture increased from 7 kg/d initially to about 12 kg/d by the end of the trial with a mean intake of about 10 kg (Table 14). The mean daily liveweight gain of 650g was associated with a dry matter intake of over 4 kg/100 kg liveweight. The intake of molasses was equivalent to about 1.8% of body wight which is similar to that observed when liquid molasses is given ad libitum together with restricted forage (Preston, 1979).

Table 14: Mean values ($\bar{X} \pm SE_{\bar{x}}$) for growth rate, feed intake and conversion of eight bulls fed a diet of molasses, poultry litter, bagasse and protein supplement (185-day trial).

Initial weight, kg	144.2
Final weight, kg	264.9
Liveweight gain, g/d	649 ± 55
Feed intake, kg/d	
Complete diet	10.8
Dry matter	8.22
Consumption index[1]	4.02
Conversion[2]	12.7

1) kg DM.100 LW   2) DM consumed/LW gain

Discussion: The important feature of the results of this trial is that although the feed conversion rate (12.7 kg DM/kg gain) was poor, there was still a reasonable growth rate of 650 g/d. Similar results have been observed in commercial feedlots in El Salvador, where an almost identical ration has been used (Preston, T.R. unpublished observation). In comparison, liquid molassess/urea based diets employing restricted levels of cassava or sweet potato forage as the only source of protein and roughage have supported similar growth rates, with a much better feed conversion (Ffoulkes & Preston, 1978 and Hulman et al., 1978).

It, therefore, appears that the efficiency of the rumen fermentation is inferior on the poultry litter/bagasse/molasse diet. One possible reason for this could be a low turnover rate of rumen digesta, which is known (a) to reduce the efficiency of microbial protein synthesis (Stouthamer and Bettenhousen, 1973, Elliott et al., 1978) and (b) to also lead to wasteful secondary fermentation associated with oxidation of VFA to methane and carbon dioxide (Rowe et al., 1979).

Other work with molasses based diets (Salais et al., 1977) has shown that sugar cane fibre fed with liquid molasses/urea does not result in efficient feed conversion or rapid growth. It is suggested that this is because the cane fibres do not have "good" roughage characteristics. It may be that the diet used here would be improved by the inclusion of a forage known to have beneficial effects on rumen function such as for emple the legume Leucaena (Alvarez et al., 1978). This hypothesis will be examined in future studies with this diet.

High molasses/urea diets for Mike Production: Nutritive value of molasses/bagasse mixtures as a production ration for milking cows (Ma Poon, Delaitre and Preston).

When the molasses/bagasse pith mixture developed as part of the activities of the Milk and Meat Project (Mar/63/504), was fed to the entire milking heard at Curepipe LBS, over a complete lactation results were unsatisfactory. There was considerable loss of live wight and milk yield was less than had been the case previously when the standard cereal-based concentrate had been used. It was therefore decided to determine more precisely the relative feed value of the mixture in comparison with grass alone and the cereal-based cow feed, as negative and positive control treatments, respectively. Opportunity was also taken to include a modified molasses/bagasse feed with additional maize grain, and a treatment in which only groundnut cake was given.

Materials and Methods: A changeover design was used to compare the following treatments

a) Grass only
b) Standard cereal-based cow feed at 500 g/litre of milk
c) Molasses/bagasse mixture (MB at 600g/litre of milk)
d) Molasses/bagasse mixture with additional maize (MB_g)
e) Molasses/bagasse mixture with maize but omitting the groundnut cake (MB_m)

f) Groundnut cake fed at 200g/litre of milk

The composition ofthe mixtures is given in Table 15.

There were 10 cows on each treatment and the experimental arrangement was

S_1 ----- E ------ S_2 where

S_1 = standardization period, days 1 to 30

E = experimental period, days 41 to 100

S_2 = standardization period, days 111 to 140

Days 31 to 40, and 101 to 110 were for ration changeover.

All cows received fresh grass <u>ad libitum</u>, in addition to the experimental treatments. Milking was done by hand twice daily. The cows were mainly Creole, with some grade Friesians.

Table 15: Composition of experimental rations (% as received).

	MB_g	MB_{mg}	MB_m	Cereal cow feed
Molasses	73.4	52.4	58.4	2,5
Bagasse pith (dried)	14	10	12	-
Groundnut cake	8	8	-	10
Urea	2.5	2.5	2.5	-
Vit, A & D premix	0.1	0.1	0.1	0.1
Dicalcium phosphate	1	1	1	1.5
Salt	1	1	1	1.0
Maize grain	-	25	25	32.4
Cotton Seed Meal	-	-	-	20
Rice Bran	-	-	-	10

Results and Discussion: Mean values of milk yield during the standardization and experimental periods, yield persistency and daily live weight gain during the experimental period are given in Table 16.

Table 16: Mean values for milk yield, persistency and live weight change according to treatment.

	S_1 1-30	E 41-100	S_2 111-140	Persistency, % 1	Daily LW gain kg 2
Control grass	11.43	6.08	5.12	$.74^{a}$	$.72^{a}$
MB_g	10.70	6,78	5,86	$.83^{ab}$	$.31^{ab}$
MB_g	11.62	7.61	6.06	$.88^{bc}$	$.36^{ab}$
MB_m	9.97	6,90	5,76	$.88^{bc}$	$.00^{b}$
Cereal Concentrate	10.2	7.65	6.62	1.00^{c}	$.00^{b}$
Groundnut Cake	10.2	7.77	6.13	$.95^{c}$	$.13^{b}$
SE				±.033	±.17

$$1 \frac{E}{S_1 + S_2}$$

2 During experimental period

ab Means without common superscript differ at $P<.05$.

Persistency was significantly less for cows receiving only cut grass than for all other treatments, other than the standard molasses/bagasse mixture (MB_g), where some supplement was given. The standard molasses/bagasse mixture (MB_g) was also poorer than the cereal concentrate but did not differ from the other modified molasses/bagasse mixtures (MB_g and MB_m). A similar tendency was noted for both weight change during the time when the experimental rations were fed. All the molasses0bagasse rations, when grouped together, were significantly poorer for persistency, than the cereal concentrate.

The results thus confirm the earlier observation that molasses/bagasse mixtures are not as efficient as cereal concentrates in supporting milk yield. There was a suggestion of improvement from modifying them by inclusion of 25% maize; but without additional maize they were not significantly better than grass alone. Surprisingly, groundnut cake given alone gave both good persistency and live weight gain. From an economic point of view it was also cheaper than the cereal concentrate.

Effect of adding unsaturated oil to a molasses/bagasse mixture fed as a production ration to milking cows (Ma Poon, Delaitre, and Preston).

The justification for adding unsaturated oil to molasses/bagasse rations is:

a) such rations are deficient in dietary lipids, and a proportion of milk fat is of dietary origin; and

b) there is evidence that inclusion of unsaturated oils in the diets of ruminants leads to an increase in the production of propionic acid in the rumen - and it is generally considered that gluconeogenic procursors, the chief of which is propionic acid, are limiting on molasses-based rations. This experiment was aimed to provide preliminary evidence on this aspect.

Materials and Methods: A changeover design was used to compare the standard molasses/bagasse mixture (MB_g), alone or with 100ml unsaturated oil daily, against the standard cereal-based cow feed. As the cows available were already advanced in lactation, the experiment had to be carried out over the latter part of the lactation curve. Six cows were used on each treatment, employing the following changeover design.

S E S where

S_1 = standardization period (cow feed) from days 101 to 115

E = experimental period days 121 to 150

S_2 = standardization period (cow feed) days 156 to 170

Days 116 to 120 and 151 to 155 were for ration changeover. The standard molasses/bagasse mixture contained (%) - molasses 73.5. Urea 2.5, Bagasse pith (dried) 14, groundnut cake 8, dicalcium phosphate 1 and salt 1. It was fed at the rate of 500 g per litre of milk. Feeding was identical for the oil treatment, except that 100ml of oil were given daily, mixed into molasses/bagasse feed. The rest of the ration was fresh forage ad libitum. Creole cows were used and the trials were carried out at Curepipe LBS. Soybean oil was used.

Results and Discussion: Not all the cows have completed the experiment hence only preliminary data are presented (see Table 17).

Table 17: Effect of unsaturated oil on milk yield persistency and live weight gain, using a molasses/bagasse feed (MB) as a production ration (preliminary data only; no. of cows in brackets).

	Control	Oil
Yield persistency	.92(1)	.96 (3)
D[illegible]y live weight gain, kg	-.30(3)	+.098(4)

Care must be exercised in the interpretion of these data in view of the small number of animals involved, nevertheless, there is an indication from particularly, the weight gain data that the oil is having some beneficial effect. The loss in weight on the control ration (MB_g) is of the same order as was observed in the previous experiment.

High molasses/urea feeding to goats trials had to be stopped as the animals got very messy with the molasses resultng infly strike.

Bagasse as a feed

As said earlier nothing could be more fibrous and less nutritive than bagasse. It had been reported in the literature that whenever whole bagasse would be fed to ruminants for long period there was an irritant to the mucosa of the rumen resulting in ruminitis.

Results of using steam treated bagasse as a source of roughage is reported hereunder.

Raw and steamed bagasse as roughage sources for bulls fattened on molasses/urea (Naidoo, Delaitre and Preston, 1975)

Green forage, either as cut grass or cane tops, can often be a constraint to cattle production in Mauritius because of availability. It is also relatively expensive at Rs. 50. - per ton fresh basis, equivalent to Rs. 250. -/ton dry matter (which is more expensive than molasses). Excess bagasse (i.e. surplus to needs for steam raising) is available on most sugar estates, and total yearly production is of the order of 130,000 tons (dry basis). It has good physical characteristics as a roughage for molasses fattening, however, it is not very palatable. Raw bagasse can be imnproved in both palatability and nutritive value by steam cooking it under pressure for 10 minutes (d'Espaignet et al 1974). This experiment aimed to evaluate both raw and cooked bagasse as sources of roughage in the molasses/urea fattening programme.

Materials and Methods: The four treatments in a random block design were - (a) raw bagasse; (b) cooked bagasse; and (c) fresh forage. There were two groups of 5 Zebu bulls on each treatment. Feeding was molasses/urea ad libitum, 200 g fish meal, 1 kg maize and minerals; bagasse was given ad libitum and fresh forage at 3% of live weight. The experiment lasted 316 days and was conducted at Palmar LBS.

Results and Discussion: Mean values for live weight gain and feed intake are given in Table 18.

Table 18: Raw or steam cooked bagasse as sources of roughage in a fattening diet based on molasses/urea.

	Raw bagasse	Steam cooked bagasse	Green forage
Live weight, kg			
Initial	176	195	210
Final	271	298	367
Daily gain	.336[a]	.337[a]	.496[a]
Feed intake, kg/d			
Molasses	5.2	5.2	5.8
Urea	.127	.128	.144
Bagasse	.51	.78	10
Fish Meal	.2	.2	.2
Maize Meal	1	1	1
Salt	.025	.025	.025
Dicalcium phosphate	.025	.025	.025

Table 19: Analysis of variance for gain (g/d).

Source of variation	Degrees of freedom	Mean square	F. value	Significant
Treatment	2	78 797	6.08	P .05
Replicate	1	54 267		
Interaction	2	6 370		
Error	20	12 950		

There were no differences in rate of gain as between raw and steam treated bagasse but both were inferior to fresh forage; the advantage of the latter may be that it provided additional protein, as well as roughage. In this case, when bagasse is used, it may be necessary to give additional amounts of protein supplement. This aspect should be investigated. Please refer to earlier section pagasse pith has been used as an absorbent for molasses.

Scums:

The author ran a digestibility trial (1960) by feeding scum rations to cattle and pigs.

The salient features established were that the wax (benzene extract) portion of the scum were apparently digested by cattle to the extent of 72% whilst the supposedly proteinous part (Nx6.25) showed a digestibility of 50%. However, both the Benzene extract fraction and the Nitrogenous fraction appeared to be undigested by the monogastric pig. Unpublished results of observations made by Delaitre, Lam Thon Mine (1976) are shown hereunder.

Results of Analysis of Scum for Animal Production Division:

To determine the variation of Protein and fibre content of a specimen of scum left to decompose at Mon Desert Alma. A specimen of scum has been set aside in September 1975 at Alma and left to decompose. Every seven days two samples top and middle were collected and analysed for DM, protein and fibre. Sample "top" was collected 1/2 to 1 inch immediately under uppermost layer. Sample "middle" i.e the undecomposed part was collected from the middle of the specimen.

The protein of the top layer rose from 12.9% in September 1975 to attain a maximum of 24.0% in May 1976 and afterwards remained around 21.0 and 22.0% and evidenced by the graph. That of the middle layer did not show any appreciable change.

Filter cake scum is surely one of the by-products of the sugar industry requiring further studies. The material becomes fowl smelling soon after production resulting in the nitrogenous components becoming so stable that it can not be digested by monogastics.
As for the increase of nitrogenous component on storage it is believed to be due to the elimination of sugar from the Dry Matter component by fermentation and release of carbon dioxide.

Sugar (Brown and White):

In 1970, the author replaced 10% of maize in chicken and layers rations by brown sugar.

Table 20: Top Layer (Results on DM Basis).

Date of collection	% DM	% moisture	Prot, % DM	Fibre % DM	Date of collection	%DM	% moisture	Prot. % DM	Fibre % DM
29.09.75	20.6	79.4	12.9	19.3	29.03.76	17.5	82.5	21.8	14.5
06.10.75	21.0	79.0	13.0	22,5	05.04.76	17.5	82.5	17.5	21.[illegible]
13.10.75	21.6	78.4	13.1	23.6	12.04.76	19.8	80.2	23.3	23.3
21.10.75	20.7	79.3	17.2	20.7	20.04.76	17.7	82.3	22.8	10.[illegible]
27.10.75	23.3	76.7	14.2	20.1	26.04.76	19.2	80.8	22.8	12.4
04.11.75	22.9	77.1	13.4	23.4	03.05.76	18.5	81.5	22.3	14.0
10.11.75	29.1	70.9	17.8	22.1	10.05.76	15.7	84.3	24.0	15.9
24.11.75	18.3	81.7	14.4	29,3	17.05.76	15.2	84.8	21.6	16.6
03.12.75	28.6	71.4	17.4	22.9	24,05.76	20.0	80.0	21.0	14.0
26.01.76	18.2	81.8	20.2	14.3	31.05.76	16.4	83.6	23.9	14.8
02.02.76	15.5	84.5	19.5	17.4	14.06.76	15.9	84.1	21.9	15.1
18.02.76	15.0	85.0	20.4	22.4	21.06.76	15.0	85.0	20.1	15.3
01.03.76	16.2	83.8	20.4	13.0	28.06.76	14.6	85.4	21.5	14.5
08.03.76	16.0	84.0	23.6	15.2	05.07.76	16.0	84.0	21.7	17.4
15.03.76	17.0	83.0	22.8	12.5	12.07.76	14.4	85.6	20.7	16.2
22.03.76	19.6	80.4	22.8	29.1	19.07.76	17.3	82.7	22.3	15.5

Observations (a) high mortality up to 20% in chicks 1-10 days P . M . observation inflammed intestine.

(b) no difference in performance of birds that survived.

(c) layers performed well on the ration.

Most of the poultry feed presently manufactured in Mauritius contain up to 10% sugar - some problems have been encountered with these rations during periods of high relative humidity, however, this problem has been controlled by the addition of calcium poprionate at the rate of 2 kgs per ton of feed.

Table 21: Middle Layer (Results on D.M. Basis)

Date of Collection	% D.M.	% Moisture	Protein % D.M.	Fibre % D.M.
26.1.76	19.0	81.0	16.4	23.4
2.2.76	17.6	82.4	14.0	28.1
18.2.76	15.9	84.1	18.6	20.2
1.3.76	17.1	82.9	17.5	20.2
8.3.76	15.2	84.8	20.0	14.0
15.3.76	16.7	83.3	19.7	13.8
22.3.76	17.5	82.5	16.8	15.8
29.3.76	19,1	80.9	15.6	21.8
5.4.76	18.3	81.7	16.4	24.0
12.4.76	19,0	81.0	17.0	25.6
20.4.76	17.1	82.9	16.3	23.8
26.4.76	13.7	87.3	17.5	22.4
3.5.76	17.8	82.2	15.8	25.2
10.5.76	16.3	83.7	15.3	26.4
17.5.76	16.4	83.6	16.2	22.4
24.5.76	17.4	82.6	16.6	20.6
31.5.76	16.2	83.8	25.3	23.0
14.6.76	14.6	85.4	19.0	13.4
21.6.76	14.5	85.5	14.8	22.6
28.6.76	14.2	85.8	15.7	21.5
5.7.76	14.7	85.3	19.4	15.6
12.7.76	16.0	84.0	16.4	24.5
19.7.76	14.7	85.3	17.3	20.0

UTILISATION OF BY - PRODUCTS BY PIGS

The author wished to present the following results so far unpublished carried out in 1975 by Delaitre, Brasse and Duvivier working at St Antoine Piggery in Mauritius.

The piggery was at the time facing great economic difficulties. It was the application of results obtained in Trial 6 that allowed the piggery to survive.

Trial "Scums, molasses and fish meal"

This trial was carried out in an attempt to find means of lowering the cost of production of porkers using locally available products such as molasses, scums and cow dung. Cow dung is the sun dried waste obtained from corrals where cattle are kept overnight.

This tested feed was formulated as follows:

Scum	50 %
Molasses	20 %
Fish Meal	30 %

Total Cost Rs. 670.-/M ton

Three group of pigs were used in this trial

Group I	Balanced ration "EPOL" + ad lib test formulation
Group II	1/2 " " "EPOL" + " " "
Group III	Balanced ration "EPOL" only. This group is the control group

Table 22: Results

	Group I	Group II	Group III
Start of trial	16.5.75	16.6.75	23.6.75
Age at start (wks)	9	9	10
No of animals	6	6	6
Combined weight at start,kg	91.5	109.5	144.5
Average weight, kg	15.25	18.25	24.0
Combined weight @ end, kg	354	336	417
Average weight @ end, kg	59	56	69.5
Age @ end (wks)	21	21	20
L.weight gain, day, gm	552	384	624
F. C. R.	3.7	4.9	2.6

N.B.: Trials were carried out to determine feed intake and it was noted that the best method of feeding was to give a 50:50 mixture of "EPOL" balanced ration and test formulation.

Table 23: Cost of Production (from 7.8.75 to 21.8.75).

Group	L.W gain (kg)	Feed consu. (kg)	Cost of feed (Rs.)	Labour costs (Rs.)	Other expenses (Rs.)	Total exp. (Rs.)	Cost of product. (Rs./kg)
I	57.0	238	222,53	5.18	10.00	257.71	4.17
II	63.0	257	237.49	5.18	10.00	252.67	4.01

Trial ad lib "EPOL" Feed

This trial was carried out to determine means of achieving the maximum liveweight gain in the shortest possible time.

Feed was placed in the feeders and the amount left in the feeders every morning was weighed. This gives an estimate of daily feed consumption.

Table 24.

Details	Batch ad-lib
Start of trial	1.4.75
Age at start, wk	5
No. of animals	11 (4males, 7 females)
Combined weight @ start,kg	77.5
Average weight @ start, kg	7.0
Combined weight @ end, kg	792
Average weight @ end, kg	72
Age at end (28.7.75), wk	15
Liveweight gain, day, grms	774
F.C.R.	2.6

Table 25: Cost of Production (from 1.4.75 to 2.6.75)

Detail	Batch ad-lib
Liveweight gain, kg	343.5
Feed consumed, kg	1152.5
Cost of feed, Rs.	1407.75
Labour cost, Rs.	20.72
Other expenses, Rs.	10.00
Total expenses, Rs.	1438.47
Cost of Production, Rs./kg	4.19

Trial ad lib No. 2 "EPOL" Feed:

This trial was carried out to have a comparison and, at the same time, improve the results.

Table 26:

Details	Batch ad-lib No. 2
Start of trial	25. 7.75
Age at start, wk	5
No. of animals	7(4 males,3 females)
Combined weight @ start, kg	81.5
Average weight @ start, kg	11.6
Combined weight @ end, kg	527
Average weight @ end, kg	75.2
End of Trial	11.11.75
Age at end, wk	20
Duration of experiment, wk	15
Liveweight gain, day, grms	790
F.C.R.	2.9

Table 27: Cost of production

Details	Batch ad-lib No. 2
Liveweight gain, kg	379.5
Feed consumed, kg	1533.5
Cost of feed, Rs.	1851.70
Labour costs, Rs.	28.31
Other expenses, Rs	10.00
Total expenses, Rs.	1890.01
Cost of production, Rs./kg	4.90

N.B.: This was calculated only for the animals sold.

Trial + cow dung, molasses and fish meal:

Further trials were made with cow dung which contains 18% protein DM. The objective was to reduce cost of production.

The tested feed was formulated as follows:

Cow dung	50 %
Molasses	25 %
Fish meal	25 %
Total cost	Rs. 560. -/ton

This feed is given mixed with "EPOL feed in the ration of 1:1.

Table 28:

Details	
Start of trial	6.9.75
Age at start wks	8
No. of animals	8(6 males, 2 females)
Combined weight @ start kg	125.0
Average weight @ start, kg	15.6
Combined weight @ end, kg	570
Average weight @ end, kg	71.2
End of trial	22.12.75
Age at end, wk	25
Duration of trial wk	15
Liveweight gain day grm	738
F.C.R.	3.5

Table 29: Cost of Production (from 6.9.75 to 16.12.75)

Details	
Liveweight gain, kg	400
Feed consumed, kg	1820
Cost of feed, Rs.	1638.00
Labour costs, Rs.	36.26
Floxaid, Rs.	14.00
Other expenses	-
Total expenses, Rs.	1688.20
Cost of production, Rs./kg	4.03

Trial "Scums, molasses, fish meal" No.2

This trial was carried out to compare the efficiency of cow dung and scums in mixtures which were composed of locally available products.

Tested feed formulation

Scums	15 %
Molasses	50 %
Fish Meal	35 %

Total cost Rs. 775. -/ton

The above feed is given mixed with 50% imported feed so as to compensate for loss of vitamins.

Table 30:

Details	
Start of trial	6.9.75
Age at start, wk	8
No. of animals	10 (5 males, 5 females)
Combined weight @ start, kg	143.0
Average weight @ start, kg	14.3
Combined weight @ end, kg	628.0
Average weight @ end, kg	62.8
End of trial	22.12.75
Age at end, wk	23
Duration of trial, wk	15
Liveweight gain, day, grms	599
F.C.R.	4.0

Table 31: Cost of Production (Period 6.9.75 - 16.12.75)

Details	
Liveweight gain, kg	437
Feed consumed, kg	1820
Labour cost, Rs.	36.26
Floxaid, Rs.	14.00
Other cost, Rs.	-
Total cost, Rs.	1870.20
Cost of Production, Rs./kg	4.27

Trial "cow dung, molasses, groundnut cake"

This trial was carried out to see whether or not fish meal could be replaced by groundnut cake, the latter being a cheaper product.

Feed formulation was as follows.

Cow dung	50%
Groundnut Cake	25%
Molasses	25%

Total cost Rs. 400/ton

Table 32 :

Details	
Start of trial	19.11.75
Age at start, wk	7
No. of animals	10(2 males, 8 females)
Combined weight @ start, kg	125.5
Average weight @ start, kg	12.55
F.C.R (as on 16.12.75)	2.7
Combined weight as on 16.12.75,kg	2640
Average weight as " " kg	26.4
Age of animal " " " kg	11
Liveweight gain per day/grm	513.9

CONCLUSIONS

In this paper, comprehensive data had been provided on efforts being made by Mauritius, a relatively small Island, in its endeav-ours to employ a new technology with a view to providing milk and meat for its population and thereby saving on foreign exchange.

It is known that the population of 41,000 head of cattle and 90,000 head of goat has reached saturation point to produce milk and meat on orthodox methods of feeding cattle and goats. However, there are very large quantities of by-products of the sugar industry which can be utilised in aequately feeding the existing animal population. The estimated quantities available are as follows:

200,000 tons of molasses
1,700,000 tons of cans tops
100,000 tons of excess bagasse
200,000 tons of scums

It has been further estimated that the total feed value of these by-products when supplemented with urea and or ammonia and some natural protein should be sufficient to satisfy the needs of a cattle population of some 200,000 head. The production from this National herd would be the equivalent of 17,000 tons of beef and 100 millions litres of milk per year. This potential production is sufficient to supply the needs of Mauritius during the next decade at a level of over 100 litres of milk and 25 kg of beef per capita per year.

These can well be the targets of the long term efficient livestock development of Mauritius with the aim of feeding the cattle production industry almost entirely on by-products of the sugar industry.

It is further believed with a fair degree of certainty that pigs of less sophisticated characteristics than the Landrance and the Large White breeds, possibly crosses of the Saddleback or Tamworth with local pigs, and also ducks could be reared on a feeding system based on molasses, scums and some natural protein.

This planning for the future has three major elements.

1) To carry out research aimed at developing efficient feeding systems for milk, beef and other types of livestock production based on the maximum use of locally available by-products of the sugar industry or other industries and on fodder from cane grown on marginal lands.

2) To build up cattle numbers from the present 40,000 to the projected potential of 2000,000 and also to develop suitable types of pigs and ducks to perform efficiently on molasses diets.

3) To establish models for production of milk and beef and other types of livestock production at a level of State Enterprises and as types of light industries on the sugar estates and at village levels through some form of cooperative schemes.

Lastly, I should point out that all of us have a duty towards the future development of our countries. Success for the future, therefore rests on us to develop new technologies, create training facilities for our youths and collaborate as much as we can in sharing our know now. We should have regular forums where the on coming generating of young technicians and professionals can not only present the result of their work, but also have fruitful discussions for the economic well-being and happiness of all our people.

REFERENCES

1. ANON. (1976) Energy allowances and feeding systems for ruminants. Technical Bulletin 33. Ministry of Agriculture, Fisheries and Food. United Kingdom.

2. GAYA, H., DELAITRE, J.A.C. and PRESTON, T.R. (1977) Effect of restricted suckling and bucket feeding on the growth rate of calves and on milk yield. Tropical Animal Production 2, 284-287.

3. GAYA, H., HULMAN, B. and PRESTON, T.R. (1978) Effect of two methods of restricted suckling on performance of the cows and growth rate of the calves. Tropical Animal Production 3, 118-124.

4. GOHL, B. (1975) Tropical Feeds, Feeds Information Summaries and Nutritive Values. Food and Agriculture Organization of the United Nations, Rome. 661 pp.

5. HARDOUIN, J. (1973) Milk and Meat Project, Mauritius. Final field draft. Food and Agriculture Organization of the United Nations, Rome.

6. AULMAN, B., DELAITRE, J.A.C. and PRESTON, T.R. (1975) Grazing time on acacia (Leucaena leucocephala), with or without supplementary groundnutmeal, on performance of bullsfattened on molasses/urea in Milk and beef from sugarcane and its by-products. Ministry of Agriculture and Natural Resources and the Environment in collaboration with the UNDP project MAR/73/006, Mauritius.

7. HULMAN, B., OWEN, E. and PRESTON, T.R. (1978) Comparison of Leucaena leucocephala and groundnut cake as protein sources of or beef cattle fed ad libitum molasses/urea in Mauritius. Tropical Animal Production 3, 1-8.

8. LENG, R.A. and PRESTON, T.R. (1976) Sugar cane for cattle production. Present constraints, Perspectives and Research Priorities. Tropical Animal.

9. PRESTON, T.R., ELIAS, A. WILLIS, M.B. and SUTHERLAND, T.M. (1967) Intensive beef production from molasses and urea. Nature 216, 721-722.

10. PRESTON, T.R. and WILLIS, M.B. (1974) Intensive beef production (2nd edition) Pergamon Press. Oxford, London, New York, Toronto, Sydney.

11. PRESTON, T.R., WILLIS, M.B. and ELIAS, A. (1967) Intensive beef production from sugarcane. I. Different levels of urea in molasses given ad libitum to fattening bulls as a supplement to a grain diet. Revista Cubana de Ciencia Agricola (English edition) I, 33-40.

12. THOMSON, D.J. (1978) Utilization of the end products of digestion for growth. In Ruminant Digestion and Feed Evaluation. Osbown, D.F. Beever, D.E. and Thomson, D.J. (Editors). Grassland Research Institute. Hurley. Berkshire. England.

13. MA POON, L.K., DELAITRE, J.A.C. and PRESTON, T.R. (1975) Comparison of groundnut meal, formaldehyde-treated groundnut meal and fish meal as protein sources in a molasses/urea fattening diet in Milk and beef from sugarcane and its by-products. Ministry of Agriculture and Natural Resources and the Environment in collaboration with UNDP project MAR/73/006, Mauritius.

14. ———————— (1977) The value for milk production of supplements of mixtures of final molasses, bagasse pith and urea, with and without combinations of maize and groundnut cake. Tropical Animal Production 2, 148-150.

15. ———————— (1975) Effect of adding unsaturated oil to a molasses/bagasse mixture fed as a production ration to milking cows in Milk and beef from sugar cane and its by-products. Ministry of Agriculture and Natural Resources and the Environment in collaboration with UNDP project MAR/73/006, Mauritius.

16. MARTIN, J.L., PRESTON, T.R. and WILLIS, M.B. (1968) Intensive beef production from sugarcane. 6. Napier or maize as forage sources at two levels in diets based on molasses/urea. Revista Cubana de Cienda Agricola (English edition) 2, 175-181.

17. MILES, D.A. (1971) Investigations into the composition, digestibility and feeding value of dried sugar cane scums in Milk and Meat Project, Mauritius. Thechnical Report I. Food and Agriculture Organization of the United Nations, Rome.

18. NAIDOO, G., DELAITRE, J.A.C. and PRESTON, T.R. (1975) Raw and steam treated bagasse as roughage sources for bulls fattened on molasses/urea in Milk and beef from sugarcane and its by-products. Ministry of Agriculture and Natural Resources and the Environment in collaboration with UNDP project MAR/73/006, Mauritius.

19. PRESTON, T.R. (1979) Milk and beef production from sugarcane and its by-products. Report to the Ministry of Agriculture and Natural Resources and the Environment, Mauritius. Mission from 14th - 27th May, 1979.

20. PRESTON, T.R., ELIAS, A. and WILLIS, M.B. (1968) Intensive beef production from sugarcane. 7. The performance of bulls given high levels of molasses/urea at different dilutions. Revista Cubana de Ciencia Agricola (English edition) 2, 263-268.

21. UGARTE, J. and PRESTON, T.R. (1972) Rearing dairy calves by restricted suckling. (I) Effect of suckling once or twice daily on milk production and calf growth. Revista Cubana de Ciencia Agricola (English edition) 6, 173-182.

22. —————— (1975) Restricted suckling, VI. Effects on milk production, reproductive performance and incidence of clinical mastitis throughout the lactation, Cuban Journal of Agricultural Science 9, 15-26.

23. DELAITRE, J.A.C., BRASSE, and DUVIVIER (1975) Unpublished information. HULMAN, B. (1979) Milk and Milk Production - Review of recent research work by the Ministry of Agriculture and Natural Resources and the Environment.

Proc. AAAS/ILCA Workshop on the Utilization of Waste Products in Africa, 17-12 Nov. 1980, Douala, Cameroun, p.261-269.

UTILIZATION OF GUINEA-GRASS-CITRUS PULP SILAGE BY SHEEP

By
F.O. OLUBAJO
Department of Animal Science,
University of Ibadan, Ibadan.

INTRODUCTION

Greater liveweight losses are encountered by grazing livestock in the dry season in most tropical countries as a result of little or no intake of nutrients particularly energy and protein from the meagre and unpalatable pasture available during this period of the year. Excess pastures produced in time of lush is usually conserved either as hay or silage for dry season feeding.

Evidence abounds in the literature on the composition and the nutritive value of ensiled temperate grasses and legumes with or without additives (Thomas et al., 1961, Jones et al., 1971 & Brown and Radeliff, 1972). Very scanty information is, however, available on ensiled tropical pastures (Lansbury, 1959; Miller et al., 1963 & Semple et al., 1966).

At present silage making in Nigeria is restricted to the government or university farms and in almost all cases no information is available on the chemical composition and the feeding value of the ensiled herbage.

The present study was designed to investigate the chemical composition and the nutritive value of guinea grass - (Panicum maximum Schum) and guinea grass-citrus pulp silages fed to West African dwarf farms.

Materials and Methods

The experiment was carried out at the University of Ibadan Teaching and Research Farm. Ibadan is approximately 150 m above sea level with an annual rainfall of between 120 and 150 cm.

Pasture Management

The guinea grass used in the experiment was cut from an established pasture in its third year of grazing. In the year of harvest for silage 504 kg/ha of sulphate of ammonia (21%N) was applied to the pasture in two equal instalments in April and August respectively. 126 kg/ha of triple super phosphate (32-48% P_2O_5) was also applied during the second dressing. Between the sixth and seventh week of regrowth the grass was harvested for silage. The citrus pulp (orange pulp) used was collected fresh from the Lafia Canning Factory, Ibadan and was used the same day.

Ensilage

The cut grass was left to wilt for about two hours and was chopped into bits with tractor mounted forage chopper. The silage mixtures were prepared on fresh weight basis as follows:

100% guinea grass 400 kg (101 kg dry matter, DM)

90% guinea grass to 10% citrus pulp (86 kg and 8.5 kg DM. respectively).

75% grass to 25% citrus pulp (72 kg to 19 kg DM, respectively) and 50% grass to 50% citrus pulp (49.1 kg and 47.3 kg DM, respectively).

For convenience the treatments shall be referred to subsequently as 0%, 10%, 25% and 50% grass-citrus pulp silages.

Each silage mixture was mixed thoroughly and made to pass through a tractor mounted chopper and packed well in double-layered polythene bags, sealed, and each bag placed in 180 litre (40 gallon) drum. The contents were weighted down with heavy stones and ensiled in duplicates for approximately three months. All treatment mixtures were ensiled the same day.

Sampling

Approximately 3 kg was taken from each of the fresh treatment mixtures before ensilage and kept at -5°C in well-stoppered jars until required for analysis. Similar amount was taken from eachbag of silages from the top middle and bottom layers bulked, thoroughly mixed and 2.5 kg taken and treated as for fresh mixtures. 0.5 kg was expressed and the pH of the juice was taken.

Digestion trials

Six West African dwarf rams (mean liveweight 32.6 $\pm$ 2.09 kg) were fed the control silage in separate metabolism crates for 21 days consisting of 14 - and 7 day - adjustment and collection periods respectively. Ad libitum intake was established during the first 7 days of adjustment and each animal was offered the mean of its intake plus 10% twice daily at 0800 and 1600 hrs during the last 7 days of the adjustment period and the collection period. Each ram had free access to tap water and salt licks at all times. The six rams were later randomly assigned in groups of two to each of the three grass - citrus pulp silage treatments and fed for the same period. A two week period was allowed between the digestion trials.

Samples of feed, orts and faeces for each animal were collected each day weighed, and bulked at the end of each collection period.

Dry mater was determined on 200g duplicate samples at 100°C to constant weight and by toluene distillation method (Dewar and MacDonald, 1961) as modified by Minson and Lancaster (1963) on silage samples. Proximate analysis were conducted by Standard AOAC (1970) methods. Energy was determined with Gallenkamp oxygen Ballistic bomb calorimeter and pH of the expressed juices from silage was read in a Copenhagen Radiometer pH meter.

Statistical analysis was based on 2-way classification in which animals were regarded as replicates and the 4 treatments as the main treatments (Steel and Torrie, 1960). All values are expressed on dry matter basis.

RESULTS

Chemical composition

The dry matter (DM) and the crude protein (CP) contents of the silage mixtures were low (Table 1). Replacement of the grass with citrus pulp led to decreases of approximately 43%, 13% and 4.8% in the silica-free ash, CP and the crude fibre (C.F) contents of the control. These decreases were not consistent with increased addition of citrus pulp. As would be expected the nitrogen-free extract (NFE) showed a general increase with increased amount of citrus pulp in the mixtures due largely to higher content of sugar in the citrus pulp. Similar trend was observed for ether extract (EE) except for the 10% citrus pulp-grass mixture. The data in Table 1 showed that the silages were not of the desired quality as indicated by the acidity. Addition of citrus pulp however resulted in increased DM content with the 50% grass-citrus pulp silage having approximately 8% more DM than the corresponding grass silages. The CP (NX6.25) was generally lower than in the corresponding fresh mixtures. The loss of CP as a result of enzilage varied between 27.1 and 7% in the control and the 50% grass-citrus pulp silages respectively.

Voluntary intake, digestibility and utilization of dietary constituents

The results of intake, digestibility and utilization of energy (E) of the four silage types are presented in Table 2 and 3, respectively. The intake of DM per kg of metabolic size ($g/Wkg^{0.75}$) was significantly higher for the 50% silage than the control ($P<0.005$) while the remaining two silages showed no improvement over the control. Dry matter digestibility was improved with increased replacement of grass with citrus pulp in the silages ($P<0.005$) and each of the grass-citrus pulp silage was more digestible than the pure grass silage ($P<0.05$). Except for NFE in which there were no significant differences among the treatments, the digestibility of either CP or energy followed similar trends as that of DM. The digestible crude protein (CDP) intake was very low but more ($P<0.01$) was consumed from each of the grass-citrus pulp than from the control.

The mean daily intakes of gross energy (GE) and digestible energy (DE) per kg metabolic size ($Mcal/wkg^{0.75}$) were significantly ($P<0.001$) higher for grass-citrus pulp silages. Using the formulae proposed by Garrett et al. (1959) for DE and metabolisable (ME) energy requirements of sheep for maintenance, the calculated DE and ME requirements of sheep fed grass- and 50% grass-citrus pulp silages are approximately 1.86 Mcal and 1.51 Mcal, and 1.95 Mcal and 1.58 Mcal, respectively.

DISCUSSION

Except for the slightly lower percentage content of CP and ether extract the values for the proximate constituents of the citrus pulp were in agreement with the values reported in the literature (Ammerman

TABLE 1. The chemical composition of guinea grass and of guinea grass-citrus pulp mixtures at harvest and their silages.

		grass	9:1 grass citrus pulp	3:1 grass citrus pulp	1:1 grass citrus pulp	Citrus pulp
Dry matter (%)	a*	25.32	25.89	27.30	27.42	16.30
	b*	24.80	25.31	26.53	26.93	-
	c	25.07	26.42	28.37	27.13	-
SiO_2-free ash (%)	a*	7.69	6.55	4.37	7.06	1.88
	b	7.40	6.07	4.89	6.82	-
Crude protein (%)	a*	5.58	4.85	5.01	5.17	4.81
	b	4.07	4.52	4.73	4.81	-
Ether Extract (%)	a*	1.91	1.78	2.15	2.32	2.95
	b	1.50	1.05	1.78	1.80	-
Crude fibre (%)	a*	36.23	35.94	35.88	34.50	13.70
	b	38.50	37.50	37.72	37.95	-
Nitrogen-free Extract (%)	a*	48.59	50.88	52.59	48.56	76.66
	b	48.53	50.86	50.88	51.01	-
	pH	4.85	4.73	4.67	4.60	-

a = Fresh mixtures before ensilation b = Silages c = Toluene distillation values
* = Values on dry matter basis.

TABLE 2. The intake and digestibility coefficients of proximate constituents of silages by sheep.

	100%	9:1	3:1	1:1	S.E.
	grass	grass	citrus	pulp	
DM intake (g/head/day)	467^{ab}	414^{b}	502^{a}	721^{c}	27.71***
DM intake (g/wkg$^{0.75}$)	34.3^{ab}	30.9^{b}	37.7^{a}	51.1^{c}	1.97***
DM digestibility (%)	48.4^{a}	53.8^{b}	56.7^{c}	60.6^{d}	1.10***
CP digestibility (%)	20.0^{a}	31.9^{b}	36.4^{c}	40.9^{d}	0.78**
CF digestibility (%)	62.9^{a}	65.3^{ab}	68.5^{bc}	69.0^{c}	1.37*
NFE digestibility (%)	58.3^{a}	63.2^{a}	67.5^{a}	66.9^{a}	4.05 N.S.
Energy digestibility (%)	51.7^{a}	55.6^{b}	57.7^{a}	63.9^{d}	0.60***
DCP intake (%)	0.81^{a}	1.44^{b}	1.72^{c}	1.97^{d}	0.03**

Values in the same tow with the same letter scripts are not significantly different ($P < 0.05$)

* $P < 0.05$

** $P < 0.01$

*** $P < 0.005$

N.S. $P < 0.05$

TABLE 3. **Mean utilization of dietary energy**

	Level of citrus pulp 0%	10%	25%	50%	S.E. of diff. between means
G.E. in feed (Mcal/kg)	3.75	3.87	4.81	4.75	-
G.E. Intake (Mcal/head/day)	1.76^{b}	1.60^{b}	2.42^{ab}	3.43^{a}	± 0.39*
G.E. Intake (Mcal/wkg$^{0.75}$)	0.13^{a}	0.12^{a}	0.18^{b}	0.24^{c}	± 0.02***
D.E. intake (Mcal/wkg$^{0.75}$)	0.07^{a}	0.07^{a}	0.10^{b}	0.16^{c}	± 0.004***

* $P < 0.05$

*** $P < 0.001$

Values with different superscripts in the same row are significantly different.

et al., 1966 and 1968 & Keener et al., 1957). The lower DM content of the silages in contrast to that in the fresh mixtures was probably due to seepage of moisture from the outer layer into the lower and central mass. The DM content of the silages was lower than the levels of 30% to 35% usually recommended for the production of good silage. Previous reports have shown that the DM content of guinea grass at the stage it is usually grazed or cut is usually between 21 and 26% (Olubajo and Oyenuga, 1974). The lower content of DM obtained by the conventional oven-drying method as compared to the toluene distillation technique is attributed to losses of volatiles during drying (Wilson et al., 1964 ; Dewar and McDonald, 1961; Minson and Lancaster, 1963).

Addition of citrus pulp to the grass affected the pH of the resulting silages very little (Table 1). The high pH values obtained was due probably to the high initial moisture content, inadequate compaction of the mass and the shallowness of the type of silo rather than to insufficient sources of fermentable carbohydrates. It has been reported that moisture content of forage ensiled is one of the most important factors that affects the ensiling characteristics and the nutritive value of silage (Gordon et al., 1964 ; Archibald et al., 1960 and Thomas et al., 1961).

The loss in CP and the increase in CF contents of the silages in contrast to those in the corresponding fresh mixtures is usually a common feature of ensilage and the mean value of 27% loss in the CP of grass silage was close to those reported in the literature (Sample et al., 1966).

The results of digestibility trials on silage samples have been used (Miller et al., 1963) as criteria for recommending the adoption of ensilage for the conservation of fodder for dry season feeding on some goverment farms in Nigeria and levels of 3% DCP and 50% DOM in the silage have been selected as the minima, as materials with lower levels will not provide maintenance requirements. The results of the present studies indicate that with the exception of the 100% grass silage the DOM requirements are met but the percent DCP in all the silages fell short of the criteria for DCP requirement for maintenance (Table 2). Lack of energy is probably the most common manifestation of nutritional deficiency in sheep. It would appear from the results obtained in these studies that the mean daily energy intake by the experimental animals was inadequate to supply the maintenance energy level (Table 3).

The results of the experiment reported in this paper indicate that silage made from guinea grass harvested between the sixth and seventh week of regrowth supplied less than maintenance DE requirements when fed to sheep as a result of low DM consumption. It is relevant that more investigations should be carried out to ascertain the appropriate stage of growth at which local grasses should be cut for ensilage and to find other cheaper high energy and protein sources to augment the low energy source which grazing animals have access to in the dry season.

REFERENCES

Ammerman , C.B., J.F. Easeley, D.R. Arrington, and F.G. Martin, (1966) Factors affecting the physical and nutrient composition of dried citrus pulp. Proceedings of the Florida State Horticultural Society, 97 233-238.

Ammerman, C.B., E.G. Martin, and L.R. Arrington (1968) Nutrient and mineral composition of citrus pulp as related to production source. Proceedings of the Florida State Horticultural Society, 81, 301-306.

Archibald, J.G., J.W. Kuzmeski and S. Russell (1960) Grass silage quality as affected by crop composition and by additives. Journal of Dairy Science, 43, 1648-1653.

Association of Official Agricultural Chemists (1970) Official Methods of Analysis 11th edn. Washington, D.C. (A.O.A.C.).

Brown, D.C. and J.C. Radcliff (1972) The relationship between intake of silage and its chemical composition and in vitro digestibility. Australian Journal of gricultural Research. 23, 25-33.

Dewar, W.A. and P.M. McDonald (1961) Determination of dry matter in silage by distilation with toluene. Journal of the science of Food and Agriculture, 12, 790-795.

Garrett, W.N., J.H. Meyer and G.O. Lofgreen (1959) Comparative energy requirements of sheep and cattle for maintenance and gain. Journal of Animal Science, 18, 528-547.

Gordon, C.N., J.C. Derbyshire, H.G. Wiseman and W.C. Jacobson, (1964) Variation in initial composition of orchard grass as related to silage composition and feeding value, Journal of Dairy Science, 47, 987-992.

Jones, G.M., E. Donefer, A.H. Javed and J.M. Graudreau (1971) Intake and digestibility by sheep of w lted alfalfatimothy or corn silages ensiled at low and high dry matter levels. Journal of Animal Science, 33, 1315-1320.

Keener, H.A., N.F. Colovos, and R.B. Eckberg (1957) The nutritive value of dried citrus pulp for dairy cattle. New Hampshire Agricultural Experiment Station Bulletin No. 438.

Lansbury, T.J. (1959) The composition and digestibility of some conserved fodder crops for dry season feeding in Ghana. Tropical Agriculture, 36, 65-69.

Maynard, L.A. and J.K. Lossli (1969) "Animal Nutrition" 6th edn. New York, McGraw-Hill Book Company.

Miller, T.B., A.B. Rains and R.J. Phorpe (1963) The nutritive value and agronomic aspects of some fodders in Northern Nigeria. II. Silages. Journal of the British Grassland Society, 18, 223-229.

Minson, D.J. and R.J. Lancaster (1963) The effect of oven temperature on the error in estimating the dry matter content of silage. New Zealand Journal of Agricultural Research, 6, 140-146.

Olubajo, F.O. and V.A. Oyenuga (1974) The yield, intake and animal production of four tropical grass species grown at Ibadan. Nigerian Journal of Animal Production, 1, 217-224.

Semple, J.A. , C.M. Grieve and D.F. Osbourn (1966) The preparation and feeding value of Pangola grass silage. Tropical Agriculture Trinidad, 43, 251-255.

Steel, R.G.D. and J.H. Torrie (1960) "Principles and Procedures of Statistics", New York, McGraw-Hill Book Company, Incorporated.

Thomas, J.W., L.A. Moore, N. Okamoto and J.F. Sykes (1964) A study of factors affecting rate of intake of heifers fed silage. Journal of Dairy Science, 44, 1471-1483.

Wilson, R.F., J.M. Tilley and Maria, A-TH Steemers (1964) Comparison of oven drying and toluene distillation in the determination of the dry matter content of silage. Journal of the Science of Food and Agriculture, 15, 197-200.

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EVALUATION OF COCOA-POD AS A FEED INGREDIENT FOR CATTLE

BY

O.B. Smith and A.A. Adegbola

Dept. of Animal Science, University of Ife, Ile-Ife, Nigeria.

INTRODUCTION

According to Branckaert (1976) and Göhl (1975), about one million and 3.6 million metric tons of cocoa-pods are left to rot and waste on the plantations annually in Nigeria and the Camerouns, respectively. This is not only a potential danger, since the discarded pods constitute excellent media for the organism causing black pod disease, but alo a phenomenal wastage in terms of lost nutrients.

On the average, cocoa-pod contains 89% dry matter of which proteins make up about 6%, crude fibre 24%, ether extract 3%, ash 13% and Nitrogen-free extract 54%. In other words, energy-yielding components constitute about 80% of the dry matter. Cocoa-pod is, therefore, a potentially good source of energy for livestock, particularly, ruminants that can accomodate its bulkiness and efficiently metabolise its high fibrous component, thanks to the rumen and its microbes.

Unfortunately, this potential energy feed has, to date, neither been adequately evaluated, nor utilised. A detailed resedarch programme designed to establish the feeding value of cocoa pods for livestock and define safe maximal dietary levels is being carried out at the University of Ife, in Nigeria. My presentation will be limited to a discussion of two cattle feeding trials, in which cocoa-pod replaced varying levels of corn or guinea-corn for all concentrate feedlot diet.

FIRST TRIAL

Meterials and Methods:

A total of 36 local type cattle including the Keteku, N'dama and N'dama x White Fulani crosses purchased from a local cattle market were used for the first trial. The animals were dewormed, deticked and injected with a vitamin A, D & E preparation on arrival. Since the animals were not used to concentrate feeding, they had to be gradually introduced to this type of feeding during initial 4-week quarantine period. The diet used was made up of corn, brewers dry grains, groundnut cake and mineral-vitamins supplements.

On day 1 of the experimental period, the animals were weighed after an 18-hr and 10-hr feed and water fast, respectively, to obtain an initial shrunk weight which averaged 106 kg. They were then ranked by weight into 3 comparative groups of 12 cattle each. The three groups were in turn randomly assigned to three experimental diets designated control, low cocoa-pod and high cocoa-pod diets.

The control diet contained 2[illegible]% guinea corn, 19.5% brewers dried grains, 47% groundnut cake, 11.7% molasses with salt, mac[illegible] and micro mineral/supplements taking up the slack. The low cocoa-pod diet was similar in composition except that cocoa-pod replaced a part of the guinea-corn, to constitute 20% of the diet, while the high cocoa-pod diet contained 40% cocoa-pod.

The animals were fed their respective diets for 112 days, at the end of which final live weights were recorded after an 18-hour and 12-hour feed and water fast, respectively. Three animals were randomly selected from each treatment, slaughtered, and the carcass weight, longissimus dosi muscle area and dressing %. Recorded, the relationship between carcass weight and final live weight of the 9 slaughtered cattle was defined by a regression equation with an R^2 value of 0.96. This equation was then used to estimate the carcass weights of the unslaughtered animals whose dressing % was subsequently calculated.

RESULTS:

Mean dry matter intake during the 112-day experimental period was 5.2 kg Dm/for the control, 5.5 kg Dm/day for the low cocoa-pod diet, and 5.6 kg/Dm/head/day for the high cocoa-pod diet. These figures are not statistically different. A definite trend of increasing feed intake with increasing dietary levels of cocoa-pod is, however, evident.

Daily gains were 0.79 kg/day for the control group, 0.63 kg/day and 0.51/day for the low and high cocoa-pod groups, respectively. These differences were also not significant, but a clear trend of reduced grains with increasing levels of cocoa-pod emerges, and this is confirmed by the feed efficiency figures calculated. Control cattle required 6.6 kg Dm. for every kg of gain. This was significantly lower than the 8.8 kg and 10.9 kg required by those fed low and high cocoa-pod diets, respectively. The low cocoa-pod diet was in turn significantly better utilised than the high cocoa-pod diet.

We observed no significant treatment effect on any of the carcass paramenters measured. Carcass wieght, dressing % and longissimus dorsi muscle area were similar across treatment.

SECOND TRIAL

Materials and methods:

The second cattle feeding trial was conducted essentially alon the same lines as first one, except that:

1. The levels of cocoa-pod in the test diets were changed from 20 and 40% to 30 and 60% for the low and high cocoa-pod diets, respectively.

2. Corn, instead of guinea-corn was the main energy source replaced with cocoa-pod.

3. Molasses was excluded in this trial, because it is a seasonal, scarce and difficult to transport product, which small scale farmers may not easily obtain. The parger-scale farmers that may have access to it will pass the extra cost of procurement to the consumers. So molasses was replaced by the same amount of wheat bran.

Results:

This second trial ended quite recently as such only daily gain figures are available. Control animals gained 0.5 kg/day, while the daily gains of those on the 30% cocoa-pod diet was similar at 0.4 kg/day, many of the cattle fed to the 60% cocoa-pod diet lost weight and the average gain. For this group was a low 0.1 kg/day. This extremely low growth rate was not due to a low feed intake but to very poor utilization. Fecal output of the animals was excessively high suggesting a very rapid rate of passage.

DISCUSSION

The objective of these experiments was not to compare corn or guineacorn with cocoa-pod, but to determine how much of these readily available but expensive and highly competitive sources of energy could be replaced by cocoa-pod without reducing performance to the point where it became unprofitable. Based on presently available data we recommend inccusion rates of up to 40% cocoa-pod at the expense of corn of guinea-corn in feedlot diets. A level of 60% as of now appears exessive. It may be possible, however, to use even higher levels by manipulating certain factors, such as:

1. Increasing the particle size of the ground cocoa-pod in order to slow down the rate of passage.

2. Feeding a minimum amount of roughage to ensure proper rumen function.

All of these should improve feed utilization and allow the use of higher levels of cocoa-pod in feedlot diets.

In our evaluation of cocoa-pod as a feed ingredient for cattle we did not limit our observations to the effect of feeding the material on performance and carcass merit alone. We examined three other parameters:

1. The potential health hazard to both the animal that consumes it directly and the humans that will evatually eat the animal. cocoapod is rich in some alkaloid such as theobromine whose toxicity has been adequately demonstrated. Cocoa-pod may also contain high levels of some toxic minerals such as copper and zinc which are active ingredients of some insecticides usually sprayed on cocoa. Such minerals if present in sufficiently large amounts may not only intoxicate the animal but also the consumers of meat and offals, since storage in tissues and organs is one of the mechanisms employed by the animal to eliminate excess dietary minerals and maintain mineral homeostasis.

In our experiments, we did not observe any symptoms of alkaloid mineral toxicity in the animals, neither did we find excessively high mineral concentrations in either the experimental diets or animal tissues that might constitute a health hazard to the consumers.

2. We also studied the effect of feeding cocoa-pods to cattle on the organoleptic quality and consumer acceptance of the resulting beef. Evidence exists that certain dietary factors may alter the composition and nature of body fat in the ruminant, in spite of the legendary degradative role of the rumen. The results of two consumer acceptance tests carried out indicated that beef from cocoa-pod fed cattle was as tender, well flavoured and acceptable as beef from the control cattle.

3. Finally, we looked into the economics of collecting, drying and feeding cocoa-pods. Our figures are not definite yet, but preliminary calculations suggest that incorporating cocoa-pod into a corn-or guinea-corn based feedlot diet to the tune of 40% of total diet may reduce feed cost by about 11%.

CONCLUSION

In conclusion, it is clear that cocoa-pod has a definite feeding and economic value for cattle, which appears to be the most suitable species for its utilization, since it can constitute a large proportion of the diet unlike in monogastrics where it can only be used as a minor supplement.

Proc. AAASA/ILCA Workshop on the Utilization of Waste Products in Africa, 17-22 Nov. 1980, Douala, Cameroun, p. 275-282.

L'EMBOUCHE BOVINE AVEC UTILISATION MAXIMALE DE MELASSE DE CANNE

Par
Henri Peleton
Institut d'Elevage et de Medecine Veterinaire
des Pays Tropicaux (I.E.M.V.T.)

10, rue Pierre-Curie, 94700 Maisons-Alfort, France

Résumé

Sur le plan des cultures fourragéres, Pennisetum purpureum local donne de bons résultats aux niveaux rendement (75 tonnes/ha de matiére verte en 5 coupes annuelles), appétibilité et valeur alimentaire.

L'exploitation mécanique de Stylosanthes guyanensis est difficile en saison des pluies. L'usage envisagé pour cette légumineuse est donc l'ensilage.

Tripsacum laxum permet de grands espoirs vu sa parfaite adaptation en essais dans la région de Mbandjock.

La mélasse est distribuée à volonté selon la méthode de PRESTON aprés une phase d'adaptation de 14 jours. 2 p 100 d'urée sont incorporés à la mélasse.

La complément proteique est apporté sous forme de tourteau de coton. Les minéraux indispensables (Na, P, Ca) sont mélangés au tourteau.

L'indice de consommation est trés satisfaisant car il est inférieur é 8 jusqu'au 8le jour pour atteindre 12 au 130e jour.

Le G.M.Q. est en moyenne de g/jour avec des extrêmes allant de 450 à 1300 g/jour.

Sure le pland des abattages, le rendement carcasse de 54,6 p 100 confirme une bonne finition.

Dans l'avenir, il sera indispensable de faire un choix dans les emplois possibles de la mélasse. Il semble logique de penser que l'option production de viande soit prioritaire vu les carences en proteines animales et la raroté des aliments du bétail dans de nombreux pays en voie de développement.

Le rendement carcasse est en moyenne de 54,6 p100, chiffre confirmant une finition satisfaisante.

INTRODUCTION

La mission de Développement de l'Embouche Bovine de Mbandjock (MIDEBOM) a pour rôle durant //3 ans, à partir des résultats acquis de dégager l'intérêt économique de l'utilisation maximale de mélasse pour l'embouche bovine afin d'envisager une extension possible du feed-lot.

Les actions de la Cellule d'Appui Technique auprés de la MIDEBOM portent essentiellement sur les essais de cultures fourragéres, sur l'utilisation de la mélasse dans l'embouche bovine et sur l'exploitation des premiers résultats.

MBANDJOCK est à une centaine de kilométres de Yaoundé sur la route nationale I. Le siter retenu se trouve à 4 km de la Société Sucriére de Cameroun (SOSUCAM), à 25 km de la Cameroun Sugar Company (CAMSUCO) et à proximité de la voie ferree DOUALA-YAOUNDE-NGAOUNDERE.

La moyenne annuelle des précipitations est de 1444 mm avec une saison séche marquée de Décembre à Février, une saison des pluies de Mars à Juin, une petite saison séche en Juillet-Août et une grande saison des pluies de Septembre à Novembre.

La zone du projet est à une altitude de 600 métres.

ACHAT DES ANIMAUX

Le premier lot de zébus a été acheté en février 1980 dans la région de NGAOUNDERE sur l'ADAMAOUA. Ce troupeau comportait 57 animaux mâles entiers ou castrés, de race Goudali, âgés de 3 à 4 ans. C'est sur ce lot que nous avons obtenu nos premiers résultats techniques, les données du second lot étant en cours d'étude.

Les 3e, 4e et 5e lots ne sont pas encore commercialisables.

PROPHYLAXIE DES GRANDES HALADIES-AFFECTIONS RENCONTREES

It est hors de doute qu'on ne peut bâtir un projet que sur du bétail sain. C'est pourquoi une prophylaxie rigoureuse est appliquée dés l'arrivée des animaux qui sont mis en quarantaine pendant doux semaines.

1. Le ler jour:

Les animaux sont mis a parc aprés une diéte complete de 12 heures, ils sont pesés et marqués. Le détiquage est effectué a l'aide d'un pulvérisateur é dos.

Il convient de noter que les boeufs ont reçu un traitement préventif contre les trypanosomiases dés leur rassemblement au centre d'achat.

De plus, ces animaux vont être élevés en zero-grazing, la région de MBANDJOCK étant favorable aux Glossines (G.palpalis) infectantes par Trypanosoma vivax, aux Tabanidés et aux Stomoxes qui constituent un vecteur des Trypanosomiases. C'est pour cotte raison que les infrastructures des parces sont traitées à l'aide d'un insecticide:

a) Déparasitage contre les vers ronds.
b) Traitement curatif systématique. contre les trypanosomiases pour "blanchir" définitivement l'organisme.
c) Détermination de l'âge, de la race, et du sexe (il est prévu d'engraisser des vaches de réforme).

2. Le 3e JOUR

Vaccination contre la pasteurellose.

3. Le 7e JOUR

Vacination contre la peste bovime et la péripneumonie ontagieuse bovine.

4. Le 9e JOUR:

a) Vaccination contre le charbon bactéridien.
b) Vaccination contre le charbon symptômatique.
c) Traitement contre la fasciolose.

Les principales affections rencontrées sont:

- Le Heart-Water pouvant être traité dans les formes aiguës par la Terramycine. Les formes suraiguës sont foudroyantes et tout traitement curatif est utopique.

  · Enquête entomologique dans la zone de Mbandjock. Laboratoire déntomologie médicale ONAREST 1976.

- Les maladies d'ordre alimentaire, en particulier les météorisations basiques dues é une forte production d'ammoniac dans le rumen suite é l'ingestion d'une grande quantité de mélasse contenant 2 p 100 d'urée.

En effet, pour passer du régime pâturage à l'ingestion de mélasse ad libitum, il est indispensable de prévoir une période d'adaptation à la mélasse-urée. C'est ce que nous verrons dans le chapitre alimentation.

ALIMENTATION

La méthode d'embouche des bovines avec distribution de mélasse à volonté a été mise au point par PRESTON à Cuba.

A la MIDEBOM, la ration des animaux se compose d'une quantité limitée de fourrage, de mélasse dans laquelle sont incorporés 2 p 100 d'urée préalablement mise en solution, de tourteau de coton, de sel marin, de phophate bicalcique et d'eau.

La MIDEBOM utilisera les repousses de canne récoltées sur les parcelles "gelées", ainsi que les bouts blancs. La bagasse n'est pas disponible car la SOSUCAM la brûle dans ses chaudiéres pour fournir l'énergie indispensable à l'usine. Donc actuellement, la MIDEBOM a mis en place des cultures fourragéres qui feront l'objet de notre prochain paragraphe.

Cultures Fourrageres:

Pennisetum purpureum (Napier. Herbe à Elephant-Sisongo). La cellule d'Appui Technique a commencé ses essais sur cette Graminée en septembre 1979. C'est du Pennisetum local qui a été utilisé, car il résiste aux maladies, en particulier aux borers.

La plantation a été faite sur billons écartés de 0,75 m. Le Napier a été planté en boutures é 3 noeuds aoutés, ou en éclats de souche distatnts de 0,5 m. Des essais ont été entropris en adoptant la méthode utilisée pour la canne à savoir, la mise dans le sillon de tiges entiéres recouvertes de terre.

Les temoins consistaiont en boutures, écla ts de souche et tiges ne recevant ni traitement insecticide, ni traitement fongicide, ni engrais.

Nouse ne ferons pas une communication exhaustive sur les données chiffrées recueillies. Cependant, pour les parcelles traitées et ayant reçu 100 unités de N, 100 unités de P_2O_5 et 100 unités de K 20 en fumure, de fond, avec 50 unités d'N aprés chaque coupe on obtient un rendement de 75 tonnes de matiére verte à l'hectane en 5 coupes annuelles.

La valeur bromatologique du sisongo est bonne (se reporter aux annexes).

Stylosanthes Guyanensis: Aucun essai véritable n'a été mis en place pour cette légumineuse.

Semé en Octobre 1979, la premiére coupe a été faite en Juillet 1980, donc tardivement.

De nombreuses difficultés sont apparues dans l'exploitation de la plante. Outre l'envahissement par du Panicum et des Solanées, les tiges trop longues du Stylo "bourraient" dans la récolteuse. Puis la saison des pluies s'installant en septembre, les engins ont eu de grosses difficultés dans une terre gorgée d'eau (490 mm de pluie en Octobre 1980).

De plus une maladie est apparue sur le Stylo, vraisemblablement une mycose.

Seleon notre avis, le seul moyen d'exploiter le Stylo dans la région de Mbandjock est de faire de l'ensilage, les rendements atteints étant de 25 t/ha à la lére coupe.

Sepinieres. Nous avons reçu de la station de WAKWA, des écla ets de souche de Tripsacum Laxum (Guatemela grass) et de Panicum sp. La surface plantée unités de P2 05 et 250 unités de K_2O.Cette graminée s'est trés bien adaptée à la région et à partir de cette pépiniére, nous avons pu replanter environ 20 fois la surface primitive en boutures à 3 ou 4 neoeuds aoutés.

Certes, le Tripsacum est une plante exigeante en engrais mais il est trés bien appété et le rapport feuille/tige est trés important. Sur le plan économique, une surface de Guatemela grass, bien exploitée a une durée d'exploitation quasiment illimitée ce qui amortit considérablement le prix de revient.

Alimentation proprement dite. Comme nous le disions plus haut, la mélasses est la source d'énergie principale. Le fourrage limité à 8,5 kg de matiére verte par animal et par jour a essentiellement un rôle mécanique dans la rumination. Le tourteau de coton, onéreux, eşt limité à 0,8 kg par animal et par jour (52 F CFA rendu MIDEBOM). C'est ce qui nous a amené à utiliser l'urée comme source de protéines (2 p 100 due poids de la mélasse). Nous répétons que l'urée doit être diluée dans l'eau avant son incorporation à la mélasse, puis bien mélangée.

La flore et la faune due rumen contenant peu de microorganismes produisant l'uréase, il est donc indispensable de prévoir une période d'adaptation s'étalant sur 14 jours selon le schéma suivant:

kg/tête/jour

Jours	Fourrage MV	Melasse	Uree	Tourteau de coton	Sel	Bicalcique
1	12,5	0,5	0,01	0,2	0,01	0,01
2	12,5	0,5	0,01	0,2	0,01	0,01
3	12,5	1	0,02	0,3	0,02	0,02
4	12,5	1	0,02	0,3	0,02	0,02
5	12,5	1,5	0,03	0,4	0,03	0,03
6	12,5	1,5	0,03	0,4	0,03	0,03
7	12,5	2	0,04	0,5	0,04	0,04
8	12,5	2	0,041	0,5	0,04	0,04
9	12,5	2,5	0,05	0,6	0,04	0,04
10	11	2,5	0,05	0,6	0,04	0,04
11	11	3	0,06	0,7	0,04	0,04
12	10	3	0,06	0,7	0,04	0,04
13	10	3,5	0,07	0,7	0,04	0,04
14	8,5	4	0,08	0,7	0,04	0,04
15	8,5	4,5	0,09	0,8	0,05	0,05
Fin De La Periode D'Adaptation						
16 et	8,5	ad libitum	2 p 100	0,8	0,05	0,05

La mélasse et le tourteau de coton sont trés bienappétés.

La mise au point d'une pierre à lécher s'étant avérée quasimant impossible, les minéraux sont distribués en saupoudrant le tourteau, ce qui permet un excellent contrôle de la consommation. Le sel (Na Cl) est indispensable car la richesse en potassium de la mélasse entraîne une perte de sodium trés importante.

Rationnement: Les normes moyennes suivantes établies d'aprés des analyses de réference ont été retenues pour l'établissement de la ration.

Aliments	% matiers seche	UF/kg MS	MAD g/kg MS
Mélasse	82%	1	-
Tourteau de coton	91%	0,9	350
Pennisetum	20%	0,4	70
Urée	100%	-	2.000

La ration théorique prévisible a pu être estiméeen quantité et apports nutritifs (UF et MAD).

Aliments	Quantites d'aliments/TETE/JOUR.
Mélasse	5 kg
Tourteau de coton	0,8kg
Fourrage	8,5kg
Urée	0,1kg
APPORT UF/TETE/JOUR.	5,4
APPORT MAD g/TETE/JOUR.	575

Les besoins minima en énergie et matiéres azotées digestibles peuvent être évaluées comme suit d'aprés les normes classiques pour 1 animal de 300 kg.

Besoins totaux pour 1 kg de croît/jour = 5,3 à 6 UF

Besoins et MAD (90 g/UF) = 450 g

Il appraît donc que la ration permet théoriquement un croît d'environ 1 kg/jour.

Periode et duree: Les animaux sont entrés en embouche le 26 février 1980. Les derniers boeufs ont été vendus le 3 Octobre 1980.

Consommation: Toutes les consommations ont été contrôlées et enrégistrées.

Pesees: Les animaux sont pesés tous les 14 jours aprés un jeûne de 12 heures.

Resultats d'abattage: Les pesées, le calcul du rendement brut ont pu être faits sur les animaux abattus à Mbandjock.

DEROULEMENT DE L'EMBOUCHE

Resultats Ponderaux:

Les animaux achetés au poids moyen de 256 kg ont été vendus à un poids moyen de 373 kg soit une variation pondérale de 117 kg. Le record observé a été de 461 kg pour un animal de 4 ans. Son gain quotidien moyen étant de l'ordre du kilogramme.

Consommation et efficacite de la ration:

Let tableau ci-dessous donne l'évolution des consommations des divers constituants de la ration à 25, 53, 81 et 130 jours.

Aliments EN KG	25 jours	53 jours	81 jours	130 jours
Rourrage	5,3	18,3	11,6	8,53
Melasse	4,6	6,8	7,5	8,8
Uree	0,092	0,136	0,15	0,176
Tourteau de coton	0,8	0,8	0,8	0,8
Sel	0,018	0,015	0,015	0,05
Phosphate bicalcique	0,018	0,015	0,015	0,015

D'où les consommations globales et individuelles suivantes pendant la durée d'embouche =

Aliment (en kg)	Aliments totaux	Ration moyenne
Fourrage	93,384	9,9
Melasse	63,113	6,7
Uree	1,262	0,134
Tourteau	6,998	0,74
Sel	296	0,31
Phosphate bicalcique	296	0,31

Le maximum de consommation de mélasse se situe vers le 120e jour (9,6 kg/animal/jour). A ce moment lé, l'urée covre 56 p 100 des besoins en M.A.D. Au cours de l'embouche, le rapport M.A.D/MF évolue de 106 à 85, ce qui est normal.

Aprés le 120e jour, on note une diminution constante de la consommation de mélasse comme l'avait observé le Docteur-Vétérinaire RIVIERE.

Gain Moyen Quotidien:

	27e jour	55e jour	83e jour	126e jour
GMQ	595 g/j	870 g/j	821 g/j	853 g/j

Les extremes vont de 450 g/jour à 1300 g/jour.
Les indices de consommation sont les suivants:

	25e jour	53e jour	81e jour	130e jour
I.C.	5,1	8,05	7,99	12,0

RESULTATS D'ABATTAGE

Le poids moyen d'&abattage a été de 373 kg poids vif. L'animal le plus lourd, âgé de 4 ans, pesait 461 kg au moment de la vente (6. M. Q. = 1.000 g/jour).

Les résultats portents uniquement sur les rendements poids vif avant abattage, les animaux abattus à YAOUNDE n'ayant pu être étudiés.

CONCLUSION

Sure le plan technique les résultats sont satisfaisants, l'indice de consommation étant inférieur é 8 jusqu'au 8le jour et le rendement boucher supérieur à 54 p 100.

A court terme, le probléme de prix de la mélasse va se poser, co sous-produit étant fourni gratuitement à la MIDEBOM josqu'à la fin de la phase expérimentale. De plus la mélasse trouve de nombreux emplois concurrentiels dans de nombreux pays. Ce sont notamment:

- fabrication d'alcool,
- fabrication de vinaigre;
- revêtement de route;
- engrais potassique;
- milieu de cultures pour la préparation des lévures;
- extraction de produits chimiques (acide glutamique, bétaine).

Si fabrication d'alcool présente un intérêt économique pour les gouvernements (prix de vente et taxes perçues), il nous semble que les autres usages soient aberrants dans des pays où la production de viande est déficiente et où les aliments du bétail sont rares.