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IDDA Expert Group Meeting on
Applications of Biotechnology to
Food Processing in Africa
Ibadan, Nigeria
16 - 20 December 1991

REPORT*

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I. INTRODUCTION

The UNIDO Expert Group Meeting on "Applications of Biotechnology to Food Processing in Africa" was held at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, from 16 - 20 December 1991. Its objective was to review constraints to food production and processing in Africa and discuss potential applications of biotechnology to overcome these constraints.

The meeting was attended by 44 experts from 14 African countries and from other developing countries of Asia and Latin America, as well as experts from Europe, the U.S.A. and the IITA. A list of participants is attached as Annex II.

In her welcome address to the participants, the UNIDO representative reviewed the efforts of UNIDO to enable the African countries to benefit from advances in genetic engineering and biotechnology, particularly in applications appropriate to the food industry. Studies carried out by UNIDO have emphasized the potential contribution of biotechnology and genetic engineering to African fermented food processes; several regional meetings have also identified food processes and food crops where the benefits of modern biotechnology techniques could be applied.

UNIDO began with the initiative that led to the establishment of the International Centre for Genetic Engineering and Biotechnology (ICGEB) with its two research facilities at Trieste (Italy) and New Delhi (India) and its network of affiliated centres, three of which are located in Africa. Ms. Campbell stressed that it was now time to go a step further by identifying concrete areas where biotechnology research results could be applied to African food crops and food processing.

The keynote address to the meeting was given by Dr. Lucas Brader, Director-General, International Institute of Tropical Agriculture (IITA), Ibadan. He began by reviewing key issues in biotechnology research on food crops and food processing in Africa, then described the biotechnology activities at IITA in relation to food crops production and processing, notably in the areas of cell and tissue culture (for disease-free, in-vitro conservation and rapid multiplication of germplasm), genetic mapping techniques (for plant breeding), genetic engineering (for introducing desirable traits into plant varieties), agricultural diagnostics (for identifying plant pathogens, hormones, and other chemicals, and for promoting plant health), and agricultural microbiology (including bioprocessing of food products). In addition to its in-house R&D, IITA regularly organizes meetings, workshops and group training courses as a means of transferring the results of its biotechnology research to African national programmes.

Dr. Brader went on to describe the envisaged new directions of IITA's work in the area of biotechnology and genetic engineering, both in strengthening and improving efficiency in the institute's traditional areas of crop improvement as well as in broadening its work in the newer area of food processing, food quality and postharvest handling techniques. In particular, programmes involving genetic transformation technologies for producing pest and disease-resistant crop varieties will be promoted; research needs in postharvest processing of crops, in preventing postharvest losses, and in expanding the scope of crop uses will strengthened; and fermentation processes and fermentation technologies will be studied.

While acknowledging the possibilities and opportunities offered through the applications of biotechnology and genetic engineering, Dr. Brader also emphasized the importance for researchers/scientists to ensure that the biotechnology research programmes they work on, and the biotechnology products they develop, meet real needs of the countries they serve. Biotechnology research and development should be less resource-driven and instead be need-driven, he stressed.

In his conclusion, Dr. Brader referred to the need for countries to formulate, adopt and ensure policies on biosafety and on proprietary rights; biosafety policies to govern/regulate the nature and scope of the biotechnology research that is done; controls over testing and evaluation of results, particularly as they affect human health and the environment; and regulations over the release of products for public consumption. He felt that each African country ought to establish at least some minimum set of guidelines regulating these activities. In reference to the question of ownership of biotechnology research results and profits resulting from distribution of the products, Dr. Brader emphasized that national governments would need to coordinate action with the international community in forging a new regulatory framework for protecting intellectual property rights of biotechnology research that will be equitable to developing countries.

In his opening address to the Expert Group Meeting on the Applications of Biotechnology to Food Processing in Africa, the Director General, Federal Ministry of Science and Technology, Nigeria, Professor Ephraim E. Okon, emphasized the importance attached to the subject of biotechnology by the Government of Nigeria. To the Federal Ministry of Science and Technology, biotechnology represents the integrated use of a variety of scientific disciplines, including chemistry, experimental biology, biochemistry, engineering and genetics, to solve biological and ecological problems as well as to provide goods and services. In recognition of the importance of this scientific endeavour, the Federal Ministry, in 1985, prepared a blueprint on genetic engineering and biotechnology for the country, and followed this up with the application for affiliate membership in the ICGEB.

The Ministry has also established a National Centre for Genetic Resources and Biotechnology at Moor Plantation, Ibadan, which has the responsibility for coordinating the efforts of the Government in the conservation of genetic resources and the promotion of biotechnological research in Nigeria.

Professor Okon enumerated some of the areas where biotechnology results could be applied to African food processes, such as in the fermentation into gari and ogi (Nigeria), kenkey (Ghana) as well as corn or sorghum beer (West and Southern Africa). He also referred to the potential and opportunities offered by biotechnology to African agriculture. He expressed the hope that the benefits of the biotechnology revolution in the production of food crops could be made available quickly to the rural poor in sub-Saharan Africa.

In his conclusion, Professor Okon reminded the meeting participants not to lose sight of safety considerations. He noted that it is easy for scientists to get carried away by the fascination of biotechnological research while overlooking the social and environmental implications and consequences of their work. Biosafety issues should be tackled simultaneously, with all seriousness, he emphasized. He wished the participants a happy stay in Nigeria and a successful meeting.

Discussions in the Expert Group Meeting were based on background papers prepared by UNIDO consultants on each of the agenda items as well as supporting papers prepared and presented by the participating experts. The list of papers presented at the meeting is attached as Annex II.

The meeting established Working Groups for discussions on the following four subjects:

(i) Fermentation of African Foods - Chairman: Dr. M. Souane
(ii) Guidelines for the Transfer of Technology - Chairman: Dr. R. Zilinskas
(iii) Networking and Training - Chairman: Dr. S. K. Hahn
(iv) Biosafety Issues - Chairman: Dr. S. N. C. Okonkwo

The Chairman of each Working Group also acted as its Rapporteur, reporting back on the work of his group to the plenary meeting. A set of conclusions and recommendations was then formulated based on these discussions. Dr. Raymond Zilinskas, UNIDO Consultant, served as the overall Rapporteur for the Expert Group Meeting.

II. CONCLUSIONS AND RECOMMENDATIONS

A. Fermentation of African Foods

The importance of food fermentation as a low-cost food processing method to improve the nutritional value of foods, to convert inedible commodities into palatable foods, and its potential to produce value-added materials from different sources was recognized.

The need to survey by country and region existing indigenous food fermentation technologies, and to classify the end products on the basis of the fermentation technologies used and the converted substrates was emphasized.

Research is needed to develop simple processes, to achieve the industrialization of the major fermented foods, to mechanize labour-intensive processes, to develop or expand the use of starter culture and to achieve quality standardization.

B. The Transfer of Technology to Africa

It was recognized that sustainable development of science in Africa cannot be achieved unless African governments commit themselves to the long-term, adequate support of their researchers and research institutions. However, the development of capabilities in science and technology in Africa is integral to endeavours made by governments to achieve their overall objectives; it is not an end in itself. This, in turn, means that policy decisions made by governments on science and technology issues should be taken to serve those objectives in the best way possible and that resources committed to implement decisions are vital investments in the future of nations. Scientists and technologists have an important role to play in the process of selective objectives and formulating policies. In order to be able to present their views forcefully and voice their requirements convincingly, scientists need to organize themselves in professional societies.

It was recognized that the strong development of science in Africa necessitates that the region acquire technologies from industrialized countries on a selective basis, and that results and findings from indigenous research be effectively transferred to the applied sectors. A number of requirements must be met to effectively transfer science and technology:

1. The biotechnological capabilities of local universities and research institutions must be strengthened by governments and international agencies providing, inter alia, additional opportunities for advanced training to researchers, adequate facilities and equipment for research, and improvements to the infrastructure supporting research efforts.

2. Basic and applied research need to be integrated and the strategic role of basic research must be fully recognized by governments and international agencies.

3. Professional societies should take on the responsibility of informing and assisting policy makers and legislators on the significance of scientific/technical matters, and on their social and environmental implications, so they will be well prepared to adopt and implement policies and strategies for effective technology transfer.

4. To enhance the linkage between the research establishment and the applied sectors, measures must by taken by professional societies, industrial interest groups, farmers' associations and governments to promote direct contacts between researchers and technology users.

5. Further to the previous point, African universities should consider setting up technology transfer units whose tasks would include presenting results and findings from university research to technology users and brokering joint cooperative R&D projects between the two.

6. The scientific community should be encouraged to participate in the process of policy making concerning the exchange of scientific knowledge and technology between the private and public sectors.

7. Non-governmental organizations should be strongly encouraged to take on the role of sensitizing government officials, legislators, technology end users and the public to the practical problems and social consequences of technology transfer. If appropriate non-governmental organizations do not exist in a country, their establishment should be supported.

8. There is a strong need to set up a regional bioinformatics network, including E-mail and CD ROM, to facilitate African researchers accessing scientific/technical information and communicating with one another.

C. Networking and Training for African Scientists

It is a well known fact that most aspects of biotechnology principally associated with African women are less developed and most of the end products of such preparations are not usually properly processed. Moreover, biotechnology has yet to reach an advanced stage of development in Africa. In view of this, it was recognized that there is a need for a Biotechnology network involving women in Africa. It was recommended that a series of regional and sub-regional workshops for African women be organized on the processing of African foods to include training in food processing technologies, nutrition, and management skills. Graduates of these workshops would be trained to teach the same skills to other women in their home regions.

In addition, it was recognized that there is an urgent need to link researchers and research networks already existing in Africa not only to maximize contact, to stimulate indigenous research, and to make the best use of the limited funds available, but also to avoid wasteful duplications of effort. It was proposed that a network be created to carry out research activities on both a regional and country-wide basis with the objective of identifying local expertise to participate in the network, and to identify easily available and often utilized local food crops that could be considered for further scientific research. Such activities could very well be carried out by local agriculturalists/industrialists and researchers active in various fields of biotechnology, thereby increasing the potential of transferring technologies and fostering the development of human resources through education and training. A vital aspect to this end, would be the extensive dissemination of relevant information, for example, by circulating newsletters within each country participating in the network as well as an exchange of such information material at the regional level.

It was suggested that the network be headed by a coordinator, assisted by a steering committee and a secretariat located in one of the participating countries. The network should hold annual workshops that would be rotated among the regions. Adequate funds as well as sufficient local and international expert and support staff should be allocated to the network to ensure its proper performance and impact.

Initially, the following subjects for networking activities were suggested for consideration:

1. Food processing

   (i) Lactic acid fermentation technology
   (ii) Cassava: this could be processed into several food items including Gari, Fufu, Tapioka, Kpokpogari and Starch
   (iii) Locust bean seeds: processed to Iru/Dawadawa
   (iv) Mushroom cultivation on waste materials
   (v) Soybean processing

2. Fermented traditional drinks e.g. wines from sorghum, pineapple, palm trees, etc.

3. Rapid multiplication of important food crops that are resistant to diseases and insect pests.

4. Market feasibility.

D. Biosafety Issues of Relevance to Africa

It was proposed that the Expert Group Meeting urge governments of African countries to develop an appropriate set of policies as a matter of national interest for domestic research, development and utilization of new crops and foods. Each government should present the case positively to its own constituency and seek affirmation of a biotechnology research policy that is aimed at vitally needed improvements in food production, nutrition, food stability and hygiene.

The distribution, dissemination and adoption of the Voluntary International Code of Conduct for Biotechnology Safety prepared by the UNIDO Secretariat for the UNIDO/UNEP/WHO/FAO Informal Working Group on Biotechnology Safety in 1991 in all appropriate national fora was endorsed.

It was recommended that UNIDO coordinate an advisory service network on biosafety issues to provide expert advice, on request, to governments of developing countries lacking regulatory policies.

It was recommended that institutions involved in biotechnology research and development in African countries should establish institutional biosafety committees.

It was recommended that FAO and international donor agencies support a baseline field study programme on African food crops that are likely to be genetically - modified and as such will be candidates for release to the environment.

African countries were strongly urged to develop African expertise in all scientific disciplines relevant to biosafety issues.

E. Recommendations for UNIDO

UNIDO was requested by the Expert Group Meeting to:

1. Formulate a project on Lactic Acid Fermentation Technology for African scientists. The project should include training, pilot plant production, and the establishment of a network to link scientists once they have completed training.

2. Establish a Network on Food Fermentation and Processing Technology to stimulate research activities and information exchange within Africa and with other regions of the world.

3. Expand training opportunities through network activities and interaction with international training centres to strengthen the capabilities of African scientists in fermentation technology.

4. Organize and fund a programme for transferring mushroom growing technology on waste materials to Africa.

5. Organize and fund a series of regional and sub-regional workshops for African women on processing of African foods.

6. Set up an Advisory Service on Biosafety Issues to provide expert advice, on request, to governments of developing countries seeking to develop or improve regulatory policies.

7. Disseminate technologies developed in Nigeria for soybean processing and utilization throughout the region. These technologies, which have been widely accepted by Nigerian consumers, may be used to fortify African food, significantly improving its protein content.

8. Formulate a project to study and implement ways of improving indigenous cropping strategies of famine stricken African countries by improving famine food continuance and stability.

9. Survey traditional biotechnologies indigenous to African sub-regions or countries and assess their utility as a possible starting point for more wide-ranging projects or as candidates for up-grading using modern biotechnological techniques.

10. Undertake a study on mechanisms how best to promote the involvement of the private sector in biotechnology within the African context. This study should consider model legislation that when adopted by African countries would encourage private sector involvement in biotechnology R&D.

11. Publish these recommendations widely; use them as a basis for projects; integrate them as appropriate in the terms of references for UNIDO consultants; and refer to them when negotiating with governments.

III. SUMMARY OF PRESENTATIONS

1. Food Fermentation and Processing

Professor Hamid A. Dirar of the University of Khartoum, Sudan, presented a paper on the indigenous fermented foods and beverages of Sudan. Professor Dirar took the personal initiative to document the fermented foods of one African country, the Sudan. The endeavour took him six years and he is now putting the information obtained in a manuscript for a book. He found that Sudan has 85 fermented foods and beverages, of which 60 are quite different from one another. Sorghum products are the most sophisticated and are prepared by the most complicated procedures. He gave examples of food preparation procedures that are basically similar in Sudan and in West Africa but those indigenous to Sudan seem to be more complicated. The Sudanese ferment just about anything - meat, fat, bone, fish, insects, wild leaves, etc. The bulk of the fermented foods are either sorghum staples or their relishes. He stressed the point that these foods have a strong connection with the coping strategies to combat food shortage and famine. All these foods are the invention or rural women whose role in nutrition must be recognized.

Dr. J.A. Buswell of the Department of Biology of the Chinese University of Hong Kong presented a paper on bioconversion of waste materials to food and

useful products by fungi. His paper concentrated on the cultivation of mushrooms on lignocellulosic materials. The nutritional worth of mushrooms has been recognized in recent years as these fungi contain 18-35 per cent protein (dry wt. basis). Mushrooms also contain vitamins and in general compare well with the best food. In recent years the cultivation of mushrooms has spread to many countries of the world and their total production is increasing annually. These fungi possess complex enzyme systems which make them able to degrade tough molecules of cellulose, lignin and hemicellulose on which they grow. Examples of waste materials that can support the growth of mushrooms are cereal, straw, bagasse, banana leaves, and coffee waste. The most important commercial mushrooms now are the European types but in southeast Asia villagers have local species which could be developed by researchers in Africa to fit African conditions.

Ms. S.M. Osho of the IITA presented a paper on soybean utilization research at IITA. Soybean was introduced into Nigeria because it is needed for more protein sources to feed children of the rural regions. Traditional protein sources such as meat, poultry, fish and milk are very expensive in Nigeria and poor families cannot get their daily requirements from them. IITA is collaborating with other institutes and universities in a programme to incorporate soybeans into many Nigerian foods and they have been found to be quite acceptable to the consumer. The spreading use of soybeans has also reached commercial food processing enterprises, particularly in the area of weaning foods. The project at IITA to spread the use of soybeans even into wider circles is still continuing.

Professor S.A. Ondunfa, Director of the Federal Institute of Industrial Research at Oshodi, presented a paper on the current status and potential of biotechnology in food industries in Nigeria. Fermented foods are connected to the total culture of the people and any attempt to develop them must take into consideration social as well as nutritional aspects. The speaker discussed his research on dawadawa, a West African fermented meat substitute and flavour prepared from African locus bean Parkia subylobosa. He showed how a number of bacteria of the Bacillus genus work in concert to produce the desired characteristics of the product. A mixed culture of three bacterial species is employed as a starter instead of only one.

Dr. S.K. Hahn of the IITA presented an overview of African traditiona' cassava processing. Dr. Hahn gave a photographic survey of the uses of cassava across the continent. He divided the continent into four cassava food type zones, including the gari zone (West Africa), chicwangue zone (Central Africa and Congo Basin), atap zone, and ugali zone of East Africa. Cassava is the most important staple crop of Africa of which both tuber and leaves are consumed. Cassava is processed in various forms: boiled, roasted, fermented and unfermented. Because cassava is hardy, drought-tolerant, and an efficient producer of starch (energy), it plays an important role in efforts to alleviate the effects of the food crisis in Africa. The crop also fits well in the food-producing system of the African, particularly with respect to the women who cultivate and process practically all cassava in A rica now.

Professor Cherl-Ho Lee of the Department of Food Technology, Korea University, Seoul, presented a paper on the industrialization of lactic acid fermentation technology of cereals and its dissemination to developing countries. Professor Lee enumerated the advantages of lactic fermentation of foods. Lactic acid improves the keeping quality of the food and many such foods are to be found in Africa, Asia and other continents. Lactic

fermentation can be applied to cereal, fish, dairy and vegetable food products. Because of its importance to developing countries, a UNIDO-sponsored research project to develop high-protein lactic beverages from vegetables at Korea University and at MIT in the USA was started in 1987. Its objective was to establish optimum conditions for prefermentation and extrusion cooking of substrates for lactic fermentation. Useful microbial strains have been selected and improved. The project includes a training programme for third world young scientists at Korea University.

2. Cassava Biotechnologies

Dr. S.K. Hahn gave a presentation on cassava. He stated that cassava is the most important staple in sub-Saharan Africa. It is becoming more important as soil fertility declines due to increasing population pressure on the land. Cassava suits well the existing farming and food systems in Africa. It is most tolerant of stresses such as drought and soil acidity, providing food security to the millions of resource-poor people in Africa.

Cassava and its wild relative species are indigenous to South Africa. They all have chromosomes of 2n=36. While IITA's scientists are trying to introgress useful genes from wild species into cassava, several spontaneous sexual and asexual polyploids were found. They exhibited enormous vigor and high yield potential. Triploids resulting from the crosses between improved diploids and tetraploids gave twice as much yield as the normal diploid cassava. This is due to heterosis effects manifested in the triploids. Future breeding strategies for cassava improvement will be to produce improved triploids through hybridization between improved diploids and improved tetraploids.

The biotechnologies that are most cost-effective and affordable in Africa are fermentation, tissue culture and mono-clonal antibody for virus indexing. Research on applications of molecular biology for genetic engineering of cassava lags behind to other crops, primarily due to the inability to regenerate plantlets from a single somatic cell. An IITA scientist reported that production of plantlets from callus produced from cassava leaf has become possible using several cassava varieties resistant for Africa cassava mosaic virus.

Tissue culture methodologies such as meristem culture, shoot tip and node cutting cultures are routinely used to eliminate virus infection from improved clones of cassava and to micropropagate them. Virus-tested improved clones of cassava have been distributed by IITA to national programmes for evaluation and testing.

The in vitro reduced growth storage method is applied to conserve clonal germplasm cassava. A total of more than two thousand accessions of root crops germplasm are maintained.

Embryo culture techniques for the germination of mature embryos and immature embryos of cassava are being developed.

Biotechnology may improve traditional cassava processing by use of efficient strains of microorganisms associated with fermentation. Improved processing methods can lead to reduction of cyanide which is poisonous to both human and animals, reduction of losses during processing, improvement of

quality of processed products, and reduction of drudgery of women who are the primary producers and processors of cassava in Africa.

3. Cocoa

Dr. M.R. Söndahl of the DNA Plant Technology Corporation (DNAP) in the USA gave a presentation on new methods to produce cocoa somatic embryos from non-sexual tissues like flower petals and immature fruits. The relevance to these new methods is in the applications of a micro-propagation process since these protocols now allow for sampling superior mature cocoa plants.

During the question period, a participant inquired if the process can provide clonal fidelity. It was answered that this aspect is going to be investigated by a field plot in a cocoa growing region scheduled to be established next summer. A question was raised on the production of synthetic cocoa butter. It was answered that there is a shortage of cocoa butter for the chocolate manufacturers since cocoa fruits have only ca. 50 per cent fat and chocolate products require ca. 65 per cent cocoa butter. The level of substitution can bridge this 15 per cent gap. The really critical aspect is the possibility of producing synthetic cocoa powder (artificial chocolate). This possibility is very unlikely due to the complexity of flavours and fragrances present in cocoa powder. What progress has been made on cocoa transformation? This line of research is not currently being done by Dr. Söndahl's group but a group at the University of Pennsylvania is working to establish these techniques. Is the cocoa propagation method good enough to guarantee the original quality of cocoa clone? His answer was in the affirmative, if the process provides true-to-type copies of the donor plant. But it must be kept in mind that quality is also affected by the fermentation process. Is it possible that the current research programmes on cocoa at DNAP and the University of Pennsylvania will lead to the development of artificial cocoa? His response to this question was negative; first, this is not the objective of these research programmes; and second, it is technically very difficult to accomplish; third, the cocoa market price will probably assure that the natural product will be cheaper than any synthetic product due to cost of production. Cocoa biotechnology programmes are focusing on disease-resistance and other benefits for the cocoa farmer. A comment was made that the cocoa quality produced in Malaysia is not as good as the products produced in Nigeria.

A second presentation was given by Dr. E.B. Esan of the Cocoa Research Institute of Nigeria. Cocoa is still the number one agriculture export for Nigeria and the country is the sixth largest cocoa producer in the world (and the largest of 23 in Africa). Nigerian cocoa production is equivalent to 150,000 ton/year. Regarding cocoa substitute, cocoa butter is being produced from oils from coconut, palm kernel and fruits, and soybean. Carot is being suggested as a cocoa powder substitute. Some of the cocoa breeding goals for Nigeria include (1) the development of clones with more vegetative vigor to facilitate field establishment; (b) precocious maturing (2-3 years versus 3-4 years); (c) disease and pest resistance cultivars; and (d) development of a rapid clonal propagation method, specially for self-fertile selections. The Cocoa Research Institute of Nigeria initiated cocoa tissue culture work in 1974 and produced the first results on somatic embryogenesis from seed embryos. The major limitations to cocoa production in Nigeria are (a) insufficient funding of research; (b) inadequate research (man-power and

infrastructure); and (c) poor collaboration with cocoa research groups in other parts of the world.

A question was raised on the use of grafting in cocoa to reduce the juvenile stage allowing early production. Dr. Esan answered that grafting is possible but it is not commercially practised. In fact, rooting of cuttings and grafting can both reduce the time for the first production of cocoa plants to 2.5 year (as opposed 3-4 years). A comment was made to use cocoa husk as a source of biomaterials which account for ca. 70 per cent of the pod weight. A question was raised on why to use somatic embryos for micro-propagation instead of axillary buds. The difference is in the total number of clonal material available since there are limited numbers of axillary buds in one single cocoa plant. Using the somatic embryogenesis process, there is no limitation on the total number of cloned plants to be produced from a single selected plant. Another question was raised on the possibility of producing cocoa butter competitively or more cheaply than cocoa butter substitute. The problem in accomplishing this goal lies in the numerous production problems for cocoa requiring a lot of inputs, and in establishing limits in lowering the cost of cocoa production.

4. Coffee

Dr. M.R. Söndahl gave a presentation on biotechnology programmes for coffee improvement. The presentation focused on a "Somaclone Program" to screen new useful, variants out of existing high yielding varieties and on advances in developing a "micropropagation method" via somatic embryogenesis utilizing liquid cultures in bioreactor vessels.

The first question concerned the stability of somaclonal variants. Up to the present time, a complete answer could not be provided since the first progenies of most interesting somaclones are now being planted on the field. However, stability has been observed for variants from year to year and some of these variants are already six years in the field. Interest was manifested on the cost of production of coffee clones. The speaker noticed that a final cost is not available since the process of cloning coffee is not completed yet, but the goal is to release cloned coffee plants competitive with the price of seedlings which sell for US$0.10-0.15. Another question was posed on how to ascertain somaclonal stability. The current process is to evaluate the somaclones at field conditions for first and second generations. Is there commercial interest in low caffeine coffee? The objective of Dr. Söndahl's project is to examine a wide array of useful variations which will meet consumer needs, coffee processing needs, and farming benefits. As far as caffeine, he believes that there is consumer interest in high, medium and low caffeine coffee. A question was made on the control of variability of cloned coffee plants to avoid the problem encountered in banana. His answer in that his target is to manage a process which minimizes variation. Today the cloning of banana is a well established business in several countries and variation is controlled to 3 per cent or less. During the presentation, five breeding methods were mentioned and the question was raised as to which is the most efficient method. Introduction and selection is a very simple method and it has been used efficiently in the past. It is believed that there are still opportunities for exploiting natural coffee populations but other methods (such as interspecific hybridization) must be applied now. There is a correlation between big leaves and larger beans, is this stable trait or just environmentally affected? Clearly there is a genetic basis for bean size, for

instance the Maragogype trait is a single dominant gene that produces very large beans. Is there any intent to do a backcross programme on the coffee somaclones selected? The benefit of the somaclone programme is to speed up breeding so the new variants are evaluated for two generations and then considered ready for release. In other words, no backcross programme is planned. What is the commercialization aspect of this programme? Seeds of selected plants will be provided to coffee farmers and DNAP will buy back the coffee beans of commercial interest.

A presentation was provided by Dr. Michael Abberton from Malawi focusing on the need to select Arabica coffee with resistance to coffee berry disease (CBD). This disease is caused by a fungus which requires very extensive chemical control, and if not treated, the yield losses can reach 80 per cent of total production. A RFLP programme is being implemented to characterize the pathogen and coffee plants with resistance reactions to assist breeding and solution. Other long-term problems for coffee production in Malawi include: (a) drought tolerance; (b) efficiency in fertilizer utilization; and (c) grafting of Catimor to avoid die-back problems (this process may also be assisted by tissue culture). Technical constraints can be identified as the availability of suitable genes for coffee improvement and new sources of high yielding materials. In terms of institutional constraints, it was mentioned that long-term financing, continuity of existing programmes, and training of research personnel are to be considered.

A presentation was given by Dr. C. Omondo of the Coffee Research Institute in Kenya. The coffee breeding programme in Kenya began in 1971, stimulated by losses caused by rust and CBD. A joint Kenyan and Dutch research programme was initiated using germplasm introduction, crosses and selection. In 1986, a new coffee variety was released - Ruinu-11. This variety has a short stature derived from Catimor. Now the coffee breeding programme in Kenya is directed to horizontal resistance in assumption that the vertical resistance of Ruinu-11 will be broken one day. There is interest in developing RFLP and iso-enzyme markers to assist coffee breeding. New coffee breeding programmes are being conducted based on two segregating populations. One from a cross between Kenyan Catimor and Colombian Catimor and the crosses from Robusta tetraploide with Arabica.

A comment was made on the possibilities of using molecular biological techniques for coffee breeding utilizing existing expertise in Africa. A recent survey indicated that there are several African countries with such capabilities. A question was raised in the interest of improving coffee quality. The response was that this is a difficult task to be accomplished by standard breeding methods and that more progress could be made if assisted by biotechnology tools. Another question referred to the existing situation of coffee production in Kenya. There is an actual percentage (5-10 per cent) of coffee growers abandoning coffee farming due to economic constraints.

5. Oil Palm

A presentation on oil palm was made by Dr. L.H. Jones of Cambridge University in the United Kingdom. Biotechnology has provided the means of propagation of clones of oil palms. There are still some problems but these can be overcome. rDNA technology is not yet available and there are no clear targets. This is not a priority area. The use of RFLP (and other) molecular markers are already proving to be valuable tools both for clonal propagation

and plant breeding. This is a high priority area. Cloning know-how resides mainly in the integrated management of large scale plant propagation at minimal cost while maintaining high quality. Recent developments in the use of embryogenic suspension cultures have high promise for automation and reduced costs. This development could also lead to improved cell genetic systems. The use of biotechnology must be integrated into an active palm breeding programme utilizing the wide spread of native germplasm available in Africa (the centre of origin of oil palm). This is the highest priority area. By breeding specifically for clonal propagation, using scientifically based selection criteria, rapid crop improvement is possible. There is plenty of unutilized variation available in the crop, without needing RDNA technology.

Political strategies are needed to reinstate the palm oil industry in Nigeria, and revitalize NIFOR as a centre of excellence for oil palm research.

The question of the threat of modified temperate oil crops, e.g. oilseed rape, was addressed. Oil palm has the advantage of 6 x the yield of annual temperate oil crops, the latter are only viable as a result of subsidy. In a free world market palm oil should easily compete on cost with other oil sources. In addition, there is still a large potential for increased yield and reduced cost in palm oil production.

A question was raised concerning alternative oil crops in the tropics. It is not sensible to attempt to adapt temperate crops for growth in the tropics. The emphasis must be on utilization and improvement of indigenous crops.

Government policies have discouraged overseas investment and, for example, Unilever no longer has plantations in Nigeria and Cameroon. Investment (including tissue culture technology) has gone to Malaysia, Papua New Guinea and Colombia where foreign capital is welcomed and agreements can be made to mutual benefit while allowing the investing companies to extract sufficient profits to make investment worthwhile.

A final comment was a very strong appeal for African countries to develop and exploit their own high potential for oil palm improvement.

6. Constraints to the Transfer of Technology to Africa

The first point made was that, in Africa, biotechnology will be used primarily to improve on present processes or products, especially in agriculture and food processing. This means that market pull will not be an important factor. The second point was that in all African situations there is a lack of financial resources. The question, therefore, is how to promote biotechnology in Africa under this severe restriction.

Important factors affecting biotechnology applications are the following: (a) the availability of trained personnel, (b) adequate funding of basic and applied research, (c) adequate funding and positive tax incentives for firms to undertake R&D, and (d) for developing countries, effective international technology transfer, investments and trade.

Constraints to concept development in developing countries include the lack of applied research units in universities, forming barriers to universities undertaking applied research or contract research, and a lack of

technology transfer units at universities. Constraints are also due to a lack of applied research units in industry (economic/social barriers preventing industrialists from involving university researchers in commercially-directed activities). Circumstances peculiar to the African situation that affect the commercialization of biotechnology involve the central role of governments in the concept development process. This includes a lack of knowledge about biotechnology, as well as unrealistic expectations of biotechnology, and to low support of R&D due to a country's debt burden, diminished income from exports, high military costs and other, more pressing priorities. In addition, the poor environment for entrepreneurs based on unfavourable tax structures, small capital goods market (<5 per cent), and the low probability for raising capital have important, unfavourable effects upon prospects for successful commercialization of biotechnology products.

ANNEX I

Agenda of the Meeting

Monday, 16 December 1991

Registration

Welcome Address by the United Nations Industrial Development Organization (UNIDO)

Address by Dr. L. Brader, Director General, International Institute of Tropical Agriculture (IITA)

Opening of the Expert Group Meeting by Prof. E. O. Okon, Federal Ministry of Science and Technology, Nigeria

Election of Bureau and Discussion of Programme

Presentations

Session 1. Food Fermentation and Processing
Chairman: Dr. H. A. Dirar

"The Indigenous Fermented Foods and Beverages of Sudan" by H. A. Dirar

"Biotechnology and Food Fermentations" by P. E. Cook

"Processing of Cassava into Gari" by S. A. Odunfa

"Industrialization of Lactic Acid Fermentation Technology of Cereals and Its Dissemination to Developing Countries" by Cherl Ho-Lee

"Production of Wine from Cocoa Juice (Theobroma cacao L. Kuntze) Using Saccharomyces Specie Isolated from Palm Wine and Cashew Juice" by H. O. Adesioye

"Soybeans: The Answer to Malnutrition: The Impact of Soybean Processing and Utilization in Nigeria" by S. M. Osho

"Bioconversion of Waste Materials to Food and Useful Products by Fungi" by J. A. Buswell and S. T. Chang

"Recent Trends in World Production of Cultivated and Edible Mushrooms" by S. T. Chang and P. G. Miles

"Review on the Role of Biotechnology and Applied Microbiology in Food" by M. M. Mustafa

Tuesday, 17 December 1991

Session 2. Cassava: New Research Advances and Applications of Biotechnology
Chairman: Dr. S. K. Hahn

"Summary of Cassava Biotechnologies" by S. K. Hahn

"Mutation Breeding in Cassava: An Aspect of In-Vitro Culture Approach" by E. N. A. Mbanaso

"Biotechnology's Contribution to Cassava Production and Processing" by A. I. Robertson

Session 3. Cacao and Coffee: New Research Advances and Applications of Biotechnology
Chairman: Dr. M. Söndahl

"Coffee: New Research Advances and Applications of Biotechnology" by M. R. Söndahl

"Cacao: New Research Advances and Applications of Biotechnology" by M. R. Söndahl

"Status of Cacao Research, Production and Biotechnological Advances in Nigeria" by E. B. Esan

"Biotechnology and Coffee Breeding" by C. Omondi

"Constraints to Coffee Production in Malawi and the Potential Role of Biotechnology" by M. Abberton

Session 4. Requirements for Doing Biotechnology Research
Chairman: Dr. G. Thottappilly

"Minimum Requirements for Doing Biotechnology Research" by G. Thottappilly and S. Y. C. Ng

Wednesday, 18 December 1991

Session 5. Oil Palm: Uses of Biotechnology for Improvements in Oil Palm
Chairman: Dr. L. H. Jones

"Use of Biotechnology for Oil Palm Improvement" by L. H. Jones

"Research on Oil Palm in Nigeria" by M. E. Bafor

Session 6. Applications of Biotechnology to other African Foods
Chairman: Dr. M. Bokanga

"Biotechnology: An Aid to Crop Improvement" by D. Thottappilly, D. Vylsteke, S. Y. C. Ng, S. K. Hahn, G. Myers, R. Asiedu, N. Q. Ng, M. Bokanga, M. D. Winslow, K. V. Bai, and R. Terauchi

"Cytogenetics of Cassava and Related Species" by K. V. Bai, S. K. Hahn, and R. Asiedu

"Root and Tuber Crops Tissue Culture Research Activity at IITA" by S. Y. C. Ng

Session 7. Issues of Relevance to Applications of Biotechnology in Africa
Chairman: Dr. S. N. C. Okonkwo

"The Potential for Biotechnology in Africa" by S. N. C. Okonkwo

"Biotechnology in Sub-Saharan Africa: Creating and utilizing endogenous technological capability" by J. O. Mugabe

"Biosafety Issues: On the Voluntary Code of Conduct for the Release of Organisms into the Environment, prepared by the UNIDO Secretariat for the Informal UNIDO/UNEP/WHO/FAO Working Group on Biosafety" by UNIDO

Thursday, 19 December 1991

Session 8. Constraints in Achieving the Full Potential of Biotechnology
Chairman: Dr. R. Zilinskas

"Bridging the Gap Between Research and Applications in the Third World" by R. Zilinskas

"Barriers to Science in Africa" by R. Zilinskas

Session 9. Solutions for Achieving the Full Potential of Biotechnology
Chairperson: Dr. J. E. W. Broerse

"Industrial Biotechnology and Natural Product Chemistry as Tools for Development: Coca Plant Substitution Strategies" by J. C. Castilla-Rubio

"How to Realize the Potential of Biotechnology for Rural Small-Scale Producers in Developing Countries" by J. W. Broerse

Session 10. Networking and Training Programmes in Biotechnology in Africa
Chairman: Dr. G. Thottappilly

Meetings and Discussions of Working Groups

Friday, 20 December 1991

Guided Tour of IITA organized by Dr. G. Thottappilly

Reports of Working Group Chairmen to Expert Group Meeting
Moderator: Dr. J. E. W. Broerse

Conclusions and Recommendations
Chairman: Dr. Ray Zilinskas

ANNEX II

Meeting Papers

Background Papers:

How to Realize the Potential of Biotechnology for Rural Small-Scale Producers in Developing Countries - J. W. Broerse

Biotechnology and Food Fermentations - P. E. Cook

The Indigenous Fermented Foods and Beverages of Sudan - H.A. Dirar

Summary of Cassava Biotechnologies - S. K. Hahn

Uses of Biotechnology for Oil Palm Improvement - L. H. Jones

The Potential for Biotechnology in Africa - S.N.C. Okonkwo

Cacao: New Research Advances and Applications of Biotechnology - M. R. Sōndahl

Coffee: New Research Advances and Applications of Biotechnology - M. R. Sōndahl

Biotechnology: An Aid to Crop Improvement - G. Thottappilly, D. Vylsteke, S. Y. C. Ng, S. K. Hahn, G. Myers, R. Asiedu, N. Q. Ng, M. Bokanga, M. D. Winslow, K. V. Bai, and R. Terauchi

Barriers to Science in Africa - R. Zilinskas

Bridging the Gap Between Research and Applications in the Third World - R. Zilinskas

Papers submitted by experts:

Production of Wine from Cocoa Juice (Theobroma cacao L. Kuntze) Using Saccharomyces Specie Isolated from Palm Wine and Cashew Juice - H. O. Adesioye

Cytogenetics of Cassava and Related Species - K. Bai, S. K. Hahn, and R. Asiedu

Bioconversion of Waste Materials to Food & Useful Products by Fungi - J.A. Buswell & S. T. Chang

Industrial Biotechnology and Natural Product Chemistry as Tools for Development: Coca Plant Substitution Strategies - J.C.Castilla-Rubio

Recent Trends in World Production of Cultivated & Edible Mushrooms - S.T. Chang & P. G. Miles

Status of Cacao Research, Production and Biotechnological Advances in Nigeria - E. B. Esan

Industrialization of Lactic Acid Fermentation Technology of Cereals and Its Dissemination to Developing Countries - Cherl Ho-Lee

Mutation Breeding in Cassava: An Aspect of In-Vitro Culture Approach - E.N.A. Mbanaso

Biotechnology in Sub-Saharan Africa: Creating and utilizing endogenous technological capability - J. O. Mugabe

Review on the Role of Biotechnology and Applied Microbiology in Food - M. M. Mustafa

Roots and Tuber Crops Tissue Culture Research Activity at IITA - S. Y. C. Ng

Soybeans: The Answer to Malnutrition: The Impact of Soybean Processing and Utilization in Nigeria - S.M. Osho

Biotechnology's Contribution to Cassava Production and Processing - A. I. Robertson

ANNEX III

UNIDO EXPERT GROUP MEETING ON APPLICATIONS OF BIOTECHNOLOGY TO FOOD PROCESSING IN AFRICA, 16-20 DECEMBER 1991

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