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THE POTENTIAL FOR SMALL SCALE OILSEED PROCESSING IN ZAMBIA

ZAMBIA AGRIBUSINESS AND MANAGEMENT SUPPORT PROJECT (ZAMS)
Contract No. 623-0214-C-00-9045-00

November–December 1991

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PREFACE

This study was commissioned by USAID/Zambia through the Zambia Agribusiness and Management Support Project (ZAMS) in order to assess the potential for a project intervention in support of small scale oilseed processing. As such, its primary objective is to provide practical guidance to the Mission for direct action in support of business development in this subsector. The range of action was left open to encompass possibilities as diverse as micro-scale village industry as well as small scale agribusiness in the more important rural market towns, and all types of oilseeds were included in the scope of work.

Zambia is undergoing profound changes in government policy and orientation at this time with the advent of multi-party democracy and a change in government. The prevailing mood in the country is one of optimism and hope for the future, despite the difficulties of the past which have seen the steady deterioration of the economy and quality of life over the last fifteen years. The country has enormous agricultural potential, which has been largely neglected in favor of a mining sector battered by falling world prices for its one major export commodity, copper. This trend is about to change, as the new government recognizes both the importance of diversification in the national economy, and the great potential of the agricultural sector. Consequently, this study seems to be well timed to take advantage of an improving policy environment and a growing emphasis on agriculture and agribusiness in Zambia.

Large scale industrial oilseed processing is developed to some extent in the country. Both private companies and parastatals are active in the production of cooking oil and livestock feed from soybeans, sunflower, groundnut and cottonseed. This study focusses on opportunities for the small scale village processor for several reasons. The large millers have not been able to meet demand for cooking oil despite ample installed capacity. There are many explanations for this, but as we will show below, there is good reason to believe that local village scale processing will overcome many of the obstacles confronting large industry. Local millers will not only serve local demand for cooking oil and stock feed, but improve the marketing situation for oilseeds, which are an important cash crop for small farmers in many parts of the country. Other linkages deriving from this new small industry will serve to strengthen local services to agriculture, such as machine shops, input supply, and agricultural production credit. Supporting this subsector is a direct route for USAID to strengthen the diversification of the agricultural economy of Zambia.

The benefits of a new small local oilseed processing industry need not be gained at the expense of existing large industry. A large urban market and an export market exist to permit substantial utilization of existing capacity even while cooking oil demand in rural areas is being satisfied by local industry.

More than half the cooking oil consumed in Zambia is currently imported. Local production could save scarce foreign exchange to the tune of $20,000,000.00 per annum. Satisfaction of local demand by rural industry might permit large scale millers access to export markets, thereby increasing the foreign exchange earning power of the country.

The nutritional benefits of readily available cooking oil, and inexpensive locally available stockfeed, are not to be neglected. Certain areas of the country, notably Luapula Province, are known for fat soluble vitamin deficiency syndrome. In all areas, rural people prefer diversity in their diet, and would benefit from the fat and energy content of good quality cooking oil. Poultry and pig producers, dairymen and feedlot operators will all derive benefit from inexpensive good quality oilseed cake, and these benefits will pass on to local consumers of meat, milk, and eggs.

The potential for development of industrial oil from castor bean appears great, but this industry is in its infancy in Zambia, local markets are undeveloped, and the crop has never been grown commercially. Therefore, we have chosen to focus on village cooking oil production, where the potential for immediate positive impact of project activities appears greatest.

In short, USAID's objective of finding a practical approach to the development of small scale oilseed processing in Zambia is timely, and likely to show extensive benefits to rural people and the agricultural economy of the country.

EXECUTIVE SUMMARY

Profound political changes have taken place in Zambia within the past few months. These changes are expected to have a positive influence on economic development in the country, especially through policy reforms, by creating a climate conducive to private enterprise development. With emphasis on agricultural reforms and a freer market economy, opportunities in agribusiness appear promising. The focus of this study has specifically been business opportunities in village level and small-scale oil (edible and industrial) processing.

Findings

The demand for cooking oil in Zambia is estimated at over 50,000 tons per annum; yet only one-third of that is produced from locally grown oilseed. Currently, demand is not being met, especially in the rural areas of the country, although scarce foreign exchange is used to import large amounts of crude oil for refining by parastatal industry. In discussions with consumers, businesses producing cooking oil, retail and wholesale shop owners, and vendors in several provinces (Southern, Eastern, Lusaka, Central, and the Copperbelt) the unmet demand and desire for cooking oil is striking. Demand by sellers has been described as "insatiable"; rural consumers describe walking for several hours in search of oil only to find it not available.

Zambia could be self-sufficient in cooking oil and seedcake given its agricultural base and the installed capacity of oil expellers already in the country. There are four readily available sources of edible oil in Zambia : cottonseed, groundnuts, soybean, and sunflower. Soybean and cottonseed are difficult to process at a small-scale level and were not considered for further study. Minor oilseed crops in Zambia include sesame, oil palm, and mungongo nuts. These crops have limited potential by comparison with the major oilseed crops, sunflower and groundnut, and were excluded from this analysis because they do not offer the same potential for immediate impact on the national need for cooking oil. By the same token, the alternatives to sunflower and groundnut do not offer the same degree of business opportunity, nor the potential for rapid expansion of project services in support of small scale processing.

Groundnut production ranks high in most parts of the country. They are grown primarily as a food crop by small-scale farmers, except in Eastern province where groundnuts are an important cash crop and foreign exchange earner. As such, they bring a high price for the confectionery market, and are therefore sometimes too expensive to produce an economical cooking oil. However, it is a high oil content crop easily processed at the village level. Where producers do not have ready access to a cash market for their crop, they may prefer to process it to oil.

The consultants have several areas of concern in promoting groundnut processing at a small-scale level, the most important of which is the risk of aflatoxin in the seed cake, whether used for human food or animal feed. This risk is greater for groundnuts than for other oilcrops. As long as processing is done on a microscale as a village enterprise, the risk will probably remain low, just as it is today in the groundnut flour sold by rural women in most markets in the country. If production reaches a larger scale, the risk of processing seed

which is visibly contaminated (moldy), or of improper storage of seed cake for extended periods of time, leading to higher risk of aflatoxin contamination, will become greater.

There are also possible negative nutritional consequences of introducing groundnut processing. Commercialization of groundnut processing, which is traditionally a women's activity, may result in decreased cash income opportunities for women if men dominate the processing activity once it requires investment and improved technology. Availability of groundnut flour for household consumption may also be adversely affected, with consequences for protein availability, a problem which will have a particularly adverse impact on small children.

Sunflower is a cash crop grown almost exclusively by small-farmers. It is a secondary crop, sown late resulting in low yields and low oil content. Since it is not a high value crop for other uses, it is grown primarily for its value as an oilseed. Composite varieties developed in the national research program can contain as much as 37% oil, which compares favorably with groundnut. The technology required for village processing of sunflower is generally more complex than for groundnut, but several systems are currently in use and the technical problems are manageable. In the short to medium term, the consultants believe that sunflower is the most appropriate crop to promote for small-scale oil processing and will have the greatest overall impact in increasing the availability of cooking oil. The availability of high quality sumflower planting seed is a major constraint to development of village processing, since higher quality seed would contain more oil, and could also have thinner hulls, thereby improving the extraction rate in processing and reducing wear on the equipment used.

The supply of oilseeds available for processing is low for a variety of reasons, including:

- Lack of financial incentives for farmers to grow oilseeds in comparison to other crops;
- Insufficient supplies of improved variety seeds for planting;
- Poor planting and harvesting practices by farmers resulting in low yields and low oil content seeds;
- Poor agricultural marketing and distribution systems for oilseeds.

The urban oil processing sector is limited to a few large-scale parastatals and a few medium-scale private and cooperative ventures. Even though installed processing capacity is high, throughput and profitability have been low for numerous reasons including:

- Lack of sufficient oilseeds to process;
- Low oil content of available oilseeds;
- Artificially low price-setting by parastatal producers;
- High transportation costs in obtaining oilseeds;
- Lack of foreign exchange to import needed wear parts for machinery.

In Zambia there are currently several types of small oil processing technologies in use--manual, animal powered, and motorized. Although limited amounts of rural oil processing is done using traditional methods (especially palm oil), small, manual technologies for

processing sunflower and groundnut oil are relatively new and are not widespread in the country; there are few motorized expellers, as well. This sector has been hampered by a lack of profitable technologies available on the market, lack of workable equipment, and a lack of technical data available to potential manufacturers and users of oilseed processing equipment.

In a Deloitte study conducted in 1987, 33 small motorized expellers were identified in 7 provinces in the country. Although the consultants were not able to identify and visit even a representative sampling of these enterprises, there were commonalities among all those visited. All of the operators visited had severe problems in maintaining the equipment due to the poor quality of locally produced wear parts and lack of foreign exchange to import parts; this results in considerable downtime. Sunflower seed purchased was often of poor quality with low oil content and exceptionally dirty; 20% of the seed by weight could be lost due to trash and shrinkage. Groundnut processing was not done to any large extent due primarily to the high cost of groundnuts resulting in a high priced product, although processing groundnuts would result in much less wear on the expellers.

Motorized small expellers have a much larger capacity than village technologies, and therefore are better suited to meeting the needs of the larger rural population centers. The team estimated, for example, that the market for cooking oil in the town of Monze is currently about 100 tons per month. However, the leap from village technology and small rural business to a small industrial plant using motorized equipment is fraught with difficulties at this time. Some of the major problems which such a small rural industry would face currently are :

- High cost of capital and limited availability of credit;
- Lack of technical support for local manufacture and repair of machinery, and of wear parts;
- Shortages of foreign exchange make importation of equipment and wear parts difficult and time consuming;
- Weakness of agricultural marketing institutions make supply of good quality oilseed unreliable;
- Lack of agricultural production credit for oilseed crops and a good supply of high quality seed discourages producers.

The team feels that there is good potential for development of a small scale oilseed processing industry in the rural market towns in the medium term, but in the short run, these operators do not have the support systems they require for profitability.

Therefore, it is the recommendation of the consultants that USAID/Zambia concentrate its resources on the development and dissemination of village level oil processing technologies for the following reasons:

- The rural population suffers the greatest shortage of cooking oil;
- The cost of transporting oilseeds from rural areas to urban areas, and then transporting oil and oilseed cake back to the rural areas is high, and will

remain so for some time to come, thus favoring local production and processing of oilseeds;

- A few thousand small, manual oil presses could provide one and a half million consumers (20% of the population) with their cooking oil requirements. This activity would complement the hammermill program and lessons learned from it can be utilized.
- Small oil pressing enterprises can be established which would both serve community needs (cooking oil and stockfeed) and be profit-making activities for the entrepreneurs involved.
- The forward and backward linkages resulting from these enterprises would create additional employment and income in the rural areas.
- Village technology businesses are a first step toward the development of a new small rural industry in Zambia which will evolve toward motorized equipment in time.

Four types of manual or animal powered oil processing technologies are currently being used or tested in Zambia: a ram press, an animal powered oilpress, a spindle press with auxiliary equipment for seed pre-conditioning (KIT/UNATA/Lutanda), and a spindle press with a modified seed pre-conditioning process. Currently, all of the technologies have some drawbacks.

The animal powered oilpress in use in Zambia consists of an expeller powered by draft power instead of an electric or diesel motor. The use of an expeller makes this a relatively expensive operation and the problems already discussed with expellers in Zambia apply to this system as well. The consultants are not aware of any animal powered ghanis in operation in Zambia, although this alternative would be considerably less costly.

The KIT system consists of a series of equipment (dehuller, winnower, roller mill, spindle press) similar to that used in industrial processing. The number of machines used makes this a relatively expensive processing system, but it does have a fairly high throughput (200+ kgs a day of whole seed) for a manual system and a good extraction rate for sunflower. The system is somewhat modified for processing oil palm and works quite well. The drawbacks of this system include the cost of equipment and its technical complexity. For a group of rural people, or an entrepreneur, to master the operation of the entire series of machines, and also to achieve the teamwork necessary to operate the system near its capacity requires considerable training and experience. The KIT processes currently in operation have all required considerable amounts of outside assistance (financial and management assistance, assistance with seed supply, technical assistance) to operate. Because of the large amounts of raw material needed to operate profitably, large amounts of working capital are needed to purchase seed.

In order to alleviate the problems listed above with the KIT process, a simplified process is currently being tested with the hope that the equipment can be modified to be less costly as well as to eliminate at least some of the machines needed for seed pre-processing and still achieve an acceptable extraction efficiency. Smaller spindle presses with less throughput offer several advantages over the KIT system--service pressing can be accomplished, seed input is reduced, and therefore less working capital is needed, and the cost of the machine

is reduced because of less material used in manufacture. The consultants believe that the testing currently being done is worthwhile and test results can be completed in a relatively short time period. With the limited information currently available, preliminary economic analysis indicates that this would be a profitable enterprise for a rural entrepreneur. The effort to identify a more economical processing system based on the spindle press should focus on pieces of equipment which have already been developed and proven in other Appropriate Technology programs. For example, sunflower dehullers and winnowers are available from ITDG, KIT, and UNATA. In other words, use "off-the-shelf" equipment to the greatest extent possible.

The other manual technology being used in Zambia is a ram press. The ram press is used on undecorticated sunflowerseed and therefore eliminates the need for seed preconditioning (other than heating in the sun). Because only one machine is used it is a relatively simple operation. It is also physically demanding. However, the Zambian produced ram press has not performed well in the field and has been subject to serious wear and breakdowns. The press was originally designed in Tanzania to be used on thin-hulled, high oil content seed. The majority of sunflowerseed in the rural areas is thick-hulled and has a relatively low oil content. The poor results in the field with the ram press are probably a result of many factors--the type of seed used, the modifications made on the machine, and the lack of proper seed cleaning and machine usage by operators. It is thought that hardening some parts of the machine through the use of hard steel or a hardening process may improve the performance of the press. There are several versions of the ram press that have been successfully used in other countries. The consultants believe it would be worthwhile to test these presses in Zambia and have results available in a short period of time. Assuming that a ram press design that works with locally available seed becomes available, the initial analysis indicates this could be a profitable enterprise.

In addition to the technical probiems to be solved as outlined above, village level oil processing also entails the need for additional inputs--credit, improved seed supply, training and education, and rural repair facilities. These are not insurmountable obstacles and can be addressed through a well thought out project working with a variety of local organizations involved in these activities.

Conclusions

1. Village and small-scale oil processing is the most viable option for increasing the availability and affordability of cooking oil in rural areas.

2. There is strong potential for profitable oil processing enterprises in rural areas with village-level technologies; enthusiasm is shown by people once they are aware of processing technologies.

3. Supply of planting seed for oilseed crops to rural small-scale farmers is unreliable. The main strategy adopted by farmers to solve this problem, is to retain some of their own production for planting next year, or to buy from their neighbors' retained production. This results in low yields and low oil content seed, and is a constraint for any oil processing

activity. Ways of reducing the high cost and improving the availability of seed through the promotion of local seed production projects should be investigated.

4. Processors are aware of seed quality issues and are willing to pay a premium for high oil content seed (some ram press owners are testing seed before purchasing it and adjusting prices accordingly; Premium Oils is paying a premium for hybrid seed). For both ram press and small motorized expeller operators, availability of a soft-shelled seed would offer the advantage of reduced wear on their presses and consequently improved extraction rates.

5. Lack of nearby markets and price distortions have discouraged the production of oilseeds. In other African countries it has been shown that oilseed production goes up when local processing technologies have been introduced.

6. In the short to medium term, urban based oil mills will not supply adequate supplies of cooking oil to rural areas because of inefficiencies inherent in the system and the lack of infrastructure.

7. Village and local based oil processing will result in rural employment generation and increased incomes through backward and forward linkages (repair services, traders, increased value of livestock)

8. Vegetable oil intake among the rural population can be increased by making oil more affordable and more readily available through:

- low- or no-cost packaging (i.e., bring own containers);
- service pressing (farm families can be sure of being able to process their own production locally at low cost and money does not need to change hands);
- decreasing the distance traveled to obtain oil;
- increasing purchasing power through employment generation in rural areas (oil processing enterprises and forward and backward linkages).

9. The extraction efficiency of all types of processing equipment is dependent both on the quality of seed and preconditioning of seed.

10. Despite deforestation problems and general shortage of fuelwood, preconditioning of seed is efficient and will be adopted spontaneously, even if cold pressing is promoted.

11. It is necessary to introduce efficient cooking systems at the village level (for pre-processing and clarification) which minimize fuelwood consumption. This innovation can be adapted to other industries, especially brewing of beer, as well as household use of fuelwood for cooking.

12. The ram press has a good extraction efficiency without the need for fuelwood in preconditioning of seed (seed is preheated in the sun).

13. Repair and maintenance of all types of small-scale oil processing equipment is difficult in rural and market town areas.

14. There is a large leap in expertise required to go from village technology repair to small industry (expeller) repair.

15. There are no machine shops in Zambia which are currently set-up to manufacture wear parts for small motorized expellers. Some shops have done it on a one-off basis, with mixed results. Until parts are manufactured in quantity they will be expensive.

16. The capacity for commercial manufacture of village level technology is available in Zambia, but a market (profit potential) has to be developed to encourage manufacturers to begin commercial production.

17. Village level oil processing technologies available in Zambia are not yet ready for widespread dissemination :

- problems remain with the ram press;
- the simplified spindle press system is an unknown quantity, since present experience is limited to the KIT system;
- current animal powered systems are still experimental and face problems similar to small expellers;
- ghanis are unknown in Zambia.

However, with continued support to development and field testing, dissemination of workable technologies should be possible in the near future.

18. The most appropriate oilseed crop for village processing will be different in different parts of the country due to agronomic and economic conditions.

19. The most appropriate village technology for oil processing will also differ by crop and location.

20. Sunflower is widely grown, widely adapted, easily processed, and has a low value for other uses; the seed cake has good value especially when decorticated. Among the oil crops currently available for processing, sunflower is the only one which derives its primary value from being processed into cooking oil. However, quality seed supply is a major constraint in the short-term, and current farming practices (late planting, no weeding, saving own seed) result in low yields per hectare and reduction of oil content in seed.

21. Groundnuts are widely grown, easy to process, and have a relatively high oil content. However, they have a high market value for confectionery uses and are a staple food, important for food security and protein nutrition in rural areas. Although the aflatoxin problem exists for other oilseeds, the problem is particularly critical in groundnuts. The fact that it is difficult to detect aflatoxin contamination makes oil extraction from groundnuts and selling the cake for human consumption a risky business in rural areas.

22. Sesame is not widely cultivated in Zambia, but it offers good potential especially in drier areas of the country where groundnuts and sunflower cannot be grown. Sesame is easy to process at the village level and has a high oil content.

23. Oil palm is the easiest crop to process at the village level, but it only grows in Luapula and parts of Northern Province, so project activities in oil palm processing will have only a limited impact in Zambia.

24. Castor oil, which sells for up to four times the price of vegetable oil on the world market, has the potential to be a high value cash crop for small farmers if a local market were identified and developed. Small scale processing should be relatively easy.

25. The market for cooking oil already exists; however, the market for seed cake as an ingredient for animal feed for use by the small-scale farmer has to be developed (commercial farmers already know its value). The market for decorticated seed cake, both groundnut and sunflower, as a human food may have potential, but the risk of aflatoxin contamination must not be ignored.

26. In the current situation, the ram press and KIT processing system are both financially viable enterprises. Oil processing using a spindle press and modified pre-conditioning equipment should also be a financially viable enterprise.

27. Given a choice, rural entrepreneurs will prefer powered equipment (expellers) over manual equipment (although they generally are not aware of the actual costs and range of difficulties associated with powered equipment). However, the management skills, financial resources, input supply, and technical resources needed to operate an expeller in rural areas are not readily available.

28. Even in market towns, where management skills and financial resources may be adequate for motorized equipment, the weakness of agricultural infrastructure (seed supply, production credit for oilseeds, working capital credit for processors, agricultural marketing services and extension services) and technical support (wear parts and repair services) are still problematic.

29. In the short to medium term, the low purchasing power of the rural population, the high inflation rate, the shortage of credit and high (nominal) interest rates suggest the need for small, inexpensive oil processing technologies that are both profitable and require little financing.

30. Working capital is a constraint for all oil processing activities; the larger the equipment capacity, the more raw materials needed. Zambia has only one growing season (for oilseeds) per year; oilseeds have to be purchased at time of harvest to guarantee availability. Either an enterprise will grow slowly in reaching full capacity utilization or credit for working capital is needed.

31. Rapid diffusion of village oil processing technologies may depend on the ability of small, rural entrepreneurs to obtain credit for initial purchase of equipment. The level of expenditure required for village scale enterprise (K100,000 to K150,000) is within the norms for rural lending for Zambian financial institutions.

Action Plan Recommendations

Focus on village oilseed processing technology in the short run. This is an area which offers great opportunity, even in the medium to long run, and in which USAID has a comparative advantage over other donors because of experience with Africare, TDAU, and in other countries. Other donors (UNDP, FAO, IFAD) are already moving rapidly toward promoting motorized expellers; leave this area, which faces many obstacles (technical, agricultural, and financial) in the short run, to them. The ZAMS Project can still assist in the development of motorized oilseed processing technology by making foreign exchange available to innovators and providing technical support from in-house expertise, and in the process keep in touch with progress in this area.

Recognize that there is as yet no technically and economically efficient village scale oilseed processing system ready for wide diffusion in Zambia, and that no one system will meet the diverse needs of people in different areas processing different types of oilseed. The team feels that of the remaining technical problems, some may be resolved in a relatively short timeframe, while others may require a one year program of research, development, and field testing, as outlined below. Wide diffusion of results should not be attempted before completion of successful field testing, in cooperation with end users, of the systems developed. Field testing should be initiated as quickly as possible once pretesting results are positive in order to shorten the development cycle.

The importance of timing of activities relative to the agricultural calendar cannot be over-emphasized, since slipping the schedule by one season may slow development by a full year. It might be possible to begin some field testing, depending on the start date and success of Phase One, described below, as early as mid- to late-1992. In that case, a realistic target for the beginning of Phase Three would be mid-1993.

Phase One - Technology Choice (six to nine months)

1. Act as an initial clearinghouse for information in Zambia on village scale oilseed processing technologies. Initiate a meeting to ascertain status, problems, performance of the 50+ ram presses in Zambia purchased by private parties, NORAD, GTZ, ADRA, etc., the KIT systems installed at Kasisi Mission, Sinazeze, and in Luapula, the GAMECO spindle presses distributed around Pemba, the animal powered mills operating in Eastern Province, etc. This meeting will help to identify potential project partners for further development of village scale oilseed processing technology in Zambia and provide a broad basis for identification of opportunities and potential problem areas. The importance of successful outreach and wide dissemination for phases two and three requires an early start of efforts to identify interested private parties and NGOs with strong grassroots networks.

2. Try to shorten the development cycle of effective technologies and avoid re-inventing the wheel. A study trip to visit the Appropriate Technology houses in Europe who have been working on oilseed processing equipment for a long time could save a lot of time in the technology identification phase. The following institutions should be visited :

ITDG in the UK

Tropical Products Institute in the UK
Royal Tropical Institute in the Netherlands (KIT)
ATOL/UNATA in Belgium
GRET in France

Some research, perhaps with the assistance of Appropriate Technology International in Washington, might help to identify other worthwhile stops, or individuals to visit. When planning the trip, make sure that the person responsible for oilseed work is available for discussion, since this is a fact-finding mission, not a shopping trip.

In addition to useful personal contacts which would come out of this trip, items of equipment could be identified for purchase from european manufacturers or for fabrication in Zambia based on proven designs. Since the spindle press system will almost certainly require supplementary equipment for pre-conditioning of seed, and perhaps different items of equipment will be needed for each type of oilseed processed, this trip would have the objective of identification of appropriate configurations of equipment to meet this need.

For ram presses, buy all equipment for testing "off-the-shelf" from experienced manufacturers in other countries, because Zambian-made equipment has not performed well to date. Try several different ram press designs (Allen, Fischer, CAPU) to determine which, if any, works well in Zambia. The possibility and cost of local manufacture can be assessed if any of these machines prove viable using locally available types of seed.

For spindle presses, the KIT spindle press has been proven effective on sunflower, groundnut, and oilpalm. Other commercial suppliers of spindle presses can be identified, both in Europe and the Copperbelt. Smaller cylinder sizes to encourage cold pressing may require more research and development effort than anticipated, because of the greater efficiency and ease of extraction when seed is preconditioned. Rural users are likely to begin preconditioning seed on their own initiative, using inefficient systems for preheating resulting in excessive fuelwood consumption, neglect of the potential of hulls for fuel, etc. in an effort to improve yields and reduce the labor required to operate this type of press. These factors should be evaluated carefully during the field testing phase. Equipment configurations in support of spindle press based systems must be appropriate to the various oilseeds available to villagers for processing.

3. Shorten the development cycle of appropriate technology selection by working in close partnership with commercial manufacturers and villagers. Zambian industry has the capability to manufacture appropriate equipment for village scale oilseed processing, and several manufacturers have expressed serious interest in diversifying into the agricultural processing equipment area in discussions with the team. Only acceptance by village people will ultimately determine the success or failure of the project, therefore they should be involved from the beginning in identification of needs, evaluation of alternatives, and choice of solutions. Rural entrepreneurs are easier to work with during R&D phases than groups, and preference should be given to individuals in the beginning of the development cycle.

4. The emphasis should be placed on sunflower and groundnut for Phase One technology selection because these are the most widely available and easily processed crops

suitable for village cooking oil production. Adaptation of the equipment to sesame and castor can be evaluated, recognizing that results with these crops are likely to require longer lead time because of the limited availability of these crops for processing at this time, and the uncertain market for castor oil. Field testing of equipment for sesame and castor can be initiated in those areas where the crops are available.

5. Preconditioning of seed must be a part of the testing process. First round testing and evaluation should be done intensively in a "laboratory" setting, but not by any organization which has a vested interest in modifying the equipment. The project can hire laborers, design an evaluation system, and perform its own tests, possibly with the support of an independent consulting engineer who has no vested interest in any of the machines being tested. The ZAMS Agricultural Engineer can play a key role in oversight of this phase of the program.

Testing should emulate field conditions to the extent possible, and seek solutions to some of the practical problems faced by rural operators, e.g., dirt, field trash, and stones mixed with seed for processing, the time consuming process of oil clarification and/or filtration, how to process seed cake into a marketable form quickly and economically, etc. Accurate evaluation of oil content of seed and extraction efficiencies of the equipment in use is essential during this phase to guide selection of equipment for dissemination. Feed value of oilmeal should also be assessed to provide the basis for recommendations for its use during dissemination. Accurate costing of all inputs, rates of wear (meaning a significant quantity of seed must be processed), and other operating costs must be done to assure preliminary economic feasibility before field testing of equipment.

The risk of aflatoxin contamination and measures to mitigate this risk should be studied carefully. This problem is particularly important for gorundnuts but also exists for sunflower and other oilseeds, where improper handling and storage of seed and cake can lead to mold growth.

6. Once preliminary selection has been made of the most effective systems for oil extraction on the various oilseeds (sunflower, groundnut, sesame, and castor), local commercial manufacturers can be brought in to produce the equipment on a test basis prior to field testing. Facilitate access to appropriate raw materials (quality steel, component parts, etc.) as necessary. Their products must meet acceptable performance criteria established during the early technical trials. Once their prototypes are acceptable, proceed to production system design. Dr. de Silva of BOART in Kitwe and Mr. Jung have both expressed an interest in this effort. BOART owns Kaleya Engineering in Mazabuka, which is where their agricultural equipment would be manufactured, but input from Dr. de Silva might greatly reduce the cost and increase efficiency of manufacture. GAMECO is also seriously interested in going into manufacture of this type of equipment. Reunited Engineering in Lusaka is another possible player. Competition among manufacturers is healthy and should be encouraged.

7. The planting seed supply problem is fundamental to development of the oilseed processing industry in Zambia regardless of the scale of the industry or the technology in use. Take steps early in the project to begin researching ways of resolving the seed supply

problem in order to raise the yield level and oil content of oilseed crops in Zambia and to develop or introduce soft-shelled varieties of sunflower. (see ANNEX 2 for further discussion)

Phase Two - Field Testing (six months to one year)

1. Select village operators, preferably entrepreneurial individuals, to do field testing and provide feed back to the local commercial manufacturers. The individuals and groups must be carefully selected, and should be profit motivated to insure the most rapid feedback and greatest effort on their part to overcome obstacles to effective operations. Africare can support this effort in the Southern Province. Other NGOs identified in the initial networking meeting (see #1 above) can also help. Regional Integrated Development Projects may be able to provide assistance in other areas (Eastern Province, Luapula).

Management training sufficient to insure meaningful conclusions should be one of the benefits received by participants at this stage of the program. A "management package" can be developed and tested during this phase, i.e., simple bookkeeping and record keeping systems, a business plan, a marketing plan, credit-worthiness analysis and loan application package, technical manuals, etc.

2. Share the economic risk with early adopters and pilot project partners by providing equipment through a lease/purchase plan. Giving equipment to people tends to encourage the belief that it is worthless. Users must have a commitment to making it work, and be profit motivated as indicated above. This may slow identification of project partners, but will speed the process of achieving meaningful results.

3. Monitoring and evaluation of practices and choices made by the test groups is critical during the field evaluation phase. Regular site visits and extended periods of time for on-site observation and discussion with the people will be necessary to benefit from their insight and experience. This must be a priority element of project activities, and resources (human, transportation, etc.) must be available on a timely basis, otherwise the field testing phase must be postponed.

4. Identify target zones of action which offer the possibility of field testing the equipment on the variety of oilseeds currently available. In each area, insure that systems are tested on all oilseeds available in that area. Management will be crucial for the quality of information obtained, so should be insured by the project. Local people can receive management training from project personnel on-site during this phase. The village level economics of each process must be analyzed as well as the technical problems.

5. Give people a choice of equipment and processing methods during the field testing phase. Provide ram presses and spindle presses to selected entrepreneurs or groups on a lease/purchase basis, and supplementary equipment as necessary for preconditioning of seed, as appropriate to each target area. Recognize that people will quickly discover for themselves the benefits of preconditioning of seed, and will do it any way they can, resulting in greater fuelwood consumption than if the project provided an efficient method of

preheating seed. Introduce techniques for simple clarification and refining of oil, because rural people are not insensitive to the quality of foodstuffs.

6. Locally available seed can be used by those doing field testing in the beginning, although tests using ZAMSEED's improved varieties of sunflower and groundnut should also be arranged. Every effort should be made to compare the machines on an equal basis, recognizing that raw materials will vary in quality from region to region. Initial adoption will depend on the ability of the equipment to process seed already available. Improved seed should be made available as quickly as possible. Liaise with those involved in seed research and supply issues - Ministry of Agriculture, Premium Oils, ZAMSEED, the OILS committee, etc.

7. Initiate immediate research into recommended uses of all type of oilcake based upon data from phase one (amounts, mixtures, suitability for different animals, for human consumption, etc.). Distribute information and guidelines through extension services, radio, the NGO network, etc. Developing a rural market for these oilmeal products will greatly improve the economics of village oilseed processing.

8. We have not made recommendations for action on Oil Palm because as a village scale technology it will have only a very limited impact in Zambia. The oil palm only grows in a small part of the country, and palm oil is not widely used in the Zambian diet. The project could investigate the possibility of doing something for village processing of oil palm once other oilseed processing activities are well under way, but this should not be a high priority. Nonetheless, we would like to point out that this is probably an area where a village industry could be introduced very successfully, although only on a small scale in Zambia.

Phase Three - Diffusion (two to three years)

1. Facilitate importation of appropriate raw materials (steel, component parts, etc.) for the commercial shops to both speed the development cycle and reduce the cost of first run locally manufactured equipment. Provide expert assistance to reduce cost of manufacture, possibly, for example, by working through BOART (Dr. de Silva) and Kaleya, or by using a consultant to advise other interested shops (Jung). The project could also cover the cost of drawings and other development costs to keep the final cost of equipment to end users to a minimum. This work would have to be done by an independent engineering consulting firm with no intention of developing a proprietary product. The simplicity of the equipment in question should make it accessible to a variety of potential manufacturers, and good drawings could speed the development of healthy competition, or regional suppliers, for this industry.

2. Establish a revolving fund to contract with manufacturer(s) to produce ram and spindle presses in batches to reduce cost. The project should provide quality control assurance to equipment buyers until competition in the marketplace is adequate to insure quality. Contract arrangements with manufacturers could simplify this process. Provide initial marketing assistance to manufacturers (i.e., field demonstrations, pamphlets, advertising).

3. In addition to support of manufacturers of village scale equipment, repair shops will also need support and training in some areas. There is a shortage of skilled labor in rural areas. Support to training workshops (such as VIS or SIDO) or vocational schools might be a way to have a positive impact in this area. To some extent, training machine owners to dismantle and repair their own equipment, or at least disassemble the machine to facilitate transport of parts needing repair to a local shop, can help overcome this problem.

4. Work closely with local NGOs and financing institutions once a processing system is proven viable and ready for wide diffusion. Prepare and distribute detailed information (feasibility studies, technical manuals, user's guides, etc.) to organizations interested in funding and/or disseminating press activities--VIS, SIDO, CUSA, ZCF Finance, Lima Bank, IFAD, etc. Provide short-term technical assistance. Deliver a technical and economic package to them for diffusion :

Appropriate configuration of equipment for processing, as defined above;

Suitable management system, including simple bookkeeping (training of trainers);

Business plan, including a marketing plan for products (cooking oil, oilmeal, industrial oil);

Credit facility if necessary (probably by guarantees through existing local credit institutions such as Lima Bank, ZCF Finance or CUSA);

Technical backup in the form of replacement parts and locally available repair services, as well as training of trainers for operation, maintenance, and repair of equipment by end users.

5. Establish an initial seed distribution system in vicinity of presses. For example, each purchaser of a press could purchase enough seed to sell to nearby farmers in small, affordable packages, to ensure a minimum first year seed supply. Seed is not always available even to primary cooperatives interested in supplying their members, so the project can play a role in making seed available in the short run, until ZAMSEED or other suppliers develop a more effective distribution network. Work with interested parties such as cooperatives, seed stockists, traders, hammermill owners, etc., in establishing sunflower, groundnut, sesame and/or castor seed distribution systems.

6. Facilitate exchange of information directly among potential users by financing local study trips, bringing villagers to the pilot sites where people are experienced with the equipment and can explain its use and value. Additional information dissemination through national radio programs could effectively address key issues, such as the nutritional value of village processed oilseed products, use of oil cake for livestock feed, the dangers of aflatoxin in certain products, the importance of protein and lipid nutrition for small children, etc. Publicizing the processing systems and encouraging people to visit users could speed dissemination. Certain users could be compensated for promotional efforts, perhaps in creative ways such as priority access to improved seed, study trips to visit other users in different countries, etc.

7. Provide management services and training to users through the NGO network (training of trainers). This is an area which will require careful monitoring and evaluation insofar as the quality of services delivered to end users by NGOs is concerned. The major thrust should be institutional strengthening, since the scale of equipment we are proposing does not require sophisticated management, and many rural people will find innovative ways of making this activity profitable.

8. Establish a monitoring and evaluation system, beginning with a baseline study which should be executed during phases one or two (i.e., before diffusion). This study could focus on availability and cost of cooking oil and stockfeed supplements, use of same by villagers, nutritional and food security impact of processing groundnuts for cooking oil, income generation gender issues in cooking oil production, and oilseed production. Equipment manufacturing services and capability should be evaluated, as well as availability of repair services for small scale agricultural equipment in rural areas. The objective of this M & E effort will be to identify potential areas for additional project support.

9. Keep the option open to move into support activities for motorized expellers later in project life when economic and technical considerations may be much more favorable than they are at this time. This may be a natural avenue of expansion for some entrepreneurs who have begun operations with manual equipment. If the UNDP/FAO project in Central Province is successful, USAID might take up a dissemination role in one or a few provinces in collaboration with other donor agencies such as the World Bank or IFAD. As discussed in the introduction to this section, providing foreign exchange facility and technical support to those working at this level of technology during the village technology project can facilitate entry into small scale motorized oilseed industry support when economic and technical circumstances are more favorable.

<u>Questions for Further Study</u>

- Identification of minimum cost configurations of spindle press based oilseed processing systems which are effective and economical for village cooking oil production, for example, supplementary equipment needs such as:

  Pre-heating systems for sunflower, groundnut;
  Sunflower and groundnut dehullers;
  Sunflower roller mill for seed crushing;
  Groundnut crusher.

- What can be done to improve seed supply and distribution systems so that small scale operators have access to higher oil content seed? (An approach through multiplication and distribution, not breeding and agricultural research.)

- How can a project encourage and facilitate local manufacture of appropriate oilseed processing equipment?

- What can be done to address the need for repair services for owners of processing equipment in rural areas (including hammer mills)?

- How can we provide credit through existing institutions on an affordable basis to speed diffusion of oilseed processing technology and make it accessible to women and other disadvantaged groups?

- What is the potential for small enterprise promotion and technology innovation for oil palm processing in Luapula Province?

- What is the potential for sesame production as a village oilseed crop in the Zambia? Are the technologies available for sunflower or groundnut appropriate for crushing sesame?

- What is the local market for unrefined castor oil, and is the crop potentially attractive to small farmers?

- Can the project insure that the risk of aflatoxin is minimized through the improvement of handling, drying, and storage technology, introduction of simple testing methods, or other preventive measures?

I. OVERVIEW OF THE AGRICULTURAL ECONOMY

The Zambian economy as a whole has suffered from dependency on a single major export commodity, copper. Lack of diversification in the economy resulted in the steady deterioration of the national financial situation when the world copper price fell. Resulting debt, balance of payments and foreign exchange crises have had a strong negative effect on the underpinnings of the economy. The inevitable deterioration of infrastructure, compounded by a policy of nationalization of industry, has resulted in shortages of goods and inflation. In response to these difficulties, government resorted to price and exchange rate policies which have distorted incentives in agriculture and aggravated the crisis at the treasury.

Restructuring of the economy will be painful in the short run, but optimism is justified in the long run because of the great natural wealth of the country. The agricultural potential of Zambia has barely been tapped, and the basic conditions for development of the agricultural economy are favorable. Land is abundant, and the climate favorable to a wide variety of crops and livestock production. Commercial farming has a long history in Zambia, and is well organized to make its wishes known to government. Even traditional farmers are familiar with cashcropping and animal traction, putting them far in advance of their counterparts in other countries. The cooperative movement has had its ups and downs, but in some areas, structures are in place which can greatly facilitate input supply, production credit, crop marketing and extension. The country is well located to take advantage of potential export markets for agricultural products in the Southern Africa region.

Basic industry is relatively well developed by sub-saharan African standards, and the capable firms which have been serving mining in the copperbelt are already turning toward agriculture as a new area of opportunity for their machining and manufacturing skills. The food processing industry has been diversifying in recent years, creating a knowledge base on which to build for the future. Electricity is cheap and abundant, if not widely available.

Changing agricultural policy will open the door to new opportunities for farmers and food processors. The previous emphasis on maize production and consolidated milling by parastatal industry will give way to diversification of cash crops and decentralization of industry. Zambia's main policy objectives in agricultural development are:

1. To increase agricultural productivity.
2. To raise the incomes of small farmers and improve their nutritional intake.
3. To create jobs in the rural areas in order to slow migration into urban centers.

The development strategies of the past twenty seven years, which were characterized by increased state involvement in the economy, the expansion of free social services, and subsidies to consumers, are being abandoned; liberalization towards a more free market approach is being adopted. The worsening state of the economy has caused the country to think more about questions of economic efficiency and production rather than ones of equity and social welfare. Marketing and input supply liberalization is being pursued in order to

improve services to farmers. This opens the door to entrepreneurs to get involved in both input supply (especially supply of quality planting seed) and marketing of farm produce.

Oilseeds, in particular, stand to benefit in the short run from more realistic policies regarding maize prices. The oilseed crops are familiar to both commercial and traditional farmers. Small farmers are the major producers of sunflower seed and groundnuts, the most likely oilseeds for small scale local milling. The relaxation of price controls has allowed oilseed processors to pay competitive prices for quality crops. This is a stimulus to oilseeds production. Processors have begun to pay a premium for higher oil content recently. This is contributing to raising awareness among farmers of the importance of high quality seed to produce a crop with a high oil content. The reduction of subsidies on fertilizer has encouraged small-scale farmers' move from heavy dependency on maize (which is heavily dependent on chemical fertilizers) for both food and cash needs, to less demanding crops for cash. This is stimulating an expansion in production of low input crops, such as sunflower and groundnuts.

Underinvestment in family farm-based agriculture and continued low agricultural productivity on small farms, and the over- emphasis on production and consumption of hybrid maize at the expense of other crops has contributed to food insecurity. Rural oilseed processing is an indirect way of improving rural food security in Zambia. Increased attention to non-maize commercial food crops such as oilseeds in the more remote and less developed areas of the Republic would alleviate some food shortages. Zambia's rural population, especially the poorer farm households, is widely dispersed across a vast agricultural area. Rural oilseeds processing would provide more income earning opportunities to poor households. It would also offer income opportunities for the young people entering the labor market,

Lack of foreign exchange has forced the country to reduce imports of agricultural commodities. The shortage of foreign exchange to bring in crude vegetable oil has resulted in an inadequate supply of cooking oil. Consequently, a policy to promote the production of crops that are import substitutes is being pursued. The declining contribution of copper towards Zambia's foreign exchange earnings means the contraction of the urban economy. For Zambia to come out of this dilemma, the rural economy must expand to provide both food production and employment for the country. The question of what crops farmers in remote locations can produce profitably if they have to bear some or all of the costs of marketing their crops will need to be raised again. Low-bulk, high-value products must be sought. Oil processing in the areas of production is the only way of transforming oilseeds, especially sunflower, into a low-bulk, high-value commodity.

Research capability in oilseeds is well developed, and high oil content varieties of sunflower and groundnut are available which perform well under Zambian conditions. The cashcrop orientation of the Zambian farming community is favorable for rapid growth of the industry. Markets for cooking oil and stockfeed are not satisfied at present, offering immediate opportunity for small producers. The large scale industry, dominated by parastatal corporations, is in disarray.

However, there are some powerful negative factors at work in the business environment. While the large urban population offers a market for agricultural products of all kinds, people are distinctly poorer today than they were fifteen years ago. Unemployment and underemployment are high in both urban and rural areas. Rampant inflation and the decline of the mining sector have resulted in weakening consumer purchasing power.

In an effort to control inflation, the GRZ has restricted the money supply and allowed interest rates to rise to around 50%, resulting in a credit crunch which will discourage new investment. The current inflation rate and high cost and unavailability of credit inhibit importation of much needed agricultural processing machinery. Shortage of foreign exchange compounds the problem. The high cost of imported steel is a constraint to the development of an indigenous manufacturing industry for food processing equipment.

The pain of restructuring the economy will hit the poor and the under- and unemployed hardest, further weakening the purchasing power of the urban consumer. Infrastructure is rundown and underdeveloped. Roads, railways, electric power and water systems are in need of repair and maintenance, and only serve a small percentage of the population.

Distortions induced in the agricultural economy by a policy devoted to providing abundant cheap maize to urban consumers have resulted in undeveloped systems for alternative crops. Oilseeds, for example, lack adequate seed supply and distribution systems, credit, and crop marketing support.

In the short run, the future is unclear, not only because of the current desperate state of the economy, but also because the new government has no track record, and it remains to be seen how effectively it will deal with the problems facing the country. Parastatal enterprise dominates the economy, and this is a notoriously difficult area in which to make rapid progress in restructuring. Voters have high expectations of the new government, but improvement in living conditions for the man in the street will be slow in coming. Pervasive influence of government in the "private sector" has resulted in weak institutions, such as the provincial cooperative marketing unions, which are needed for the development of agriculture.

In short, the business outlook is fair to partly cloudy at best, with constraints in credit, infrastructure, institutions, and markets all serving to discourage investment in new industry. The strategy advocated in this report is to focus on the small informal sector, where, hopefully, the impact of these problems is minimal. It is risky to introduce project interventions designed to promote development of agriculture and the private sector into such an uncertain an environment. However, if the business environment were entirely favorable, it would be difficult to justify investment in project support for the private sector. It is precisely in such uncertain and difficult times that the donor community can undertake to share the risks with the business community, and thereby make a real contribution to the economic development of the country.

II. SUB-SECTOR SURVEY - OILSEEDS AND VEGETABLE OIL

A. General Discussion of Supply, Processing, and Demand

This discussion will focus on vegetable oil supply and demand, and the market for oilseed meal as an input to the stockfeed industry. Since this study is oriented toward oilseed processing for cooking oil, even though the soybean offers considerable potential for small scale processing, it will not play a prominent role in the discussion, for reasons explained elsewhere in the text.

1. Demand for Cooking Oil

All sources agree that the demand for cooking oil (as vegetable oil is commonly called in Zambia) exceeds supply. Statistical estimates of demand indicate that national consumption should be around 45,000 tons per annum to meet the basic nutritional needs of the population. Potential effective demand is estimated at over 55,000 tons per annum when the estimate is adjusted for additional demand from the more affluent consumer. Interviews with traders in market towns and rural areas conducted during the course of this study indicate that unreliability of supply is the principle constraint on sales. Demand was characterized as "insatiable" by a sophisticated informant.

In the current situation of inadequate supply, and given the recent rapid rise in the price of cooking oil, the consumer is obliged to take whatever oil is available, but when given a choice seems to be more concerned with price than with quality. Unrefined oils, such as the blend of soy and sunflower oil sold by Southern African Oil Mills, apparently sell well, and less expensive local cooking oils, such as Premium Oil's products, are preferred to the superior refined products from Zimbabwe and South Africa (Somol, Covol, Olivine) when they are available.

Increase in Cooking Oil Prices
(Kwacha per 5 liter container)

	1988	1989	1990	1991
June	49.5	91	243.5	750
December		160.5	390	840

Despite the general situation of perpetual shortages of cooking oil in the country, locally produced oil finds its way across the border into neighboring countries. The factory manager at ZATCO informed us that he has found his product in Namibia and Tanzania, for example. Most countries in southern and eastern Africa are net importers of vegetable oil, and represent a potentially important export market.

Although about one-half of the population of Zambia reside in urban centers, the country is vast and the road network poorly developed resulting in a large rural population which finds itself far removed from services and consumer goods. Availability of cooking oil in these rural areas is a continual problem. The rural consumer is also hard hit by price

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increases, since disposable cash income is hard to come by. If we accept the rough estimate of a national nutritional requirement for cooking oil of 45,000 tons per annum, perhaps 20% of this represents the needs of those people in the more remote rural areas. This implies that there is a potential demand of about 9,000 tons of cooking oil which could be met by local village scale production from oilcrops already being grown by small farmers. If this amount of locally produced oil were sold for only K120 per liter, this small rural industry would generate almost $15,000,000 a year in sales at the current rate of exchange ($1.00 = K80)

2. Supply of Cooking Oil

Despite current installed crushing capacity of about 50,000 tons oil equivalent (roughly equal to potential demand), national production falls well below demand every year. Estimates of supply for 1990 vary from 32,000 tons to 40,000 tons, of which only about 50% was produced from local oilseed. The balance came from direct importation of refined oil (only about 1,000 tons) and imports of crude oil which was then refined and packaged by local industry.

Imported oils have been brought in under the PL480 food aid program, but the quantities imported under PL480 are being reduced significantly (from about 8,500 tons in FY 1990 to only about 2,500 tons in FY 1991). Commercial imports of oil will have to make up the difference. This will pose a problem for local large scale industry, because shortages of foreign exchange will make large scale imports of crude oil difficult, and this is an important factor in their capacity utilization.

Imported oil is currently dutied at 30% plus an additional 15% sales tax. Local small scale processors can probably rely on continued protection from imported oil at these levels for the foreseeable future, since the GRZ recognizes the importance of expanding the local oilseed processing industry. While the new government's policies are not yet fully articulated, the idea of promoting small scale decentralized processing has been accepted for some time.

Prices of cooking oil have increased dramatically in the last 18 months due to inflation, devaluation and liberalization of price controls which were previously imposed on the parastatal producers (Premium and ROP). Despite this dramatic run-up in price, demand continues to exceed supply in all parts of the country. The problem is most acute in rural areas, and is aggravated by irregular, unreliable deliveries which cause consumers to rush to buy whenever the product is available.

Domestic production is dominated by two parastatal corporations, ROP and Premium Oils, located in Ndola and Lusaka, respectively. Between them, they hold about 70% of the national crushing capacity, and virtually all of the national refining capacity. Six smaller, medium scale producers control another 20% of national capacity, all but two of which are also located in either Copperbelt or Lusaka provinces. Thus crushing and refining capacity is centralized in the major urbanized regions of the country, in the capital city and in the Copperbelt, instead of being located in the heart of the oilseed producing regions.

Concentration of the industry in this way was consistent with GRZ policy of providing cheap food supplies to the urban consumer at the expense of the rural population. Currently, the two major producers find themselves in difficult financial straights, facing a very uncertain future given the new government's attitude toward state industry. Historically they have suffered from shortages of raw materials due to poor grower relations, weak input supply, credit and marketing services for oilseeds, and the distortions of price incentives in agriculture caused by GRZ maize policy. Capacity utilization has been low due to inadequate seed supply and excessive downtime caused by difficulties of access to foreign exchange and some technical management problems.

Distortions in the subsector have resulted in highly inefficient operation of the existing milling capacity, poor development of oilseed production and marketing systems, and significant foreign exchange costs for imported crude oil, all of which appear to be unnecessary in the Zambian context.

Government price policy for oilseeds and cooking oil have also forced the industry to operate at a severe loss. In the interest of encouraging oilseed production, high support prices were offered for oilseeds, particularly soybean, while cooking oil sale price was kept low by price setting by the parastatal producers who dominate the marketplace (not by an official fixed price). One consequence of this has been that millers have tried to make up the difference in the sale price of oilmeal. Soybean meal, for example, is currently priced at about K28,000 per ton. This has had a severe impact on the broiler industry, shown by the fact that chicken sells for about twice the price of beef in Lusaka. Recent devaluation and inflation have eroded consumer buying power to the point that many people are no longer able to afford meat. Consumer resistance has fed back to the oil millers, who are now sitting on large stocks of soybean meal which they are unable to sell.

The outlook for a small scale feed industry in the agricultural areas is good, however, with dairymen, feedlot operators, and small producers of pigs and poultry all complaining about unreliability of supply of feedstuffs, and irregular quality. Small millers and village industry should be able to capitalize on local demand for their oil cake.

A policy of promoting local production of cooking oil by small scale expeller presses has been advocated for some time in the national development plans. Local processing of locally produced oilseeds would offer many advantages. Current practice is to ship whole oilseed to the major processors in Lusaka and Ndola, then ship cooking oil and seed cake or livestock feed back to the rural areas from whence the oilseed originally came. Transportation is difficult and costly in Zambia because of the poor state of the road and rail network, the high cost of vehicle operations, and the poor condition of the national vehicle park.

On the input supply side, soybeans and sunflower are the principal oil crops at this time, although small quantities of cottonseed and groundnut are also processed for cooking oil. Total cooking oil equivalent from national oilseed production is only adequate to meet about half of the national demand for cooking oil, and a very significant part of that "cooking oil equivalent" is never realized in oil production. This is particularly true for groundnut. A large part of the crop is reserved for home consumption, where it plays a key

role in food security and protein nutrition, particularly important for small children. That which is marketed goes almost exclusively for confectionery purposes. For all oilseeds, storage losses and set-asides for seed supply also reduce the marketed amount.

To summarize, problems currently facing the oilseed industry include:

- Oilseed supply is inadequate to meet the demand for cooking oil;
- Oilseed supply only meets about 50% or less of installed crushing capacity;
- The oilseed production industry is hampered by a history of distorted agricultural price policy;
- Consequences of these policies are inadequate seed supply, unavailability of credit for oil crops, weak marketing institutions, and lack of extension support;
- Existing cooking oil production capacity is at risk due to financial difficulties caused in part by a history of unfavorable GRZ price policy for its products, shortages of raw materials from domestic production, a lack of foreign exchange to import raw materials, and rundown plant and equipment;
- The depressed situation in the feed industry in Lusaka is also due to distortions in agricultural price policy and in the policies which dictated sale price of cooking oil to the consumer.

B. Availability of Raw Materials for Processing

Next to maize, oilseeds are the most important crops in Zambia since they provide cooking oil, an essential commodity, protein meals for human food, and animal feedstuffs, as well as raw materials to several agro-industries.

Oils and fats are the most concentrated source of energy of all nutrients. One gram of fat yields 9 calories whereas the same amount of carbohydrates or protein yields only 4 calories. Thus, it is a particularly valuable food for people who carry out heavy and exhausting work and for small children who need a lot of energy for growth. Fats and oils improve the palatability and consistency of a food. They also add to the energy value of a typical rural meal, which consists mainly of carbohydrates, without increasing its bulk. This makes them a good supplement in children's diets. Oils and fats also act as carriers for fat soluble vitamins. The seed cake resulting from crushing the seed for its oil is high in protein, which makes it highly valuable for animal feeds.

Maize being the staple food, almost all its growers retain some of this produce for home consumption and only sell the excess. Given a choice, the oilseeds growers would retain some of produce of these crops (especially sunflower) for local processing in order to assure their household supply of cooking oil.

In the Fourth National Development Plan for Zambia rural oil expelling is identified as one way to improve the nutritional status of rural people, as well as a means of generating employment in rural areas.

The development of local small scale processing will tend to retain substantial portions of both the vegetable oil and the cake in rural areas, as well as stimulating rural industry

thereby creating employment. This will help slow the increasing rate of urbanization Zambia is experiencing.

Zambia's edible vegetable oil demand is estimated at 50,000 tonnes per annum. Currently, the country is only producing about one third of her needs. To meet the deficit, Zambia needs to import about 20 million United States Dollars (US$) worth of crude oil every year.

1. Sources of Vegetable Oils in Zambia

The four sources of edible vegetable oil in Zambia are: Cotton, Groundnut, Soybean, and Sunflower. Cotton is principally grown for lint. This crop's promotional activities are carried out by Lint Company (LintCo). Vegetable oil from cotton seed is a tertiary product from a by product, cotton seed. Cottonseed is not suitable for small-scale processing because of the need for detoxification of the oil.

Soybean with oil content of only 18%, is the most important source of protein for the stockfeed industry in the country with oil as a by product. The main reason the farming community have gone into soybean production is for cash. This crop also enables large-scale farmers two crops per year, with Soybean during the growing season and wheat/green maize under irrigation. Soybean needs a complicated process to extract oil from it, rendering it unsuitable for small scale processing.

Groundnuts are second only to maize in both Southern and Eastern Provinces and rank very high in most parts of the country. The crop is primarily grown for food by small-scale farmers. However, in Eastern Province, groundnut is also a very important cash earner in both local currency and foreign exchange. In most parts of the country the excess is sold for cash or exchanged for other essentials such as clothing (blankets and chitenge material).

Groundnuts have a high oil content of about 38 per cent for the Virginia types and 45 per cent for spanish types. The crop is relatively easy to process for oil extraction at village level with good oil quality. However, groundnuts are highly valued both for family food and cash by small holders, and they are consequently very expensive on the open market, often fetching up to four times the official price. The profitability of groundnut processing will depend on whether the meal (by-product) is sold for human consumption. This is problematic because of the high risk of aflatoxin (see Annex 5) contamination associated with groundnut meal.

Sunflower, on the other hand appears to be the logical choice for oilseed production in Zambia, and is the crop most likely to be exploited by small-scale farmers in the country's quest for self-sufficiency in vegetable oils. Over 95 per cent of the sunflower produced in Zambia is grown by small scale farmers for cash. Sunflower is popular among this group of farmers because it is an alternative crop which almost always gives something in return no matter how one grows it (late-planted, low input, and drought tolerant). It also has the potential to produce more oil (with composite variety CCA 81 averaging 35 per cent in oil content and hybrids with as much as 40 per cent) per hectare than other existing annual oilseed crops in Zambia. At the village level it is also the easiest to process.

2. Sunflower

Production Trends: Sunflower was actively introduced to Zambia's farming community in 1973 to provide the raw material to substitute for the cooking oil the country was importing. With a centralized marketing system in place which ensured the purchasing of all crops produced by farmers, sunflower production rose rapidly from 10,000 tonnes in 1975 to 40,000 tonnes in 1984. The failure of the marketing organization in the following years, however, resulted in a decline in crop production, from 26,600 tonnes in 1985 to 7,400 in 1989. Sunflower production started picking up again with direct purchasing by processors, primarily Premium Oil Industries Limited (POIL), Southern African Oil Mills (SAOM), and Zambia Trading Company (ZATCO). In 1989/90 season 18,647 tonnes were sold while about 42,000 tonnes of the 1990/91 sunflower crop has been sold.

Cultural Practices: Most oilseed crops are grown during the rainy season which begins in late October and ends early April. The concentration of such growers is found in Eastern, Central, Lusaka and Southern Provinces of Zambia.

Sunflower is grown chiefly by traditional small-scale farmers and, to a small extent, by emergent and commercial farmers. Most sunflower fields are less than a hectare.

The average planting date for sunflower in Zambia is around February first. Planting this late means that there is not enough soil moisture during seed filling (milking stage) resulting in yield reduction of about 50%, and a drop in oil content of between 5% to 10%.

Most small scale farmers plant, weed and harvest manually. The most common labor used for farming among the small holders is family labor.

A majority of farmers drill their seed behind the plough, while planting in lines marked by either a cultivator or hoes is only done by about 20% of them. This results in low plant populations per hectare. The sunflower crop is hardly weeded. All this leads to low yields, with, most growers obtaining less than 500 Kilogram per hectare (less than 10 bags).

Almost all sunflower growers use local varieties due to nonavailability of improved seed. The source of seed is usually the farmers' own retained seed, or that of their neighbors.

Constraints: Most farmers usually plant staples (maize, sorghum and cassava) first, followed by other crops. A Baseline Survey on Crop and Livestock Production for the Strategic Extension Program in the Southern Province found that maize, being the staple food crop, is given priority in terms of both acreage and time of cultivation (planted first) by farmers. Credit agencies provide production credit for purchase of inputs almost exclusively for maize. When it is too late to plant any other crop, and usually a month later than recommended dates for planting, sunflower is planted. Sunflower fields are hardly weeded because by the time other crops are weeded it is usually too late to weed the sunflower fields. Water stress due to late planting, further aggravated by weed competition, results in decreased grain yield and oil content.

The research work carried out by Research Branch of the Ministry of Agriculture, Food and Fisheries (MAFF) found that sunflower yields declined an average of 15 per cent for each 2 weeks delay beyond recommended planting dates. Planting a month later than recommended caused more than 50% loss of the potential yield. Such late planted fields also lose 5 to 10 per cent in oil content.

The Sunflower Commodity Research Team also discovered that weed competition during the first 4 weeks after emergence could cause 10 to 15 per cent yield loss. If weeding was delayed for 6 weeks yield reduction could range from 15 to 30 per cent. Likewise, a delay of 8 weeks after emergence could reduce the yield by 25-50 per cent. No weeding at all could result in yield losses of 30 to 75 per cent.

Use of poor seed also contributes to poor yields (Sunflower Commodity Research Team, Mount Makulu Central Research Station, Chilanga). Inadequate supply of improved seed has resulted in most farmers using retained seed of usually obsolete varieties year after year. A study which was undertaken by the Ministry of Agriculture (National Seed Availability Study: Seed problems, practices and requirements among small-scale farmers in Zambia, Lusaka, July 1991) to investigate small-scale farmers' seed uses, problems and requirements, states that for all the crops (39) reported only 14% were grown with commercial seed. Only 8% were grown with seed purchased at the local rural seed stockists (mostly co-operative depots). Uncertified seed produced by farmers themselves was used for 85% of the crops reported in the survey. More than half (55%) of the reported crops were grown using the farmers' own retained seed. The rest were purchases from other local farmers. It is estimated that use of retained seed instead of fresh seed from ZAMSEED results in yield reduction of about 20%.

Potential: 57% of the national sunflower crop is grown on traditional farms, and 30% by emergent small holders. Sunflower, as a cash crop offers certain advantages, most notably as a "catch crop" and "row crop". Sunflower is fairly drought-tolerant and can be planted late (when it is too late to plant maize) and still gives relatively good yields in comparison to other crops.

Sunflower is not fastidious as to soil requirements. Fertile sandy loams are the best, and reasonable yields can even be expected on soils that are too alkaline, clayey, or sandy and too poor in tilth for maize. Sunflower provides a row crop in areas that are not suitable for growing other cash row crops. Its rooting system is such that it is able to use soil nutrients from a greater depth than most cereal crops and thus it usually does quite well when following a well-fertilized maize crop.

Maize or groundnuts could well precede or follow sunflower. The belief that sunflowers exhaust soils more than other crops is not backed by yields obtained from crops which followed sunflowers. Sunflowers do exhaust the soil of moisture to the extent that, when little or no winter or early summer rains fall, succeeding crop yields are reduced.

Sunflower hybrids developed in Zambia yield as well as those developed anywhere in the world. In fact, at home no foreign material has yet beaten locally developed hybrids

(Sunflower Commodity Research Team, MAFF). The open pollinated varieties have also shown good yield potential.

There have also been big strides in oil content improvement. An increase of oil content from 25 per cent in Chilanga Black Giant variety in 1976 to over 40 per cent in Kayula (Chilanga Hybrid CH 311) is the result of continuous research efforts. However, the yield and oil content potential of the locally developed sunflower planting material is not currently realized by farmers, due to poor cultural practices and unavailability of improved seed. Up to now, there has been no real incentive for farmers to produce quality sunflower crops, since the buyers did not pay any premium for higher oil content.

Small-scale farmers would begin to place a higher priority on their sunflower crop if they saw that it pays to grow quality crop by receiving a premium price for higher oil content seed, and supplying improved planting seed to them. The National Seed Availability Study states that maize, sunflower and groundnuts were the seeds required most frequently in Central, Lusaka, Eastern and Southern Provinces, the sunflower belt.

The reduction of subsidies on fertilizer is causing small-scale farmers' to move away from heavy dependency on maize (which requires chemical fertilizers) for both food and cash needs, to less demanding crops for cash. The fact that reasonable yields can be obtained without fertilizer is likely to induce small-scale farmers to plant sunflower at recommended dates, and keep the fields weedfree.

While price of seed was a major concern for many farmers, particularly for large seeded crops such as maize, groundnuts and beans, the surveyors in the National Seed Availability Study discovered that the small holders' expressed requirements indicate that demand for seed far exceeds the supply at local level. The farmers' most common complaint was lack of availability. The high multiplication factor of sunflower makes the seed price issue less important. Only 5 kilograms of seed are need to plant a hectare of sunflower. The average sunflower field in the sunflower belt is only a quarter of a hectare. At about K80 per kilogram of hybrid sunflower seed, a farmer needs only K160 worth of seed for his lima.

Of all the farmers interviewed in the Seed Study, 78 per cent said they preferred to have seed delivered to their local depot between September and November. Some liberalization of seed marketing may improve availability at village level. This could include areas where village-level presses are situated.

Zambia Seed Company (ZAMSEED) have been using large scale farmers to produce sunflower seed for them. This group of producers is reluctant to grow seed because they complain that yields at around 500 kilogram per hectare (for hybrids) are too low. Ways of reducing the high cost and improving the availability of seed through the promotion of local seed production projects should be investigated. This could be initiated by interested NGOs with the technical support of the Department of Agriculture and SCCI. IFAD working through the Zambia Cooperative Federation (ZCF), has a project on groundnut seed production with small holders in Luapula Province. They should be approached to see if they can take up sunflower seed production as well.

The Ram press owners visited by the authors are becoming aware of the value of good seed and are willing to pay a premium for it. They quickly realize the value of high oil content seed when they process the seed themselves for oil. The variation experienced in different qualities of seed is considerable. Some ram press owning groups are already testing a kilo of seed for oil yield before buying. Higher oil content seed brings a higher price. This will help create a demand for better seed and likely lead to more efficient planting practices. The agronomy work done by the Sunflower Team at MAFF has demonstrated that timely planting with proper row arrangement and adequate plant population would result in doubling the yield and improving oil content by as much as 5 per cent.

While for open pollinated varieties, seed from the previous crop can be used for 1 to 2 years, hybrid seed must be purchased every year. However, it pays to grow hybrids as a cash crop since they yield on average 30 per cent more than open pollinated varieties (Sunflower Team, MAFF). Timely planting coupled with use of improved seed, especially hybrids, would easily give a farmer 20 50kg bags per hectare. This would translate into K22,000 per hectare at the 1992 offer price of K 1,100 per bag. Farm gate prices are lower, depending on location.

Feed Value of Sunflower Meal: Sunflower meal has high value for dairy cattle, beef cattle, and poultry.

a) Dairy Cattle

Sunflower meal is well-utilized in growing calves and heifers. Sunflower meal is adequate as the sole source of supplemental protein in dairy rations.

b) Beef Cattle

Sunflower meal is as good a source of nitrogen as Urea when fed to steers at up to 20% of the ration, and, as good a source of protein as Cottonseed Meal when fed at 11% of a growing-finishing ration.

c) Poultry

While fiber control restricts use of sunflower meal to 8 percent in broiler growing diets and to 16 percent in broiler finishing diets, it does not limit use of meal in layer diets.

Other Uses of Sunflower: Hulls can also serve as feed material for ruminants, for example as palatability enhancers, as carriers for molasses and as roughage extenders. Hulls can also be used for making fireplace pressed logs or burned in pellet form, for synthetic fuels, fertilizer, furfural-like chemicals and fiberboard. Several sunflower crushing plants burn the hulls for energy for the plants. Hulls can be used as livestock and poultry bedding.

A study carried out by an FAO Consultant in conjunction with Extension Personnel of MAFF (Baseline Survey on Crop and Livestock Production for the Strategic Extension Program in the Southern Province) found that a large majority (90%) of the people in

Southern Province are fully engaged in farming. For almost all of them (82%) a combination of crop cultivation and livestock rearing is the dominant practice (mixed farming). Only 17.4% of all farmers cultivated crops alone, and none reared livestock only.

The study also states that of the farmers interviewed about 87% of them reared poultry and over 70% kept cattle. Cattle breeding was commonly practiced in all districts. Besides these two animals, goats and swine were also reared by 41.7% and 31.9% of the respondents respectively.

The most common power owned by farmers in Southern Province is a combination of ox-drawn implements and handtools, owned by 87% percent of them.

Southern Province has the highest livestock population of any province in Zambia. Despite recent problems with corridor disease, a substantial market for oilseed cake exists in this province, as in Central Province, among large scale commercial farmers who are engaged in ranching and dairying.

3. Groundnuts

Groundnuts are second in importance only to maize to small scale farmers in most parts of the country. Groundnuts have been grown in Zambia for ages, largely by traditional farmers for home consumption, with any surplus sold in the local market for cash or traded. Currently, insignificant quantities go for oil extraction. On average, groundnuts are the most important source of protein in the rural diet. Groundnut flour is used in relishes which accompany the staples (nsima made from maize, sorghum or cassava meals), in weaning and breakfast foods (porridge made out of a mixture of a staple flour and groundnut flour). The rural population also consume groundnuts as snacks, either raw or cooked, or fresh (at harvesting) or dried, throughout the year.

Cultural Practices: Although groundnuts are grown in most parts of the country, they are best adapted to the Eastern, Southern and Central provinces.

It is difficult to know the national production of groundnuts since a lot of them are consumed and sold locally. In groundnut production areas, more than 50% of the growers have less than 4 hectares of arable land, of which about 0.6 hectare is planted with groundnuts. High labor costs for this crop limit the production to areas with some surplus of family labor.

The most commonly used seed for groundnut is the local variety which is planted by over 80% of farmers. Seed is usually obtained through farmers' own sources, such as left-over seed from a previous season.

The harvesting method commonly used is "dig and stack", which is practiced by more than 75% of the farmers. Other methods are pull and stack or a combination of dig and pull and stack. Groundnut yields are also very low. 84.5 per cent of groundnut growers harvest less than 500 kilograms per hectare.

After harvesting, the produce is stored unshelled, either in bins or sacks.

Marketing of groundnuts is largely free from control. This means that farmers can sell their product to the highest bidder and the Provincial Cooperative Unions are buyers of last resort. Farmers receive higher prices and quick cash at their "door step" from private traders. The free market price for groundnuts is reported to be as high as four times greater than the floor price (offered by the cooperative unions) in some locations.

Constraints: Low yields of groundnuts are usually attributed in part to competition for labor, especially at planting, weeding, and harvesting times, since the requirements for groundnut conflict with the requirements for maize. In addition, improved seeds or fertilizers are seldom used due to lack of financial resources. Availability of family and hired labor, especially for shelling, is also a constraint to increased production.

Traditionally, only women grow groundnuts to meet their household requirements, and sell any surplus for cash.

The National Seed Availability Study discovered three problems relative to groundnut seed. The main problem is lack of availability at local depots. A second is the high price. In the groundnut belt and high rainfall areas, late delivery and limited supply are also cited as major problems in the study.

Poor supply of improved seed also contributes to poor yields in groundnut crops. Less than 10% of groundnut growers obtained their planting seed from a marketing agency. The most commonly used seed for groundnut was the local variety which was planted by over 80% of the farmers. Retaining own seed, such as left-over seed from previous season, was the single most important seed source. Buying seed from neighbors or in the town markets was the alternative to retaining their own seed.

Seed price for groundnuts is cited as a major concern for many farmers in the National Seed Availability Study. In the Baseline Study on Crop and Livestock Production the consultant found that an overwhelming majority of farmers (86.7%) do not have adequate capital to finance their farming activities. Almost 40% of the farmers resorted to credit offered by financial institutions to overcome their shortage of funds. The most common institution where credit can be obtained is the Cooperative. Production credit is also available from the commercial banks, LINTCO, CUSA and others.

Almost all lending institutions have favored maize over all other crops, making it difficult for small farmers to buy improved seed for groundnuts.

Nutritional Factors: While groundnuts are well adapted countrywide, and the oil types have higher oil content than other oilseeds grown in Zambia, their role as a principal protein source for most diets in rural areas is so important that promoting oil processing could aggravate protein malnutrition among small children, especially those under five.

Although aflatoxin occurs in other oilseeds, the problem is particularly critical in groundnuts. E.A. Weiss (Oilseed Crops, Tropical Agriculture Series. Longman Group Limited, 1983)

states that groundnut is the most commonly contaminated cake. The fact that it is difficult to detect aflatoxin, unless electronic sorting machines are used, makes oil extraction from groundnuts a risky business in rural areas. This is particularly true because of the importance of groundnut flour in the rural diet. If the cake is of good quality, it will be much more valuable processed for human consumption than for animal feed. Weiss writes that after processing, incorrect drying of cake and meal, poor storage, or insect infestation can produce conditions which favor mold growth and consequently aflatoxin production. The allowable level of aflatoxin for human food, for feed for chicks under 1 month old, and as feed for chickens and piglets less than 2 months and all other livestock are 5, 10 and 20 parts per million. Feeds produced from meals containing aflatoxin contribute to susceptibility to other diseases, long-term degeneration of internal organs from cancer, or death (Weiss).

Groundnut meal is an excellent source of protein to balance diets high in cereals and starchy foods, and supplement animal proteins. The multipurpose use of the groundnut makes it an excellent cash crop for domestic markets as well as a good foreign exchange earner.

Groundnuts are suitable for food in rural areas because they store very well in the shell. As long as they are kept in a dry place they can be stored for a long period in the shell without molding. In the rural household, nuts are processed only at the time they are needed, hence reducing the dangers of aflatoxin. Therefore, handling and storage of seed and of seed cake will be vitally important in the case of small scale groundnut processing.

4. Oil Palm

Oil palm is a major crop in many Central and West African countries. It is found from The Gambia to Southern Angola, with isolated occurrences in other areas. It grows in humid regions with rainfall of over 1000 ml annually and at altitudes of 500 meters (and higher) above sea level. The oil palm begins producing fruit about five years after planting and bears fruit for approximately 50 years. Semi-wild oil palm is a crop that provides income with no real inputs (some watering and bush clearing); improved varieties of oil palm require considerable effort during the first years of establishment.

In Zambia, oil palm is found in limited areas in Luapula and Northern Provinces. In the early 1950's, oil palm from Nigeria and the Belgian Congo was introduced to cross with local varieties; seed was imported from Malaysia in the 1970's. From colonial times until the present, schemes for commercial production of palm have been considered but not carried through. Although a very minor crop for the country as a whole, oil palm plays a significant role--both economically and nutritionally-- in the areas where it is grown on a subsistence basis. Palm oil is a good source of vitamins A and B complex, which is needed with a local diet of cassava and fish. Making palm oil to sell provides a substantial amount of income to women in oil palm areas (along with beer making).

We found very little documentation on the production of oil palm in Zambia, which is not surprising since it occurs in only a limited region in the far north. In 1986-87, a study was undertaken by IRDP/Luapula on oil palm grown in Nchelenge District and interviews were

conducted with 264 oil palm owners. On average, each owner had four trees with the number of (fruit) bunches per tree averaging eight and weight per bunch ranging from 6 kg to 25 kg. Tests indicated that 22 kg of fruit yielded 3.3 liters of oil.

It was found that oil palm is planted by farmers during the rainy season; the oil palm was watered during the first dry season but after that no care was given (no fertilizer or compost was used). The local varieties flower twice a year - once during the rainy season and once during the dry season. Peak harvests appeared to be between August and December. The National Council for Scientific Research analyzed improved Nigeria palm oil nuts and local Zambian palm oil nuts for oil content. Oil content of the pulp was between 68% and 77% and between 19% and 22% for the nut.

Traditional processing of palm oil appears to be extensive. Palm oil processing is mainly an income generating activity for women--as compared to processing for home consumption. Approximately 80% to 90% of the household level production is sold.

Traditional processing methods used in Zambia require a great deal of water and fuelwood; it is a labor intensive process. Approximately two bunches of fruits can be processed a day. Palm oil fruits are boiled until soft, the fruits are then pounded in a mortar until the pulp separates from the skin and seeds. The mixture is strained and the pulp is again boiled in water until oil is released; it is then skimmed from the water. This is referred to as a "soft oil" process; it yields an oil with an acceptable FFA content for food use (UNIFEM). The oil from the fruit is used for cooking; processed traditionally the red palm oil can keep for about a month before rancidity sets in. A "hard oil" process involves fermentation and the oil produced is usually used for soapmaking.

Oil is also extracted from the seeds. The shell of the seed is cracked between stones, the seed is then removed and fried, pounded, and boiled until the oil is released. The clear oil obtained from the seed is used for cooking or as a skin ointment. The seeds are also sometimes eaten directly as a snack.

The local market for palm oil appears to be good--Zambian palm oil is sold both in the areas where the oil palm is grown and in neighboring Zaire. It is consumed daily with a variety of relishes.

A variety of improved technologies exist for processing palm oil. Screw-operated batch presses have been used in Africa since the 1930's; there are at least five systems in operation of differing sizes. KIT has a village level palm oil processing system using a screw press; this system has been introduced in Zambia. TDAU indicates that the Kit process worked both technically and financially; however, social problems developed which hampered its use (no agreement could be made by the people involved on how to allocate the profits generated). It appears that one KIT press is still in operation.

It is almost certain that improved palm oil processing technologies can be introduced which would improve efficiencies, increase production, and increase income generation compared to that of traditional methods. However, the type and size of equipment needed is dependent on the production levels of oil palm and the type of oil palm grown; the relative

efficiency of different types of presses (and the economics) depends on the ratio of pulp to kernel which differs by oil palm variety. The consultants do not have enough information to suggest which technology might be the most appropriate for Zambia. An FAO oil palm expert is currently undertaking a study of oil palm in Zambia; the suggested course of action is to curtail activities in this area until his report is available.

5. Minor Crops

a. Castor

The castor bean contains a high percentage, sometimes in excess of fifty percent, of an inedible oil which has diverse uses in industry and medicine. On the world market, this oil brings roughly four times the price of edible oils, and, according to informal sources contacted locally in Zambia, the world demand for this oil is growing more rapidly than the supply. Local demand exists, but is apparently limited at this time to simple lubricants (e.g. for bicycles). Deloitte-Touche is currently undertaking a study of the local market for castor oil with funding from ADF. The results of this study should be available by early next year. The GM of ROP indicated to the team that he could use about 1,000 tons of crude castor oil per year as a substitute for 20% of the tallow currently imported for soap manufacture, but the value of the oil for this purpose would be very low, perhaps only K50,000 per ton (at current, December 1991, prices).

Castor grows wild over large areas of the Zambia, particularly in the Western and Northwestern and Northern Provinces, but is found almost everywhere. Many varieties of castor bean are known, with variations in oil content and quality among them. The American Oil Chemists Society has standards for oil quality for industrial use, which should be used to evaluate the commercial industrial value of local varieties. The particulars for the wild varieties of Zambia are presently unknown. Cultivars are available from major producing countries, and some limited experiments have been done on the possibility of introduction of castor as a cashcrop. Apparently, at one time the Israelis were prepared to put about 10,000 hectares into production, with the intention of producing a crude oil for export to Israel for further refining. UNIDO estimates the minimal size of a commercial castor oil processing facility at 30 to 60 tons per day processing capacity, while more efficient processes require upwards of 300 tons per day. A 60 ton-per-day plant cost $US 4,000,000 in 1984, just to give an idea of the level of investment required to refine locally produced crude oil.

Mr. Bachoo Parbhoo of Nabusanga Farms of Kabwe has imported 4 tons of improved hybrid castor seed from Israel and grew 10 hectares last year. He reports first year yields of 2.5 tons per hectare, and expects to achieve as much as 4 tons per hectare as the stand matures. Production should continue for as long as ten years. He has supplied seed to his neighbors, and intends to put in about 250 hectares on his own farm. He intends to crush the seed himself with a small Tiny Oil Mill expeller imported through ZCF, selling the oil locally for seed storage. It apparently serves to preserve seed for planting. He will use the oilmeal on his fields as fertilizer, and claims that the castor meal has a nematocide effect which he hopes will prove beneficial to his tomato crop.

Since there have been very few serious experiments on growing conditions, selection of cultivars, yields and oil content, etc., done in the Zambia, it is difficult at this time to say whether this crop would be an attractive cash crop for small, emergent, or commercial farmers. It does possess certain characteristics which appear favorable, notably :

- Hardiness and drought resistance;
- Perennial growth habit, allowing for relatively low cost production in the long run;
- High yield with low maintenance once the crop is established;
- High oil content (implying a high value for the extraction industry);
- High value oil on the world market, although the local market is currently undeveloped;
- A local market for oil for pharmaceutical and lubricating oil purposes, and a potentially large market for soap manufacture (ROP), although the value of the oil as a substitute for tallow would only be about K50/liter at this time;
- Oil easily extracted by simple equipment, thus assuring relatively easy start-up of local industry, even on a very small scale, and a local market for the farmer's product;
- By-product useful as fertilizer and possibly as a nematocide, which is apparently an increasing problem in the Zambia.

The principal drawback to castor processing at this time is that all material would have to be collected from the wild, or the plant would have to be introduced as a new, presently unknown, cash crop.

b. Sesame

Sesame is a very minor crop in the Zambia. It is apparently grown in some parts of the Luangwa Valley in Lusaka Province, but we have not heard of it elsewhere. Its drought resistance might make it an excellent crop for local small scale cooking oil production in areas where even sunflower suffers from low rainfall (Zone 1).

Very little research has been done on the crop. Experiments conducted with imported shatter resistant varieties were not successful at Mt. Makuru because of severe disease problems, possibly due to high rainfall, or early planting. Collection of local germplasm and rapid simple selection from existing local material might produce good results in a short time for production of a seed well adapted to wide dissemination in Zambia. The extent of the area where sesame might gain rapid acceptance by small farmers as an alternative to other, better known oilseed crops such as sunflower, groundnut, soybean, or cottonseed, is unknown.

Sesame has excellent properties as a raw material for small scale oil extraction, since it is rich (over 50%) in oil, and the oil is of high quality, excellent flavor, and is relatively stable when unrefined. The Ram Press has been successfully modified in Kenya to extract sesame, and, because of the higher oil content of the seed relative to sunflower, was actually preferred to sunflower by some experienced practitioners (Hugh Allen, personal

communication). Sesame seed cake is appropriate as a feed supplement for ruminants, and can be fed in limited quantities, like sunflower cake, to pigs and chickens as well.

Sesame is widely grown in the sahel for confectionery uses, as it resists drought well and requires little maintenance. Shatter is a problem if harvest is delayed, but early harvest, stacking and drying help minimize the problem. Yields are generally low, but appropriate to the level of inputs and energy expended on the crop, which plays a role in other farming systems similar to the role of sunflower in Southern Province in Zambia today. That is to say, farmers will sow an area to sesame late in the planting season when the staple crops are already in the ground and food security is assured. The low yields resulting from this practice are acceptable because of the low level of input and low opportunity cost of putting in the crop. Oil content may suffer, as is the case with sunflower, if planting is delayed, but this is a question which should be investigated.

The team is not in a position to assess the potential for widespread acceptance of sesame in the Zambia because of the general lack of research and data on the crop in this country. There is no supply of improved seed available, and the oil content and suitability for processing of locally available cultivars has not been tested. For these reasons we recommend that the emphasis on oilseeds for village scale cooking oil production should remain focused on the well-known, widely grown crops, sunflower and groundnut, at this time. If a technology is identified which works well for oil extraction from sesame, field testing of the equipment in sesame growing areas should be undertaken to test the acceptability of the system. If it results in increased production of the crop and availability of cooking oil in villages in areas too dry for sunflower or groundnut, the project can study ways to capitalize on this opportunity for wider dissemination.

c. Mungango Nuts

The mungango nut is produced by a tree which grows wild in the western provinces of the Zambia. It is processed in villages in those areas by a laborious traditional method, to yield an edible oil. UNIDO is currently working on the design of a machine which could crack the mungango nut (apparently it's a tough nut to crack), and feel that there is some potential for edible oil production on a small scale in those areas where the tree grows wild.

Since the plant is not cultivated, and no research has been done on growing conditions for commercial production, this technology will remain marginal for the foreseeable future. It is not clear whether gathering and processing mungango nuts is an efficient way to produce cooking oil at the village level relative to sunflower or groundnut production and processing. The team is unaware of any special properties of the oil of the mungango nut which might make the oil more valuable than other edible oils.

d. Other oilseed crops

Research is in preliminary stages on a few other lesser known oilseeds at the national agricultural research station in Kitwe. The team feels that there is sufficient potential for cooking oil and stockfeed production from oilseeds already grown in Zambia to make this

research irrelevant for the purpose of this study, primarily because of the long lead time required to achieve useful results from research, and then introduce a new oilseed crop.

C. Current Technology of Small Scale Processing

1. Traditional Processing Technology

Traditional processing of oilseeds is tedious and relatively inefficient. For sunflower and groundnuts it usually involves 1) roasting the seed, 2) pounding the seed to a flour, 3) boiling the flour with water for several hours, and 4) skimming off the oil and sometimes reboiling it.

Indications are that neither groundnut nor sunflower oil processing using the traditional method is commonly done in the Southern or Eastern provinces. When it is done, it is done for household consumption and not for income.

In 1986 VITA conducted a survey of 6 women's groups (61 women) on food processing activities in Serenje District. Women responded that it took approximately one-half day to produce one-quarter liter of cooking oil. After grinding of foods, producing cooking oil by hand was listed as the most time consuming food processing activity. Women, therefore, preferred to buy their cooking oil even though they believed the hand produced oil was of better quality than the commercially produced oil.

The members of the Nanchengwa Club in Mazabuka district stated that before they had a ram press they were purchasing oil in Mazabuka (approximately a two hour drive) when it was available, and they would stretch a 750 ml bottle for as long as possible. It was also stated that older women did not have money to purchase cooking oil and thus made do with groundnut flour for the relish. At the Tusole Women's Club it was also said that very few women in the area used the traditional method for processing oil.

The Provincial Home Economics Officer in the Southern province also stated that, although some individuals traditionally process groundnuts, pumpkin seeds, and sunflower seed for oil, it is not done extensively. She stated that old women would sometimes make groundnut oil, but young women would not, as they prefer to buy it. The same type of responses were heard in interviewing people in the Eastern province.

The situation with palm oil processing is very different. Traditional methods of processing are used extensively in Luapula Province to produce palm oil. However, since the team did not have time to visit Luapula, and since palm oil and the oil palm are not significant in the diet and the agriculture of Zambia, this subject will not be discussed further here.

2. Manual Technology

a. RAM PRESS

The ram press was designed in Tanzania to extract oil from undecorticated, soft shelled, high oil content, sunflower seed. With this type of seed, the ram press has an extraction

efficiency of 70-80%; expellers have a 90% efficiency. Tanzania has an open pollinating sunflower seed--Black Record--that fits the above requirements. It was designed as a village level technology appropriate to the needs and skills of village users. Other oilseeds have been tested with the ram press (copra, sesame, neemseed, groundnuts) with varying results. It has since been modified by numerous individuals and organizations in several African countries.

Quantity and Quality of Production: Two Bielenberg-Fisher ram presses were brought to Zambia by Africare in 1988; TDAU modified the press design in order to make it more suited to the hard seed available in Zambia as well as to contain costs and began manufacture of the presses in 1990. As of July 1991, 53 ram presses had been sold by TDAU; this included one press sold to GAMECO. GAMECO is the only private company currently planning to manufacture the ram press. Since July, TDAU has sold at least 14 additional presses, although only four have been delivered.

After a short period of usage in the field, the TDAU presses placed by Africare experienced major unforeseen problems. This included restrictor problems, excessive wear on the pivot and crank pins which resulted in wear on the piston and cylinder sleeves; as well, the handles were not strong enough at the bending point causing breakage. Problems stem from a combination of factors including misuse of the press, quality of design modifications and manufacture, lack of proper seed cleaning, and the extra stress placed on the press by the hard hulled sunflower seed used. TDAU's current plans are to use hardened mild steel (or hard steel) for some component parts as well as greasing points.

There is limited knowledge about the majority of ram presses used by groups other than Africare. It is believed that they have experienced less technical problems to date because they are not being used as extensively as the Africare presses (they were mainly purchased for food security reasons and not for income generation).

Who are the producers?: As of December 1991, Africare had distributed 23 ram presses to women and youth groups. To date, TDAU has sold presses (with one exception) to community groups, NGO's, and similar groups as part of their operating policy; this situation is expected to change once commercial manufacture of the press begins and the technology is available to private individuals.

Although women's groups may not be the ideal vehicle for business-like testing of a new technology such as the ram press, it did serve the function of ensuring the technology is introduced in a gender-neutral fashion.

Geography of Production: As far as known by the consultants, all of the ram presses in Zambia are being used exclusively with sunflower. Sunflower is grown throughout Zambia, although it is concentrated in the Southern, Central, and Eastern Provinces. Africare has distributed 14 ram presses to women and youth groups in the Southern province, 1 in the Eastern province, and 8 in the N.W. province. Other NGO's have also purchased ram presses for use in the Southern, Eastern, Central, Luapula, and Lusaka provinces.

Market Situation Faced by Processors: It is apparent from the July 1991 Africare Southern Province Oil Project evaluation, as well as visits to four ram press operations by the consultants, that the processors have experienced no problems in marketing the sunflower oil produced. The ram presses are in rural locations where commercially produced cooking oil is hard to come by and expensive. The oil produced is considered of good quality. In addition, it can be sold in small quantities which consumers prefer instead of the commercially produced oil sold in larger containers. The demand for oil in the sites visited far exceeded the amount of oil produced; all groups hope to process more seed.

It was noticed that the sale price set by producing groups tended to be well below the market price. For example the Nanchengwa group sold their oil for only K100 per liter locally, whereas in the market at Mazabuka they sold it for K150 per liter. This fact highlights one difference between social group management and individual entrepreneur management. Groups are not strictly profit motivated, and may choose to sell their product at a price which implies that they are rendering a social service to their community. This is fine, as long as they are able to repay their loans and continue operations (afford repairs, replacement of worn-out equipment, etc.).

By-Products: The seed cake by-product is a valuable commodity for use in livestock feed. The seed cake increases the profit potential from a press operation if it can be sold; in some circumstances it may make the difference between operating at a profit or a loss. The market for the seed cake varies by location. The ram press owners have had difficulties in selling the cake when they are not situated by commercial farmers. Commercial farmers are aware of the value of the cake and have provided a market for it in some locations. However, many small farmers are not aware of the cake's value, how to use it, and are not used to paying for animal feed. Information dissemination on the uses and value of seed cake is needed in order to build local markets for the cake. Even without this information being available, ram press owners are selling some seed cake to local pig and poultry producers. They sell for K5 or K6 per kilo, which is roughly one-half the price of the next cheapest feed supplement, cottonseed meal, which is K10 to K12 per kilo delivered to Southern Province.

Current and Proposed Project Activities: The modified ram presses manufactured in Zambia have had major technical problems when placed in the field. Nevertheless, there is substantial interest in this technology and orders for them are still forthcoming. Even at a cost of $1300, initial financial analysis indicates high profitability at very moderate levels of usage.

It is suggested that the project take the lead in importing and testing ram presses that are known to have worked in other countries (CAPU, Hugh Allen/CARE, Martin Fisher/Action-AID) before abandoning the technology or commencing any other modification work.

--The CAPU design is being used more extensively than any other design ram press design. It is small (65 kgs without the base and can be transported for repairs), costs less than $400 to purchase in Tanzania, has a lower throughput than the Bielenberg-Fisher model but maintains the same efficiency; is said to work better on hard-hulled

sunflower seeds than earlier models; and has a narrow cage bar spacing allowing it to process sunflowerseed, sesame, and copra.

--The Hugh Allen/CARE version of the press is produced in Kenya and Lesotho; it is easier to use and more rugged than the Bielenberg-Fisher design but also requires more steel and machining (in 1990 estimated material cost in Kenya was $240 but current selling prices are unknown); and therefore is more expensive to manufacture.

In the short-term, availability of good quality seed is a major constraint for the ram press which was designed for soft-shelled, high oil content seed. Ram press owners are becoming more aware of the value of good seed and are willing to pay a premium for it; this will help to create a demand for better seed and may lead to more efficient planting practices. Unfortunately, the supply of high quality composite or hybrid seed in Zambia is very limited; this has serious consequences for any sunflower processing technology. A breeding program to develop soft-shelled high oil content varieties such as those available in Tanzania would be the most effective way to ensure the long-term success of village processing based on the ram press technology.

The most extensive use of the ram press has been in Tanzania. Over 430 presses are currently in use in Tanzania villages in 19 out of 20 regions. Information from the Tanzania experience may be applicable to Zambia--not only for the ram press, but for the spindle press as well. Some highlights are as follows:

1) Individually owned presses are used more extensively than group-owned presses.

2) The ram press proved durable enough that even the original presses produced five years earlier were still working. Almost all of the press owners had minor repairs done each year (between $10 and $26 per year); most repair work was done within 5 km of the press site.

3) After obtaining a press, those owners growing sunflower increased their acreage of sunflower; farmers also switched from a local seed to the higher oil content seed, Black Record (80% of sunflower growers were growing poor quality seed initially).

4) Hired labor is almost always used to operate the press even though the majority of press owners are men.

5) The majority of press owners do service pressing for nearby farmers; payment is usually in-kind. Most press owners do not have enough working capital to buy all of the seed they need at one time.

6) The market for the seed cake has built up over time as people become aware of its value as an animal feed.

7) There was initial resistance to a small, manually operated machine; sales of the ram press increased over time as its profitability became known. As well, feedback from the field resulted in several press modifications during the pilot project.

(For further information, please see Eric Hyman's Final Evaluation of Village Oil Projects in Tanzania available from ATI.)

The ram press technology, while being introduced in a number of other countries (Zimbabwe, Kenya, Rwanda, Lesotho, etc.) has not spread to the extent it has in Tanzania. Some reasons for this are as follows:

--Manufacturing problems: The ram press is not an improvement on an existing technology; rather, it is a new technology. As such, the demand and market for the press is not known. This, coupled with the fact that rural oilseed processing is not common, makes it difficult to interest established manufacturers in producing it. For example, in Zimbabwe it was assumed that the manufacture of the ram press would not be a problem because of the high manufacturing capacity and skills available in the country. However, medium and large scale machine shops capable of producing the press were not interested because they already had established product lines and were not interested in investing in a technology that did not have a proven market. When they did produce the ram press, it was a low priority item and long delays were experienced. In some countries, materials as specified are not readily available and substitutes are used; this requires additional modification and testing of the machines.

--Dissemination support: The ram press is not just an improvement of a known technology, but is actually something new. It is therefore not realistic to expect spontaneous replication of this technology without information and support being available. In Tanzania, project staff worked full-time on dissemination of the ram press. In other programs, the ram press is part of an integrated development project in which several activities are being pursued.

b. SPINDLE PRESSES

The KIT System: This system is described in detail and analyzed in Burgess, "A Report on the Economic Comparison of the Bielenberg Hand Operated Ram Press and the KIT Hand Operated Spindle Press". The process is currently in use in the Gwembe Valley area (at Sinanjola and at Siabaswe) by two women's groups sponsored by the Sinazeze Gossner Mission. It has also been used since 1984 at Kasisi Mission just outside of Lusaka. While the system is expensive and complicated due to a series of machines which emulate the standard process of large scale industrial vegetable oil extraction, it does have a fairly high throughput for manual equipment (200+ kg of whole seed per day), and produces a good extraction rate from sunflower and a high value oilmeal because of dehulling. The final stage of extraction is accomplished by a spindle type press, which could be used to extract oil from other oilseeds, such as groundnut (this has been done in Malawi, but not in Zambia to our knowledge, except on an experimental basis), and sesame. The system is also apparently in use in Luapula Province for processing oil palm, using a modified pre-conditioning process. This system worked very well technically (personal communication from A. Lemmens) but failed because of social problems.

While the system has apparently been accepted by its users in the Gwembe Valley and at Kasisi Mission, the KIT system has not gained wide acceptance anywhere in Africa as far

as we know. The pros and cons of this process are summarized in Annex 1, but in brief, the most likely cause is the high cost of the set of equipment, which includes four machines :

Dehuller
Winnower
Roller Mill
Spindle Press

and also requires basins for moisturizing seed and roasting pans and some sort of firebox for pre-conditioning before pressing. The total cost of this system ex-works in Belgium is about $5,000, although Jung of Kitwe claims to have made comparable equipment for roughly 2/3 the cost. The machinery furnished by UNATA of Belgium is of high quality, durable, and performs well (based upon the personal experience of a member of the team). The groups operating this equipment in Zambia have said that it works well in general, and requires relatively little maintenance or repair. However, Mr. Moyo, the man in charge of the Appropriate Technology Workshop at Kasisi Mission where the KIT system has been used most extensively, expressed the opinion that this set of machines is not appropriate for rural areas because of the complexity of operation and also because of the need for fairly regular maintenance and minor repairs. He indicated that, in his opinion, the Bielenberg Ram Press is a much more suitable solution for oil extraction at the village level because of the simplicity of the machine.

The team feels that it should be possible to manufacture this equipment in Zambia to acceptable standards, although certain component parts might have to be imported (particularly the high multiplication gearbox for the dehuller, and certain bearings and springs).

One disadvantage of the system is its technical complexity. For a group of rural people, or a rural entrepreneur, to master the operation of the entire series of machines, and also to achieve the teamwork necessary to operate the system near its capacity (i.e., good level of throughput) requires training and experience. A team of six persons is required to operate the system (this is the case at Kasisi, and was also our experience in Rwanda, although Burgess estimates labor requirement at only four persons). While throughput as high as 300 kg of whole seed per day has been recorded under actual village operating conditions (in Rwanda), in the long run 200 to 250 kg per day is a more practical target. The capacity of the various machines differs, so that, according to Burgess, it would be possible to operate four spindle presses using only one set of pre-conditioning equipment. This could raise the throughput to 800 kg per day or more, although the large number of laborers required would make management difficult. Financial management of such an operation would be quite complex also, because of the working capital required for seed purchase.

A further disadvantage of the system is that it does not lend itself well to service pressing small quantities of seed. Integration of the operation of the entire series of machines is difficult. Processing small batches at a time would greatly reduce the daily throughput, while hardly reducing the labor requirement at all.

A significant level of effort is required for seed dehulling, roller milling, and in the final stages of spindle pressing. Roasting the dehulled, moisturized seed to attain the best possible extraction rate requires experience and is physically demanding. Women's groups have complained of the difficulty of operating the machinery, and only achieve high throughput if large numbers of women are available to work the equipment (more than the six required for efficient operation.)

If the seed is overheated during the final stage of pre-conditioning, the oil develops a distinctly burned flavor and becomes darker in color. Fuelwood consumption can be a problem in areas where it is scarce or expensive, although hulls can be used to meet part of this requirement. Hulls are used for fuel at Kasisi, but not in the Gwembe Valley.

At Kasisi Mission, where the same group of men (with very little turnover in personnel) has operated the system for several years, the team does 200 kg per day without difficulty. Several different systems have been used to operate the equipment at Kasisi. At one time, the workers were paid a daily wage. Then they were paid based upon output. Currently, they are renting the equipment from the mission, paying in kind with the seed cake. From 200 kg of whole seed, they will produce roughly 70 kg of good quality dehulled sunflower seed cake, worth roughly K10/kg ex-works, so they are paying K700/day of operation to rent the equipment. (This estimate of the value of cake is based upon K9,500 per ton for cottonseed meal ex-works at SupaOil in Kabwe.) Maintenance and repair is assured by the Appropriate Technology Workshop at the mission. Management support has been intensive, and the overall success of this project owes a great deal to Father McKenna, who first bought the equipment and worked closely with TDAU to overcome many problems.

In the Gwembe Valley, where the machines are operated by rural women's groups, the equipment is operated sporadically, and throughput varies from 50 kg to 200 kg per day, depending on social conditions and other factors. Oil is sold for K150 per 750 milliliters, but little use is made of the seed cake. A few women have begun processing it to flour for household consumption, but no market for it has been developed for animal feed.

The Gossner Mission, which originally provided the equipment to the women's groups, realized after the first two seasons that the system was too complex for the women to manage without outside assistance. Currently the VIS Project is providing management assistance, helping with seed supply, and providing technical training and assistance with maintenance and repair of the equipment. It would appear from this experience that the KIT system can only be introduced as a sustainable technology in rural areas with considerable support from outside sources.

On balance, as a manual system for processing sunflower seed the system works fairly well. However, it is not obvious that this system can be successfully introduced to rural areas without considerable support on both the technical and the managerial sides of the operation. The fairly significant capacity of the system, which might process 40 to 50 tons of sunflower per year, is a double-edged sword. The cost of high capacity equipment is high, and the working capital and management skills necessary to fully exploit such a system are often lacking in rural areas.

The Simplified Spindle Press System: Following on several years of discouraging results with the Bielenberg Ram Press in Zambia, efforts are currently underway to provide a simple, low-cost method of village cooking oil manufacture based upon spindle press technology. The spindle press, as pointed out by Burgess (cited above), offers several technical advantages over the ram press, among which :

- Each cycle of operation treats a much larger quantity of seed, thereby reducing wear relative to throughput;
- The spindle and nut are virtually the only wear parts in the machine, are extremely robust and have a very long service life;
- The seed to be treated may be dehulled before pressing in a machine specifically designed for this purpose, thereby reducing the most significant wear factor in the process, the abrasiveness of hull material;
- Oil meal produced from dehulled seed has a higher feed value (higher protein content) than that produced from whole seed;
- When an appropriate pre-conditioning process is used, the extraction rate achieved by a spindle press is comparable to that achieved by a ram press, but with much less pressure applied to the oil bearing material, thereby reducing the human effort required, as well as the wear on the machine;
- The spindle press can process groundnuts, something the ram press cannot do.

Keeping in mind the practical problems outlined above which have been encountered in Zambia with the introduction of the KIT system, it appears to be worth some effort to explore the possibility of using the spindle press as an alternative to the ram press for village oilseed processing.

Unfortunately, only very limited experience has been gained to date in this area, and there are no simplified spindle press systems ready for wide diffusion in rural areas. A few different alternatives are worthy of study :

1) Cold pressing of groundnut appears to offer a low-cost method of oil extraction, and requires only a groundnut dehuller and a spindle press. Preliminary results indicate that a fairly high extraction rate is possible even when cold pressing, although most groundnuts produced in Zambia are not oilseed varieties, and seed supply for higher oil content varieties is a problem. The extraction rate increases when seed is pre-heated. Dehulling could be done by hand in a mortar and pestle, separation of hulls and nutmeats is not difficult, and in this case only the spindle press would have to be purchased and maintained. The dehulled groundnut cake might have a high value when processed to flour for relish. Whole groundnut flour sells for K200 per kg at retail in small market towns. Most rural households, however, make their own. There is a risk of aflatoxin contamination in groundnut cake that must not be ignored if this type of approach is disseminated in rural areas. Furthermore, the potential nutritional consequences for rural households if groundnut is processed for oil, but the cake is not utilized for human nutrition, should also be carefully assessed.

2) Cold pressing of whole sunflower seed permits extraction of some oil, although extraction efficiency is certain to be very low, and the value of the cake for feed will be

relatively low also. The low oil content of most sunflower available for processing in rural areas, due to problems of distribution of improved seed, is a discouraging factor for this possibility. Dehulling of sunflower by mortar and pestle, waterbath separation of nutmeats and hulls, followed by preheating to achieve appropriate seed condition, and then spindle pressing might give good results, although this would be a laborious process.

3) Sesame might give good results cold pressed, without any processing other than assuring use of clean seed. Modification of the pressing cage to accommodate the small size seed relative to sunflower and groundnut will probably be required. Pre-heating would surely increase the extraction rate. The value of sesame seed cake is a question mark at this time, and should be investigated, both for confectionery purposes and as livestock feed.

4) Castor lends itself well to spindle pressing because of the high oil content of the seed. Pre-heating increases oil yield relative to cold pressing, as in the case of all oilseeds. Market conditions for castor oil in Zambia are currently under study by Deloitte on contract to the African Development Foundation. There appear to be several possibilities, ranging from small quantities for machinery lubrication (bicycles, sewing machines, etc.) in rural areas to a fairly significant market opportunity of 1,000 tons per year for soap manufacture at ROP in Ndola if the price is competitive with imported tallow (the GM indicated that crude castor oil might bring K50,000 per ton for this purpose).

5) Oil Palm processing with spindle press technology works well in other African countries, although the addition of a hydraulic jack to increase the pressure and ease the labor requirement can make the enterprise much more attractive if the market can justify the investment. This opportunity has not been studied in the field by the team because of the difficulty of traveling to Luapula Province in the time available, and because it represents only a limited opportunity in the Zambian context. Oil palm is a very minor crop, and palm oil is not widely used in local cooking outside of the area where the oilpalm grows. This possibility should be investigated in the future, once solutions for the more important oilseeds have been found.

Leaving aside the question of oil palm, which requires a different process prior to pressing, one factor emerges for all oilseeds when considering the introduction of the spindle press. This is the improved extraction rate which results when seed is preheated. When GAMECO began distributing small spindle presses for groundnut processing, users began experimenting spontaneously with preheating of seed. Lutanda Agricultural Machinery did experiments with the KIT spindle press they made and determined that the oil extraction rate without pre-conditioning of sunflower was only 45% of the rate achieved when the entire system was applied. Similar results are documented by the Institute for Production Innovation in Dar Es Salaam, although this documentation is not currently available in Zambia.

Consequently, the team feels that introduction of the spindle press technology should be accompanied by recommendation for pre-conditioning of seed. The system recommended should be as simple and inexpensive as possible, but MUST include a method of preheating seed. An appropriate firebox, easily constructed of local materials, and roasting pans should be made available to users for two reasons :

- The higher extraction rate will encourage rapid adoption of the technology;
- A more efficient method of fuel use will reduce the ecological consequences of firewood consumption for cooking oil manufacture.

The introduction of improved wood stoves for small industry in Zambia might find rapid acceptance among traditional beer brewers, since they probably consume large amounts of firewood in their process, and could significantly reduced their costs by reducing fuelwood consumption. This is an observation made on the basis of experience in other African countries, not on field experience in Zambia, but the idea is worthy of investigation.

Due to the lack of reliable data on a simplified spindle press system, we have not been able to do more than provide a very rough estimation of the economics of the system (see below under Business Models, and Annex 4). The alternative configurations discussed above, the unknown extraction rates with various degrees of pre-conditioning for the various oilseeds, and the cost of equipment are all open to question at this point. The analysis in Annex 4, Table 2, assumes a large cage spindle press, capabile of processing 9 kilos of nutmeats per hour. This scale of operations appears to be very prfitable from the analysis, but the technical assumptions are unverified, and this result should not be taken literally.

3. Animal Powered Oil Press/Village Oriented Development Program (VODP)

VODP, with the Diocese of Chipata, and the Institute for International Cooperation (Vienna) have developed an animal powered oilpress. There are presently two of these presses in Chipata district: 16 are planned to be in operation by 1995.

The oilpress is operated by draught animals moving in a circle and setting a driving gear in motion; this gear is connected to a gear box. The gear box drives a spindle which squeezes the oilseeds against a press chamber. The oil drops out of the press chamber; the oilcake is forced through a nozzle. (GTZ Aug 1991)

The site visited has had an animal powered oil press for three years. There are 8 groups of women that alternate using the press machine; it is not usually in operation more than three times a week. The press has only had one breakdown in three years.

A minimum of two oxen and three women are needed for oil pressing (one drives the oxen, one cleans the seed, and one fills the expeller); there is also a (male) machine supervisor who does maintenance work. Before beginning operations, seed is cleaned, the unit is assembled and the press cylinder is heated using charcoal until 90 degrees Celsius is reached.

One bag of seed is processed per day; the women work from approximately 6 am until 2 pm or 3pm. Five or six women are generally involved. The group visited was pressing a combination of sunflower and soybean (2 parts sunflower; 1 part soybean). They believe they are getting approximately 15 liters of oil per bag. The cake expressed was extremely dry. They also use seed that has been stored for at least six months in order to reduce the moisture content.

Although they expressed a taste preference for pure sunflower oil, soybean was being used in order to make use of this item.

The groups each pay K400.00 a day for machine usage. The women bring their own seed to be processed; each woman keeps a small amount of oil and the rest is sold (this is their choice--they want the cash income). They sell the oil for K20 per cup measurement in the local area and have no problems selling it. Currently, the members are feeding their pigs the cake byproduct; it is not sold and it appears most of it is being thrown away. The oxen are not being fed any of the cake; they are all free range.

The major drawback expressed with this technology was the need for two pair of trained oxen a day; each pair can only work for 1 1/2 hours without resting. As well, one pair of oxen cannot be used more than 3 times a week. Depending on the season, the oxen are needed for other work as well.

An improved animal powered oil mill has been developed and is expected to be installed in January. GTZ/PAS gives the following expected outputs and specifications on the new animal powered presses:

1) Purchase price of approximately US $4,400.00
2) 6-8 liters of oil per hour depending on seed
3) Appropriate oilseeds include sunflower, soybeans, and groundnuts

4. Motorized Technology for Cooking Oil and Stockfeed

A small number of motorized expeller presses are operated in the Zambia for the production of cooking oil or stockfeed. The primary product varies with the user, some users being more interested in stockfeed and treating the oil as a by-product, and other users, the opposite. The Prices and Incomes Commission (PIC) study on Cooking Oil (1991) and the Deloitte study on the Oil Seed Sector both refer to 33 mini-oil mills in operation in the country. For lack of time in country, the team was not able to visit even a representative sample of these mills, but we were able to visit two operators of Komet presses in Southern Province, two operators in Lusaka of Indian and Japanese presses, and a commercial farmer near Kabwe using a locally manufactured expeller for stockfeed production. These machines were producing some cooking oil, and their owners felt that they were, in some sense, "profitable", although it was impossible in most cases to identify just what was meant by profitability. Only two operations visited were privately owned and profit motivated. In one case, the cooking oil was strictly a by-product, and it was not clear if the machine was in fact an economical solution to the owner's problem of availability of stockfeed.

The Quantity and Quality of Production: The PIC Study estimated that total installed capacity in small mini-mills is less than 4,000 tons, or slightly less than 10% of total production in 1990. However, the actual production of these mills is certainly far less than this, because most are either operated on a limited basis for various reasons (i.e., are not commercially operated), or are experiencing severe problems with downtime due to unavailability of wear parts and adequate repair services.

The quality of oil produced by these small mills seems to be quite acceptable to the loc market. The owners of the mills contacted were all very pleased with the quality of th cooking oil they were able to produce, and none had any difficulty selling it. The feedl owner using a local expeller to process sunflower was very happy with the results he wa getting with his animals. All operators reported no difficulty in selling the cake fo stockfeed, with prices varying from K10 per kg in Pemba to K14 per kg in Lusaka.

Who are the producers?: Small motorized mills are mostly owned either by not-for-profi institutions or by commercial farmers or small businessmen. None are owned by women a far as we were able to determine. It would be useful to try to inventory the small presse listed in the Deloitte report, to determine how many are still operating, and to test th conclusions presented in this report against their experiences. Unfortunately, the team di not have time for this, particularly since the person responsible for the Deloitte report is n longer in the country, and we were therefore unable to find most of these machines in th limited time available to us.

Geography of Production: The small mills identified in the Deloitte study are located i seven of the nine provinces. Only Luapula and Eastern provinces have no small scale oi expellers. At this time (five years after the Deloitte report) there are animal powere screwpress expellers in Eastern Province, and at least one small motorized expeller wa introduced on an experimental basis in Luapula. These machines, operating in ever province in the country, are processing mostly sunflower, with some groundnut and a ver limited amount of soybean. As discussed elsewhere in this report, groundnuts are generall too expensive to make cooking oil at a reasonable price; soybeans have a very low oil content, and the cake resulting from small expeller extraction is too high in oil content to make high quality feed.

Small businessmen and shopkeepers in the Southern Province expressed a lot of interest in the idea of setting up small scale motorized oil mills when they were contacted during our survey of the market for cooking oil. Some had already taken steps to try to find out about suitable equipment, i.e., they had written away for pro-formas from various suppliers, and a few had submitted projects for approval to the GRZ. They were aware, because of the nature of their business, of the great demand for cooking oil in their area, and felt that there must be a business opportunity in this sub-sector. Lack of technical knowledge, lack of access to reliable information, lack of foreign exchange and the difficulties of dealing with the bureaucracy regarding approvals were cited as reasons for abandoning these projects.

The most serious enquiries we met in Southern Province came from the SPCMU, where the intention to go ahead with a project of this type is apparently quite clear. SPCMU have already ordered four small expellers, through ZCF Financial Services, with a capacity of about 50 kg/hr, and are seeking information for procurement of two additional expellers with a capacity of about 600 kg/hr or more. At the time of our visit to Southern Province, there were apparently over 100,000 bags of sunflower (more than 5,000 tons) sitting in SPCMU storage facilities.

Given the problems identified below relating to diseconomies of scale for small mills, it would be most appropriate that new mills be owned by either established businesses or the

cooperative unions. Either of these will be able to take advantage of existing facilities, warehouse space, transportation, office overhead, power, water, and telephone lines, etc. etc. and thereby greatly reduce their cost of setting up a small scale mill.

Market Situation Faced by Small Scale Processors: Sale of cooking oil produced in small expellers by cold pressing from sunflower presents no problem whatsoever. Likewise, sale of oilcake from sunflower has been very easy for all millers contacted by the team. In fact, on both accounts, none have been able to satisfy demand. In general, they sell their cooking oil for K100 to K120 per liter wholesale, which seems to be highly competitive with the products of Premium Oils and ROP. In market towns, a wholesale price of K150 per liter for unrefined filtered sunflower oil results in immediate sale. This oil is then broken down into small lots and sold for the equivalent of K175 per liter. This compares very favorably with a price of K840 per 5 liter jug for Premium oil. Most consumers cannot afford this much cash outlay, so in the open market, this is essentially the equivalent of a wholesale price of K168 per liter. Buyers of these jugs break them down into smaller lots, which often sell for as much as K30 per 100 ml, or K300 per liter.

Seed Cake Sales: The oil meal from sunflower processing is very acceptable to dairymen and feedlot operators, even when the sunflower is not dehulled. Dehulled sunflower meal fetches as much as K14 per kg, comparing favorably in feed value with cottonseed meal, which sells for K9.5 per kg factory gate price at SupaOil in Kabwe. We were unable to locate a small scale miller producing groundnut meal, but ECU in Eastern Province is obliged to sell their groundnut meal as stockfeed, despite the fact that groundnut powder is a staple in the diet of the region. Virtually all households produce their own groundnut powder from their own crop of groundnuts, or buy or trade very small quantities with their neighbors. As stockfeed, groundnut meal presents a hazard because of the high risk of aflatoxin. Therefore, stockmen and dairymen are reluctant to buy from any supplier whose management practices are the least bit suspect. For whatever reason, ECU is generally unable to sell their groundnut meal.

Current and Proposed Project Activities: The most significant small scale oil expeller project currently underway in the Zambia is the UNDP/FAO Central Province Small Scale Industry through Cooperatives project, based in Kabwe. This project has a target of about 40 small expellers installed in Central Province within three years. It is a pilot project, which might be extended to other provinces by other agencies, such as UNDP or the World Bank, if it proves successful.

ZCF is supporting the initiative of the SPCMU to set up and operate several small expellers in Southern Province, as discussed above. They have apparently purchased about 40 machines already, most, if not all, are Tiny Oil Mills from India.

Economics of Small Scale Oil Expellers Currently in Operation: Perhaps the most eloquent and succinct statement regarding the profitability of small oil expellers was made by an entrepreneur in Lusaka, who has been operating several different types of small expellers on a commercial basis since 1988. He said :

> **"Small is NOT beautiful."**

All the operators contacted reported very serious difficulties having worn worms and other wear parts rebuilt or replaced. Downtime represents a high cost to these small operations. Incidentally, this appears to be true for the medium scale millers as well, judging by the current situation at ZATCO and ECU/Katete mills, although some operations are more successful in dealing with these problems than others.

Availability and cost of seed did not appear to pose much of a problem, but the quality of sunflower seed was generally low. Several small millers commented on the fact, and indicated that they have begun to pay a premium for higher oil content seed. Their seed supply often required cleaning before processing because farmers are not the least conscientious about supplying clean seed. Many buyers accused farmers of deliberately adding dirt, stones, even bricks to their bags of seed to bring them up to weight. ZATCO estimates that 15% to 30% by weight of the seed they buy is trash (sand, dirt, stones, etc.) A private miller in Lusaka estimates 20% loss to trash and shrinkage (moisture loss, spillage, etc.) is normal under good management.

Groundnut seed is not purchased in any quantity by operators of small expellers as far as we were able to determine. It is too expensive to produce a price competitive cooking oil. This is unfortunate to the extent that groundnut processing would result in much less wear on the expellers, which is the major problem experienced by all small operators. However, given the aflatoxin risk associated with groundnut cake, and the likelihood that it would be marketed at a high margin for human consumption, it is perhaps for the best that small millers cannot afford to process groundnuts at this time.

It was difficult for the team to get a clear picture of the profitability of small scale oil expellers for several reasons :

- Non-profit institutions don't keep the records necessary to evaluate the profitability of their operations, which invariably involve many hidden subsidies (management, structures, power, etc.);

- Private millers are rightfully reluctant to discuss the profitability of their operations with strangers in any but the most general and uninformative terms;

- The few institutions which were making a conscientious effort to keep track of their expenses were unable to furnish us with hard data on paper which we could evaluate;

- Those who seemed to have the clearest idea of the profitability of their operations all felt that the activity was marginally profitable at best, but were interested in continuing with it, perhaps the single clearest indication that the situation is not hopeless.

Financing: The majority of small expellers in the country have been purchased by benevolent organizations, donated by church groups, set up on a project basis, installed as an experiment in an appropriate technology workshop, or otherwise installed without

commercial financing of any kind. Commercial farmers who own small machines have generally bought them outright, since the cost is not great relative to their level of operations. Small millers in general fear credit at the moment, because of its high cost, and the unreliability of their cashflow due to downtime problems. Medium scale millers, on the other hand, are operating with large lines of credit from the commercial banking system.

Management and Ownership: The cost of the machinery and the degree of management and technical skill necessary to operate it limit ownership of motorized expellers to private business (including commercial farmers) and not-for-profit institutions. Cooperative Unions own some small presses. This technology does not appear to be appropriate for small groups, rural womens' groups, or any sort of informal association because of the relatively high costs, level of risk, and difficulties of management associated with it.

D. Problems and Constraints

The following are some of the major difficulties confronting small scale agribusiness in the oilseed processing subsector :

1. Constraints on the Input Side

a. Seed Supply

On the input side, the single biggest constraint to production of high oil content oilseed is unavailability of high quality seed to the farmer. Virtually all farmers contacted in rural areas complained that both sunflower and groundnut seed are unavailable. While it is practical to save seed for groundnut, since the crop is self-pollinating, farmers need to purchase sunflower seed every year or two to insure good yields and high oil content. The oil content of the seed is the single biggest factor in profitability of sunflower milling for cooking oil. The historical importance and preference in rural areas for confectionary groundnuts suggest that seed for high oil content varieties should be made available if groundnuts are to be sold for oil extraction. Unavailability of seed is due to several factors, none of which are likely to be remedied in the near future :

- Sunflower seed has proven difficult to produce for a variety of reasons (staggered planting requirement for hybrids, unfavorable pattern of rains in the last few years, low yields of seed quality crop, etc.) and consequently ZAMSEED has great difficulty finding farmers willing to grow it out;

- Groundnut seed also is difficult to produce in quantity, because of shortages of basic seed, the low multiplication factor, and also it is unattractive to commercial farmers because of its high labor requirement at harvest time; small farmers are too often tempted to sell their seed crop to the confectionary market because prices are so high there;

- The distribution system for seed other than maize seed is very poorly developed in Zambia, and farmers are reluctant to travel long distances to

buy seed when they cannot be sure to find what they are looking for at their journey's end.

The problem of a weak agricultural marketing system is a constraint to the developement of agriculture in general in the Zambia. Unavailability of seed of all types is a widespread complaint among small farmers (see MAWD/ARPT National Seed Availability Study, July 1991). Seed is unavailable, or arrives too late for planting, or is of poor quality and low germination rate, or is of the wrong variety. The importance of seed supply for sunflower in particular is brought out by the finding of the above mentioned study that while 55% of seed supply in general is from farmers' own saved seed, for sunflower 74% of growers in the sample purchased seed.

The oilseed processing industry has only recently begun paying a premium for higher oil content seed, but this is clearly necessary to maximize the profitability of crushing both sunflower and groundnut. This implies that the availability of high quality seed will be of increasing importance in the future. The current tendancy of ZAMSEED to work through independent stockists is favorable for the medium term outlook, but at present, seed supply to the small farmer remains a serious constraint to development of the industry.

b. Availability of Inputs and Production Credit

The general weakness of the agricultural marketing system results in unavailability of inputs of all types, not just seed. At present, small farmers growing sunflower use no inputs other than seed, but if it were to become a more important cash crop, as it could if the market were developed by small local millers or village industry, then they would be more willing to invest in production. At that time availability of fertilizer, pesticides, and production credit would become a constraint to production.

Production credit for small farmers is almost exclusively for maize at this time. Both CUSA and Lima Bank indicate that they are unable to meet the demand for production credit for maize, so availability of credit for oilseed production is a problem.

c. Extension Services

As farmers treat oilseeds more as a cash crop and find it economic, because of favorable prices and an assured market, to increase their inputs, extension becomes more important. Variety selection and cultural practices, pest control and handling at harvest time, etc. are areas where an extension service could intervene to improve farmers' incomes from oilseed crops. Unfortunately, the extension service in the Zambia is non-functional for lack of resources. The Provincial Agricultural Officer in Choma told us that he doesn't even have bicycles for his people. You can't do ag extension sitting in your office.

d. Crop Marketing

This side of the agricultural marketing system is barely able to keep up with the demands placed upon it by the maize harvest. Since maize is the key to food security in Zambia, it would be naive to think that scarce resources for collection, handling, transportation and

storage will be made available for oilseeds when they are barely adequate to meet the need for maize.

Similarly, payment to farmer's for their crop must be immediately forthcoming if they are to be encouraged to produce more and better quality oilseed. Currently, farmers sometimes wait more than a year for payment for their cash crops. This is unacceptable for the development of the oilseed industry. Both cotton production and soybean production by small farmers have increased dramatically in the last few years, primarily because of crop marketing services and prompt payment by LINTCO.

These are, of course, reasons for advocating local small scale processing. The local miller will have to take charge of all these agricultural marketing problems : input supply, production credit, and crop marketing (prompt payment to farmers, handling, transportation and storage of the crop). We have seen that in general existing institutions (ZAMSEED, the Provincial Cooperative Unions, CUSA, Lima Bank, etc. etc.) are not capable of taking on this burden at this time for oilseeds because of the continuing priority of maize in the national agricultural economy. While it may be fine in theory to try to devolve these functions onto local institutions, such as the small scale millers, in practice these responsibilities will strain the limits of their resources.

2. Constraints on the Operations Side

a. Equipment Selection, Set-up, and Operations (Technical Assistance)

Those persons contacted in the course of this study who were either already engaged in small scale motorized oil milling or were thinking seriously of investing all complained of lack of technical information and support. Equipment selection has been haphazard up to now for lack of knowledge about alternatives. Small scale oilseed milling is widespread in India, but only recently have Indian oil expellers been imported to Zambia. Donor organizations have financed extensive research on small expellers, but have only investigated the economics and technical feasibility of using machinery produced in their own country, where small scale milling is non-existent. These ill-adapted systems have provided the model for local manufacture of oil expellers, which have also been marginally profitable at best. At present, some progress is being made in finding local solutions to these problems, but it is slow going.

b. Technical Back-up for Wear Parts and Repairs

In parallel to the problems of equipment selection, set-up, and operations outlined above, availability of parts or the local manufacture of wear parts have been an ongoing problem for small expeller users. Even the large and medium scale millers have experienced problems of this type. Worms and cage bars, worm and cylinder sets, worm and ring sets all wear steadily under normal use crushing oilseeds. The rate of wear is greater for some types of seed, and for undehulled or dirty seed. Worms need rebuilding and replacement several times a year at least with normal use. CECOCO, for example, claims that a worm and cage bar set should last 1000 hours in normal use. Experience with locally

manufactured or rebuilt worms using inappropriate steels or welding rods (for rebuilding) has been that wear on these replacement parts occurs at an unacceptable rate. One small miller in Lusaka is replacing his worms every five days.

c. Seed Quality

The single most significant factor for profitability in oilseed crushing is the oil content of the seed. The miller can compensate for lower oil content to some extent by paying a reduced price for lower quality seed, but there is still a cost to bear in terms of high rates of wear relative to oil yield and lower oil output per unit time. Both sunflower and groundnut seed which are commonly grown in the Zambia at this time are relatively low in oil content. In order for farmers to begin producing higher oil content oilseed, they must first have access to, and be willing to pay for, improved seed. As discussed above, seed supply is currently a problem for the entire industry, and likely to remain so for some time to come.

Sunflower composites which are now available for multiplication have only 25% - 35% oil (versus about 40% for hybrids, which ZAMSEED is having trouble producing in any quantity). The preferred varieties of groundnuts grown by small farmers contain about 25 - 30% oil, whereas Makulu Red, an oilseed variety, contains over 40% oil, but only represents about 10% of the national crop at this time.

3. Market Constraints

Small scale millers will not be able to produce an oil of the same appearance and quality as large scale millers, who refine their products. The quality of the cooking oil produced by Premium and ROP at this time is not much better than a good cold pressed oil, so in the near term this is not an obstacle to small scale production. In the medium to long term, if the large mills in Zambia reorganize and begin to operate more efficiently, both price and quality competition may become obstacles to profitability for the small miller. It is possible for a small scale mill to operate a simple waterbath-vacuum pump refinery, but this adds to the cost and complexity of operations.

The quality of seed cake produced by small mills is lower than that of the large solvent extraction plants because of its higher oil content. It will not keep as well as the very low oil content meal from the large scale miller, and has lower feed value for some uses because of its higher oil content. However, in rural areas, where people do not have access to blended feeds, or where they cannot afford them, these simpler, lower cost products from the small miller can serve to improve yields from chickens, pigs, and dairy cows, and boost the productivity of working oxen.

In summary, while the market side of the equation is relatively favorable to the small miller at present, most other factors in the operating environment are not.

E. Markets Open to Small Scale Producers

1. Unmet Demand

The demand for cooking oil is a function of price, buying power and the culinary habits of the people in the marketplace. Animal fats are the best substitute, but these products are even more expensive than cooking oil, and harder to come by in rural areas. A recent study (Kawana, Cooking Oil Situation in Zambia, 1991) estimated the "requirement demand" based upon 6 kg. per person per year for the entire nation at 46,800 tons. Comparing the "cooking oil equivalent" production of each province to demand based upon population, only two provinces were in a situation of surplus, Eastern and Southern. The cooking oil equivalent was estimated based on the assumption that all oil crops produced were converted to cooking oil. In fact, quantities set aside for seed, losses, and the very low percentage of the groundnut crop actually processed for oil imply that every province is in a deficit situation. Even if all oilseed in the country had been processed for cooking oil, the national production would have been only 24,367 tons. Production by Zambian industry was 43,200 tons, of which roughly one half was derived from imported crude oil valued at about $20,000,000.

The outlook for cooking oil availability in the short term is poor. USAID has greatly reduced PL480 imports of vegetable oil, and foreign exchange is in short supply for commercial purchases by the major producers, ROP and Premium Oils. Medium scale plants suffer a variety of problems, ranging from total shutdown due to a fire in the plant at ZAMOIL of Luanshya, to poor quality products from ECU in Eastern Province and ZATCO in Southern Province. SupaOil of Kabwe is operating at the limit of its capacity for cottonseed oil extraction. Southern African Oil Mills of Lusaka is currently hamstrung by a huge overhang of high cost soybean meal for which there is little demand at this time, certainly no place to park one's working capital. Production by very small and micro-scale producers is insignificant. Therefore, in summary, in the near term market conditions will remain highly favorable for local producers of cooking oil.

In the medium term, the outlook is more difficult to assess because of the very uncertain future of Premium Oils. This parastatal is slated for privatization. Its ability to continue operating without heavy subsidy is in doubt. The attractiveness of this investment to private parties will depend on many factors, including the flexibility of the new government in assessing bids and imposing conditions on buyers. Premium is the largest producer of cooking oil in the country, accounting for roughly 40% of all local production in 1990. It would appear that there will be room for small players in the cooking oil business in Zambia for some time to come.

This crude analysis was confirmed by the findings of the team in the field. In every province we visited, we contacted wholesale, retail, and open market vendors of cooking oil in the small towns along the main roads, and everywhere the story was the same. Demand exceeds supply, even at today's high prices. Supply from large scale industry in Lusaka is erratic and unreliable. Many small business people have already been seriously thinking about trying to manufacture cooking oil from locally available raw materials, because the market

situation is clearly favorable. Many small traders in rural markets make their living supplying only this one commodity.

In the villages, cooking oil is even harder to get and more expensive relative to purchasing power. Where people have found a simple method of oil extraction, such as the ram press or the spindle press, demand exceeds supply for crude locally produced oil. The oil is sold easily, either to neighbors or in the nearest market town. Even in market towns, the crude, unrefined oil from village producers brings a good price, for example K150/liter in Mazabuka.

Oil cake sales are more problematic for small scale processors. In the more remote rural areas, people are generally unaware of the value of cake as feed for their chickens, pigs, dairy cows and oxen. Some few progressive individuals have begun buying seed cake for their animals, but demand is slow to develop, and village processors don't know how to market it. Commercial farmers engaged in dairy farming or feedlot operations indicated that they would readily purchase sunflower meal at a price at least equal to the price of cottonseed meal (currently K9,500 per ton plus transportation and handling from Kabwe) if it were locally available. This market could be readily exploited by market town processors, and in fact those small expellers operating in market towns have no difficulty selling seed cake. The value of seed cake for commercial farmers depends primarily on its protein content, which in the case of sunflower cake is higher when the sunflower is dehulled before processing.

The situation with groundnut oil is difficult to assess because there is virtually no groundnut oil available in the marketplace. The product of the Eastern Province Cooperative Union is more expensive than Premium Oil's cooking oil, and of lower quality, and therefore does not sell well at all in Eastern Province. The reasons for this are not clear, but mismanagement at the mill is likely. The high price fetched by groundnuts on the open market is a strong deterrent to groundnut oil production in general. The team feels that there may be potential for village scale processing in those areas where growers do not have access to market, and therefore the value of their groundnuts remains low. In principle, the quality of the oil should be excellent, and present no problems of acceptability in rural areas.

Groundnut cake presents a higher risk of aflatoxin contamination than any other oilseed meal. Groundnut flour made from whole groundnut is found in markets throughout the country, however, as it is a staple in the Zambian diet, and the risk of aflatoxin in this product is similar to that in processed groundnut. The processor, however, will have large quantities of cake to market, relatively speaking, and there will be a tendency to store the cake until a marketable quantity is accumulated, hence increasing the risk of mold growth and aflatoxin contamination. The question of the safety of groundnut cake from small scale producers for human and animal consumption needs to be carefully evaluated before any serious effort to promote groundnut processing is launched.

There is some question whether the defatted groundnut flour made from oilcake will bring as high a price as fullfat groundnut flour. At retail, in small quantities, whole groundnut flour sells for about K200 per kilo.

2. Consumer Preferences

The target population for a village scale technology project is that portion of the rural population which does not have easy access to a market town. Perhaps 20% to 25% of the population of the country falls into this category. For these people, availability of cooking oil is a serious problem, and purchasing power is low. Small shops in remote areas sell cooking oil by the 100 milliliter cup for as much as K30, the equivalent of K300 per liter. The consumer accepts this price because the cash outlay required for access to the product is low. The alternative is to travel long distances to a market town, in the hopes of finding cooking oil available, which is not always the case. For village industry, an ex-works "wholesale" price for cooking oil of K150 per liter would be very reasonable at this time, and demand would exceed supply.

Consumers find themselves in a situation of preferring whatever is available due to the recurrent problem of shortages and non-supply. When alternatives are available, price is the primary consideration because of the problems posed by inflation and declining purchasing power, and because of the low cash income levels of village people. We did find, however, wherever we had the opportunity to discuss the quality of various cooking oils available on the local market, that buyers are discriminating, and have clear preferences for certain brands over others based on quality considerations. The products of ZATCO and ECU for example, are held in low esteem, and only purchased as a last resort.

This implies the possibly obvious conclusion that there will be competition among village level cooking oil producers on the basis of the quality of their product as well as its price. The implications for alternative technologies are clear : a process which results in a product of distinctly inferior quality will be a high risk venture for the rural entrepreneur. Rural people's preferences, in terms of color, clarity, taste, and odor of cooking oil, may differ from those of urban dwellers used to more refined products. The sunflower oil produced at Sinanjola, for example, is dark and strongly flavored due to the roasting process used for pre-conditioning, but this oil is acceptable to local consumers, who have few alternatives. Some indicated that they prefer a cooking oil which has flavor to a refined product.

There are dishes (relishes) for which cooking oil is preferred to groundnut flour, for example in the preparation of fresh vegetables, fish, and cowpeas, while groundnut flour is preferred when preparing dried vegetables. As well, cooking oil is an item that can be stored in the household and is therefore convenient to use. Groundnut flour, however, is perishable and its preparation is done at the time of consumption.

Consumers, even in rural areas, have a desire for diversity in their diets. When asked why they had a need for cooking oil when they had groundnuts for use in relish, the members of the Demu Women's Club were emphatic that their diets were monotonous and it was important to have options. Thus, they would walk two hours to the nearest store (in Pemba) to purchase cooking oil; and sometimes they would have to go as far as Monze or Choma to find it.

Rural consumers are also concerned with the quality of oil when given a choice. This was especially apparent in the Eastern Province--from Sinda to Chipata--where it was expected

to find groundnut oil from ECU being sold in the shops and instead Premium Oil purchased in Lusaka was being sold. Numerous shopkeepers and consumers questioned indicated that they considered the ECU oil to be inferior because of its smell (ECU states that they have left room on their labels to tell consumers to boil the oil before using it, and this does, in fact, improve the quality of the oil.)

3. Price Considerations

The Africare SPOP project has demonstrated that rural consumers appreciate good quality cooking oil but that they do not need fancy packaging which will increase the price of the product. Rural consumers are willing to provide their own bottles if it lowers the price they must pay.

In open markets traders sell small quantities of cooking oil for substantially more than the cost of standard size containers; although the unit price is high, this provides a service to customers who cannot afford a high cash outlay at one time. Retail shops surveyed in the Southern and Eastern provinces indicated that it is generally the cheapest oil which sells first. As well, consumers like to buy small containers when available even when the unit price is higher. For example, in Chipata, Malawian cooking oil is sometimes available and is packaged in 200 ml containers; it sells very quickly.

One factor to keep in mind when working with rural groups in small scale processing is the social motivation of their activities. This appears most clearly in what might be called "benevolent price setting", where the group sells their product for a price far below market, for the simple reason that they are trying to provide a service to their community. As long as financial management is adequate, this practice does no harm (i.e., if the group can afford it, there is no reason why they should not operate on this basis). In practice, however, this is done at the expense of meeting financial obligations (loan repayments) from other sources of revenue.

4. Competition

Rural producers face little competition at this time because of the general cooking oil shortage prevailing in the country. This shortage is not likely to disappear any time soon, unless the donor community begins either importing commodities directly, or finances such imports indirectly by making foreign exchange available. The fact that the short run market outlook is so positive is favorable, because it gives new producers a little time to get set up, learn to operate, develop their markets and stabilize the quality of their product.

In the long run, the cost of transportation will be a big factor in whether or not the large scale producers can compete on a price basis with small local producers. There will always be some point at which local production becomes more economic than centralized production, but these boundaries shift with changing factor prices. In the short and medium term, the balance will remain in favor of local production, meaning that the area of the country which can be economically served by local producers is large.

5. Distribution Systems and Transport Cost

The price problem for the rural consumer is tied to packaging, as noted above. Availability of small, affordable quantities is probably the single most important factor in marketing cooking oil in rural areas. A producer, even using a ram press, might find it tedious and even expensive to deal with the large number of customers required to sell 2,000 liters of production per year in 100 milliliter lots. Therefore some approaches to wholesaling, either to local institutions (such as schools or military camps for example) or to local retailers who will breakdown the commodity into small lots, will become important as production increases to commercial levels. Some costs will most likely be incurred by the more successful oilseed processors for storage and distribution of their product in lots of 5 liters, 20 liters, or more.

Distribution and transportation problems are minimized by the village scale technology approach. A ram or a spindle press which treats 10 to 20 tons of seed in a year, producing 2,000 to 4,000 liters of cooking oil, can only serve the "requirement demand" (6 kg per person per year) of about 300 to 600 people. Some of this production will find its way to a higher value market in 20 liter jugs transported by bus or other local public transport. At this scale, the needs of two small villages could be met from local production, all of which could be sold to buyers within walking distance.

6. Points of Sale

For the village processor of a commodity in high demand, the principal point of sale will be the site of production. Local shopkeepers will come to buy in small lots of 5 to 20 liters, as they do now in the market towns, then sell to individual consumers in very small 100 ml cupfuls. Such points of sale are distributed around the countryside, and these small shopkeepers will prefer a lower cost local product which is readily available for sale.

As production increases, and marketable surplus remains small, other alternatives should be easy to identify as long as the general shortage of cooking oil persists in Zambia. The women of Nanchengwa took their surplus oil to the open market in Mazabuka, where they sold it very quickly for K150 per liter. They were selling locally, among themselves and to neighbors, for only K100 per liter.

The identification of points of sale and development of a distribution system become increasingly important as production increases. The choice and purchase of storage containers, handling of finished product, maintenance of quality, and techniques for distribution to avoid accumulation of product and immobilization of working capital are real management issues which even small scale rural processors will have to face. Profit motivated operators will expand until they are constrained by some factor. For small rural business, lack of management know-how, particularly in the area of marketing, is very often the limiting factor.

One great advantage of the cooking oil business is the high demand for the product which will drive a spontaneous distribution system. The processor stands to benefit if they are able

to share in the marketing margins as well as the production profit. There are as many potential points of sale for cooking oil as there are small shopkeepers.

The problem of seed cake sales, on the other hand, is likely to be more acute, depending upon the number of livestock in the area and the standards of animal husbandry. The problem of corridor disease in Southern Province, for example, has decimated the population of working oxen to the point where land preparation has become a problem for many people, as it was in the old days of hand cultivation. The proximity of commercial farmers running dairy or feedlot operations would be the most ideal situation for small producers, since these people will provide transportation for usable quantities. To the commercial farmer, however, one ton is a rather insignificant amount, as they are used to buying by the truckload to minimize transport costs.

Some organization of the marketing of seed cake to commercial farmers and feedlot operators by the project might pay high dividends to small village processors in the long run. Once relationships are established, and an economical collection system is worked out, commercial farmers have told us several times that they would prefer doing business with local people. This does imply certain standards of handling and storage of seed cake, so that a marketable quantity can be accumulated and kept in good condition until time of delivery, which will further raise the cost of operations to village processors. Lacking a market among their neighbors, however, investment in a simple storage facility might be an economical alternative to discarding the cake, which has been done by many of the groups sponsored by Africare.

7. Export Potential

The team was not able to do a serious evaluation of export potential for locally produced cooking oil in the time available. The export market will be open primarily to larger commercial producers because of packaging requirements and economies of scale in shipping. This market is important to the small local producer to the extent that it can relieve some of the pressure of competition from large scale producers by providing them with an attractive alternative to domestic sales. It is fair to say that, since virtually all countries in the Southern African region are net importers of vegetable oil, the potential for export of cooking oil from Zambia exists.

8. Seed Cake

An important aspect of local oil processing is the seed cake byproduct. Sunflower seedcake--both decorticated and undecorticated--has good protein content, and energy value from the residual oil, and therefore makes a good supplementary feed for livestock. Decorticated sunflower cake is of higher value because of its higher protein content relative to weight. It is especially appropriate for cattle and pigs. Undecorticated sunflower seed cake can be used for beef cattle and is considered a good ingredient for cattle fattening.

Groundnut cake is a high value/high cost stockfeed ingredient; this actually may make it a more difficult by-product to sell. ECU sells their groundnut cake for K864 per 50 kg bag (K17,300 per ton); although expected to go up, last year when sunflower seedcake was

available it sold for K138. ECU has a stockpile of groundnut cake for which they have no market. Although there is a risk of aflatoxin in other seedcake as well, the risk is highest in groundnuts and quality assurance is needed. Groundnut hulls can also be used as a feed ingredient for ruminants.

However, because locally available seedcake is a new product in many rural areas, especially with small farmers, a market will have to be developed. It is important to determine which animal feeds are currently being used in an area, for which animals, the amount of feeds being purchased plus what is obtained at the farm level, and prices. Recommendations for the utilization of the seed cake can be made depending on the animal's weight, production levels, and mixture of other feedstuff.

The Southern Province Dairy Development Program Officer indicated that they have started a new program in Choma and it currently has 9 small-scale dairy farmers; Monze has 120. He indicates that the average small-scale dairy farmer has 5 crossbreeds and that it is difficult for the farmer to get feed unless he has his own transport. SDDP recommends farmers feed their dairy cattle one-half of their production level (i.e., if they produce 6 liters of milk/day, feed should be 3 kgs) at a mixture of 1 part cottonseed or sunflower cake to 2 parts maize bran. He believes local sunflower oil processing using the ram press would be an asset to dairy farmers in the surrounding areas.

A commercial farmer visited in the Southern Province (450 dairy cattle, 2000 beef cattle) indicates he is currently mixing cottonseed meal (2 kilos/day) with maize bran and molasses. He believes that decorticated sunflower seedcake is a better feed than cottonseed and therefore would be willing to pay somewhat more for it. He is currently paying approximately K12,000 per ton (K12 per kilo) for cottonseed meal delivered from Kabwe to his farm.

1989 estimates for the livestock population in Zambia is as follows: Traditional farmers: 2.3 million cattle, 557,000 sheep and goats, 186,000 pigs; Commercial farmers: .5 million cattle, 604,000 sheep and goats, 218,000 pigs.

The Southern Province has more cattle than any other province. In a survey undertaken by MOA/FAO (Nov 1991), more than 70% of the 400 farmers interviewed owned livestock. About 57% of the farmers indicated they kept livestock to sell as a source of income. This is where the market for seed cake should be developed as compared to ownership of animals for home consumption or ceremonial purposes in which it is unlikely owners would spend cash for animal feed. Its potential as a feed supplement for working oxen should also be explained to small farmers through a promotional campaign.

Decorticated groundnut cake and sunflower cake can be used as human food as well. However, groundnut cake created from processing oil will not taste the same as traditional groundnut flour because of the removal of the oil, therefore market acceptance is unknown. Sunflower cake is a completely new food item. One group of women have been using Lutanda equipment (KIT) since about 1986. Some women have started to use small amounts of sunflower seedcake with vegetables during the last six months. However, most of it is being thrown away although a few people buy it for chickens. No other instances of

decorticated sunflower cake being sold or used as a food item (through cake produced by the KIT process or by expellers) were found.

The risk of aflatoxin contamination in seedcake is a concern, especially for groundnuts. Traditionally, groundnuts are kept in the shell until preparation of the groundnut flour; this reduces the risk of aflatoxin. As well, at the household level, care is taken when preparing groundnuts for relish; the same care would be required of a commercial producer.

F. Choice of Technology and Gender Issues

When traditional oil processing is supplanted by improved technologies, women often lose out financially in the process (UNIFEM, 1987). The complexity of the technology, the large amounts of capital needed, and the managerial skills necessary to operate the equipment dictate the involvement of men as managers and owners as a consequence of their access to education, credit, and training.

Women in Zambia not only have less access to educational opportunities than men, but even less than the norm for sub-saharan Africa (UNIDO, 1990). However, Zambian women, probably through necessity, play an important role in the microenterprise sector in the country. A 1985 survey conducted of businesses with less than 50 employees indicated that 65% of the entrepreneurs were women; however, their enterprises tended to be smaller than male-owned enterprises. As well, there appear to be no cultural biases against women owning businesses in Zambia and employing male workers. In Luapula Province, with men involved in fishing and migration to the Copperbelt, women have a tradition of entrepreneurship and business skills.

Zambian women are not currently earning money from selling groundnut or sunflower oil made at the household level using traditional processing; it appears to be done only at low levels for home consumption. This implies that introducing oil processing technologies will not take away a current source of income to women. But it will only improve their income generating power if they have access to the technologies and support services needed to get established. In addition to oil processing enterprises, women may benefit from secondary enterprises such as selling sunflower or groundnut flour, fried foods, etc.

In the case of groundnuts, there are areas in the country where women derive some income from selling groundnuts in the local markets (groundnuts can be considered a "women's" crop to some extent). If groundnuts are used for village oil processing, and the technologies are owned by men, there is the possibility that women may become financially worse off. It is generally accepted, and there is evidence to support, that in many African countries, women's income is used within the family (for food, clothes, etc.) to a larger extent then men's income.

Both the spindle press and the ram press are technologies that--relative to expellers--can be easily owned by women because of the lower capital and operating costs. Whether a woman is physically strong enough to operate a press should not be the issue--if the cost of hired labor cannot be met by an enterprise then it is not a viable undertaking. The separation of ownership and labor is essential--people become wealthy by owning assets, not by doing

physical labor. In Tanzania, the owners of ram presses are generally male but even so they hire labor to operate the presses.

The ram press does have an important advantage over a spindle press, which requires a preheating treatment, on the workload of women. Walking many kilometers to collect firewood and water is a woman's "responsibility." To the extent that water and firewood collection is minimized (as in the case of the ram press) women will benefit both from time and labor savings. As well, in a modified spindle press process, if the unpaid labor of women (in dehulling, pounding, etc.) is substituted for what is now being done by machines in the KIT process, then women's workload will be increased.

Further comparison of alternative technologies will be found in Annex 1, "Pros and Cons and Unknowns" of the various technologies and oilseeds available for processing.

III. BUSINESS OPPORTUNITIES

A. Introduction

This section tries to develop several "business models" of viable small enterprises engaged in oilseed processing. These are not feasibility studies, and the financial analyses presented in Annex 4 are not based on the kind of detailed study required for a serious business proposal or a loan application. These are preliminary studies which indicate that feasibility study of these business ideas is worthwhile, and will probably have a positive result. At the level of investigation undertaken by the team in the short time available in country, these studies have been very encouraging (See Tables 1 through 6 in Annex 4 for cashflow analyses). Complete feasibility studies will need to be done for each and every individual enterprise in order to fully identify cost factors, market conditions, capital costs, etc. etc.

Since the studies presented here are only preliminary sketches, and as such are incomplete, extensive and detailed financial analysis as called for in the Terms of Reference ("pro-forma income, balance sheet, and cashflow statements") is not really appropriate. Such a level of detail would be misleading in a preliminary evaluation. We have, nonetheless, tried to provide a fairly detailed, quantified analysis of why we feel that each business idea presented below has the potential to achieve profitability. Several caveats are in order, however, so that the reader will be able to study these analyses in a realistic economic context.

The current annual rate of inflation in Zambia is sometimes estimated to exceed 100%. Interest rates are currently less than 50% (47% is the rate most commonly quoted). The exchange rate is falling almost every week. It is virtually impossible to do a meaningful 10-year financial projection under these circumstances for several reasons :

- The level of uncertainty surrounding prices and factor costs in the future is extremely high, making all long term projections risky and unreliable;

- The real rate of interest, defined as the nominal rate of interest minus the rate of inflation, is negative, implying that one would do well to borrow as much as possible regardless of need, since the bank is, in effect, paying you to take their money;

- In order to do financial projections using the current nominal rate of interest, one must also project inflation rates for all factors and prices in the model, and the future exchange rate for all imported inputs, clearly an impossible task over a ten-year horizon under the current conditions of rapid change and uncertainty.

The foregoing does not mean that we cannot evaluate the economic potential of our business models. But the most reliable sort of analysis under these circumstances is a simple economic cashflow analysis, meaning that all costs and prices in the analysis are put in constant terms. We don't have to make any assumptions about future inflation and exchange rates, and we get a fairly realistic assessment of whether the enterprise in question

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can "make money" under current circumstances based on evaluation of the cashflow and the economic rate of return.

We can look at the enterprise's ability to carry debt based on real rates of interest, but not based on the nominal rates of interest currently quoted by the banks. This is essentially an academic exercise, however, because we know that, aside from serious anomalies in the cashflow picture, if the real rate of interest is lower than the economic rate of return calculated for the enterprise, it can afford to carry debt, and the financial rate of return to the owner(s) will be higher than the economic rate of return because of the financial leverage provided by debt. This is a mathematical truism. Under present circumstances of negative real rates of interest, theoretically it would be possible to make money in an uneconomic enterprise (one which loses money in real terms), if only you can carry enough debt!

Since we cannot use nominal interest rates, and therefore cannot make any detailed assumptions about debt financing, we cannot do meaningful projected Balance Sheets and Sources and Uses statements, because these are based on assumptions about how the enterprise is financed. Table 1 in Annex 4 does present a simple financial cashflow analysis of a Ram Press operation using assumed real interest rates of 10% for investment capital and 12% for working capital. This analysis is illustrative of the results which we would obtain for any of these models, as explained above (i.e., when the internal rate of return is higher than the real rate of interest, the project can carry debt).

The models discussed below and presented in spreadsheet form in Annex 4 should be sufficient to permit a financial analyst to appreciate the profit potential of these business ideas, despite the difficulties described above. In Annex 4 the reader will find cashflow analyses for the following business models :

Table 1.	Ram Press processing sunflower purchased by the enterprise.
Table 2.	Ram Press processing sunflower, some of which is purchased, some of which is crushed for a fee.
Table 3.	Simplified Spindle Press System processing groundnut
Table 4.	Simplified Spindle Press System processing sunflower
Table 5.	KIT System processing sunflower
Table 6.	Tiny Oil Mill motorized oilmill processing sunflower

In each case we have tried to be as consistent as possible in our basic assumptions, so that the relative profitability of these alternatives can be compared fairly. The basic assumptions common to all models of manual processing systems are :

Sunflower Seed costs K550 per bag.
Sunflower Oil sells for K150 per liter.
Sunflower Seed Cake sells for K5 per kilo.

One spindle press model uses groundnut, and is therefore not a good basis for comparison with the other analyses. The results of the analyses are as follows :

CASE		ERR	NPV
1.	Ram Press, no service pressing	22%	257,121
2.	Ram Press, service pressing	17%	145,319
3.	Spindle Press for groundnut	30%	542,409
4.	Spindle Press for sunflower	19%	168,577
5.	KIT System for sunflower	12%	601,851
6.	Tiny Oil Mill for sunflower	32%	19,062,954

Cases 5 and 6 are for much more complicated technical options, operating at a higher capacity than the other alternatives, and consequently involving considerably more uncertainty in the analysis. The most valid comparison among cases can be made among cases 1, 2, and 4, and the only conclusion one can draw from these numbers is that there does not seem to be any significant difference in the profit potential of spindle presses versus ram presses. The reader is warned that there is relatively little reliable data available on the true operating costs and technical efficiency of a simplified spindle press operation. We have tried to extrapolate from the data obtained on the KIT System, but there is a lot of room for error in the analysis. This is particularly true for case 3, Spindle Press for groundnut, where we have no hard technical data on which to base our analysis. The results do appear very promising, however, which indicates that this is an option which deserves further study.

The quantitative measures employed are the Economic Rate of Return and the Net Present Value at a discount rate of 5%. Each of these deserves a few brief remarks.

The Economic Rate of Return is calculated from the annual cashflow generated by the project. It is that interest rate which would reduce the Net Present Value of the project to zero. It is commonly used in business analyses together with the notion of a "hurdle rate". The hurdle rate is the lowest acceptable rate of return for a project to go forward. A commonly used hurdle rate in industries with relatively low risk is 15%. Although the KIT system shows an ERR of only 12%, this would become 15% if the value of seed cake were to rise by only 3 kwacha per kilo, which is in fact highly likely. Therefore, none of our analyses exclude any of these options categorically. We refer to this measure as the "Economic" Rate of Return instead of the more commonly used "Internal" Rate of Return because all factor costs and prices in the model are in constant terms (constant kwacha).

The Net Present Value measure calculates the present worth of the project's cashflow stream when all future cashflows are discounted at the specified rate, in this case 5%. We chose 5% because it represents a minimal real rate of interest. All analyses show positive NPV at 5%. The higher NPVs for cases 3, 5, and 6 are due primarily to higher levels of production in those cases, i.e., the equipment has a greater capacity. Once again, this measure is most appropriate as a means of comparison among cases 1, 2, and 4, since these alternatives are technically similar. On this basis, the ram press would appear to be the option with the greatest profit potential for village scale oilseed processing.

The Internal Rate of Return calculated in Table 1C Annex 4 is based upon assumed REAL rates of interest (not the nominal rates currently quoted by lenders), and is therefore not

a true Internal Rate of Return in the sense relevant for a financial analysis. This model does indicate that a Ram Press operation could probably afford to finance 50% of the cost of the press and 50% of its working capital requirements from debt, but the owners will still have to raise about K100,000 in order to go into business, and from time to time will have to inject additional capital into the business (in years 4 and 8 when we assume they need to replace the press).

In summary, we can conclude, based on these cashflow models, that the ram and spindle press alternatives both seem to offer an economic solution to the problem of village scale oilseed processing.

The numbers on the spreadsheet do not tell the whole story, however. These numbers are based on many assumptions and consequently present a very tentative picture of what is possible. But even beyond the level of uncertainty inherent in any economic projections, are the many factors discussed below which will have an effect on the viability of a small enterprise. On balance, the team has concluded that very small scale village processing is a potentially viable business activity in Zambia at this time, but that small motorized presses face an unacceptably high level of risk due to many factors in the operating environment. The discussion below on Small Motorized Expellers belies the relatively positive picture presented in the spreadsheet analysis, Annex 4 Table 6, for this reason.

B. Village Level Business Idea - Ram Press or Simplified Spindle Press System used with Sunflower, Groundnuts, or Sesame

1. Crop Choice

A widespread business opportunity exists for entrepreneurs to produce sunflower oil with a ram press at the village level. The ram press was designed to process sunflower and the crop is grown in many parts of the country. Cold processed sunflower oil is of good quality and widely accepted. The throughput of the press is such that oil produced can be easily marketed in the nearby area without transportation costs being incurred. The profitability of an enterprise depends primarily on the amount of oil extracted from the seed (the value of seed cake is only 15% of that of oil). The ram press is not appropriate for groundnut processing, but has been shown to work well on sesame.

Spindle presses can be used to process sunflower, groundnut, or sesame. The KIT system is the only spindle press system which has been in use for any length of time in Zambia. Based on the experience at Kasisi Mission, it appears to be a workable system, if enough managerial and technical support is provided. Kasisi has processed only sunflower. Problems with groundnut as a raw material are discussed elsewhere in this report (high cost, aflatoxin risk). Sesame is not generally available in any quantity.

2. Geographic Area

This business opportunity will be viable wherever sunflower is grown or could be grown economically. That is, wherever farmers find it profitable to have some acreage in sunflower, thereby providing some assurance to the press owner that raw materials will be

available locally. Limiting factors would include alternative cash crops which discourage farmers from growing sunflower, and the local cost and availability of cooking oil.

Even in those areas too dry for sunflower, it might be feasible to set up a ram or spindle press operation to process sesame, if the crop were grown in sufficient quantity and local farmers are willing to consider it a new cash crop.

The ram press does not process groundnuts efficiently, therefore this press is only viable for sunflower and sesame growing areas.

To a certain extent, a small press operation can survive by processing seed on a contract basis for farmers. That is, oilseed growers can simply pay the press owner to crush their oilseed for them, either in cash or in kind. This is less profitable for the press owner than purchase of seed and processing, however, and therefore the business is more attractive financially in areas where the oilseeds are grown as cash crops. From a development perspective, however, contract milling permits the farmer to capture more of the value of his crop than is possible by selling it for cash.

3. Technology Choice

The rampress offers certain advantages over other available technologies (see Annex 1 for a summary of the pros and cons of the alternative technologies). The most significant factors in its favor seem to be the following :

- Management skills are minimal because of the size of the operation;
- Investment and operating expenses are low;
- The need for only one machine reduces the technical complexity and amount of repair work needed;
- The extraction efficiency is good for a manual technology;
- The process does not require fuel consumption for preconditioning of seed.

Spindle presses offer certain advantages, namely :

- Simplicity, robustness, and low cost of the press itself;
- Possibility of processing many different oilseeds, and even other products (fruit for juices, cheese);
- Easy to manufacture and repair.

The Kit system is complicated for village scale processing, and it is not clear whether a simplified spindle press system can compete economically with the ram press, particularly with respect to extraction rate and throughput. This has yet to be proven.

4. Ownership and Management

The ram press requires relatively little capital, management expertise, and technical know-how, making it well suited to rural entrepreneurs, even in the more remote areas of the country. For an initial investment of under K200,000, a rural entrepreneur or group can

purchase one press and a the few supplementary items required for operations, and go directly into business. The low capacity of the machine is an advantage to the extent that working capital requirements are minimized, and financial management remains simple. If the market and raw material supply justifies expansion, it is easy enough to buy additional presses. The simplicity of the equipment, its operation and maintenance, are particularly important. It requires little training to learn to operate the system correctly, and unskilled labor can quickly master the operation of the machine. The general lack of repair services away from the major market towns along the road and rail lines argues in favor of the simplest process possible, mechanically speaking.

If a simplified spindle press system can be shown to work well and offer a good extraction rate, then it will offer most of the advantages discussed above for the ram press.

The project should focus on individual entrepreneurs in the early stages for several reasons. Individuals are more likely to utilize the equipment fully, solve practical problems associated with their operation, and demonstrate the profit potential of this business idea. This has been the case in Tanzania (see Hyman, referenced in the bibliography). Successful small enterprises based upon the equipment will be the best possible publicity for the project. Also, entrepreneurial individuals are more likely to qualify for commercial loans to go into business, and may already have other activities which provide a basis for launching a new small business activity. Some business experience, spreading the overhead of operations over several activities, availability of equity capital, and a more businesslike attitude to the whole affair are all advantages which are easier to find among individual entrepreneurs in rural areas. Some rural women may qualify under these criteria in some parts of the country, and they can be actively sought out to promote greater gender-neutrality in the distribution of project benefits.

As the enterprise idea proves itself, as the technical and managerial "bugs" are worked out, the project can explore promotional activities focussing on other forms of ownership which are likely to be more problematical and therefore promise a higher failure rate, such as informal groups, women's groups, and disadvantaged entrepreneurs.

5. Source of Capital and Financing

Since the investment requirement is under K200,000 (current prices at the end of 1991), these technologies are accessible to many rural entrepreneurs and groups. ZCF Financial Services considers this (i.e., under K200,000) an appropriate level of investment for rural entrepreneurs, one which fits with their criteria for loan selection in this category. Other lenders also consider loans of this size appropriate for rural investors.

All new businesses are subject to risk and uncertainty, and are likely to go through some difficult periods in their early years. In our analyses we have assumed that it takes a few years for the business to really "get up to speed" and operate at full capacity. Consequently, it is preferable to minimize debt capital in a new business, keep repayment obligations to a minimum, and allow the owner some margin for error and misfortune. Nonetheless, from a project point of view, wider and more rapid dissemination of a good small business idea

will certainly be facilitated by availability of credit. This will make the investment accessible to a larger pool of potential investors.

Practically speaking, a constraint to debt financing is the availability of seed for processing. This determines the level of production, and therefore the amount of cash throw-off available to service debt. This is typically a constraint in the first year or two of operations, when the debt service burden is heaviest. In our cashflow analyses we have assumed in all cases that the first couple of years of operations show gradually increasing levels of production. As farmers grow more seed, as working capital accumulates, and as the press owner(s) learn to better manage their business, the level of operations will grow. An illustration of the possibility of debt financing will be found in Table 1, parts B and C. Similar results could be obtained for the other models of small manual press operations. In fact, given the degree of uncertainty (both technical and economic) in many of the parameters of these models, it would be easy to present a defensible analysis showing that all these business ideas are highly profitable. We prefer to interpret this to mean that the potential for profitable businesses of this type exists, but hesitate to claim that any particular case will actually succeed. Such a claim could only be based on a complete feasibility study.

It is preferable that debt financing come from local financial institutions rather than from a project entity for several reasons. Management of a loan portfolio is costly and time consuming, and will divert project resources from promotional activities. There is a temptation to believe in one's own projects, and a need to show quantifiable "results", which tends to result in a higher percentage of bad loans when the credit program is managed by the project. Almost all lending institutions have difficulty identifying good projects, so if the small enterprise idea promoted by the project is really a good one, it shouldn't be too difficult to find a lender who is interested in supporting it. It is healthy to have an independent institution involved in the appraisal of each enterprise, its credit worthiness, the quality of its owner(s) as entrepreneurs, etc.

6. Constraints and Potential Problems

The first problem any investors in rural oilseed processing are going to encounter is availability of appropriate equipment for their processing activities. This must be a primary focus of the project in support of this enterprise idea.

Access to credit will also be an issue from the very beginning, and needs to be addressed through local institutions. Investment capital is probably less difficult to find than working capital. Working capital requirements are generally equal to or significantly higher than the cost of equipment in these business models. The number to look at on the spreadsheet is the negative number in the 10th year of the cashflow adjustments line "less Working Capital", which shows the recovery of all working capital funds invested in the enterprise over the years, i.e., the total working capital requirement of the business.

Availability of good quality seed to process will also be a problem. Low oil content seed means low profits for processors. All users of village scale equipment learn very quickly the importance of oil content of seed, since the throughput is low, and the difference in the amount of oil produced in one day is very noticeable. Availability of high quality planting

seed is the major constraint to production of higher oil content oilseeds in rural areas. The project must find ways to address this problem, also, as discussed elsewhere in this report (see Annex 2).

Maintenance and repair of the presses will be difficult because of the lack of qualified small workshops in rural areas. The ram press is a simple machine, but is subject to a lot of wear in operation, and requires regular maintenance and occasional repair. The project can help address this issue by offering training and access to materials and spare parts to rural workshops. Spindle presses would appear to offer the advantage of simplicity and robustness, with hardly any parts which wear. However, they may require additional processing equipment, such as dehullers, in order to attain an acceptable extraction rate, and these items could require repair and maintenance.

7. Cashflow Analysis and Discussion of Hypotheses

Ram Press (see Tables 1 and 2, found in Annex 4)

An investment of approximately K114,000 is needed for equipment purchase (ram press, installation, filtration, storage). As well, it is assumed that two operators are needed and one supervisor (who may or may not be the owner); this is a manageable workforce even for a new entrepreneur.

It is logical to assume that utilization of the press will increase over time as the owner becomes more knowledgeable about the business and can reinvest profits to increase the working capital needed to purchase seed. In Year 1 it is assumed 100 bags (100 days) of seed is processed; this is increased to 200 bags by Year 4.

In this scenario, it is assumed that no service pressing is done but instead the press owner buys seed from his neighbors to process. Initial working capital of K58,846 is needed in Year 1 to purchase sunflower seed (100 bags at K550) and pay operating expenses for the first month; this could be somewhat less if the owner is growing some of the sunflower.

Therefore, an initial minimum investment of K172,846 is needed to begin operations. Although there are some entrepreneurs who will have this amount of cash available, for the majority of individuals credit facilities will be needed. It is also possible for several individuals to join together in a partnership (share the investment cost) and still have a workable enterprise without all of the problems associated with group ownership.

This scenario uses the assumption that 50 kgs of sunflower will result in 8 liters of saleable oil. This presupposes that good sunflowerseed is not available; this extraction rate has been found in the field with the TDAU ram presses.

Even with only 100 bags of sunflower processed in Year 1, there is a positive net income of K15,550 (assuming oil sells for K150/litre and seedcake K5/kg). This increases to K62,300 annually by Year 4 when 200 bags of sunflower are processed. This scenario has an economic rate of return of 22%.

The major constraints the entrepreneur will face under this scenario are related to working capital and storage. Under present conditions it is necessary for the press owner to purchase the entire stock of sunflower early after harvest, otherwise it will be sold to other buyers. Farmers want cash immediately; if the ram press owner agreed to buy a farmer's sunflower for a higher price than another buyer, but at some future date, the farmer would still have an incentive (immediate cash) to part with his crop for the lower price. He would also be wise, considering inflation, to sell his crop immediately.

Storage space and security will also be a problem, even for relatively small amounts of seed - i.e., 100 to 200 bags. The seed will need to be kept dry and away from rodents for at least 4 months.

If the sunflower is sold to a cooperative it may be possible for the press owner to purchase it at a later date from the cooperative. But extra costs will be incurred--the cooperative will have added a mark-up and there will be transportation costs the press owner will incur.

Spindle Press (see Tables 3 and 4, Annex 4)

The market potential for the spindle press is assumed the same as for the ram press.

The scenario for the spindle press differs depending on what, if any, preprocessing of seed is done--i.e., decortication, heating, adding moisture, etc. With no preconditioning of sunflower seed the characteristics of the spindle press will not allow it to obtain the same pressure and breaking of the seed as the ram press, and therefore extraction efficiency will be much less.

Therefore in this scenario it is assumed that the minimum pretreatment of seed consists of decortication prior to pressing. The assumption is that 50 kgs of seed will yield 7 liters of oil. This is 12.5% less than the ram press. Tests done on the KIT process using Lutanda equipment resulted in 45% less extraction efficiency when pretreatment of seed was not done.

Costs for seed and labor and the selling price of oil and cake remain the same as for all the scenarios. It is also assumed that there will be a supervisor/owner and three laborers--for decorticating and operating the spindle press. The purchase price for a small spindle press is assumed to be K30,000 and K30,000 for an inexpensive decorticator. The expected throughput is 50 kgs a day. The press utilization is also assumed the same as the ram press -- 100 days (100 bags) in Year 1 to 200 days (200 bags) by Year 4.

In this scenario, Year 1 net income is K20,500; it increases to K50,000 annually by Year 4. The economic rate of return is 19%. This compares to K15,550, K62,300, and 22% for the ram press.

Comparison of Ram Press and Spindle Press Analyses

TOTAL REVENUE: Total revenue is higher in all years for the ram press than the spindle press when processing sunflower because the ram press produces more oil. This oil has a

greater value than the extra seedcake produced by the spindle press. The amount of oil extracted from a given amount of seed is the most important determinant of income because the value of the oil is so high compared to the by-product, seedcake. The spindle press analysis based on groundnut processing is not based on reliable technical data, and is included here only for illustrative purposes.

OPERATING EXPENSES: Operating expenses are higher for the ram press than the spindle press because of higher equipment costs resulting in higher maintenance costs and higher depreciation (10% assumed on each). As well, marketing costs are assumed at 10% of revenue, so the ram press has higher marketing costs.

NET INCOME: Only in Yr 1 does the spindle press result in higher net income than the ram press (K20,500 compared to K15,550). This is because of the low utilization rate assumed. By Year 2, when 140 bags of seed are processed (compared to 100) the extra revenue obtained by the ram press as compared to the spindle press results in greater net income.

NET CASHFLOW: Over a 10 year span, the cumulative net cashflow for the ram press is K451,650 as compared to K310,400 for the spindle press.

Other scenarios for the spindle press: If a modified, less expensive KIT process were developed for the spindle press with all pre-conditioning of seed carried out, then the extraction efficiency of the spindle press, and therefore revenue, is assumed to increase. The costs of the extra equipment involved is not known. But on average, the extraction efficiency of the KIT/UNATA process and the ram press are the same.

Service Pressing (see Table 2, Annex 4)

Pressing one's own seed is more profitable than service pressing. However, when a press owner has excess capacity, some income can be earned by service pressing as compared to no income when the press is not being utilized. As well, working capital is going to be a major constraint for oil pressing enterprises. Working capital for seed purchase is the #1 expense; this can be reduced to some extent by service pressing.

Assuming that in Yr 1 a ram press owner will do service pressing 50% of the time and thereafter 33% (as capital and experience is gained), a ram press owner pressing 50 bags of his/her own seed in Yr 1 and pressing 50 bags as a service (keeping 33% of the oil and cake as a fee), will end up with a net income of K1798 in Yr 1. If a farmer can sell one bag of sunflower seed for K550, in financial terms he would be better off having the seed locally processed and leaving 33% of oil and cake as payment. The processed value of one bag of sunflower seed is K1375 (K1200 for the oil and K175 for the seedcake). If the farmer remains with 67% of this the value is K921 for the farmer (which can be sold for cash or consumed at home) as compared to K550.

By Yr 2, (46 bags service pressed; 94 bags purchased) this increases to K21,416 and to K43,966 by Yr 4. This compares to K62,300 in Yr 4 with no service pressing as in the first scenario.

Small throughput spindle presses should be able to accommodate service pressing in the same manner as the ram press. Since the results for the KIT System financial analysis (Table 5, Annex 4) are the least favorable among all the alternatives, we have chosen not to discuss this case in detail.

C. Rural Market Town Small Scale Motorized Expellers

1. Crop Choice

Sunflower is a suitable crop for small scale motorized expellers because of its relatively low cost and high oil content. When dehulled before expelling, wear on the machine is reduced, oil yield per hour of milling increases, and the value of the cake as livestock feed is increased. In some countries, dehulled sunflower seed cake is ground and sifted, and the fine flour is sold for human consumption, while the coarse material is sold as livestock feed. Dehulled sunflower meal has a higher feed value than cottonseed meal, and under ideal conditions of processing, approaches the protein value of the soybean meal currently available in Zambia.

Groundnut is also suitable for small scale oil expellers. The crop is easily dehulled and pressed, since the hulls separate readily from the seed, which is quite soft by comparison with other oilseeds. Cold pressed peanut oil is a high quality oil with good flavor and keeping qualities. The cake, while suitable for human nutrition, presents a relatively high risk of aflatoxin, significantly higher than for other oilseeds. This is a significant risk factor for the livestock feed market as well, and small millers would have to be very careful and conscientious about controlling the quality of the seed they process. The main problem with this feedstock for small mills is its high value on the open market. In most Eastern and Southern African countries, peanuts have too high a value as a confectionery crop on the open market to make processing for cooking oil economic. This may not pose a problem for promotion of groundnut processing for village industry, since many small farmers do not have access to a market for their groundnut, and the crop therefore has a relatively low value to them. But for the small industrial miller operating in a market town along a hard road or rail line, competition for groundnuts from confectionery buyers may be fierce.

Soybean might be utilized by small scale industrial millers, but it presents several drawbacks. The ideal method for soybean extraction on a "small" scale is to run the beans through an extruder, which cooks the meal thus destroying the trypsin inhibitor factor, before introducing the extruded soy meal into the expeller for oil extraction. Investment for equipment of this type is three to five times higher than for sunflower or groundnut processing equipment (probably on the order of $60,000 to $100,000, versus only $20,000 to $35,000). If the extruder is not used, the oil extraction rate will be very low and the meal will not be suitable for stockfeed. Soybean only contains 18% to 19% oil, so the stockfeed market is crucial to profitability of the enterprise.

Sesame is not available in sufficient quantities at this time to justify adapting an expeller to process it.

Castor bean is not suitable for edible oil, and the meal is toxic, so use of castor beans in an edible oil mill would present health risks, and probably should not be recommended to a small miller. An expeller dedicated to processing castor bean, and never used for edible oilseed processing, might be a profitable operation if sufficient seed were available for processing and market conditions were favorable. The team did not have time to evaluate the feasibility of this type of operation, but further remarks on the subject will be found in section II.5.a.

2. Geographic Area

Sunflower production is concentrated in Southern, Central, and Eastern Provinces. The crop has potential for rapid increases in production in almost all parts of the country if small farmers have access to a market for it. It is primarily a cash crop, since home processing of sunflower is laborious and unrewarding. The small miller would have to compete with large scale millers for feedstock in Southern and Central Provinces, since these provinces have the most highly developed commercial agriculture and road and rail network. As the cooking oil and stockfeed industries restructure, this could pose a problem unless small millers are able to make preferential arrangements with local growers. It is not clear whether the greater economies of scale at the large mills will compensate for their higher transportation costs for feedstock sufficiently to allow them to offer a competitive price for the crop. Currently, the large mills are parastatal, and therefore unable to take advantage of economies of scale.

Groundnut production is highest in Eastern, Northern, Southern, and Luapula Provinces. Even in the more remote provinces (Eastern, Northern and Luapula Provinces), the marketed portion of the crop brings a relatively high price for confectionery purposes. If seed supply can be improved, the export market for confectionery nuts may also render the crop too expensive for the small miller. There will always be a large portion of the crop reserved for home use and local sale for relish and confectionery purposes. It is generally more difficult to introduce groundnut cultivation to new areas because of the high labor requirement of the crop.

The potential for increasing sesame production is unknown at this time.

Castor Bean production offers great potential in most of the major agricultural areas of the country, but is currently known only as a weed except to a very few progressive farmers in the Kabwe area. Given the great demand for both cooking oil and stockfeed in the rural agricultural areas of Zambia, it makes more sense at this time for small millers to focus on edible oil production. The market for castor oil is under study by Deloitte on contract to the African Development Foundation, but the results of this study will not be available before next year.

3. Technology Choice

There are a variety of different types of small scale motorized oil expellers available on the world market, and one company in Zambia, Pannico (now owned by MOPARCO), has also produced an expeller press locally. The small scale machines available in Europe tend to

be very well made and produce good results technically, but they are very expensive. We do not have current pro-formas for the Simon-Rosedowns Mini-40 or the Komet Press from Germany, but these machines, together with a power source (diesel engine or electric motor), cost between $5,000 and $10,000, and have a very low capacity (40 kg/hr for the Mini-40, and only 25 kg/hr for the largest Komet). The Komet press is best suited to testing seed for oil content, but not for production purposes, and is accordingly often found in the laboratory of large scale commercial mills. The european manufacturers do not supply supplementary equipment scaled to their small machines, because these machines are not really considered suitable for production.

Even a small scale oil expeller operation should have the following equipment in order to operate efficiently, minimize wear and tear on the expeller, and produce good quality products:

- Seed Cleaning Equipment
  - Vibrating Screens
  - Blowers
- Dehuller (necessary for both sunflower and groundnut)
- Separator Screens (for sunflower, to save fines before winnowing)
- Winnower
- Pre-heating system (optional: increases oil extraction rate, but reduces oil quality --> need for refining)
- Expeller
- Settling Tanks or Filter Pump System
- Waterbath refining system (if pre-heating is used, to deodorize the oil)
- Cake Handling System
  - Hammermill (for both sunflower and groundnut cake if destined for human consumption)
  - Screens (for sunflower cake only if it is destined for human nutrition)
  - Bagging
- Packaging System for Oil (whether in bulk or bottles)

Several companies which sell small scale oil mills complete with most of this equipment, one in Japan (CECOCO) and at least two in India. There are two Indian Tiny Oil Mills in Lusaka at this time, one at VIS and another at SARO Agricultural Equipment. The team was unable to find any CECOCO equipment operating in the country at this time, but it has given good results in Rwanda. The Tiny Oil Mill system has a landed cost of only about $10,000 CIF Lusaka, and is rated at 80 kg/hr. CECOCO makes a series of expellers, from 30 kg/hr up to 600 kg/hr, as well as dehullers, winnowers, pre-heating pans and filter presses. The CECOCO equipment is probably more than double the cost of Tiny Tech equipment, and utilizes a more sophisticated metallurgy and design of the expeller, making it more difficult to maintain and to manufacture wear parts for locally.

Since SARO Agricultural Equipment is already seriously testing the Tiny Oil Mill equipment, and considering offering it as a new line alongside their hammermills and other agricultural processing equipment, this would appear to be the most promising system for the Zambia in the short run. The simplicity of the worm and cage design, which should be

relatively easy to reproduce locally, is a strong positive factor for this equipment. However, it appears from informal sources that the Tiny Oil Mill is designed to process groundnuts, which are a very expensive feedstock for small millers. The system sold by Tiny Tech (similar name, but different company) might be more suitable, and should also be introduced on an experimental basis. A Mr. Joshi in Dar Es Salaam, who has several food processing businesses, has had good experience with the Tiny Tech mill for processing sunflower, and will welcome visitors.

4. Ownership and Management

Motorized Mills will require a significant capital investment, and will have an even more significant working capital requirement, and therefore are most likely to be owned by the larger cooperative societies (like SPCMU or ECU) and individual entrepreneurs. As discussed below, availability of credit is a major constraint for the development of small scale motorized milling, and will certainly be a limiting factor for access to this technology.

As indicated by the outline of the basic complement of factory equipment above, management of an operation of this type will require a certain level of education and business experience. The system is technically complex by rural standards. The factory will have a professional staff and laborers, so personnel management skills will be necessary. Financial management is demanding also, because of the requirement for credit and working capital management. Marketing must be adequate to move a fairly significant amount of product. One of the principal advantages to larger scale is the ability to afford competent management. Mills of this type will have a tendency to grow as rapidly as possible within the limits of their input and output markets, or fail due to competition or errors of judgement.

The tendency for motorized mills to expand as rapidly as possible to a larger scale of operations is driven by many factors :

- Permits higher overhead for management and marketing;
- Mechanized seed processing reduces waste and shrinkage losses;
- Allows establishment of own workshop for maintenance and repair of wear parts and machinery;
- Allows overhead of parts inventory;
- Reduces proportional cost of downtime because of higher throughput when operating;
- Reduces cost of wear parts and maintenance because cost is less relative to capacity;

5. Source of Capital and Financing

At this time credit availability for this type of small industry is extremely limited. It is not obvious that an entrepreneur or cooperative union would be well advised to take a long term (three to five year) loan for investment in this type of operation at an interest rate of 47%. What if inflation falls to 15% in 18 months? The operation would be saddled with a real rate of interest of 32%, an intolerable burden for any enterprise except organized

crime. We guesstimate initial investment excluding working capital at about $15,000 minimum for processing equipment and physical plant, excluding construction costs. Since working capital will be at a premium, and even more difficult to acquire than investment capital, most entrepreneurs and private institutions will find it necessary to seek a bank loan in order to get started. It is wiser to let the bank share the risk in any case, particularly with a new enterprise. But with the credit situation the way it is at this time, most banks are reluctant to lend to new borrowers. This will further limit the potential investors in this type of business to those who are already active in other areas.

The requirement for working capital is one of the biggest problems of the small scale miller. With only one harvest per year, and no reliable institutions operating to act as a buffer and ease the shock of buying at harvest time, the miller is obliged to construct storage facilities and buy at harvest time to meet his input requirement for the entire year. Even the medium scale millers in Lusaka (SAOM) identified this as their number one operating problem. A miller with a plant costing $15,000, with a capacity of 2 tons per day (24-hour operations basis), will need about 400 tons to operate for a year at a reasonable capacity utilization rate. At Kw 550 per bag (factory gate price), sunflower will cost the miller Kw 11,000 per ton and 400 tons will cost Kw 4,400,000, or $55,000 at today's rate of exchange (December 1991). It is difficult, or maybe even impossible, to reduce this working capital requirement under current conditions in Zambia.

Working capital availability is further constrained by the traditional emphasis placed by rural credit institutions on production credit for agriculture. Lima Bank, for example, makes almost all its loans to small farmers for agricultural production. This means that at harvest time, when the miller needs working capital, the bank is at its lowest cash position of the year.

The most likely sources for investment and working capital financing at this time are Lima Bank, CUSA, and ZCF Finance. However, in all cases, the very high cost of money and shortages of funds will present severe problems for financing new small oil mills. Lima Bank, for example, is only able to respond to about 20% of the requests it receives for production credit. The team did not have time to discuss the issue with commercial banks, and felt that the many factors mitigating against this type of investment at present made such an investigation fruitless for the purpose of this report.

6. Potential Constraints and Problems

The small scale industrial miller faces a host of problems at present on the input and operations side of the business. These difficulties render this type of investment highly risky despite very favorable market conditions for cooking oil and stockfeed. Only under rather special conditions will a small miller be able to operate profitably at a small scale and remain small. For example, if their equipment is purchased cheaply, second-hand, and installed in an existing structure which is underutilized, and processes surplus local oilseed production, much of it on a contract milling basis.

The difficulties facing the small scale miller trying to operate a motorized expeller press and run a small industrial plant in a rural area have been discussed in detail above, in the review of the Current Situation of Small Scale Processing. To summarize :

- On the input side, the single biggest constraint to production of high oil content oilseed is unavailability of high quality seed to the farmer. The oil content of the seed is the single biggest factor in profitability of sunflower milling for cooking oil.

- The distribution system for seed and other inputs other than maize is very poorly developed at this time, and suffers from the general weakness of the cooperative unions.

- The oilseed processing industry has only recently begun paying a premium for higher oil content seed, but at present, seed supply to the small farmer remains a serious constraint to development of the industry.

- Production credit for small farmers is almost exclusively for maize at this time. Both CUSA and Lima Bank indicate that they are unable to meet the demand for production credit for maize, so availability of credit for oilseed production is a problem.

- The agricultural marketing system is barely able to keep up with the demands placed upon it by the maize harvest. Clearly, collection, handling, transportation and storage of oilseeds be a problem.

- Payment to farmers for their crops is often delayed as long as a year by existing marketing institutions, such as the cooperative unions.

- Can the local miller be expected to take charge of all these agricultural marketing problems : input supply, production credit, and crop marketing (prompt payment to farmers, handling, transportation and storage of the crop)?

- Those persons contacted in the course of this study who were either already engaged in small scale motorized oil milling or were thinking seriously of investing all complained of lack of technical information and support.

- Availability of parts or the local manufacture of wear parts have been an ongoing problem for small expeller users.

- Small scale millers will not be able to produce an oil of the same appearance and quality as large scale millers, who refine their products.

- The quality of seed cake produced by small mills is lower than that of the large solvent extraction plants because of its higher oil content.

7. Cashflow Analysis

Table 6, Annex 4, presents an analysis of the profitability of a small motorized oil expeller operation. It is based upon discussions with individuals with some experience, and on the authors' own experiences with this type of equipment, but the reader is warned that there are many variables in this model which could change significantly on further study.

It is interesting to note, nonetheless, that this is the most favorable result obtained, quantitatively speaking, among all the cases investigated. And in this model, we have assumed a higher price for seed, and a lower selling price for oil than in the other cases. The problems faced by this type of enterprise are discussed in detail above. While it would appear that the small motorized mill offers great potential for small enterprise development in Zambia, the many practical constraints identified during the course of this study have persuaded the team that this is an idea whose time has not yet arrived.

IV. GENERAL CONSIDERATIONS

A. Linkages and Social and Economic Benefits

Decentralized, rural oil processing offers a number of benefits and opportunities that are not available when processing is done by a few large companies operating in urban areas. Cooking oil is available in rural areas, transportation costs for oil and seedcake are reduced, value is added at the rural area where the oilseeds originate and accrues to the local communities, a local market is an encouragement to increased oilseed production, jobs are created in the processing industry as well as through backward and forward linkages, and a supporting infrastructure can be created at the rural and market town level.

Currently, the shipment of oil seeds from rural to urban areas also means shipping the seedcake back to the rural farming areas. Oilseeds and cake are bulky and therefore relatively expensive items to ship considering their value. Even with increased production of oilseeds which results in excess oil production at the local level, it would be more economic to ship the higher value unrefined oil to urban areas for further processing or packaging than to ship the whole oilseed.

Decentralized production of cooking oil also creates opportunities for a support infrastructure - i.e., manufacturing and repair services. Availability of cooking oil in rural areas can create opportunities for snack food enterprises - i.e., fried sweet breads, chapatas, etc.

B. Support Infrastructure for Manufacturing and Repair

The copper mining industry in the Copperbelt Province of Zambia has provided steady work for numerous machine shops and manufacturing firms for years, dedicated to producing machinery, drilling bits, replacement parts, etc. for the mines. This industry is in decline due to the slow and steady depletion of copper reserves. Copper output will fall very significantly over the next ten years, and these firms are looking for new areas in which to apply their expertise in order to profit from the very substantial investments they have made in plant and equipment in Zambia.

The new government's emphasis on the development of agriculture as the basis for the restructuring of the Zambian economy has not gone unnoticed by these firms, nor has the great potential been recognized for growth in this sector, which has been neglected for so many years. The more aggressive firms are already diversifying into agricultural machinery production, for example BOART Engineering of Ndola recently bought a small machine shop in Mazabuka, in Southern Province, Kaleya Engineering, specifically for this purpose. They have also hired a consulting engineer, Dr. A.R.T. de Silva, to help develop new products for manufacture for agricultural production, food processing, etc.

There are also a variety of smaller industrial producers of agricultural machinery and food processing equipment (mainly maize mills), such as SARO Agricultural Equipment of Lusaka, who are actively searching for new products with good market potential. They, too, are trying hard to take advantage of the rapid changes they foresee in the agricultural sector

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in the country in the next few years. Some established job shops which have been serving the mining industry are also diversifying into production for other markets, like Jung of Kitwe for example, who manufactures lawn mowers and maize dehullers.

While the basic industrial capability exists to produce the type of equipment needed for village and small scale oilseed processing, some lead time will be required for the mining engineering firms to move into this area, develop products, and commercialize them. Problems of scale in production of certain types of parts may slow the process. Uncertainty regarding potential markets, how many units might be sold and how quickly the market may develop, will restrain these larger firms from moving quickly into unknown new areas.

From discussions with Dr. de Silva of BOART in Ndola, it would appear that the basic industrial capacity in machining, hardening, and finishing of parts is generally adequate to produce wear parts for small motorized expellers. How quickly these shops might be able to develop a really economical process for production of wear parts for expellers will depend on both technical factors (sophistication of design of the parts in question, availability of suitable steel) and market factors. The market for these parts is insufficient at this time to attract the serious interest of a company like BOART. He indicated that a market of K15,000,000 to K20,000,000 per year might be adequate to justify serious study of development of a new product of this type. For expeller worms, this would represent 300 to 500 units per year, for example, all of which would have to be of the same design. One small expeller working 24 hours per day might consume 4 new wormshafts per year if it were operating at 60% or more of capacity. It would appear, therefore, that it will be a few years before the market for this type of part in Zambia is adequate to attract the serious interest of the major engineering firms of the copperbelt.

Small scale village oilseed processing technology, on the other hand, such as ram and spindle presses, dehullers, small roller mills, winnowers, etc., are much easier to manufacture, require no casting, have only a limited requirement for harder raw materials than mild steel, and require only a few, small component parts which will have to be imported. Many public domain designs are already available for this type of equipment, which should further shorten the lead time to production if the shops have access to this information. Given the relatively low cost and ease of entry to this market, it is reasonable to expect a fair amount of competition and a fairly rapid response among potential producers of village scale oilseed processing equipment, once these people are persuaded that a saleable product exists, and that there is a market for it.

The level of interest is high among all businesses involved in supplying (either through importation or manufacture) equipment to agricultural and food processing industry. If we assume that 20% of the population of Zambia lives in sufficiently remote rural areas to make local production of cooking oil attractive, this represents a market of about 10,000 tons of cooking oil per year. A village industry oilseed processor with one machine (ram press or spindle press) might process 20 tons of oilseed per year, producing little more than 4000 kg of oil. This represents a potential market of 2,500 units for small scale oilseed processing, with a potential value of K125,000,000 for presses alone.

In short, the near term outlook for manufacture of wear parts for small motorized expellers in Zambia is not good, although interest and capability exist. However, small scale village oilseed processing equipment should present no problem of local production, once a workable technology is identified, design and production problems resolved, and the market developed.

A more serious difficulty for the village processor is the availability of local repair services for equipment. Oilseed processing results in rapid wear of some designs (as Africare has experienced with the ram press), and requires high pressures and therefore applies high stresses to equipment such as spindle presses. Winnowers and dehullers have moving parts which wear, especially when operating in an environment of abrasive dust such as that produced from sunflower hulls. And anything which can break, will, as Murphy pointed out.

Mr. Moyo, the man in charge of the appropriate technology workshop at Kasisi Mission, commented that he felt that the KIT system was inappropriate for rural areas, because it requires regular repair and maintenance due to the complexity and number of machines employed in the process. He felt that the Ram Press would be a much better alternative for rural areas, because of its simplicity. However, users of the equipment supplied by Africare have experienced severe problems of wear of their machines and have not really been able to deal with the repair and maintenance needs of their equipment without the assistance of Africare.

Training for owners in the maintenance and repair of oilseed processing equipment, at least sufficient to enable them to identify problems, and disassemble the machine in order to transport only those parts requiring repair to a shop, then correctly reassemble the machine, would be useful.

Whether it is realistic to support vocational schools or local training workshops, such as those run by VIS, SIDO, and perhaps others, in order to improve quality and availability of repair services in rural areas is a question which will require further study. In the short run, simplicity of design based on operating principles which minimize wear and breakage are the most direct approach to minimizing this problem faced by rural operators.

C. GRZ Policy Regarding Small Enterprise Development

The new government has made it clear that a radical re-orientation of the Zambian economy away from a social welfare state dominated by parastatal enterprise toward a free market system is its highest priority. It is too early to say how this philosophical stance will be translated into policy measures which will have a real impact on opportunity for small business.

There are many well-developed institutions operating in Zambia which have the promotion of small enterprise in one way or another for their primary objective. For example, SIDO, VIS, SSEP, and ZCF Financial Services, are all actively involved in the effort to promote small enterprise. Many project activities and NGOs focus directly or indirectly on small enterprise promotion also, for example the ZAMS Project itself, Africare, IFAD, UNIDO,

FAO and others have project activities in promotion of maize milling, small dairy, small scale food processing, etc.

Financial institutions in Zambia, such as Lima Bank and CUSA, also look favorably upon small enterprise as an avenue for growth in the future, although currently the financial system is operating under very difficult conditions because of the high rate of inflation and consequent negative real interest rates.

In summary, while the current economic situation is causing difficulties for the business community in general, the policy environment is improving greatly. Many institutions are already in place and have some experience which should enable them to capitalize rapidly on improving economic conditions to realize their objective of supporting small enterprise development.

D. Administrative Procedures and Bureaucratic Constraints

This is a complex area which the team did not have time to investigate fully, however much useful information will be found in the recently prepared GEMINI study on the potential for micro-enterprise promotion in Zambia. The new government intends to streamline procedures for business licenses, access to foreign exchange, etc., and some progress has already been made in these areas.

For village industry, in order to keep costs down and overhead to a minimum, operating informally is the only practical solution since their level of operations does not permit them to bear the heavy cost of lost time, fees, and other "payments" required to meet the formal administrative obligations of a small business.

E. Taxation

As for the problems of administrative procedures and approvals in general, discussed above, village enterprise will in most cases remain informal and thereby avoid the difficulties associated with taxation.

For small scale agribusiness in rural market towns, the new Investment Act of 1991 offers many advantages, provided administration of the act is such as to permit small operators access to its provisions in practice. Small scale oilseed processing will certainly qualify under the act since it meets three of the five criteria :

"b. produces products for use locally in agriculture" (in this case, feed supplements);
"d. is an import-substitution industry with a significant proportion of local raw material usage which results in net foreign exchange savings"
"e. is located in a rural area." (article 31)

Since these small rural industries will qualify under the Investment Act of 1991, in principle they will enjoy a variety of exemptions which should help them attain profitability soon after start up. These exemptions cover :

- "customs duties and sales tax on all machinery, equipment and parts required for the establishment . . . or expansion of an enterprise . . ."
- "exemption from tax on dividends for . . . seven years"
- "exemption from the payment of tax on income for companies for a period of three years . . . and thereafter exemption from such tax for the following two years at the rate of seventy-five percent"
- "exemption from the payment of selective employment tax for a period of seven years" (article 32)

The Act also facilitates access to land, power, water, transportation and communication services for qualifying enterprises. Several provisions deal with retention of foreign exchange earnings and access to foreign exchange as well.

Even smaller scale investments benefit under the Act, if they are registered under the Small Industries Development Act of 1981. Such small and village industries can benefit from the following advantages :

- exemptions from payment of tax on income for three years for enterprises operating in an urban area and five years for those operating in a rural area;
- exemptions on customs duties and sales tax on imported equipment;
- operation of a manufacturing enterprise without a certificate for the first five years;
- operation of an enterprise with an investment in plant and equipment under K500,000 without having to pay licensing fees for five years;
- exemption from payment of rates on factory premises for five years.

Mature enterprises are required to pay a flat income tax of 45%.

F. Credit Availability and Terms

Commercial lending rates are fixed by the central bank (Bank of Zambia) and are slightly lower for agricultural loans than others. The real interest rate in both cases is negative, meaning that inflation is higher than the (nominal) rate of interest declared by the bank. When credit is tight as it currently is in Zambia, there is an incentive for commercial banks to favor large, established borrowers over smaller, less established enterprises.

There is a general lack of agricultural credit available in the country other than for maize. Even for maize, the situation is not without problems. Lima Bank is the largest agricultural lender serving the small-scale farmer. They currently lend to approximately 30,000 small-scale farmers; there are over 580,000 small-scale (less than 5 hectares) in the country. Out of overall loan applications totalling K3 billion Lima Bank was able to service loans totalling K600 million this year. The vast majority of this credit was for maize seed and fertilizer.

There are several organizations in the country with mandates to provide credit to village-scale industries and small firms including SIDO, VIS, and SEP. Their potential for providing credit for oil processing activities (production and/or processing) appear limited at present. SIDO has limited funds, almost no access to forex, and although receiving

numerous requests for assistance in oil processing activities, has not been able to service them due partly to their involvement with the GOZ hammermill program. VIS, working with village level industries, has also been swamped by its credit scheme for hammermills. SEP is undergoing management reorganization and its activities are limited at present; it does not have field offices. In 1991 they have had 360 applications for assistance, but have only been able to service 30 loans under an ILO program.

CUSA is also another organization with credit facilities; it has over 270 active societies within the country. It makes predominately agricultural production loans (in-kind) although a loan program for micro-enterprises was started in 1991. CUSA assists their members in obtaining inputs and marketing agricultural produce as well.

Zambia Cooperative Federation-Finance Services Ltd. (ZCFFS) is run as a private finance company and currently manages funds from several donors, including USAID. The largest is a World Bank/IFAD smallholder project with a $7.5 million credit fund. Of this, $3.0 million is for medium-term credit for agricultural processing activities.

Their initial experience with oil processing has been with three multi-purpose plants set-up to provide a variety of services (oil press, hammermill, rice thresher, water pump, etc.). These plants have not been a success--there have been problems with the technologies, underutilization of equipment, and management problems. They are now interested in finding smaller technologies that are financially viable and are interested in ram presses, spindle presses, and small expellers.

ZCFFS is one of the few organizations that has excess funds to lend for agroprocessing purposes. They provide procurement services (importing steel and equipment duty free) which reduces the final cost of the equipment by at least 50%. In November they have a technician starting who will be providing--for a fee--repair services and procurement of spares for agroprocessing (hammermill) activities in their project area in Eastern province.

In general, the team is of the opinion that a project should work through existing financial institutions to secure loan financing for oilseed processing equipment. It is healthy to have such funds controlled and disbursed by an independent institution, which will provide an objective assessment of the credit worthiness of the business ideas and the individual borrowers identified for financing by the project.

G. Availability of Foreign Exchange

Foreign exchange is in very short supply at the moment, and applications for import licenses are often delayed in consequence. In principle, the process should only take a few weeks, but one never knows in practice when the forex will actually become available.

A number of institutions offer forex facilities for certain categories of enterprises. ZCF Finance has funds available for importation of agricultural processing machinery, and has already imported about 40 small oil mills for various cooperatives around the country. The ZAMS Project, of course, can facilitate importation of certain types of processing

equipment, and has in fact already done so for a medium scale oil miller, Southern African Oil Mills.

For village industry promotion, the foreign exchange problem will arise primarily at the level of local manufacturers of oilseed processing equipment, since they will need imported steel, and possibly some imported component parts (dehuller gearboxes, bearings and springs). A project can facilitate importation of these items, thereby reducing the unit cost of equipment to village processors. The high cost and relative unavailability of steel, for example, acts to drive prices up in the marketplace as buyers compete for a scarce, essential resource.

ANNEXES

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Pros, Cons, and Unknowns of Technologies and Oilseed Crop Choices

SPINDLE PRESS (KIT/UNATA SYSTEM)

PROS:

--processing system has proven to work in Zambia and other countries
--machinery is robust
--bulk of machinery can be manufactured and repaired in Zambia
--extraction efficiency is fairly good even for poor quality seed
--since seed is dehulled, cake is of higher value and can even be used for human consumption
--oil quality is acceptable in rural areas
--spindle press requires little maintenance or repair
--good throughput for manual technology
--can be used to process oil palm, groundnut, and other oilseeds

CONS:

--even though technology has been proven to work in Zambia and other countries, the system has not gained widespread usage in any country the consultants are aware of
--requires relatively high investment (estimated at over $5000)
--complex to manage and coordinate operations
--many machines require maintenance and repair
--requires preconditioning and fuel
--high labour requirement (six or more persons) makes management difficult
--seed roasting is difficult to control and can result in lower quality oil
--human effort required to operate entire system is high
--requires imported parts (dehuller gearbox, springs, bearings)
--requires training and experience for operating crew
--very difficult to provide service pressing (requires continuous throughput)
--requires relatively large quantities of seed for profit potential resulting in higher working capital costs, transport, storage

UNKNOWNS:

--possibly usable to press fruits for juice, cheese, etc. as with any spindle press.

MODIFIED SPINDLE PRESS PROCESS

PROS:

--no consumption of fuelwood for preconditioning if used for cold pressing
--may require fewer machines than KIT system

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--requires lower investment, maintenance, and repair costs than KIT system and may be less costly than the ram press (estimate for spindle press is from $350 onwards depending on size; other pre-processing equipment extra)
--may be used with a variety of oilseeds or fruits
--machines can be manufactured and repaired in Zambia
--service processing may be possible with smaller throughput than KIT machines

CONS:

--Lutanda tests (on the KIT process) indicate much lower oil extraction without preheating of seed (45% lower)
--requires high human effort to achieve oil extraction without preconditioning of seed
--places greater stress on machine and thereby machine has to be made stronger to reduce breakage (higher cost of machinery)
--results in higher residual oil in cake which has a lower value for livestock

UNKNOWNS:

--optimal size of press and throughput may vary for different oilseeds or other products to be pressed
--risk of aflatoxin in groundnut cake may be unacceptable
--preheating system will probably be devised by rural users, will be less fuel efficient than if designed and supplied as part of system
--extraction efficiency is unknown if only one machine is used and there is no pre-conditioning of seed
--may require fewer workers than the KIT process
--may be economical at lower levels of inputs than KIT process (less seed, less storage, less working capital needed)
--will increase women's workload if pre-conditioning of seed formerly done by machines (KIT process) is done manually by women
--fuel may be required for boiling crude oil or a filtration system may be needed

RAM PRESS

PROS:

--has gained wider acceptance in Zambia and other countries relative to other village technologies
--only one machine is required for oil extraction
--extraction rate is good for a manual technology
--relatively low investment for rural entrepreneurs ($400-$1200 depending on design and country)
--simple to manage
--requires few workers and little training
--economical at low level of input (less seed, less storage, less working capital needed)
--easy to do service pressing even for small quantities of seed
--can be used with oilseeds other than sunflower (simsim, copra, castor)

--machine can be manufactured and repaired in Zambia
--machine requires no imported parts
--provides good quality oil

CONS:

--locally produced machine has not performed well
--rate of wear is relatively high because whole sunflower seed is processed
--sunflower seedcake has a lower value than if it were decorticated
--requires high level of human effort to operate
--settling of crude oil is time consuming; to hasten process fuel is required for boiling or filtration system is needed
--quality of sunflower seed currently available in Zambia results in lower throughput, lower oil production, more physical effort
--quality of seed is vitally important, both with respect to oil content, and also the softness of the shell

UNKNOWNS:

--whether off-the-shelf designs (CAPU, Hugh Allen/CARE) will work better than TDAU's version on locally available seed
--whether hardened steel components will improve durability of press on hard-hulled seed

MOTORIZED EXPELLERS

PROS:

--high throughput relative to manual machines
--higher extraction efficiencies compared to manual machines
--achieves economies of scale
--can serve larger areas than manual operations (i.e., market towns)
--with decortication, a high quality cake produced (higher quality compared to manual because of less oil content)
--large enough to diversity into feed business

CONS:

--high initial investment; large amounts of credit needed
--high management skills required
--working capital requirement high because of large throughput
--need technically skilled labour (which is in short supply) for operations and maintenance
--replacement of parts difficult and expensive to obtain
--imported parts are required
--are currently not manufactured in country

SUNFLOWER

PROS:

--does not compete with staple crops (maize, groundnut)
--does well in farmers' fields in normal rotation
--suitable feedstock ingredient for all types of oil extraction equipment
--already well known to small farmers (essentially a small farmer crop)
--good low input crop
--oilseed meal has good value for livestock feed (only soymeal is better)
--widely adapted to growing conditions in Zambia
--drought tolerant
--oil is of good quality even when unrefined
--relatively easy to process with village technology
--requires little seed (high multiplication co-efficient)
--is a high priority crop within Zambian oilseed research sector

CONS:

--oil content declines substantially with late planting (which is the common practice among small farmers); it is a secondary crop
--under current small farmer production systems yields are low and so is oil content
--commercial farmers don't like to grow because of low price and difficulty harvesting
--quality seed supply is currently a problem

GROUNDNUTS

PROS:

--high oil content
--good oil quality
--relatively easy to process for oil extraction
--low input crop (leguminous)
--well known to small farmers
--very good in crop rotation (leguminous)
--primary crop because of its role in food security at the household level

CONS:

--requires a lot of seed (low multiplication coefficient)
--seed supply is currently a problem
--very high value for confectionery market discourages processing for oil
--aflatoxin risk may be unacceptably high especially for human consumption
--labour demanding
--encouraging marketing/oil processing may increase food security risk for poorer families and malnutrition in children
--processing reduces storage life (seedcake)

--expensive seedcake is not a viable input for livestock feed
--value of defatted groundnut meal for food (i.e., consumer acceptability) is unknown
--introduction of processing may have negative impact on women' income as men appropriate the technology and cash
--farmers currently retain most groundnuts for food security, replanting seed, and for labour payment

SESAME

PROS:

--potential oilcrop especially in drier areas (Region 1) where sunflower and groundnuts do not grow well
--high oil content
--easy to process with village technology
--is a very palatable oil

CONS:

--not known to majority of small farmers or extension service
--has high confectionery value
--no seed improvement research in Zambia has been done
--extremely limited seed availability
--no research in-country has been carried out
--low yields

CASTOR

PROS:

--high value industrial oil on the international market
--highly adapted to Zambia; grows wild and is found in drier regions of the country
--easy to process crude oil
--seedcake can be used as fertilizer and reduces pests in the soil
--low input crop

CONS:

--seed improvement research is just beginning in Zambia
--local market has not yet been identified or developed
--seedcake is toxic to humans and animals

OIL PALM

PROS:

--easy to process oil at village level and is currently being done

--low input crop
--local (Luapula and Northern Province) market exists for oil as well as in Zaire
--good source of Vitamin A

CONS:

--no improved varieties available
--production is limited to small areas in the country

AGRONOMIC RECOMMENDATIONS

Small-scale farmers in the sunflower and groundnut belts have been poorly served by the seed production industry, and deserve more attention.

1. Ways of reducing the high cost and improving the availability of quality planting seed through the promotion of local seed production projects should be investigated. Such projects could be initiated by interested NGOs, with the technical support of the Department of Agriculture and SCCI. IFAD working through the Zambia Cooperative Federation (ZCF), has a project on groundnut seed production with small holders in Luapula Province. They should be approached to see if they can take up sunflower seed production as well.

2. Availability of improved sunflower and groundnuts varieties should be improved by looking for additional sales outlets among local traders (as ZAMSEED is in fact doing in its current search for a network of seed stockists).

3. Efforts to improve the production and availability of commercial seed other than maize should be a stepping stone to setting up additional seed companies for cash crops. Greater liberalization of seed production may ease some of the availability problems by encouraging a more forceful marketing strategy by seed companies.

4. Plant breeding should go hand in hand with local seed production projects, perhaps involving non-governmental organizations and area development projects.

5. Problems in seed production for sunflower hybrids need to be addressed. The development and introduction of a soft-hulled high oil content sunflower would greatly stimulate small scale oil processing and should therefore be given attention.

6. Small-scale oilseed presses for particular crops should be encouraged in areas with comparative advantage for that particular crop.

ANNEX 3

LIST OF PERSONS CONTACTED

The Honorable Dr. Guy Scott, Minister of Agriculture, MAFF

The Honorable Dr. Chuulu Kalima, Junior Minister for Agricultural Production, MAFF

The Honorable Dr. Nkausu, Junior Minister for Food and Nutrition, MAFF

Mr. L. Banda, Assistant Director for Industry, MCI

Mr. Keith Wallace, VITA Technical Advisor, VIS

Dr. F. N. Phiri, Mechanical Engineer, VIS

Dr. Carolyn McCommon, VITA Technical Advisor, VIS

Mr. McDonald Homer, Resident Representative, Africare

Mr. Muleya, Entrepreneur, Cooking Oil Manufacture, Lusaka

Dr. Florence Chenowith, ZATPID

Mr. David Wallace, Agricultural Manager, and Mr. Makamo, Premium Oils, Ltd., Lusaka

Mr. Alex Lemmens, Manager, TDAU, University of Zambia

Dr. F. Javaheri, Soybean Co-ordinator, Mt. Makulu

Mr. A. Muyovwe, M.P., Managing Director/Mechanical Engineer, Agricultural Machinery Manufacturer, GAMECO, Lusaka

Mr. M. V. Amin, General Manager, SARO Agri Equipment Ltd., Lusaka

Mr. John Hudson, Executive Director, Commercial Farmers Bureau, Lusaka

Dr. M. C. Musambachima, Director, Institute for Human Relations, UNZA

Dr. Milimo, Rural Sociologist, UNZA, Lusaka.

Mr. Cummings, Deloitte-Touche, Lusaka

Mr. Sabin Kauti, Tax Advisor, Deloitte-Touche, Lusaka

Mrs. Eva Richards and Mr. Ricardo Lupenga, UNICEF

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Mr. Thompson, Programme Officer, FAO, Lusaka.

Mr. Taylor and Mr. Jorgenson, UNIDO

Mrs. A.B. Mwaka, DAO, Mazabuka

Mr. Bhagoos, Trader, Mazabuka

Mr. Julius Munengo, Field Officer, Africare, Monze

Mr. Maambo, DAO, Monze

Mr. _____, Branch Manager, LIMA Bank, Monze

Mr. P.S. Nkhata, Cooking Oil Trader, Monze

Mr. Mulongo, entrepreneur, clothing manufacture, Pemba

Mr. F. Bredt, Gossner Mission, Sinazeze

Mr. Hakayobe, PAO, Choma

Mr. Moses Kasaro, Factory Manager, ZATCO, Choma

Mr. C. Sakajila, Regional Manager, SIDO, Choma

Mr. Armin, Cooking Oil Producer, Pemba

Mr. T. Muzyamba, Field Officer, SDDP, Choma

Mr. P. Beckett, rancher/dairyman, Momba Farm, Choma

Mr. Bhattacharya, Financial Controller, and Prof. Rajeswaran, R&D Manager, SPCMU, Choma

Mr. F. Chama, Works Engineer, Kaleya Engineering, Mazabuka

Mr. Mutwale, Operations Manager, LIMA Bank, Lusaka

Mr. Mulala and Mr. Mbaluku, Operations Managers, LINTCO

Mr. Kokhwe, Co-ordinator, German Volunteer Service, Lusaka

Mr. Michael Mbulo, Project Officer, SSEP, Lusaka

Mr. Handili, Business Development Manager, CUSA, Lusaka

Mrs. P. N. Thole, Production Manager, ZAMSEED

Mr. Amon Sibande, entrepreneur, Reunited Engineering Ltd., Lusaka

Mr. W. K. Kawana, Chairman, Price & Incomes Commission, Lusaka

Mr. Joseph Varughese, Consultant Multipurpose Plants, IFAD Smallholder Services Rehabilitation Project

Dr. A.R.T. de Silva, Consultant Manufacturing Technology, BOART Zambia, Ndola

Mr. Bachoo Parbhoo, Castor Farmer, Kabwe

Mr. C.C. Kasongo, Principal, Kabwe Trades Training Institute, Kabwe

Mr. M. Jung, Entrepreneur, Jung Engineering Company, Kitwe

Mr. Charles Chabala, ZCF Development Services Manager, Lusaka

Dr. Kilpadi, UNDP/FAO Small Industry Development Expert, Kabwe

Mr. _____, LUTANDA, Kitwe

Mr. Mwamba, Director, National Council for Scientific Research, Kitwe.

Mr. R.H. Thanawalla, General Manager, ROP, Ndola

Mr. Mr. S. Soundara Rajan, General Manager, Supa Oil Zambia Ltd., Kabwe

Mr. Pat Doyle, Rancher, Kabwe

Mr. Hans Drechsel, Project Coordinator, Animal Power Technology Project, GTZ

J.D. Nyirenda, Stocks Clerk. Ketete Eastern Province Co-operative Union Oil Mill

G. Mitti, Officer-in-Charge for Msekera Regional Research Station and ARPT Agronomist, Eastern Province.

Mr. Chisanga, Development Manager, ZCF-Finince Services, Lusaka

Mr. Charles Chileya, Monitoring and Evaluation Officer, IFAD Smallholder Services Rehabilitation Project, Lusaka.

Mr. J. Constantino, General Manager, Southern African Oil Mills, Lusaka.

Nanchengwa Women's Club, Cooking Oil Producers, Rampress, Mazabuka District.

Choobe Women's Club, Cooking Oil Producers, Rampress, Sikalinda Village, Monze.

Tusole Women's Club, Cooking Oil Producers, Rampress, Monze.

Pemba Women's Club, Cooking Oil Producers, Rampress, Pemba.

Demu Club, 13 Villages, potential Cooking Oil Producers, Spindle Press, Pemba.

Dr. A.J. Sutherland, Sociologist-ARPT, Mt. Makulu Central Res. Station, MAFF, Lusaka.

Mr. J. Waterworth, LIRDP, Agronomist, Luangwa Valley.

Mr. Mangisi, Assistant Provincial Agricultural Officer, Chipata.

Mr. M. M. Milupi, CUSA, Chipata.

Mr. J.B. Chelwa, Branch Manager, Lima Bank Limited, Chipata.

Mr. R.M.Phiri, Head of Business Potential, Eastern Province Cooperative Union, Chipata.

Mrs. Kolala, Co-ordinator of women activities, LIRDP, Chipata.

Ms Christine Takatshi of Institute for International Cooperation, Vienna, Austria, Supervisor, Msekhocika Ox-driven Oil Expellor Project, Chipata Diocese.

Mr. J. Mshanga, Regional Manager, SIDO, Chipata.

Mr. J. Sichone, Acting Provincial Manager, ZCF Finance Services Ltd., Chipata.

Mr. B.Yousuf, Trader, Shifa Trading Centre, Chipata.

Mr. Mainza, Katete Oil Mill Branch Manager, Katete.

Mrs Grace Chibwa, Regional Manager, SIDO, Kabwe.

Mr. Chilembwe, Primary Multipurpose Society Manager, Kalola Primary Society, Kabwe District.

ANNEX 4

FINANCIAL ANALYSIS TABLES

TABLE 1A

RAM PRESS FINANCIAL ANALYSIS

ECONOMIC ASSUMPTIONS	(Kwacha)
PURCHASE PRICE OF SEED	550 PER BAG
DAILY WAGE SUPERVISOR	100
DAILY WAGE LABORERS	60
SALE PRICE OF OIL	150 PER LITER
SALE PRICE OF SEED CAKE	5 PER KILOGRAM

TECHNICAL ASSUMPTIONS	
THROUGHPUT (BAGS/DAY)	1
EXTRACTION RATE (LITERS/BAG)	8
SALEABLE CAKE YIELD (KG/BAG)	35
LABOR REQUIREMENT (WORKERS/DAY)	2

INVESTMENT	(Kwacha)
RAM PRESS	104000
INSTALLATION	1500
BAGS	1000
FILTRATION & OTHER MINOR EQPT	5000
OIL STORAGE	2500
TOTAL INVESTMENT COST	114000

Equipment replacement is assumed after four years of service, although with softshelled seed in Tanzania some presses last five years or more.

PHYSICAL FLOWS YEAR	1	2	3	4	5	6	7	8	9	10
DAYS WORKED	100	140	180	200	200	200	200	200	200	200
SEED PROCESSED (BAGS)	100	140	180	200	200	200	200	200	200	200
OIL PRODUCED (LITERS)	800	1120	1440	1600	1600	1600	1600	1600	1600	1600
CAKE PRODUCED (KG)	3500	4900	6300	7000	7000	7000	7000	7000	7000	7000

TABLE 1B

PROFORMA INCOME STATEMENT YEAR		1	2	3	4	5	6	7	8	9	10
REVENUE											
OIL SALES		120,000	168,000	216,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000
CAKE SALES		17,500	24,500	31,500	35,000	35,000	35,000	35,000	35,000	35,000	35,000
TOTAL REVENUE		137,500	192,500	247,500	275,000	275,000	275,000	275,000	275,000	275,000	275,000
OPERATING EXPENSES											
SEED PURCHASE		55,000	77,000	99,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
SUPERVISOR		10,000	14,000	18,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
LABOR		12,000	16,800	21,600	24,000	24,000	24,000	24,000	24,000	24,000	24,000
EQUIPMENT MAINT. & REPAIR		10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400
MARKETING		13,750	19,250	24,750	27,500	27,500	27,500	27,500	27,500	27,500	27,500
DEPRECIATION		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
TOTAL OPERATING EXPENSES		121,950	158,250	194,550	212,700	212,700	212,700	212,700	212,700	212,700	212,700
NET INCOME		15,550	34,250	52,950	62,300	62,300	62,300	62,300	62,300	62,300	62,300
INCOME TO CASHFLOW											
plus DEPRECIATION		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
less INVESTMENT	114,000										
less WORKING CAPITAL	58,846	23,192	23,192	11,596	0	0	0	0	0	0	(116,825)
less REPLACEMENT					114,000				114,000		
plus SALVAGE VALUE					10,400				10,400		26,000
NET CASHFLOW	(172,846)	13,158	31,858	62,154	(20,500)	83,100	83,100	83,100	(20,500)	83,100	225,925
CUMULATIVE CASHFLOW	(172,846)	(159,688)	(127,829)	(65,675)	(86,175)	(3,075)	80,025	163,125	142,625	225,725	451,650

ECONOMIC RATE OF RETURN	22%
NPV @ 5%	257,121

TABLE 1C

FINANCIAL ASSUMPTIONS

Investment

Real Interest Rate	10%
Grace Period	6 months
Repayment Period	2 years
Payment and Compounding Frequency	4 times a year (quarterly)

Period	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Principle at BOP	52,000	53,300	54,633	47,803	40,974	34,145	27,316	20,487	13,658	6,829
Interest Accumulated	1,300	1,333	1,366	1,195	1,024	854	683	512	341	171
Principle Payment	0	0	6,829	6,829	6,829	6,829	6,829	6,829	6,829	6,829
Interest Payment	0	0	1,366	1,195	1,024	854	683	512	341	171
Principle at EOP	53,300	54,633	47,803	40,974	34,145	27,316	20,487	13,658	6,829	0

PAYMENTS ANNUALIZED

Year	1	2	3
Principal	0	27,316	27,316
Interest	0	4,439	1,707
	0	31,755	29,024

Working Capital year	1	2	3	4	5	6	7	8	9	10
Assuming 50% of W. C. from Equity										
Real Interest Rate	12%									
Loan Life (% of a year)	40%	53%	66%	72%	72%	72%	72%	72%	72%	72%
Working Capital Loan Req.	29,423	41,019	52,615	58,413	58,413	58,413	58,413	58,413	58,413	58,413

TABLE 1D

PROFORMA INCOME STATEMENT YEAR		1	2	3	4	5	6	7	8	9	10
REVENUE											
OIL SALES		120,000	168,000	216,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000
CAKE SALES		17,500	24,500	31,500	35,000	35,000	35,000	35,000	35,000	35,000	35,000
TOTAL REVENUE		137,500	192,500	247,500	275,000	275,000	275,000	275,000	275,000	275,000	275,000
OPERATING EXPENSES											
SEED PURCHASE		55,000	77,000	99,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
SUPERVISOR		10,000	14,000	18,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
LABOR		12,000	16,800	21,600	24,000	24,000	24,000	24,000	24,000	24,000	24,000
EQUIPMENT MAINT. & REPAIR		10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400
MARKETING		13,750	19,250	24,750	27,500	27,500	27,500	27,500	27,500	27,500	27,500
INTEREST ON WORKING CAPITAL		1,419	2,607	4,152	5,057	5,057	5,057	5,057	5,057	5,057	5,057
INTEREST ON INVESTMENT LOAN		0	4,439	1,707	0	0	0	0	0	0	0
DEPRECIATION		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
TOTAL OPERATING EXPENSES		123,369	165,296	200,409	217,757	217,757	217,757	217,757	217,757	217,757	217,757
NET INCOME		14,131	27,204	47,091	57,243	57,243	57,243	57,243	57,243	57,243	57,243
INCOME TO CASHFLOW											
plus DEPRECIATION		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
less INVESTMENT	114,000										
plus LOAN FUNDS	52,000										
less LOAN REPAYMENT		0	27,316	27,316							
less EQUITY W. C.	29,423	11,596	11,596	5,798	0	0	0	0	0	0	(58,413)
less REPLACEMENT					114,000				114,000		
plus SALVAGE VALUE					10,400				10,400		26,000
NET CASHFLOW	(91,423)	23,335	9,092	34,777	(25,557)	78,043	78,043	78,043	(25,557)	78,043	162,455
CUMULATIVE CASHFLOW	(91,423)	(68,087)	(58,996)	(24,219)	(49,776)	28,267	106,310	184,353	158,796	236,839	399,294
INTERNAL RATE OF RETURN	31%										
NPV @ 5%	243,481										

TABLE 2A

RAM PRESS FINANCIAL ANALYSIS WITH SERVICE PRESSING

ECONOMIC ASSUMPTIONS	(Kwacha)
PURCHASE PRICE OF SEED	550 PER BAG
DAILY WAGE SUPERVISOR	100
DAILY WAGE LABORERS	60
SALE PRICE OF OIL	150 PER LITER
SALE PRICE OF SEED CAKE	5 PER KILOGRAM

TECHNICAL ASSUMPTIONS	
THROUGHPUT (BAGS/DAY)	1
EXTRACTION RATE (LITERS/BAG)	8
SALEABLE CAKE YIELD (KG/BAG)	35
LABOR REQUIREMENT (WORKERS/DAY)	2
SERVICE PRESSING CHARGE	33% OF PRODUCT

INVESTMENT	(Kwacha)
RAMPRESS	104000
INSTALLATION	1500
BAGS	1000
FILTRATION & OTHER MINOR EQPT	5000
OIL STORAGE	2500
TOTAL INVESTMENT COST	114000

Equipment replacement is assumed after four years of service, although with softshelled seed in Tanzania some presses last five years or more.

PHYSICAL ASSUMPTIONS YEAR	1	2	3	4	5	6	7	8	9	10
DAYS WORKED	100	140	180	200	200	200	200	200	200	200
SEED PROCESSED (BAGS)	100	140	180	200	200	200	200	200	200	200
OIL PRODUCED (LITERS)	800	1120	1440	1600	1600	1600	1600	1600	1600	1600
CAKE PRODUCED (KG)	3500	4900	6300	7000	7000	7000	7000	7000	7000	7000
FRACTION SERVICE PRESSED	50%	33%	33%	33%	33%	33%	33%	33%	33%	33%
SALEABLE OIL	533	871	1120	1244	1244	1244	1244	1244	1244	1244
SALEABLE CAKE	2333	3811	4900	5445	5445	5445	5445	5445	5445	5445

TABLE 2B

PROFORMA INCOME STATEMENT YEAR		1	2	3	4	5	6	7	8	9	10
REVENUE											
OIL SALES		79,998	130,669	168,002	186,669	186,669	186,669	186,669	186,669	186,669	186,669
CAKE SALES		11,666	19,056	24,500	27,223	27,223	27,223	27,223	27,223	27,223	27,223
TOTAL REVENUE		91,664	149,724	192,503	213,892	213,892	213,892	213,892	213,892	213,892	213,892
OPERATING EXPENSES											
SEED PURCHASE		27,509	51,336	66,003	73,337	73,337	73,337	73,337	73,337	73,337	73,337
SUPERVISOR		10,000	14,000	18,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
LABOR		12,000	16,800	21,600	24,000	24,000	24,000	24,000	24,000	24,000	24,000
EQUIPMENT MAINT. & REPAIR		10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400
MARKETING		9,166	14,972	19,250	21,389	21,389	21,389	21,389	21,389	21,389	21,389
DEPRECIATION		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
TOTAL OPERATING EXPENSES		89,866	128,308	156,054	169,926	169,926	169,926	169,926	169,926	169,926	169,926
NET INCOME		1,798	21,416	36,449	43,966	43,966	43,966	43,966	43,966	43,966	43,966
INCOME TO CASHFLOW											
plus DEPRECIATION		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
less INVESTMENT	114,000										
less WORKING CAPITAL	30,964	25,053	15,757	7,879	0	0	0	0	0	0	(79,653)
less REPLACEMENT					114,000				114,000		
plus SALVAGE VALUE					10,400				10,400		26,000
NET CASHFLOW	(144,964)	(2,455)	26,459	49,371	(38,834)	64,766	64,766	64,766	(38,834)	64,766	170,419
CUMULATIVE CASHFLOW	(144,964)	(147,419)	(120,960)	(71,590)	(110,424)	(45,658)	19,108	83,873	45,039	109,805	280,223
NPV @ 5%	145,319										
ECONOMIC RATE OF RETURN	17%										

TABLE 3A

SIMPLIFIED SPINDLE PRESS FINANCIAL ANALYSIS

ECONOMIC ASSUMPTIONS	(Kwacha)
PURCHASE PRICE OF SEED	450 PER BAG
DAILY WAGE SUPERVISOR	100
DAILY WAGE LABORERS	60
USEFUL HOURS OF WORK/DAY	6
SALE PRICE OF OIL	150 PER LITER
SALE PRICE OF SEED CAKE	5 PER KILOGRAM

TECHNICAL ASSUMPTIONS (these assumptions are speculative, and need verification)

UNSHELLED GROUNDNUT PER BAG	30 KG
SEED LOSS (TRASH, SHRINKAGE, ETC.)	10%
NET UNSHELLED GROUNDNUT PER BAG	27
SHELLED YIELD	67%
OIL YIELD FROM SHELLED NUTS	30%
THRUPUT SHELLED NUTS/HR	9 KG
THROUGHPUT (HRS/BAG)	2.00
THROUGHPUT (BAGS/DAY)	3.00
EXTRACTION RATE (LITERS/BAG)	5.4
SALEABLE CAKE YIELD (KG/BAG)	12.0
LABOR REQUIREMENT (WORKERS/DAY)	4

INVESTMENT	(Kwacha)	
SPINDLEPRESS	80,000	(Assuming a press as large and sturdy
DEHULLER	32,400	as the KIT press, to permit this level of through put)
INSTALLATION	1,500	
BAGS	1,000	
FILTRATION & OTHER MINOR EQPT	5,000	
OIL STORAGE	2,500	

TOTAL INVESTMENT COST	122,400	

PHYSICAL ASSUMPTIONS YEAR	1	2	3	4	5	6	7	8	9	10
DAYS WORKED	100	140	180	200	200	200	200	200	200	200
SEED PROCESSED (BAGS)	300	420	540	600	600	600	600	600	600	600
OIL PRODUCED (LITERS)	1620	2268	2916	3240	3240	3240	3240	3240	3240	3240
CAKE PRODUCED (KG)	3591	5027	6464	7182	7182	7182	7182	7182	7182	7182

TABLE 3B

PROFORMA INCOME STATEMENT	YEAR	1	2	3	4	5	6	7	8	9	
REVENUE											
OIL SALES		243,000	340,200	437,400	486,000	486,000	486,000	486,000	486,000	486,000	486,0
CAKE SALES		17,955	25,137	32,319	35,910	35,910	35,910	35,910	35,910	35,910	35,9
TOTAL REVENUE		260,955	365,337	469,719	521,910	521,910	521,910	521,910	521,910	521,910	521,9
OPERATING EXPENSES											
SEED PURCHASE		135,000	189,000	243,000	270,000	270,000	270,000	270,000	270,000	270,000	270,0
SUPERVISOR		10,000	14,000	18,000	20,000	20,000	20,000	20,000	20,000	20,000	20,0
LABOR		24,000	33,600	43,200	48,000	48,000	48,000	48,000	48,000	48,000	48,0
EQUIPMENT MAINT. & REPAIR		8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,0
MARKETING		26,096	36,534	46,972	52,191	52,191	52,191	52,191	52,191	52,191	52,1
DEPRECIATION		16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,0
TOTAL OPERATING EXPENSES		219,096	297,134	375,172	414,191	414,191	414,191	414,191	414,191	414,191	414,1
NET INCOME		41,859	68,203	94,547	107,719	107,719	107,719	107,719	107,719	107,719	107,7
INCOME TO CASHFLOW											
plus DEPRECIATION		16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,0
less INVESTMENT	122,400										
less WORKING CAPITAL	101,548	39,019	39,019	19,510	0	0	0	0	0	0	(199,0
less REPLACEMENT						122,400					
plus SALVAGE VALUE						8,000					8,0
NET CASHFLOW	(223,948)	18,840	45,184	91,037	123,719	9,319	123,719	123,719	123,719	123,719	330,8
CUMULATIVE CASHFLOW	(223,948)	(205,108)	(159,924)	(68,886)	54,832	64,151	187,870	311,589	435,307	559,026	889,8
NPV @ 5%	542,409										
ECONOMIC RATE OF RETURN	30%										

SIMPLIFIED SPINDLE PRESS FOR SUNFLOWER

ECONOMIC ASSUMPTIONS	(Kwacha)	
PURCHASE PRICE OF SEED	[illegible]	PER BAG
DAILY WAGE SUPERVISOR	[illegible]	
DAILY WAGE LABORERS	[illegible]	
SALE PRICE OF OIL	150	PER LITER
SALE PRICE OF SEED CAKE	5	PER [illegible] GRAM

TECHNICAL ASSUMPTIONS	
THROUGHPUT (BAGS/DAY)	1
EXTRACTION RATE (LITERS/BAG)	7
SALEABLE CAKE YIELD (KG/BAG)	40
LABOR REQUIREMENT (WORKERS/DAY)	3

INVESTMENT	(Kwacha)
SPINDLE PRESS W/3 KG CAPACITY	[illegible]
DEHULLER	[illegible]
INSTALLATION	[illegible]
BAGS	[illegible]
FILTRATION & OTHER MINOR EQPT	[illegible]
OIL STORAGE	[illegible]
TOTAL FIXED/INVEST COST	[illegible]

PHYSICAL FLOWS YEAR	1	2	3	4	5	6	7	8	9	10
DAYS WORKED	100	140	100	200	200	200	200	200	200	200
SEED PROCESSED (BAGS)	100	140	100	200	200	200	200	200	200	200
OIL PRODUCED (LITERS)	700	980	1200	1400	1400	1400	1400	1400	1400	1400
CAKE PRODUCED (KG)	4000	5600	7200	8000	8000	8000	8000	8000	8000	8000

PROFORMA INCOME STATEME YEAR	1	2	3	4	5	6	7	8	9	10
REVENUE										
OIL SALES	105,000	147,000	180,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000
CAKE SALES	20,000	28,000	36,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
TOTAL REVENUE	125,000	175,000	225,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
OPERATING EXPENSES										
SEED PURCHASE	55,000	77,000	88,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
SUPERVISOR	10,000	14,000	16,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
LABOR	16,000	22,400	32,400	30,000	30,000	30,000	30,000	30,000	30,000	30,000
EQUIPMENT MAINT. & REPAIR	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
MARKETING	12,500	17,500	22,500	25,000	25,000	25,000	25,000	25,000	25,000	25,000
DEPRECIATION	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
TOTAL OPERATING EXPENSES	104,500	142,700	180,800	200,000	200,000	200,000	200,000	200,000	200,000	200,000
NET INCOME	20,500	32,300	44,160	50,000	50,000	50,000	50,000	50,000	50,000	50,000
INCOME TO CASHFLOW										
plus DEPRECIATION	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
less INVESTMENT 70,000										
less WORKING CAPITAL 50,000	20,500	23,300	11,075	0	0	0	0	0	0	(117,000)
less REPLACEMENT				70,000				70,000		
plus SALVAGE VALUE				3,000				3,000		7,000
NET CASHFLOW (120,000)	3,100	14,000	38,485	(11,000)	56,000	56,000	56,000	(11,000)	56,000	193,000
CUMULATIVE CASHFLOW (120,000)	(116,470)	(102,000)	(72,100)	(83,100)	(27,100)	28,000	84,000	73,000	129,000	319,000

NPV @ 8%	169,677
ECONOMIC RATE OF RETURN	19%

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[illegible] FINANCIAL ANALYSIS

[illegible]	$ US	Remarks
Complete KOMBA system CIF Lusaka	7,000	[illegible]
Installation		[illegible]
Scales		[illegible]
Factory Tools & Other Equipment		[illegible]
Office Equipment		[illegible]
Contingency @ 5%		[illegible]
TOTAL INVESTMENT		[illegible]

ECONOMIC ASSUMPTIONS

SEED PURCHASE PRICE	[illegible]	per 50-kg bag
Supervisor's salary	[illegible]	Kwacha per month
Wage Labor	[illegible]	Kwacha per man-day
Number of workers	0	
Fuel wood cost	???????????	

SALE PRICES OF PRODUCTS

Oil	[illegible]	Kwacha/liter
Cake	[illegible]	Kwacha/kg

TECHNICAL ASSUMPTIONS

Losses due to [illegible]	[illegible]
NS whole seed equivalent/pressing	[illegible]
Oil extraction Kernels whole seed	[illegible]
Oil yield per pressing (liter)	[illegible]
Seed cake yield/pressing (kg)	[illegible]
Pressings per day	[illegible]
NS whole seed pressed per day	[illegible]
Crude oil production per day	[illegible]
Oil cake production per day	[illegible]
Oil loss in handling/filtration	[illegible]
Net oil production	[illegible]

FINANCIAL FLOWS	YEAR	1	2	3	4	5	6	7	8	9	10
WHOLE SEED PURCHASED (MT)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Clean Seed Processed		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Oil Production		4,485	6,392	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178
Cake Production (KEB)		[illegible]	11,700	15,200	16,000	16,000	16,000	16,000	16,000	16,000	16,000
Days Worked		90	110	100	100	100	100	100	100	100	100
Month Equivalent (20 day months)		4	5	5	5	5	5	5	5	5	5
Fuel Wood Consumption											

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TABLE 5B

Pro Forma Income Statement to Cashflow

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Oil Sales		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Good Coke Sales		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Sales		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Expenses											
Good purchase		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Supervisor's Salary		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wages		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Goods		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fuel/wood		0	0	0	0	0	0	0	[illegible]	[illegible]	[illegible]
Packaging		0	0	0	0	0	0	0	0	0	0
Office Supplies & Communication		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Rent		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maintenance & Repair of Equipment @ 10%		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Marketing Expenses @ 3% of sales		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Contingency @ 10% of Op Exp		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Provident Fund		[illegible]	[illegible]	11,300	11,300	11,300	11,300	11,300	11,300	11,300	11,300
Depreciation		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Expenses		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Income		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Income to Cashflow											
plus Depreciation		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
less Investment	[illegible]	0	0	0	0	[illegible]	0	0	0	0	0
Less Working Capital	[illegible]	[illegible]	[illegible]	(0)	0	0	0	0	0	0	(0)
plus Salvage Value						70,000					70,000
Net Cashflow	(1,[illegible])	[illegible]	197,011	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cumulative Cashflow	(1,[illegible])	(1,[illegible])	(1,[illegible])	(710,[illegible])	(514,114)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,204,117

Economic Rate of Return 16%
NPV @ 5% [illegible] Rupees

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TINY OIL MILL

INVESTMENT		KWACHA
PROCESSING EQUIPMENT (COMPLETE SET)		1,[illegible]
MINOR TOOLS, EQUIPMENT, ETC.		15,[illegible]
OIL STORAGE DRUMS @ Kw 1000/210 L		16,[illegible]
OFFICE EQUIPMENT, FURNITURE, SALES COUNTER, ETC.		50,[illegible]
HAMMERMILL (ABES EXPELLER MILL MOTOR)		[illegible]
STRUCTURES		5,[illegible]
		6,[illegible]

ECONOMIC ASSUMPTIONS	KWACHA	
PURCHASE PRICE OF SUNFLOWER SEED	16,[illegible]	PER TON
SALE PRICE OF OIL	110,[illegible]	PER TON
SALE PRICE OF CAKE	10,[illegible]	PER TON

OPERATING EXPENSE ASSUMPTIONS

RUNNING 24 HRS/DAY 6 DAYS/WEEK

STAFFING	PERSONS
OWNER IS FACTORY MGR, BOOKKEEPER, MARKETING MGR	
PRESS OPERATOR/FOREMAN	2
PRESS OPERATOR	2
LABORERS (WORK DAYSHIFT ONLY)	4
WELDER/MECHANIC (PART-TIME)	0.5
GUARDS	3

SALARIES	Kw/MONTH
OWNER WILL DRAW PROFIT FROM NET PROFITS AS SOLE PROPRIETOR	
PRESS OPERATOR/FOREMAN	[illegible]
PRESS OPERATOR	4,[illegible]
LABORERS (WORK DAYSHIFT ONLY)	3,[illegible]
WELDER/MECHANIC (PART-TIME)	[illegible]
GUARDS	1,[illegible]

INCENTIVES	
TRANSPORTATION ALLOWANCE @ Kw25/PERSON/DAY	7,475
PROVIDENT FUND PAYMENT AS PERCENTAGE OF SALARIES	10%

UTILITIES	
ELECTRICITY	1,[illegible]
WATER	[illegible]

CONSUMABLES		
OFFICE SUPPLIES		2,[illegible]
FILTER CLOTH		[illegible]
BAGS FOR SEED	25 Kg/BAG	3,[illegible]
LUBRICANTS		1,[illegible]

TECHNICAL ASSUMPTIONS	
SHRINKAGE ON SUNFLOWER SEED (TRASH, LOSSES, ETC.)	20%
DEHULLED SEED YIELD (KG DEHULLED/KG WHOLE)	60%
PRESS THROUGHPUT (KG. DEHULLED/HR)	[illegible]
DAYS WORKED PER MONTH	26
DOWNTIME HOURS (%)	20%
ASSUMING DAY CREW CAN SUPPLY SUFFICIENT DEHULLED SEED FOR EXPELLER	
OIL YIELD ON WHOLE SEED BASIS BY WEIGHT	20%
OIL YIELD VOLUME BASIS (AFTER FILTRATION LOSSES)	27%
CAKE YIELD ON WHOLE SEED BASIS BY WEIGHT	57%

WEAR PARTS REPLACEMENT CYCLES		
WORM REBUILDING	18	DAYS
WORM REBUILDING COST	5,[illegible]	
WORM, CAKE BAR AND CHOKE REPLACEMENT	52	DAYS
WORM, CAKE BAR AND CHOKE COST	[illegible]	

TABLE 6B

PHYSICAL FLOWS YEAR	1	2	3	4	5	6	7	8	9	10
WHOLE SEED PURCHASED (TONS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SEED PROCESSED (AFTER SHRINK- TONS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DEHULLED SEED PROCESSED (TONS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HOURS OF EXPELLER OPERATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TIMES WORM IS REBUILT	4	6	7	10	11	11	11	11	11	11
WORM, CAGE BARS, CHOKE REPLACEMEN	1	2	3	3	4	4	4	4	4	4
NET OIL PRODUCTION (TONS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NET CAKE PRODUCTION (TONS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MONTHS WORKED	3	5	6	8	9	9	9	9	9	9

PROFORMA INCOME TO CASHFLOW STATEMENT

REVENUE YEAR	1	2	3	4	5	6	7	8	9	10
OIL SALES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CAKE SALES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL REVENUE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OPERATING EXPENSES										
SEED PURCHASE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SALARIES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ELECTRICITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WATER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LUBRICANTS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FILTER CLOTHS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SEED BAGS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
EQPT MNT. & REPAIR @ 5%/YR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
EXPELLER REBUILDING	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WORM & CAGE REPLACEMENT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MARKETING @ 3% OF SALES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CONTINGENCY @ 10% OF OP EXP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRANSPORTATION INDEMNITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PROVIDENT FUND	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DEPRECIATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL OPERATING EXPENSES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NET INCOME BEFORE TAXES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
INCOME TAX	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AFTER TAX INCOME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AFTER TAX INCOME TO CASHFLOW										
plus DEPRECIATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
less INVESTMENT [illegible]										
less WORKING CAPITAL [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	[illegible]
less EQPT REPLACEMENT					[illegible]					
NET CASHFLOW [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CUMULATIVE CASHFLOW [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ECONOMIC RATE OF RETUR [illegible]%

NPV @ 5% [illegible]

Best [illegible]

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AFLATOXIN

The following is a brief synopsis of two reference works on oilseeds and aflatoxin. Please refer to the documents for further details:

1. MYCOTOXINS: ECONOMIC AND HEALTH RISKS. REPORT No. 116 NOV 1989. COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY, AMES, IOWA

A. Description

"Toxic fungal metabolites, known as mycotoxins, are chemically diverse and occur in a wide variety of substrates including feeds and foods. They impair human health and cause economic losses in livestock through disease and reduced efficiency of production. The fungi that produce mycotoxins can invade the food and feed supply during production, processing, transport, or storage. Several factors influence mycotoxin production by fungi, including substrate, moisture, temperature, pH, and stresses such as drought and associated growth of other fungi or microbes." (p 1)

"The aflatoxins (a type of mycotoxin caused by Aspergillus flavus and A. parasiticus) can cause liver damage or cancer, decreased milk and egg production, and immune suppression. The young of a species are most susceptible to the effects of aflatoxins, which may be expressed as gastrointestinal disturbances, anemia, jaundice and/or reduced feed consumption and efficiency. Nursing animals may be affected by exposure to aflatoxin metabolites secreted in milk." (p 1)

"Aflatoxins are potent liver toxins, and their effects in animals vary with dose, length of exposure, species, breed and diet or nutritional status. These toxins may be lethal when consumed in large doses. Sublethal doses produce a chronic toxicity, and low levels of chronic exposure can result in cancer, primarily liver cancer. Generally, young animals of any species are more susceptible to the toxic effects of the aflatoxins than are older animals." (p 12)

B. Presence

"The aflatoxins are frequently detected in a variety of feeds and foods produced in the United States (corn, peanuts, cotton and their derivatives), as well as in imported commodities and products. Contamination of milk, eggs, and meat can result from animal consumption of mycotoxin-contaminated feed." (p 2)

"Aflatoxins have been found to contaminate many crops...The commodities with a high risk of aflatoxin contamination include corn, peanuts, cottonseed, brazil nuts, pistachio nuts,and copra. Commodities with a lower risk of aflatoxin contamination include figs, almonds, pecans, walnuts, raisins, and spices. Soybeans, beans, pulses, cassava, grain sorghum, millet, wheat, oats, barley and rice are resistant or only moderately susceptible to aflatoxin

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contamination in the field. However, aflatoxins can occur when any of these commodities are stored under high moisture and temperature conditions. Insect or rodent infestations can create microclimates that facilitate mold invasion of some stored commodities." (p 39)

"The FDA has established specific guidelines on acceptable levels of aflatoxins in human food and animal feed by establishing action levels for the removal of violative lots from interstate commerce. The action levels from human food are 20 ppb total aflatoxins, with the exception of milk, that has an action level of 0.5 ppb. For feeds, the action level for aflatoxins is also 20 ppb, with the exception of a 300 ppb action level for aflatoxins in cottonseed meal used in feeds, 300 ppb action level for corn used for finishing beef cattle, 200 ppb for corn destined for finishing swine, and 100 ppb aflatoxins in feeds used for breeding cattle, breeding swine, and mature poultry." (p 53)

C. Effect on Humans

"Consumption of foods heavily contaminated with mycotoxins has resulted in acute intoxication episodes in human populations. Conditions enhancing the likelihood of such occurrences include limited kinds of food and food supplies, environmental conditions that favor fungal development in crops and commodities, and the absence of effective mycotoxin monitoring and control systems." (p 28)

"Clearly, under certain circumstances such as those likely to occur in developing countries, periodic episodes of acute mycotoxicoses can occur." (p 29-30)

"Evidence of acute aflatoxicosis in humans has been reported from Taiwan and Uganda (1977,1981)...More extensive documentation of an outbreak of putative aflatoxin poisoning was provided in 1974 from western India (corn)...An incident of acute aflatoxicosis in Kenya (1982) was also associated with the consumption of maize highly contaminated with aflatoxins. Thailand (1971, rice)." (p 30)

"Liver cell cancer is one of the leading causes of cancer mortality in Asia and Africa. Those regions with the highest LCC rate correspond to areas where the climate favors contamination of foodstuffs by aflatoxins." (p 31)

"There have been a number of epidemiological studies designed to obtain information on the relationship of current estimated dietary intake of aflatoxins to the incidence of LCC...Information is available from Uganda, the Philippines, Swaziland, Kenya, Thailand, and Mozambique. The latter country had the highest incidence of LCC in the world at the time of these studies, as well as an estimated daily per capita ingestion of aflatoxins several times greater than the next highest intake regions of Thailand and Swaziland...There was a positive association between high intakes of aflatoxins and high incidence rates of LCC...Combining aflatoxin load and alcohol intake gave a synergistic and statistically significant effect." (p 32)

D. Causes and Prevention - Production

"Crop residues often provide the primary inoculum for mycotoxigenic fungi when susceptible crops are grown. The fungi that are present in the crop residues may produce spores early in the season." Thus management of crop residues may be an important factor in lowering contamination in the field. (p 61)

"Crop rotation historically has been a useful method of diminishing the impact of plant disease on crops." (p 62)

"Preharvest mold growth and production of aflatoxins in peanuts and corn are favored by warm ambient temperatures and prolonged drought conditions...postharvest production of aflatoxins on corn and peanuts is favored by warm temperatures and high humidity." (p 6)

"In peanuts two types of preharvest aflatoxin contamination occur. One is associated with insect damage and is easy to explain; insect damage provides a portal of entry for contamination by the aflatoxin-producing fungus. In the second situation, the fungi apparently gain entrance into the peanut kernel prior to drought stress, but remain dormant or inactive as the result of resistance mechanisms (phytoalexins) of the peanut. However, during times of drought stress, there is moisture loss from the peanut plant which reduces the water activity of the peanut to the point that it no longer is capable of phytoalexin production." (p 63)

"Grain and oilseed crops that are susceptible to fungal deterioration should be harvested at their optimum maturity when the moisture content is lowest. Many corps are subject to deterioration in the field if harvest is delayed and delay may influence moisture levels that do not allow fungal growth." (p 63-64)

E. Causes and Prevention - Storage

"Avoiding mycotoxin accumulation in stored grains and oilseeds depends primarily on moisture control. If the product is too dry to allow fungal growth, and if it is kept dry, no further deterioration will occur. However, if there is insect activity, rodent activity, moisture migration, condensation or water leaks in storage, then fungal growth that could lead to mycotoxin contamination will occur. Insect control is important, because insect activity in stored products creates favorable microclimates for fungal growth. Once fungal growth starts, the water of metabolism from the fungus will provide sufficient water for further growth and mycotoxin development." (p 64)

F. Causes and Prevention - Processing

"Aflatoxins tend to be stable to moderately stable in most food processes, but are unstable in processes employing alkaline conditions or oxidizing steps." (p 41)

"Warm and humid environments raise the likelihood of fungal growth...Commodities should be checked for visible signs of damage, because damage to a nut, kernel or oilseed indicates a high probability of mold growth and possible mycotoxin contamination...Good

manufacturing practices for peanuts require the removal of damaged off color kernels and shrivelled nuts, because they are most likely to contain aflatoxins. Kernels removed during processing are frequently crushed for oil, because any aflatoxins in the oil are destroyed or removed during the refining process...Some manufacturers also remove the skins...to facilitate the detection of off color kernels...However, complete removal of all contaminated particles cannot be expected with physical methods of separation. Thus residual contamination may be present in the final product, but at very low concentrations." (p 64)

"Dry Milling of Corn: the distribution of aflatoxins was apparently low in grits and high in the germ, hull or degermer fines of dry milled corn. Wet Milling of Corn: aflatoxin occurred mainly in the steepwater and fiber of wet milled corn with smaller amounts present in the gluten and germ." (p 65)

"Aflatoxins are heat-stable, and were not totally destroyed by boiling water, autoclaving and a variety of food and feed processing procedures. Roasting resulted in a reduction in the aflatoxin content of nuts, oilseed meals and corn. The degradation of aflatoxins was a direct function of temperature, heating time and moisture content. Aflatoxin was apparently stable in raw milk and resistant to pasteurization and processing." (p 65)

"The adsorption of aflatoxins to bentonite clay, used for removing pigments from oils, as one of the factors resulting in aflatoxin removal from peanut and corn oil." (p 66)

2. <u>OILSEED CROPS, E.A. WEISS, LONGMAN GROUP LTD., LONDON, 1983</u>

"Groundnut meal is a valuable livestock food...and the cake...can be ground into flour for human consumption. Good quality groundnut meal is comparable with soybean meal in feeding value." (p 575)

"World consumption of groundnut meal has been relatively static, and usage is depressed by the presence of aflatoxins." (p 15)

"The toxin is produced by a fungus, Aspergillus falvus, of world-wide occurrence and commonly known as yellow seed rot. Normally, the mold is killed by hot, dry conditions following lifting, but periods of rain and delays in harvesting or drying the pods produce conditions suitable for its continued growth. Poor storage, allowing pods or kernels to become damp or contaminated by vermin faeces, also increase the possibility of aflatoxin formation...any crop which had a high incidence of fungal infection, especially if associated with moisture stress, is suspect. It can be partially controlled by good cultural methods, quick harvesting and drying, and good storage conditions." (p 144)

"Aflatoxins have also been isolated from other field and oilseed crops, including sunflower seed, soybeans and meal." (p 596)

"After processing, incorrect drying of cake and meal, poor storage, insect infestation and vermin can produce conditions suitable for aflatoxin production. Feeds produced from meals containing aflatoxin induce obvious and hidden effects in livestock varying from a general loss of condition to death, or long-term degeneration of internal organs from cancer.

Where there may be no direct effect from aflatoxin, susceptibility to other diseases can be increased." (p 595)

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