The potential for small-scale oilseed expelling in conjunction with poultry production in developing countries

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Small-scale oil expelling is a natural component of agricultural systems in the poorer African and Asian countries. This paper relates to the work of the Natural Resources Institute and the assistance it has given to the installation and operation of small-scale oilseed expellers in a number of countries including Zambia, Gambia and Sudan. A concept of integrated agricultural development is outlined comprising oilseed cultivation, small-scale expelling and poultry production. Consideration is given to differences in nutritive value of the oilseed meals produced, oilseed processing technology and the need for interdisciplinary research, coupled with co-ordinated strategies, in order to maximize the impact on farming communities which have desperately few resources.

Keywords: Development; diet; expellers; feed; nutrition, oilseed; poultry

Introduction

In recent years there has been a high rate of increase in poultry production in many developing countries, e.g. India where per capita annual egg consumption has increased from six in 1962 to 30 in 1991 (Panda, 1992). Although much of this increase has been due to proliferation of the more intensive production systems that use exotic high yielding varieties of domestic fowl, the traditional rural and backyard poultry sector has continued to prevail because indigenous birds require little attention and have characteristics suited to the harsh tropical environment (Vietmeyer, 1984). Thus, during the 1980s, poultry production in Africa increased by two-thirds, 80% of which was met by small-scale farmers with free range birds (Farrell, 1992). According to Spore (1991) villages produce more than 75% of the poultry meat consumed in Africa and have the economic potential to achieve more.

As might be expected, traditional poultry production systems are common in economies with large subsistence or semi-subsistence sectors. For example, the 1988 livestock census (SALC, 1988) showed Tanzania, which has one of the largest agricultural sectors in Africa (Harvey, 1985), to have 13.6 million indigenous domestic fowl fairly evenly distributed throughout the country. The 1986/87 Agricultural Sample Survey (ASSTM, 1992) estimated the national poultry population to be 16.13 million, including commercial birds, and further showed that 58% of farming households kept poultry, including 55% of households with less than 0.5 ha, while 7% of farming households kept ducks; the average flock size was 6–8 and average egg production was 55 eggs per bird per year. Similarly, in Bangladesh there are an estimated 66 million domestic fowl and 12 million ducks, seven birds for every 10 people. The birds are ubiquitously distributed at the rural household level with about 70% of landless and 85% of landed households holding some (Mustafa *et al.*, 1991). Significantly, these are the very countries where small-scale vegetable oil extraction technologies are of greatest importance in agricultural and rural development.

Despite the acknowledged importance of rural and backyard poultry in the poorer developing countries, agricultural projects designed to improve the productivity of this sector have generally failed for three main reasons. Firstly, inappropriate technology was promoted: for example, attempts have been made to secure improvements by providing supplementary feed through the use of local grains. However, cereals are valuable human food and, unless accompanied by other measures, their addition to the diet of birds is unlikely to have a significant impact on egg production. Secondly, as pointed out by Bradford (1989), development agencies have too often assumed that relatively low productivity of local animals is due to their inferior genetic potential without first evaluating local stock. Thirdly, at the conceptual stage projects did not recognize that village poultry production is a subsystem within a complex agricultural structure. In order to assist small backyard poultry producers a multidisciplinary approach is required. To be effective the application of the results of 'Farming Systems Research' or 'Integrated Research', such as the duck cum fish farming of south-east Asia, is likely to be necessary (Edwards, 1983).

Integration of oilseed cultivation, small-scale oil expelling and poultry production activities

The developing world abounds with various types of traditional and modern screw press oil expellers because rural and urban dwellers need cooking oil. The further the oil is produced from the location in which it is needed, the greater is the storage and transport cost and the likelihood of the oil deteriorating in quality in hot or humid tropical climates. The Natural Resources Institute (NRI) has therefore promoted a concept comprising the cultivation of oilseeds, small-scale oil expelling and poultry production (COSEP) under the premise that integration of local oil expelling and poultry production activities will encourage the cultivation of oilseeds as a cash crop on a sustainable basis. The concept is best illustrated by some case study notes taken from two recent NRI-assisted projects, one in the Gambia extracting groundnut and sesame seed and the other in Zimbabwe extracting sunflower seed.

Gambia

In the Gambian project, located at the Anglican Training Centre (ATC) in Farafenni, an NRI-designed prototype oilseed expeller was linked to a poultry production unit and the economics of the operation were assessed in terms of a combination of the value of the oil produced and the poultry meat and eggs sold in Farafenni town where, in 1992, there was no other local production. The project utilized substantial quantities of local oilseeds and demonstrated cost savings of 20–25% of those incurred using an equivalent feed imported from Senegal. The compositions of the oilseed meals and some of the diets that were formulated are shown in *Tables 1* and *2*.

The local demand for oil expelling facilities for pressing sesame seed and groundnuts was met in the following ways. People brought their seed to the expeller operator, paid for the processing and took the oil or seed cake; or the operator purchased the seed which he processed and then sold the oil and used or disposed of the seed cake. Normally, the cultivator took oil in exchange for seed.

The availability of these options added to the sustainability of the system and encouraged oilseed cultivation by small farmers. The profitability of the Gambian oil expelling project was dependent on the cost of seed, the charge made for oil

Table 1 Compositions of the groundnut and sesame seed cakes produced by an NRI prototype expeller in Gambia and the sunflower seed cake produced by a Tinytech expeller in Zimbabwe (g/100 g)

	Oilseed cakes		
	Groundnut	Sesame	Sunflower
Moisture	7.7	7.9	6.3
Crude protein	42.2	36.6	25.66
Ether extract	13.2	19.4	19.34
Crude fibre	4.0	4.7	21.24
Ash	4.8	8.1	5.65
Calcium	0.1	1.9	0.40
Phosphorous	0.5	0.5	0.85
Amino acids:			
Aspartic acid	4.58	2.79	2.33
Threonine	1.13	1.17	1.01
Serine	2.07	1.55	1.11
Glutamic acid	8.41	7.14	5.88
Glycine	2.58	1.77	1.59
Alanine	1.49	1.52	1.15
Valine	1.67	1.64	1.29
Isoleucine	1.31	1.28	1.03
Leucine	2.48	2.25	1.59
Tyrosine	1.78	1.39	0.67
Phenylalanine	2.12	1.69	1.18
Histidine	1.00	0.95	0.77
Arginine	4.63	4.29	2.37
Proline	2.13	1.19	1.10
Total lysine	1.49	0.98	1.17
Available lysine	1.45	0.96	1.14
Lysine availability (%)	97.7	98.1	97.7
Cystine	1.59	0.88	0.62
Methionine	0.49	1.05	0.82

Table 2 Examples of the least cost and nutritionally best balanced poultry diets that could be formulated using imported and locally produced groundnut cake (ATC-GNC) in the Gambian project

Ingredients (g/100 g)	Broiler chick		Egg layer	
	Imported GNC	ATC GNC	Imported GNC	ATC GNC
Groundnut cake (Senegal)	12.04	–	9.80	–
Groundnut cake (local)	–	20.00	–	18.00
Corn soya mix (USA)	43.03	63.77	26.05	45.21
Millet	34.54	9.71	47.64	23.63
Rice mill feed	–	1.20	–	–
Fishmeal	5.34	–	3.67	–
Oyster shell	–	–	7.74	7.97
Salt	0.05	0.32	0.10	0.19
Premix	5.00	5.00	5.00	5.00
Cost per ton (Gambian Dalasis)[1]	2529	2148	2406	2120
Calculated analyses:				
Crude protein	21.23	22.75	17.00	19.42
Metabolizable energy (MJ/kg)	11.95	11.95	11.30	11.30
Calcium	1.25	1.08	3.60	3.60
Phosphorus	0.94	0.85	0.80	0.76
Lysine	1.03	1.04	0.79	0.86
Methionine + cystine	0.74	0.90	0.61	0.79

[1]Prices are for June 1992. All feed ingredients were Gambian unless otherwise stated.

expelling, the rate of oil recovery, the rate of seed throughput through the expeller, the price of oil and the value of residual cake. With the slow throughput experienced in the NRI-designed expeller, the margin of profit from expelling alone proved small, but the use of the oilseed cake in the ATC poultry farm diets enhanced the profitability of the operation. Furthermore, by the end of the first phase of the project the COSEP enterprises were shown to be of benefit to the ATC, students in the college, and the local community.

Zimbabwe

Until recently the vegetable oil industry in Zimbabwe was dominated by industrial scale plants which used a combination of expelling followed by solvent extraction processing of soyabeans and sunflower seed. These processing plants were located in urban areas to which oilseeds had to be transported from the growing areas. Demand for the oil in the urban areas was high, with the result that remote rural areas were often undersupplied. In recent years aid agencies have therefore encouraged the introduction of small-scale oilseed processing units in the rural areas to enable farmers to produce local supplies of cooking oil. The Intermediate Technology Development Group (ITDG) has established seven 'Tinytech' oil expellers, with a further seven mills scheduled to be installed during the next two years. There are, in addition, a further three oil millers operating similar power expellers in Zimbabwe, and more than 54 users of manual oil presses. These decentralized edible oil producers process sunflower seed, the most widely grown communal cash crop, which also produces a cheap and nutritious cooking oil that is palatable in the unrefined state. An added benefit is that sunflower seed oilcake has become available in the rural areas. Since the price paid by animal feed companies for the oilcake is low due to the high cost of transporting the relatively small quantities of cakes generated, it is apparent that integration with poultry production enterprises is an appropriate option.

The nutritional value of high residual oil sunflower seed cakes for different livestock is, however, not clear, and research has had to be undertaken to determine the effect of processing conditions on its nutritive value for different classes of livestock. Effort has been concentrated on poultry where the greatest financial benefits lie. As the project developed, a winnower was included in one of the oil milling operations to decorticate partially the sunflower seeds in order to improve extraction efficiency and reduce the fibre content of the oilcake to enhance its nutritive value for poultry. Preliminary research has also indicated that a 60:40 ratio of sunflower seed oilcake to commercial soyabean meal (which is 20% more costly) produced the best results in terms of weight gain in a broiler chick feeding trial. However, an integrated commercial operation in Zimbabwe worthy of mention concerns an enterprise that has included a Tinytech oil expeller, a maize mill and a poultry production unit. The laying birds are fed on a simple diet consisting of 48% partially decorticated sunflower seed oilcake from the expeller, 42% maize bran generated in the maize mill and 10% of a commercial vitamin-mineral premix. This diet has resulted in peak egg production rates of about 80%. The sunflower hulls generated by the winnower were used in the poultry house as litter material from which the birds consumed any residual kernel present. The nitrogen-enriched poultry litter was sun-dried and fed to pigs, particularly at the finishing stage. (This raw material is, of course, also excellent feed for ruminant livestock.)

General considerations in COSEP

Socioeconomic features

There is generally a shortage of poultry feeds in semi-urban and rural areas, particularly in those developing countries in which the oil crushing and animal feed industries are dominated by a small number of companies operating major urban centres (e.g. in Zimbabwe). Small-scale oil expelling provides an opportunity to help to develop rural poultry production to meet the local demand for feeds and poultry products. Although fully integrated systems are likely to be more efficient, there is normally a clear opportunity for local poultry keepers to procure oilseed cakes from the oil miller to give to their birds as a supplementary feed. However, in suitable circumstances the ultimate objective in COSEP is for oil millers to produce and sell a variety of balanced finished feeds, concentrates and protein supplements, based on the oilcake from the locally grown oilseed. The potential benefits are the increased cash income to farmers due to the increased value of the oilcake; the reduced price of poultry feeds enabling greater sales; the ability to meet the animal feed requirements of local livestock producers; and the increased availability of livestock products in rural areas and urban markets. Such developments would enhance the viability of small-scale oil expelling, and thus the sustainability of oilseed cultivation, with many beneficial effects on rural communities, including a regular supply of cheap cooking oil. The central feature of this integrated system is that a number of rural needs are met by linking together various income-generating activities for a number of participants who therefore have a stake in attempting to ensure its success.

Nutritive value of oilcakes from small-scale expellers

It is estimated that there are more than 200 small-scale oil expelling activities in sub-Saharan Africa, with more than 20 in Zambia, more than 30 in The Gambia, plus numerous others in Sudan, Somalia, Cameroon, Kenya and Ghana. The NRI has been instrumental in installing a number of oil expellers, including five Simon Rosedown Mini-40 expellers in Zambia in addition to the NRI-designed prototype expeller in the Gambia. In some of these projects NRI has also provided support in the form of nutritional analysis of feeds and ration formulation advice to associated livestock production enterprises that use the cake resulting from oil extraction.

The most efficient use of oilseed meals, based on feed energy:livestock produce conversion ratios, is their inclusion in poultry diets (Whittemore, 1987) where these meals often represent the single most important source of protein. Depending on the type of expeller used, oilseed meals are also an important source of dietary energy. For these reasons they are often the most costly ingredient of the feed, calling for particular care to ensure that they are put to the most efficient use. It is, however, also pertinent to recognize the contribution that oilseed meals can make to the diet of ruminants, particularly within the context of farming systems where, with perfect knowledge and profit maximizing motives, considerations of equimarginal returns to feed usage in livestock production would predominate in decision making (Ellis, 1988). Oilseed meals are also used in peri-urban dairy enterprises throughout much of India, indicating that the price mechanism largely dictates the use to which the feed is put. There are, however, examples of livestock holdings of mixed species under considerable seasonal fluctuations in feed availability that may necessitate a more complex pattern of feed allocation.

Studies at the NRI have shown that coconut cake may be included in poultry diets at a concentration up to 400 g/kg (Panigrahi *et al.*, 1987; Panigrahi, 1989) and palm kernel meal up to 500 g/kg (Panigrahi and Powell, 1991). After treatment with a solution of ferrous sulphate to inactivate the gossypol (which causes a brown discolouration of the yolks of the eggs), cottonseed meal may be incorporated at up to 300 g/kg in layer diets (Panigrahi, 1992a) and at even higher levels in broiler chick diets (unpublished). There are no known toxicological factors that limit the use of the more conventional oilseed meals (groundnut cake and sunflower cake) in poultry diets, although with soyabean meal the trypsin inhibitors present must be destroyed by heat treatment during processing. Sesame seed cake has not been adequately studied and it may be restricted to 150 g/kg of poultry diets. This seed contains phytic acid, which may bind dietary calcium, and is also believed to be particularly prone to rancidity, thus reducing the period for which it can be stored (Gohl, 1981).

The single most important factor affecting the management of oilseeds as a resource is the oil extraction method employed, which is primarily dictated by the market conditions for oil. There is, however, a frequently ignored trade-off between maximizing the oil yield and maintaining the nutritional (and hence financial) value of the meal. The residual oil content is a valuable source of dietary energy for poultry and pigs, a component which is invariably in short supply in developing countries. Small-scale screw press expellers generally leave a higher level of lipid in the meal than the larger scale mills or solvent methods of oil extraction. These therefore have particular attraction for poultry farmers in semi-urban and rural areas where production is generally constrained by the limited availability of high energy foods that do not directly complete with food used by humans.

Of greater concern is the trade-off between maximizing the revenue from the oil and achieving the desired nutritional characteristics in the resultant meal in terms of protein digestibility for non-ruminant livestock. Excessive heat treatment resulting from the high temperatures generated under some screw press expelling procedures reduces the bioavailability of protein, the very nutrient that gives the feed its premium value. Oilseeds are often subjected to multi-stage processing, as in the Gambian project where the seeds were frequently expelled up to four times. Variation in the nutritive value of oilseed meals has been observed for cotton seeds (Panigrahi, 1988) and coconuts (Panigrahi, 1992b and other unpublished results). Shen and Yang (1992) also reported *in vitro* protein solubility of 29.5–96.3% for 13 soyabean meals produced by various screw press techniques in China.

A third factor affecting the economic value of the meal is the extent of seed decortication prior to oil removal. Here, too, technical aspects in terms of oil extraction efficiency and the cost of seed decortication remain the major considerations. However, the choice of technique is also of interest to poultry producers because the high fibre content of undecorticated seed meal effectively lowers its metabolizable energy value and thus its feeding value.

Both pre-harvesting and post-harvesting factors have been implicated in the variation in the nutritive value of oilseed meals, e.g. for copra meal the maturity of the nut at harvest and the kernel drying method are important factors. Weigel (1993) has summarized the factors that affect the quality of soya bean protein products as: variety, planting practices, weather conditions, soil characteristics, fertilization rates, storage conditions and processing conditions.

Another factor that must be considered in relation to animal feeds generally, but for oilseeds such as groundnuts in particular, is the danger of mycotoxin formation from both preharvest fungal contamination and during storage after harvesting. The use of oilseed meals from local small-scale expellers soon after production should minimize post-harvesting contamination because the storage period will be short.

On the basis of these considerations, it is reasonable to state that the nutritive value of an oilseed meal is a function of the processing methods employed, and is especially dependent on the conditions under which the expeller is operated. Unpredictable variation in the nutritive value of oilseed meals resulting from operation under different conditions will lead to less optimal poultry production, because there is a paucity of literature on nutritional strategy to be followed for optimizing production with meals of varying protein digestibility. As well as having a detrimental effect on livestock production, inappropriate processing conditions may adversely affect a country's foreign exchange reserves if a need to import is created.

Nutritional advantages of integrating activities

In addition to the socioeconomic advantages discussed above, there are technical advantages concerning the nutritional value of poultry feeds inherent in the COSEP system.

Firstly, an important factor in the management of oilseeds as a resource is that, in contrast to cereals which are important human food in developing countries, oilseed meals are generally unpalatable to humans and are not therefore in direct competition with human food (e.g. the layer diet used in the Zimbabwe case referred to above).

Secondly, as discussed above, oilseed meals from small-scale expellers are a good source of both energy and protein, the two major nutrients required by livestock. Panigrahi *et al.* (1987) give an example of how copra cake can be formulated into poultry feeds so as to replace cereals completely. It is of interest that the first press copra cake from a Simon Rosedown Mini-40 expeller supplies about 13.2 MJ/kg of metabolizable energy and 23% crude protein, roughly the nutrient requirements of poultry when the minor ingredients are taken into account.

Thirdly, whilst meals from small-scale oil expellers are generally high in residual oil (and thus dietary energy), the fat is prone to rancidity, the vulnerability being dependent on the oilseed concerned, the storage period and storage environment. The integration of activities enables the rapid use of the oilcakes, thereby reducing the possibilities of both the rancidity-related feed palatability problems and post-harvesting fungal contamination leading to mycotoxin formation.

Finally, in small scale oil expellers a lower level of heat is generated during processing compared with that in more efficient large-scale screw press expellers. This helps to preserve the bioavailability of lysine in the resultant meal (as shown in *Table 1* for groundnut, sesame and sunflower meals), a major consideration in developing countries which have neither the technical capacity to produce synthetic amino acids nor the foreign exchange to import them.

These are important reasons why the development of the oilseed and animal feed industries of developing countries should go hand in hand. The arguments presented here also apply, albeit to a lesser extent, to the integration of large-scale oil expelling and animal feed industries in more developed countries.

The diets formulated under a COSEP system will not have an ideal nutritional specification (see analyses in *Table 2*), and poultry productivity will not necessarily be comparable with that obtained using commercial compound feeds. Each socioeconomic environment determines the diet, and hence productivity, that is optimal under its own constraints. Least cost diet formulation becomes a complex art when used strategically in relation to small-scale oil expelling operations where the overriding objective is that of improving the financial viability of the operation. For example, in addition to the considerations that have been highlighted, it might sometimes be appropriate to increase oilseed dietary inclusion rates above the optimum to use up excess (seasonal) production. The Zimbabwean case study has also shown that, with oilseeds of high fibre content, there is a need to consider the nutritional, technical and financial aspects of seed decortication. This helps in the determination of the optimal choice of technology, and assists in channelling appropriate proportions of the oilcakes into feed for poultry, pigs and ruminants.

Technical research needs

Research has shown that the monitoring of the nutritive value of high protein oilseed meals by chemical analysis alone (including amino acid profiles) is normally insufficient to reveal their true feeding value for poultry. In addition, some oilseeds such as sesame seed cake have had insufficient study, especially under the low productivity backyard systems widely found in developing countries. Without reliable data, the nutritionist is unable to provide sound advice on how multi-processed meals may be incorporated in the poultry diets using the standard least-cost diet formulation approach, and how the basic nutritional strategy may be modified to optimize livestock production with meals of sub-standard quality.

Since aid organizations will, it is believed, continue to support the installation and operation of small-scale expellers for developmental and, in some cases, philanthropic reasons, there is a need for strategic research on the quality of oilseed meals produced by a range of small and large-scale oil expellers. The specific objectives of this research should be to (1) evaluate the nutritive value for poultry of oilseed meals produced by a range of expellers under different operating conditions; (2) conduct simultaneous studies on oil yield and quality; (3) determine whether any other major pre-harvesting or post-harvesting factors affect the nutritive value of oilseed meals; (4) develop appropriate nutritional strategies to optimize poultry production with oilseed meals of sub-standard quality; (5) examine the 'protein bypass' value and the effect of including cakes of high residual lipid on ruminant performance; and (6) conduct financial and economic appraisals of oil and oilcake production under different processing conditions in integrated oil milling cum livestock production operations. On the basis of their importance to the economies of sub-Saharan Africa and Asia, the following oilseeds need to be examined: groundnut, sesame seed, sunflower seed, palm kernel seed, coconut and safflower seed.

Conclusion

Small-scale oilseed expelling is a natural component of agricultural systems in most developing African and Asian countries. The COSEP concept, which builds on this foundation, should be seen as an approach to sustainable development because it attempts to generate income for under-resourced oilseed and poultry farmers while increasing the availability of vegetable oil and poultry products. It also addresses national concerns on the efficiency with which an important renewable natural source (namely oilseeds) is utilized. The concept is based on the hypothesis that ready access to an oil mill will stimulate the cultivation of oilseeds as a cash crop. This increases the production of oil for domestic (local or national) consumption or for export, while adding value to what has historically been treated as a by-product. This is achieved by linking the mill to livestock enterprises so as to make oilseed cultivation and oil expelling more attractive on financial grounds. With respect to livestock production, some technical aspects of this 'systems' approach may be emphasized. Firstly, the nutritive value of oilseed residues for poultry and other livestock in terms of metabolizable energy, digestible crude protein and available lysine depends on the oilseed concerned and on the conditions of processing. Secondly, a flexible approach to formulation of the diet is needed with the objective of achieving optimal poultry production under the prevailing socioeconomic conditions. Thirdly, the oilcakes may also play a significant role in the diet of ruminants in rural areas depending on the prevailing farming system. Finally, insufficient knowledge of their nutritive value will limit the utilization of residues from small-scale oilseed expelling in rural and backyard poultry and other livestock production systems.

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