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TECHNOLOGICAL CHOICE AND EMPLOYMENT IN FOOD PROCESSING AND STORAGE AND RELATED POLICY ISSUES

Background Paper

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TECHNOLOGICAL CHOICE AND EMPLOYMENT IN FOOD PROCESSING AND STORAGE AND RELATED POLICY ISSUES*

by

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* This paper has been prepared under the supervision of ILO.

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CHAPTER 1

Appropriate industrial technology: the dimensions of choice

The bulk of the population of the developing countries - that is, a majority of all people - are poor. They have few material possessions; they live in cramped, and often unsanitary and squalid, dwellings; they lack good medical care and adequate public health facilities; they face an unending search for fuel, which despite their efforts leaves some of them bitterly cold in winter; and all too often, they do not even have secure access to enough of the right kinds of food.[1]

Few would dispute that the goods and services just listed are basic human needs, without the satisfaction of which men and women cannot live in freedom from want. It is therefore lamentable that the world has yet to meet these basic needs for even a majority of the human race. The meeting of these needs, the eradication of poverty, should be the first concern of mankind and the overriding goal of the further development of the developing countries. No measure, institution, or practice - technology included - can be called "appropriate" in those countries unless its primary aim and effect is to assist in meeting the basic needs of the bulk of the population: in other words, unless it serves the interests of the poor.

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[1] This paper was prepared by Mr. James Keddie who is presently on the staff of the Scottish Development Agency, Glasgow: the views expressed in this paper are however not necessarily those of the Agency. He assisted the ILO, which technically supervised the preparation of this paper for the International Forum, in the drafting of a report entitled "Appropriate technology for employment generation in the food processing and drinks industries in developing countries". This report is to be discussed by the ILO Tripartite Technical Meeting on these industries in October 1978. The author wishes to acknowledge in particular his heavy debts in writing the present paper to Dr. W.H. Cleghorn (who likewise assisted in the drafting of the above-mentioned report), and to Mr. Baron of the ILO, the technical supervisor of both projects.

In the developed industrial countries, although material deprivation and degradation still exist among substantial minorities, the problem of grinding mass poverty has largely been solved. In the decades following the Second World War, the emergent nations thus not unnaturally took the progress and techniques of the industrial countries as a model for their own development, which they had only to copy or "transfer" in order to eradicate mass poverty. As the years have passed, however, doubts have arisen even in the industrial world about the long-term wisdom of this model of development. Although it has reduced material poverty, it has left many alienated by its apparent impersonality; and men have begun to wonder whether, in a world in which easily exploitable non-renewable resources are rapidly shrinking, an industrial civilisation based on intensive use of energy and metals can long endure.

Such doubts - it may be argued - are the privilege or luxury of the rich, who are morally ill-placed to insist on their restrictive implications for the development prospects of poor men on whose behalf they have made but little sacrifice. But for the developing countries, the drawbacks of the "transfer" model of industrialisation and development are more immediate and apparent than these long-term social and environmental considerations. In country after country, the perception even of casual visitors will reveal the continued juxtaposition of a "modern" sector, thriving (on its own terms) or not, with the degradation and privation of the masses in both urban and rural areas. The introduction and expansion of modern industry has done very little to remedy this deplorable situation: indeed, many industrial practices in the modern sector - the tendency to produce high-income products, to use capital-intensive and labour-saving techniques, to concentrate production in large-scale urban plants, to pay relatively high wages to the privileged cadre of workers employed - have done much to create or exacerbate the contrast between riches and poverty.

Each sector of the economy must operate in conditions largely created by the others, and too much responsibility cannot be placed with industry for the functioning or malfunctioning of the whole. Modern industry in developing countries is nevertheless an important component of the attempt to transfer, rapidly and on a large scale, the economic and technological systems of rich countries to underdeveloped economies. Government planners, and all others concerned with industrial development strategy and with development in general, should consider whether the role and practices of industry should not be radically changed in favour of a model of development that serves the interest of the poor.

But, it may be asked, can the leopard change his spots? The material success of the industrial countries overshadows the world. Their present level of technology has been attained by decades, and in some cases by centuries, of progressive research and development. It has by definition superseded their previous technological levels. Are the alternatives to large-scale "modern" technology not hopelessly obsolete? Are such alternatives in any case available in practice?

One may answer such questions on either a theoretical or an empirical level. To take theory first, "technology" does not mean gleaming tanks and pipes, powerful whirring machines, and rows of winking lights, although technology can sometimes appropriately take this form. "Technology" is merely a way of achieving material objectives, of getting things done. To its operator or designer, a technology is an expresson of human ingenuity. To the economist and the planner, it is a collection of inputs (materials, machines or tools, energy, human labour) required to produce a material output. On either of these definitions - and they are complementary - the centrepiece of a technology can just as well be a hand-operated mill as a massive set of steel roll-stands: both are methods of grinding or husking cereal grains.

Because technologies stem from human inventiveness, there is nothing in theory to restrict their range to those particular methods of getting things done which now find favour in the industrial countries. Technology is not static. Ingenuity will continue to provide new methods in the future as it has in the past. But (and this is the important point) technical ingenuity does not operate in a vacuum. It is always a response to the challenge of achieving specific material objectives in specific operating conditions. The industrial countries have large markets, high incomes and wage levels, and massive reservoirs of mechanical skills and funds for investment. In these circumstances, it is scarcely surprising that the main thrust of ingenuity has been towards ever more highly processed and packaged products, and the perfection (and particularly the automation) of mechanical processes for their production. But in a developing country, a more typical example of constructive ingenuity may be a device for improving the economical preservation of fruits and vegetables which might otherwise be available only seasonally. Such a device, a solar dryer using only polythene sheets, wood, and mud bricks, but capable of drying fruits or vegetables in three hours at 60-70°C, is in fact considered later in this paper.

This is not to argue that a collection of such apparently simple devices constitutes the whole of "appropriate" technology - industrial or other - in developing countries. But the example illustrates the proposition that these countries are not restricted to slavish imitation and transfer of the present techniques of the industrial world. They can devise solutions to their own problems, in particular the eradication of poverty and the meeting of basic needs.

Some of these solutions may take the form of the development and application of new techniques. This has already been done in many cases. Besides the solar dryer cited above, two well-known cases in food processing are the intermediate, semi-automatic technique for "garification" of cassava in Nigeria, which has proved superior in every important respect to an imported mechanised technology;[1] and the "open pan sulphitation" process devised in India for the production of crystal sugar, and now in widespread and successful use there.[2] Despite these and other successes, it has been strongly argued by Professor Hans Singer that the developing countries, with appropriate help from the industrial world, will need to devote even more effort in the future to the development of new techniques for solving the problem of poverty, so ending the present situation in which most of development work is done by the industrial countries for their own needs.[3]

But human ingenuity is not limited to the technical sphere, and the eradication of poverty may owe as much to the careful specification of problems and the comparative appraisal of existing alternative techniques, as it will to the development of new technical alternatives. It is here that the economist and the planner can make their contribution, by challenging on empirical grounds the assumed obsolesence of alternatives to gleaming tanks and powerful whirring machines.

In the past few years, a corpus of knowledge has resulted from economic investigations of alternative technologies in various manufacturing industries in developing countries. In these studies,[4] the alternatives to the "modern" technologies are for the most part neither newly developed nor belonging to

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[1] Ngoddy, P.O., "The case for appropriate technology in the mechanisation of Gari manufacture in Nigeria" (1974), OECD Study Group on Low-Cost Technology and Rural Industrialisation, Working Paper No. 23, Paris.

[2] Garg, M.K. (1974), "Appropriate technology for small-scale sugar manufacture in India", OECD, Paris.

[3] Singer, H.W., "Technologies for basic needs" (1977), ILO, Geneva.

[4] Some of these are summarised in Bhalla, A.S. (ed.), "Technology and employment in industry" (1975), ILO, Geneva, and in "The choice of technology in developing countries", special issue of <u>World Development</u>, Vol. <u>5</u>, 9/10, Oct.-Nov. 1977.

past eras. They are established techniques currently in use in developed or developing countries. In comparing such alternatives with large-scale "modern" techniques, it is frequently (though by no means always) found that they are economically better or more appropriate than the latter.

That such comparisons can be made at all demonstrates the practical continued availability of alternatives to large-scale modern technology, and their results are a sufficient indication that these alternatives at least merit serious economic consideration by development planners.

But economics is not an exact science, and its various practitioners in this field have adopted different viewpoints which have sometimes led to their reaching, from substantially the same evidence, apparently contradictory conclusions about the appropriateness of technologies.[1] Since a broadly economic approach forms the basis of this paper, it will be helpful to describe the particular viewpoint adopted here.

It is, as implied above, taken as axiomatic that the term "appropriate" should be applied in the developing world to those institutions and practices most directly serving the interests of the poor. At the simplest level, there are two complementary methods of doing this, which together constitute or indicate "appropriate technology": the provision of products at low cost, and of purchasing power permitting the poor to buy a sufficiency of them. Other criteria of appropriateness - considerations of "efficiency", of use of investible funds, of long-term energy use, and (in food processing) of nutrition - may be adduced, and are in fact also considered in what follows: but they will rarely be found to upset judgements made on the basis of the two primary indicators of appropriateness just noted.

In the industrial market economies, large-scale attempts have been made to provide purchasing power without employment, by so-called "welfare" measures. These measures have met with some degree of success, but they are not regarded as fully

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[1] Compare, for example, the favourable conclusions reached about large-scale sugar manufacture by Forsyth, D.J.C. "Appropriate technology in sugar manufacturing" (1977), World Development, 5, 3, with the more qualified conclusions of C. Baron in "Sugar-processing techniques in India" (1975), in Bhalla, A.S. (ed.), op. cit.; and the largely unfavourable conclusions of Keddie, J. and Cleghorn, W. "Choice of technology in the food and drink industries: some case studies", Chapter III of "Technology, employment and basic needs in food processing", ILO, forthcoming (1979).

satisfactory by the taxpayers, nor by most of the recipients, who naturally aspire to the self-reliance and self-respect that are given by working for one's own living. Moreover in the industrial countries such measures support only a small minority of the population. In the developing countries, it is the majority who are poor, and meeting their basic needs from the incomes of the relatively well-off few is not a practicable proposition. It is therefore a major underlying premise of this paper that in the developing countries purchasing power may only be secured for the poor by the large-scale creation, direct or indirect, of jobs earning them incomes.

On the other hand, much if not most of the value of such earnings resides in the products that they can be used to purchase; and crucial though employment creation may be to any strategy for meeting basic needs, it will largely defeat its own purpose if it drives up the costs of the principal essential commodities, foods and others, to very high levels. Indeed the conjunction, if possible, of low costs with employment creation may be expected to produce snowballing dividends in the form of a virtuous circle, with low costs leading to large markets resulting in substantial industrial employment which further enhances those markets. Thus care is taken in the case studies of Chapters 2 and 3 to present the comparative costs of production with alternative technologies, alongside the employment associated with them.

It should however be remembered that such costs, and the accompanying estimates of profitability, are calculated using the prices prevailing under existing economic conditions in the developing countries. That such conditions are unsatisfactory is evident from the continued existence of mass poverty, often observed side-by-side with a thriving modern sector, noted in the first few paragraphs of this chapter. The profitability of "modern" products and projects may derive from high output prices resting in turn on the economic privileges of a political, managerial and professional elite; and the lower ranks of this elite may be swelled by the relatively high wages often paid by such projects to the few workers they employ, and sometimes cited by project owners as a key reason for their inability to provide more employment. Under such conditions, high profits or even low costs for large-scale modern technologies might indicate their capacity to reinforce the conditions for their own survival, but they cannot demonstrate in any unqualified way their greater economic "efficiency".

Indeed the concept of economic efficiency is, at least in respect of practical application, rather imprecise. Achieving efficiency implies cost-minimisation - which, if extended over the entire economy, is also equivalent to profit-maximisation - either (as in this paper) at market prices, or at "accounting" or "shadow" prices supposedly representing the "true" opportunity costs of resources. However, both market and shadow prices reflect the distribution of incomes in the economy. If this is highly unequal to start with, there is little reason to expect that a cost-minimising (that is efficient) solution even at shadow prices will meet the basic needs of the poverty-stricken majority. Other solutions, also meeting the criteria of "efficiency" but better serving the interests of the poor, could be derived from alternative and more equitable initial distributions of income. It is likely that only exceptionally high cost premia, such as those found in this paper for the hand pounding of rice at high wages, may be taken to demonstrate the inappropriateness of a technique.[1]

Nevertheless, the question of cost and profit in the world as it is cannot and should not be ignored. In the first place, very high cost premia may in fact be found, thus indicating the probable inappropriateness of the costly technique under practically any circumstances. This will be particularly the case if it is a large-scale modern technique operating under existing conditions which are in any case probably too favourable to it; or if - supposing the people it supports to be poor - a satisfactory method is available of fully and fairly sharing with them the potential over-all gains to be reaped through its replacement by an alternative technique.

Perhaps a more important service rendered by the examination of comparative costs and profits is to focus discussion on the prospects and constraints faced by the various alternative techniques. In the final analysis, the assessment of social value and appropriateness remains a matter of judgement. It is helpful for policy purposes if, after arriving at a judgement - partly based on the evidence provided by cost and profit results - the planner can return to those results for an indication of what measures (if any) are needed in the "here and now" for the promotion of the appropriate technology.

As already noted, other factors may enter the judgement of appropriateness, but before passing briefly to these, it is

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[1] Even in such cases, "efficiency" may remain ironically theoretical in its implications. No achievement of any efficient solution implies that those who proximately suffer as a result will in fact be compensated by those who proximately gain. It implies merely that the gainers could compensate the losers fully, and still remain better off than they would be under an inefficient solution. In rice pounding as in other cases, there is very little evidence for such compensation having taken place.

worth clarifying an important point of terminology. A "technology" may either be conceived as a bundle of required inputs to meet an output objective externally given, or as a bundle including an output within some specified range of "functionally substitutable" products. The latter conception underlies the comparisons made in this paper, so that in most cases, the products of the projects compared in any one industry are not identical. The former conception - that an appropriate technology may be chosen from among the alternative techniques for producing any narrowly specified product - has inspired much interesting work,[1] but on the view of appropriateness taken here, it unduly restricts the range of productive activities which may legitimately be compared. If the products of alternative projects are approximate functional equivalents - as, for example, is assumed to be the case for preserved vegetables, whether canned, fried or frozen - then the projects may legitimately be compared as alternative "technologies", any one of which may be judged the most appropriate. This procedure does not however preclude the consideration of, for example, alternative drying techniques within the wider range of vegetable preservation technologies.

Turning now to some other factors affecting the judgement of appropriateness, it should first be noted that the employment attributable with some degree of certainty to a particular project is not limited only to the direct employment generated. It may stimulate, through "linkages", employment in other sectors of the economy, particularly those which supply it with materials or those which use its final product. Important as these indirect effects may be, it is beyond the scope of this paper to quantify them, although mention of them is made at pertinent points in the exposition.[2]

Other mechanisms of indirect employment generation are sometimes advanced. It is frequently argued that developing countries are crucially short of funds for productive investment. Projects are accordingly scrutinised, both for their use of investment funds which might generate employment if alternatively invested in industries and sectors elsewhere in the economy; and for their profitability, not merely as an indicator of their present economic feasibility but also of their capacity to generate "surplus" funds which may be

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[1] See, in particular, the special issue of World Development, op. cit.

[2] The results of some calculations for the food industries as a whole are given in Chapter II of "Appropriate technologies for employment generation in the food processing and drinks industries of developing countries", ILO, Geneva, 1978.

reinvested in the future. However, such scrutiny will not often modify favourable conclusions initially reached on the basis of low cost and substantial employment generation associated with a project. Labour-intensive projects creating large direct employment usually have low investment costs, giving them potential for indirect job creation also. However, in practice it seems likely that a large part of saved investment funds will be sent abroad, spent on conspicuous consumption, or squandered on a few prestige projects, rather than filter through the highly imperfect capital markets of the developing world to activities such as labour-intensive agriculture, or small-scale production in the urban informal sector, where the greatest potential for indirect employment creation is probably to be found. Similarly, one may be sceptical whether high profits earned in capital-intensive projects producing high-income products will be reinvested (if at all) in other than further projects of a similar type, thus perpetuating a situation in which the basic needs of the majority are not met.[1] Despite some grounds for scepticism about their relevance to indirect employment creation, comparative fixed asset investment costs and (in most cases) profits have been presented in the cast studies of this paper.

So also have direct energy costs and rates of consumption. Much concern has recently been manifested over long-run energy supplies, particularly for modern industrial civilisation. Misuse of traditional energy sources in the developing countries - notably wood - has also been alleged.[2] It is certainly not necessary to adhere to a Doomsday theory of catastrophic energy shortage or ecological collapse in order to predict very serious problems of energy supply and cost afflicting the developing countries in the medium term, or to question the long-run wisdom of industrial development based substantially on present non-renewable energy resources. The full charting of energy consumption is a very complicated business, and the subject of still-unresolved controversy.[3] It has however been possible to present in this paper the forms

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[1] On the other hand, a correspondingly "virtuous" circle might be initiated by profitable small-scale or labour-intensive projects. Profits from such enterprises might well be reinvested in projects making a similarly frugal use of funds.

[2] Eckholm, E.P., Firewood - the other energy crisis (1975), Worldwatch Institute, Washington, D.C.

[3] Energy analysis (1974), International Federation of Institutes for Advanced Study, Stockholm.

and quantities of direct process energy consumption associated with alternative technologies, together with the costs of the energy thus consumed.

Possibly linked with patterns of energy consumption (and with much else besides) are considerations of scale. Modern industrial technology, in food processing at least, tends to operate at large scales of output. This tendency has been deplored on ethical grounds,[1] and in developing countries is also thought to contribute to the massive shift of rural populations into already-crowded towns and cities, because of the associated tendency of large-scale modern factories to locate in urban areas. On the other hand, large-scale production is linked in the minds of many with "economies of scale" and low unit costs of output. Therefore it is important in any consideration of appropriate technology to compare projects of widely varying scales of output, and this has accordingly been done in the case studies in this paper.

Finally, in the food processing sector, no account of technological choices can be complete without consideration of the nutritive value of final products, since adequate nutrition is obviously a basic human need, and may be thought of as a necessary condition for securing all the other needs. A poor man is very unlikely to rise out of poverty if he is sick, or if he lacks the strength and endurance to do sustained productive work. Within the scope of this paper we can do no more than touch on the insights provided by a large and complex subject, a specialist discipline in its own right. Fortunately however it is possible to classify most important foods according to their roles in supplying the basic nutrients in the human diet - energy-supplying foods (including oils and fats as a special category), proteins, and vitamins and minerals. Using this classification, one can select for study a set of food processing activities which is reasonably representative of nutritional needs, and also make some observations on the costs of certain methods of meeting such needs. Concern for nutrition also suggests the importance of considering grain storage, an activity of great significance for the maintenance of the most basic of all foods.

The next chapter, which constitutes the nucleus of the paper, presents case studies of technological choice in some major food processing activities, concentrating on comparative costs and employment but also giving consideration to other factors such as nutrition, project scale and energy use.

Chapter 3 addresses the question of food grain storage. In the discussion of alternative technologies, large-scale

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[1] Schumacher, E.F. (1973), "Small is beautiful", London.

storage for cities and provincial towns, and small-scale storage for villages and households, are examined separately.

The last chapter gives a summary of results, and then deals with policy measures to implement appropriate food-processing technologies. The discussion embraces general controls, such as tariffs, on the development of food processing activities; promotion of appropriate R and D; the provision of credit; training; special policy measures, if any, required for individual food-processing activities; and action at the international level.

Finally, an appendix presents the standardised set of developing country prices used in the costings, and comments briefly on the method of allowing for price inflation.

CHAPTER 2

Case studies of alternative technologies and projects in selected food processing activities

Introduction

This chapter comprises case studies of the choice of appropriate technology in six major food processing activities: rice milling, bread baking, fruit and vegetable preservation, dairy products, fish preservation and beer brewing. Each study begins with brief introductions to the nutritional roles of the major products of the activity in developing countries, and to the range of alternative processing technologies available. This is followed in each case by an economic specification, in terms of the principal outputs and required inputs, of alternative projects using different technologies and covering a range of scales of outputs, which is accompanied by presentation of the costs, investment costs, and (in most cases) the revenues, which are associated with these projects. The operating conditions and prices underlying these specifications and costings are based on developing country commercial experience, and the prices have been up-dated to levels prevailing at the end of 1977. These prices form a standardised set common to all the case studies, and include two regimes of wages reflecting conditions in low-wage and high-wage developing countries. The costs and revenues are estimated totals ("present values") over the duration of project lives, using the discounted cash flow method of evaluation at a discount rate of 10 per cent per annum.[1]

The comparative costs, profitabilities and direct employment creation of the alternative projects in each study is then examined, with due consideration given to other factors which may also enter the judgement of appropriateness.

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[1] This is equivalent to assuming annual interest charges on fixed and working capital, at a real (inflation-adjusted) interest rate of 10 per cent per annum.

1. Rice milling

Cereals (food grains) are the basic foodstuff of man. This is particularly true in the developing countries. Table 1 presents a classification of the principal types of foodstuff by basic nutritional category, and shows the position within this classification of the food-processing activities chosen for study in this chapter. It will be seen that cereals are classified among the energy-producing foods. Their primary role in providing energy in developing countries is illustrated in table 2, which shows the contributions made by various types of foods to the daily intake of calories,[1] fats, and proteins, averaged over three developing countries, one Latin American, one African and one Asian.

In these three countries, the table shows that cereals provide 58 per cent of total calories. Besides this, they also provide over half the protein, and 22 per cent of the fats. The primary contribution of cereals to the developing country diet may be confirmed by a glance at table 3, which presents summary production totals, for all the developing countries, of the main foodstuffs. The production of cereals is easily the largest total; and the dominance of the category is enhanced when it is recalled that the other very large totals - those for root crops, and fruits and vegetables - should be considerably scaled down for comparative purposes to allow for the much greater water content[2] of these crops in their harvested form.

Among cereals, rice is the most important in the developing countries. In 1976, it accounted for 320 million of their total cereal output of 607 million tonnes. The next two most important cereals, wheat and maize, accounted respectively for only 139 and 110 million tonnes. The great bulk of this huge rice output is produced in Asia, where developing country rice production in 1976 was 294 million tonnes out of a total cereal output of 509 million.[3] Since Asia is almost in trade

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[1] Most foods do (or can) provide energy (calories), though it is nutritionally very inefficient to use protein as an energy source. Fats, on the other hand, are a concentrated source of energy, though their essential nutritional role is to provide certain "essential fatty acids" in the diet.

[2] Water is of course also the principal bulk constituent of milk.

[3] All figures from "FAO Production Yearbook" (1976), table 6.

balance in respect of rice,[1] its consumption is for all practical purposes equal to its production.

The paramount importance of rice production and processing to developing countries' food supply, primarily among the vast populations of Asia, will be evident from the figures above. Thus this series of case studies starts with rice milling, which is also of great interest as an example of massive and apparently uncompensated displacement of the labour of the rural poor by the introduction of mechanisation.[2] The widespread adoption in the rural areas of small-powered rice mills has considerably reduced the already low incomes of the very numerous displaced hand pounders, in spite of substantial increases in rice production. These problems are best documented for Indonesia,[3] but there can be little doubt that they are present in other Asian rice economies.

Larger-scale rice mills and storage units have also come under considerable economic criticism.[4] Besides the higher transport costs associated with them, they have been reported in Sierra Leone and the Philippines to suffer from prolonged breakdowns and low utilisation;[5] and despite their alleged potential milling superiority, they may in practice produce milled rice of equal or even inferior quality to that turned out by hand pounding or the small-powered mills.

There is thus an especially good case for examining a range of rice-milling technologies and of comparing their costs

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[1] "FAO Trade Yearbook" (1975). Imports were 0.2 million tonnes more than exports in 1975.

[2] This immiseration of the poor in processing is matched by parallel developments associated with the "green revolution"; in __production__, the reduction of incomes of rice farmers unable to use new rice varieties, caused by the price declines consequent upon the introduction of these varieties; and the displacement of local labour in __harvesting__ by workforces of contract labourers.

[3] Timmer, C.P. (1973), __Bulletin of Indonesian Economic Studies__, __9__(2), 57-76, and Collier, W.A., et al. (1974), ibid., __10__(1). 106-120.

[4] Timmer, op. cit.

[5] Spencer, D.S.C., et al. (1976), "Employment, efficiency and incomes in the rice-processing industry of Sierra Leone", African Rural Economy Paper, No. 15, Michigan State University, East Lancing; "Sharing in development: employment, equity and growth for the Philippines" (1974), ILO, Geneva.

at different scales of output and wage levels in order to probe the possible effects of the mechanisation of rice processing on employment and income distribution. The present comparison can only approximately represent any actual set of circumstances, for the economics of rice milling are very closely linked with questions of harvesting practice, drying, storage, transport and distribution facilities, climate, etc. all of which may vary widely between countries.

Rice-milling technology

Paddy,[1] the raw material in the analysis that follows, is on average 80 per cent of the weight of the harvested rice before threshing. Whether before or after threshing, rice is dried prior to milling, usually in the sun, but sometimes with artificial dryers in the larger rice mills. For the purpose of this analysis, paddy is assumed to be ready for milling without any further drying.

Rice is not normally ground into flour but is cooked and eaten whole. The purpose of rice milling is thus to remove the outer husk of the grain with minimum damage to the kernel. Hand pounding and hand milling merely separate the husk from the kernel. Power milling processes also remove the vitamin-rich seed coating ("bran") and the germ to produce polished rice which is far whiter when cooked than rice with the bran still intact. The widespread though by no means universal practice of partly cooking ("parboiling") rice before it is milled reduces vitamin losses, some of the vitamins penetrating the interior of the kernel during this process. Parboiling also toughens the kernel, making it less likely to break during milling. Its survival even after the spread of mechanised milling has doubtless been responsible for the prevention in some areas of mass outbreaks of vitamin-deficiency diseases (for example, beri beri) when consumption of unpolished hand pounded rice has given way to a taste for the polished rice produced by powered mills.

Hand pounding - the most widespread traditional method of milling - is extremely labour-intensive, with productivity rarely exceeding 5 kg per worker-hour. At the simplest level of technical improvement, Bhalla[2] describes four traditional Indian hand-powered milling devices which raise labour

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[1] The term "paddy" may be used either of rice "on the stalk" or of rice threshed from the stalk but still in the husk. In this paper, the latter usage is adhered to.

[2] Bhalla, A.S. (1965), "Choice of techniques in rice milling", Oxford Economic Papers, New Series 17, 147-157.

productivity to between 2 and 9 times that for hand pounding, in return for a very small capital investment. It is unclear to what extent if any, these devices polish the rice as well as removing the husk. The wooden "chakki", by no means the cheapest of the devices described by Bhalla, has been included in the analysis that follows, as an example of "intermediate" technology.

The traditional small power-driven rice mill is the Engelberg steel roller type, using a 10-15 H.P. engine. Such mills are sometimes used in series, a pair of them forming a husker-polisher unit. Small one-pass Japanese rubber roller mills, capable of both husking and polishing the rice, are increasingly superseding the Engelberg mill. They are of similar capacity (a fraction of a tonne per hour paddy input), but offer somewhat higher rice recovery rates[1] and superior quality output.

Larger mills tend to be owned and used by specialist commercial rice millers at central locations, and may incorporate threshers, artificial dryers and bulk or bagged storage facilities. The older types use disc shellers and multi-stage steel roll stands, but more recent designs utilise large rubber rollers. These latter have capacities ranging up to 2 tonnes and more per hour input, while large "integrated" milling and storage plants may handle up to 25 tonnes per hour.

Developing country experience with larger mills has not been particularly encouraging. Sources quoted by Timmer[2] state milling out-turns for large mills to be in the range 65-72 per cent, no higher than those reported for efficient small-powered mills, while Spencer et al. record operating out-turns of less than 50 per cent for large Sierra Leonean mills. In addition, they note that such mills experience "inability to achieve full capacity operations", and indeed report that neither large mill "has been in operation for the last eight years".[3] Similar difficulties have been found in the Philippines, including "errors in the technical design" and "lack of adequate current financing". Though larger mills may offer potential economies of scale, much therefore depends on the rate of utilisation which can be achieved in practice.

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[1] Differences of a few percentage points in recovery rates should not be underestimated: an increase in (say) the milling out-turn from 65 per cent to 70 per cent on the Asian developing country paddy output of 294 million tonnes, would make nearly 15 more million tonnes of husked rice available for consumption.

[2] Timmer, op. cit.

[3] Spencer et al., op. cit.

Table 4 summarises the range of rice-milling technologies described above.

Economic comparison of rice-milling technologies

Table 5 presents a summary of the schedules of outputs and inputs for five rice-milling projects of widely varying scales of output, each employing a different technology. The schedules are based on data provided in the published studies already listed in the footnotes - Bhalla, Collier et al., Spencer et al., etc. The implied operating characteristics are generalised "average" or "typical" figures, and actual experience will vary between countries. Nevertheless, the schedules probably represent developing country operating experience pretty fairly.[1]

Table 6 presents the results of the comparative cost and revenue analysis based on these schedules and on the standardised set of developing country prices which is common to all the studies in this chapter. These prices are updated to end-1977 price levels, and so also are the costs and revenues presented; these are - as noted at the beginning of the chapter - estimated total present values over project lives using a (real) discount rate of 10 per cent per annum.

Largely owing to their low labour productivity, the manual technologies make losses. They are not competitive with mechanised mills, even if high yields from manual methods are assumed. Among the mechanised technologies, small mills have lower costs and are more profitable than large mills,[2] despite the optimistic assumptions about the latter; and the rubber roller version of the small mill is more profitable than the Engelberg type, because of its higher yields. On the available

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[1] The assumptions about multi-stage mills are probably optimistic, particularly the alternative "high" utilisation rate. On the other hand, the advantage of the small rubber roller mills is possibly understated. Spencer et al. (op. cit.) report average out-turn percentages of 67.0 (raw rice) and 73.6 (parboiled rice) for rubber roller mills as against 64.5 (raw) and 67.7 (parboiled) for Engelberg mills, and similar advantages for rubber roller mills are reported in India; sources cited in Harriss, B. (1976), "Paddy processing in India and Sri Lanka", Tropical Science, 18 (3), 161.

[2] Since the large multi-stage mill is assumed to process 9 times as much paddy per annum as either of the small mill projects, its NPVs should be divided by 9 to achieve a fair basis for comparisons of profitability.

evidence, small rubber roller mills are also as likely as multi-stage mills to turn out rice of premium ("fine") quality, so that their superior competitive position is unaffected by assuming a "fine" rice price for output.

The above comments, however, give an account of the various technologies only from the point of view of the private entrepreneur who buys equipment, labour, paddy, etc., and sells the milled output. The results merely show that manual techniques are not attractive commercial propositions under existing conditions. At "high" wages, the further conclusion may be drawn that these techniques are always likely to have very high cost premia. Since milled rice is a basic cheap foodstuff, such cost premia would indicate the inappropriateness of manual techniques in high-wage developing countries (Singapore or Nigeria for example).

But most of the world's rice is consumed in countries where much lower wage rates prevail, for example India, Indonesia, Bangladesh. The results indicate much lower cost premia at low wages, particularly for the wooden "chakki" at high yields.[1] As explained in the previous chapter, it is only very large cost premia which indicate an unshakeable inefficiency regardless of assumed economic and social conditions.

Moreover, even if such inefficiency, i.e. the persistence of cost premia under any conditions, were to be assumed for the sake of argument and mechanisation of rice milling advocated on that ground, there is still a substantial problem in assuring that the implied "over-all gains to society" are shared fairly, particularly with the hand pounders and hand millers who are displaced from their employment in the process. Small mechanised mills provide no solution to the problem: for example, at high utilisation rates, multi-stage mills require 24 men for the milling of 5,760 tonnes of paddy per year, and small mechanised mills (of either type) require 27 men. The manning requirement for an equivalent paddy input using hand pounding is 1,000.[2] Thus over 99 per cent of the employment loss from mechanisation is incurred in moving only from hand

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[1] Cost prices per tonne of output, covering 10 per cent returns on investment, at high yields and low wages are US$284 for the "chakki", US$272 for the rubber roller mill at low utilisation, and US$264 for the same mill at high utilisation.

[2] These manning figures are derived from table 5. Six-hour days are assumed for hand pounding, eight-hour days for the mechanised mills.

pounding to the small mills; and since tens of millions of tonnes of paddy are involved, it can be seen that very large numbers of people are affected.

If these people were themselves well off, or if parallel processes smoothly provided them (n.b. them, not other people) with more productive employment, this situation might be viewed with relative equanimity. But it is the rural poor who have traditionally sought to supplement their inadequate incomes by pounding the rice of their slightly richer neighbours, and their access to alternative incomes and employment cannot be blandly assumed.[1] If mechanisation is to be approved as a process, such access must be deliberately secured by specific policies: unless policies to this end can be effectively instituted, not even the small mechanised mills can be termed "appropriate" in the face of the destitution they cause.

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[1] See, for Indonesia, Timmer, op. cit. and Collier et al. op. cit.

2. Bread baking

In contrast to milled rice bread is a grain - typically wheat - in a highly processed form. The grain is first milled into flour, and the flour then mixed with water and perhaps other ingredients into a dough which, appropriately kneaded and formed, is baked into bread. All these processes add cost to the grain nutrients, and bread may in fact be regarded as something of a luxury product in some poorer developing nations,[1] beyond the means of the poorest and least well-nourished families. However, raised bread appears to be growing in popularity in the developing world, though it is not easy to trace the growth in demand with any confidence since bread production statistics are fragmentary. As a convenience food which is neither very cheap nor very expensive, it will probably continue to be in increasing demand as incomes rise in developing countries, and it can make a valuable, albeit relatively expensive, contribution to a protein-deficient diet.[2] Moreover, evidence from Kenya[3] indicates that small-scale widely dispersed baking of raised wheaten bread by labour-intensive methods can flourish in competition with large mechanised bakeries. Thus bread, if not exactly an ideal product for meeting the nutritional basic needs of the very poor, may offer them prospects for employment. Such prospects have of course long been realised in the making of the

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[1] It is notable in this respect that a recent unpublished survey of urban households in Afghanistan showed vegetables and rice to be consumed by all income groups, whereas unleavened bread ("nan") - a far more traditional item of diet than "raised" bread of the Western type - was not consumed at all by the lowest income group, and by only about a sixth of the next lowest. "Survey of 50 Kabul households" (30 blue-collar, 20 white-collar), Faculty of Economics, Kabul University, Kabul, 1977.

[2] Kilby, P. (1965), "African enterprise: the bread industry in Nigeria", Stanford University, Palo Alto, California, USA. Kilby states that the "moderate amount" of protein in wheat flour (9 per cent) is "a valuable contribution to the Nigerian diet", though he notes that bread is expensive in comparison with some local protein sources, such as cereals and groundnuts. This is reflected in surveys of urban bread consumption per annum: 5 kg in artisan households, 15 kg in middle-class or professional households.

[3] See Chaper 5 by R. Kaplinsky entitled "A country case study: food processing in Kenya", in C. Baron (ed.), "Technology, employment and basic needs in food processing", ILO, forthcoming (1978).

traditional unleavened bread ("nan") of southern Asia and the Middle East, which is largely produced in small shops; but this case study deals with the more recently introduced "raised" product.

Bread-baking technology

To make a typical raised wheat bread, wheat flour is mixed with water, salt, yeast and (frequently) sugar in specified proportions. The mixture is worked into an elastic dough, in which the yeast is then allowed to ferment, generating carbon dioxide which is retained in the dough and causes it to rise. The dough may then be further worked before it is cut, weighed and shaped into loaves before being allowed to rise again prior to baking in an oven. The finished product is allowed to cool on it's removal from the oven, before being wrapped or packaged for sale.

Although this process has traditionally been mainly manual, most of its stages are readily mechanised: table 7 outlines the potential for mechanisation at each "core" stage.

Economic comparison of small and large bread-baking projects

Table 8 presents summary schedules of inputs and outputs for three bread-baking projects, two small and one much larger. Each project has a different technology, although that of the large project is much more mechanised than those of the other two. The schedules, together with the prices specific to baking presented in the appendix to this paper, are based on Kenyan information privately communicated by R. Kaplinsky, who emphasises that the large mechanised bakery is an exceptionally efficient example of its type. In contrast, the fuelwood consumption in the locally-constructed ovens of the two smaller projects may be more than double that found in bakeries of similar size and type in some other developing countries, Sri Lanka for example.[1]

Table 9 presents the results of the cost and revenue analysis of the three projects. The mechanised bakery is the most profitable, even after due allowance is made for its greater scale of output: at low wages for example its NPV per million loaves per annum is US$220,000. This greater profitability may be partly due to marketing differences, for a "luxury" wrapper is used for the loaves, and these are sold

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[1] Privately communicated information.

by the project half at wholesale, half directly delivered to the retailer, whereas bread from the small projects is all sold wholesale and is wrapped in "plain" wrappers only; if these latter circumstances are assumed for the large project also, its NPV per million loaves at low wages drops to US$216,000.

This is higher than the US$205,000 found in the manual bakery (the more profitable of the small projects) at low wages; and at high wages, neither small project makes a profit.

The large bakery thus has a definite competitive advantage. But it should be recalled that it is an exceptionally well-managed example of its kind, and that for the average large bakery, no such advantage would appear.[1] Moreover, the difference in profitability is marginal at low wages, and would remain so under an intermediate wage regime. If the wages of local staff were assumed doubled (instead of being increased by three to five times as occurs in moving from the "low" to the "high" wage regime) the manual bakery would have a positive NPV of US$119,000, while the NPV of the large project per million loaves would be US$201,000 under its existing marketing arrangements, and US$197,000 if its bread were sold all at wholesale and in plain wrappers.[2]

Thus it is only in the highest-wage developing countries that the manual process can be said to have inappropriately high costs vis-à-vis even well-managed large mechanised bakeries. At low or intermediate wage levels, they are to be recommended for the extra employment they bring. For every million tonnes of flour used, the manual bakeries would provide 73,000 non-management jobs as opposed to 13,000[3] provided by the mechanised process. The difference of 60,000 is very significant. Such increased employment opportunities might be considered an adequate way of sharing with the poor the benefits of producing a rather high-cost form of basic nutrition. In the manual project at low wages, for example,

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[1] This is the conclusion of Kaplinsky (op. cit.), who finds that large bakeries are generally less profitable than small ones in Kenya. They survive through, inter alia, privileged access to flour supplies from the large wheat mills.

[2] The profitability of the manual bakery would of course be further improved if fuel consumption could be reduced for relatively little investment. At Sri Lankan fuel efficiencies, energy costs in the manual project would fall to US$23,000 from their presently estimated level of US$51,000.

[3] In both cases, a "job" is taken as 300 8-hour man-shifts per annum.

cost price per tonne of the nutrients in the final baked product is about US$420, as opposed to about US$340 for the nutrients in their unbaked state, and US$264-272 for milled rice of "medium" quality from small rubber roller mills.[1]

The extra employment could moreover be widely dispersed in rural areas: Kaplinsky for instance found many small bakeries in the Kenyan countryside.[2]

A final qualification should however be mentioned. In gross terms, the manual process, with its wood-fired ovens, is much more energy-intensive than the mechanised technology. The former consumes about 632,000 tonnes of coal equivalent (tce) per million tonnes of flour used, the latter only about 121,000 tce per million tonnes of flour.[3] The difference is obviously substantial: for comparative purposes, it may be noted that the total consumption of "commercial" energy (that is, coal, oil, gas, and electricity, excluding "traditional" fuels like dung, crop residues and wood) in 1970 in Egypt - with a population of 35 million - was 11.3 million tce.[4]

Gross energy figures do not tell the whole story. To use a cheap and renewable energy source may be better in the long run than to use lesser quantities from limited and increasingly expensive "commercial" sources such as imported oil. But until firewood use is properly controlled - and sustained by afforestation programmes - in the developing world, the massive

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[1] See the previous section on rice milling.

[2] Kaplinsky, op. cit.

[3] The energy conversion factors used in this paper are: 1 tonne (= 1,100 litres) of fuel or diesel oil = 1.710 tonnes coal equivalent (tce): 1,000 kilowatt-hours (kw-hr) = 0.290 tce; 1 tonne wood = 0.602 tce. Those for oil and electricity are based on the average factors used in UK government statistics, as quoted in e.g. Foley, G. (1976) "The energy question", Penguin, Harmondsworth, England. The factor for electricity assumes a 50/50 split in electricity production between hydroelectric stations, and "thermal" stations which use fuels at 30 per cent efficiency. The factor for wood is based on the mean of two estimates of the energy content of firewood in developing countries: 15,800 Kilojoules (KJ)/kg, Makhijani, A. (1975) "Energy and agriculture in the Third World", Ballinger, Cambridge, Mass.; and 16,300 KJ/kg, private communication by J.P.M. Parry.

[4] UN Statistical Year Book, 1973, United Nations, New York, cited in Foley, op. cit.

consumption of this potentially renewable source should not be lightly encouraged. An immediate priority in any programme of small wood-fired bakeries is therefore to ensure that their ovens are of reasonable thermal efficiency. As noted above, Sri Lankan bakeries come out better in this respect than the Kenyan models analysed in this study: they would consume about 284,000 tce per million tonnes of flour. Any improvements in oven design, affecting fuel economies at low investment cost, would certainly be very welcome, and can be recommended as the object of technical R and D projects in both developing and developed countries.

3. Fruit and vegetable preservation

As noted above, fruits and vegetables bulk large as foodstuffs in the developing world. Even if starchy root crops - potatoes, sweet potatoes, cassava, and the like - are excluded, table 3 (p. 15) shows fruit and vegetables (including pulses and melons) as second only to cereals in terms of tonnage produced in the developing countries.[1] Despite their combined importance, these products are very varied, as table 10 shows. The "FAO Production Yearbook" itemises production for 36 individual crops within the scope of this table, yet the total production for these 36 is only 53 per cent of the total for fruits and vegetables as a whole. The diversity among "vegetables" proper is even more marked: within this category, the 13 itemised crops account for only 51.9 million tonnes, or 33 per cent of the total.

Faced with such diversity, it is not possible within the scope of the present paper to give more than a sketch of the general nutritional role played by fruits and vegetables, or even of the possibilities for appropriate technology offered by their processing. Pulses perhaps form a case apart. They are a particularly valuable source of protein, but tend to be stable "dry" products which are fairly easily stored.

More generally the special function of fruits and vegetables is to provide variety to the diet, and essential vitamins such as ascorbic acid (vitamin C), riboflavin, and thiamine. The particular problem which most fruit and vegetables pose for food supply is their rapid perishability, which may deprive the population, out of the harvest season, not merely of vitamins but also of the supplementary sources of the bulk nutrients - calories, proteins, and fats - which fruit and vegetables can provide. Pertinent to this issue is the recent statement of a joint FAO/UNICEF/WHO committee that "seasonal fluctuations in food distribution ... occur in many of the developing countries. It must be kept in mind that large seasonal shortages could have disastrous effects, particularly for children".[2] The preservation of perishable fruits and vegetables must therefore rank high in any list of priorities for food processing activities, with the proviso that the technology used must be appropriate, in the sense of providing the preserved products at low cost so that they can

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[1] 1976 production figures: cereals, 697 million tonnes; fruits and vegetables, 352 million tonnes; and root crops, 337 million tonnes. See table 3.

[2] "Methodology of nutritional surveillance: report of a Joint FAO/UNICEF/WHO Expert Committee", WHO, Geneva, 1976.

be afforded by the poor who need them most; and, if possible, doing this in a labour-intensive way that will provide jobs and incomes.

Fruit and vegetable preservation technology

The perishability of fruit and vegetables is caused by the action of enzymes and micro-organisms in the presence of air and the high internal moisture content of these foodstuffs. The spoilage processes are accentuated by light, and by high ambient temperatures. Losses of vitamins are particularly rapid, hence the emphasis traditionally placed on "freshness" of fruits and vegetables for consumption or use as raw materials for preservation. Eventually, the appearance, texture, and taste of the foodstuffs also deteriorates, followed finally by outright rotting.[1]

There are several principal methods of arresting the spoilage processes and so preserving the fruit or vegetable. The oldest and - in some forms - still technically the simplest of these is reducing the moisture content of the product to levels at which the spoilage agents become ineffective: in other words, drying, followed by appropriate storage. Historically, the next step was to sterilise the product of its micro-organisms by heat and seal it in airtight containers - usually tin cans - which protect it from renewed access by further micro-organisms. The third principal method is simply to freeze the product and keep it frozen until it is to be eaten: this is an alternative way of rendering the micro-organisms ineffective. It also more closely preserves the original texture and taste than does drying, but unfortunately it entails high capital costs and careful control of the "cold chain" that keeps the product frozen up to the point of consumption.

Certain other methods of preservation exist, notably "preserving" in sugared form, and irradiation. The former is usually limited to fruit, and it requires relatively high

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[1] The same processes, and the same methods of preventive preservation, can be found with root crops, notably potatoes. However, such crops are usually not as perishable as leafy vegetables and fruit, and can be cheaply and effectively stored for months in covered pits ("clamps"), or even - in the case of cassava - left in the ground. Typically, also, root crops are not so high priced as fruit and vegetables, and there is thus less incentive to spend time and money on their preservation by any other method than clamp storage. But although they are excluded from this study, it is worth bearing in mind that root crops can be preserved by the same methods as are described here for the preservation of fruit and vegetables.

capital costs and excellent raw material quality.[1] Irridiation kills the micro-organisms by exposing the fruit or vegetable to concentrated radiation, after which the product is appropriately packed or stored under controlled conditions to prevent renewed access of spoilage agents. Although it has been carefully researched technically and is claimed to have low energy consumption,[2] for application in developing countries it has the disadvantages of high capital cost and large scale which make it doubtful whether installations could be sufficiently well supplied with raw material. Also, sophisticated technology is involved, and the method has not yet been widely used even in the developed countries.[3] It must therefore be regarded as being still in the testing stage, though it may have an attractive potential for the future.

Preserving and irradiation are regarded as too limited in applicability for inclusion in the present study, which therefore concentrates on canning, drying and freezing.

Table 11 presents the core stages of the three processes as they are found in the preservation of vegetables. Minor modifications are found in fruit preservation: for example, in canning, boiling sugary syrup is often added to the fruit at the can filling stage, and less prolonged cooking is required than for vegetables.

Probably more important are the alternative techniques which are to be found within the three main technologies.[4] In

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[1] Ngoddy, P.O. (1974), "Industrial development in fruit and vegetable processing in Nigeria", in M.D. Wolfe (ed.), "Proceedings: Seminar on the Food Industry in West Africa" held at the University of Ghana, Legon, 28-29 March 1974, Legon, Ghana.

[2] "Proceedings of an International Symposium on Food Preservation by Irradiation" (1978), International Atomic Energy Agency, Vienna, Vol. II, p. 270.

[3] ibid., pp. 274, 386-7, 394-5.

[4] Two of these are not considered further here. The first is the substitution of glass jars for the more common can in "canning": this involves little material change in the process. The second is freeze drying, a sophisticated process in which the product is frozen and then dried under low pressure. This is an extremely costly process which is limited to high-value products even in developed countries; O'Brolchain, P. (1975) "Dehydration of vegetables and meat products", in "Proceedings of the International Food Industries Congress, London", Food Trade Press, London.

canning, the variation lies in the degree of mechanisation, which is usually associated with the speed of the line. At small scales, such operations as can-filling and labelling are done by hand, whereas high-speed canning lines use machines for almost all operations. Small-scale canning also has the advantage of permitting the use of an exhaust box, which evacuates the air from the unfilled space at the top of the can after filling and just prior to "seaming" (that is, sealing the lid or "end" onto the can). This technique ensures that no air is sealed inside the can. It is not practicable in higher speed lines, in which steam is injected into the unfilled space in order to expel the air. The steam flow injection method is said to lead to a shorter shelf life of the canned product.[1] Other important stages are cooling and drying. Before cooling, the seam may not be completely watertight. The can must be cooled quickly to prevent the possibility of entry of small amounts of surface water, and as an added protection the cooling water used must be chlorinated or pure. After these stages, the can has become both water- and airtight, and shelf lives of several months may be expected.

Drying techniques are very varied. The simplest - open-air drying in the sun - is not considered here. Although widely practised and obviously cheap, it does not produce uniformly reliable results, although it is sometimes perfectly satisfactory, in raisin manufacture for example. For other products, a considerable technical improvement - at a minimal investment cost - is the simple solar dryer. A small area is walled off with mudbrick walls about 70 cm high, and prepared vegetables are placed within the walls on trays. The whole is then covered with two separated layers of transparent polythene stretched over a woooden frame. This device, by a "greenhouse effect", increases the air temperature inside the walls to a maximum of 60-70°C in hot sun.[2] This cuts drying times to as little as three hours, reduces vitamin loss, and kills off many of the micro-organisms in the fruit or vegetable matter. The

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[1] "With these high-speed lines, people seem to have got away from the original idea of canning, which was preservation: it's become a container." Private communication from a major can and canning machinery manufacturer.

[2] McDowell, J. (1977), "Appropriate technologies for tackling malnutrition", Conference Paper, National Institute of Nutrition, Hyderabad, India, 17-21 Nov. 1977. Reproduced in "Contact 45", Christian Medical Commission, World Council of Churches, Geneva, issue of June 1978.

dried product may then be satisfactorily stored in thin-walled cement jars[1] which may also be cheaply made on a small scale.[2]

Should the heat of the sun not be strong or constant enough at the harvest season for reliance on the solar dryer, a simple artifical dryer fired by wood or crop wastes may be used. The product is dried on trays in hot air rising from a fire in a pit. A shed is erected over the drying area to keep off rain, and oil drums may be used as fireboxes.[3] The dried product may be stored as before in cement jars, or packed in smaller lots in sealed plastic bags.

Larger-scale methods are no more than sophisticated, controlled, and mechanised variants of the simple artificial dryer. Two such methods are analysed in this paper. Both employ steam scalding prior to drying, and even out the temperature and moisture content of the dried product in "conditioners". The product is then packed mechanically in plastic bags which seal out moisture; varying degrees of mechanisation are employed in preparing the product for drying. Lower-speed lines use tray dryers, the trays being moved progressively by hand from the upper to the lower levels of drying racks. High-speed lines use moving steel belts, the drying products falling or "cascading" from one level to another.[4] Both methods aim to achieve control of the drying process into defined stages corresponding to the degree and location of the moisture still in the product.[5]

Industrial freezing of fruits or vegetables is usually practised on a large scale. Though variants are possible,[6] only one method is analysed here, a mechanised preparation and packaging line, followed by bed-freezing and a refrigerated cold store. The product must then be transported to the market in refrigerated transport and kept frozen in refrigerated

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[1] Dried fruit and vegetables should be stored in opaque containers or otherwise protected from light, since exposure to light reduces riboflavin content. Ngoddy, op. cit.

[2] McDowell, op. cit.

[3] McDowell, op. cit.

[4] O'Brolchain, op. cit.

[5] ibid.

[6] Astrom, S. (1975), "Technology and economics of food freezing", in "Proceedings of the International Food Industries Congress, London", op. cit.

warehouses, retail cold stores and freezers, and perhaps in domestic refrigerators as well. With so many links in this long "cold chain", it is eminently susceptible to failure at some point or other and would almost certainly be too expensive to serve as a method of food supply to the poor.

No preservation method is perfect. Even frozen food in a faultless cold chain has a limited shelf life.[1] The essential technical requirement from the point of view of meeting basic needs is preservation of the product in palatable for several months, the "off" season when fresh fruit and vegetables are expensive or unobtainable. This requirement is met by all the methods described above, provided normal care is taken in hygiene and the details of the processes. The other issue is nutrient conservation, particularly of vitamins. The matter is well summarised by Ngoddy,[2] who (in an article otherwise favourable to drying) admits that, while conservation with canning and freezing is "good" or "very good", with drying "there are difficulties with labile components such as carotenoids and ascorbic acid which are sensitive to oxidation; riboflavin is unstable to light and thiamine is destroyed by SO_2".

Ngoddy states that as a consequence "nutrient retention is therefore very closely associated with storage conditions", i.e. away from heat, light, moisture and - as a last resort - air.[3] However, he concludes that "(the) nutrient level (is) considered acceptable".

Economic comparisons of vegetable preservation projects

Table 12 presents summary schedules of inputs and outputs for eight vegetable preservation projects applying different technologies at varying scales of operation. They are based mainly on data privately communicated by UK food processors and

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[1] ibid.

[2] Ngoddy, op. cit.

[3] O'Brolchain, op. cit., states that "Oxygen also can also cause spoilage, and this is particularly true in the case of freeze-dried products. Air-dried products are not so susceptible to spoilage by oxygen and, under normal conditions, most air-dried foods will store for more than a year, provided they are packed in such a way as to prevent excessive moisture pickup. In order to achieve very long storage life for air-dried foods, they should be packed in an inert atmosphere".

equipment manufacturers.[1] Attempts have been made to adjust operating coefficients to reflect developing country conditions, in particular by assuming lower labour productivities, and to check the adjusted coefficients against observed developing country productivity in other industries with similar operations.[2] It is possible however that the required manning levels have been understated for the freezing and continuous belt-drying projects and overstated for the modern tray dryer.

Each fruit or vegetable entails different schedules of inputs and inputs, particularly in respect of the weight-ratios between raw material and finished product. The schedules presented may be taken as typical of hard vegetables such as carrots. Other fruits and vegetables have different dried weights, and most canned fruits require a considerable input of sugar. In practice, a preservation plant processes various fruits and vegetables during the course of the year to achieve a reasonable level of capacity utilisation, and Ngoddy[3] presents a narrow spread of unit processing costs for the various products handled by a Nigerian canning plant. The schedules presented may therefore be taken as representative of those which apply for most fruits and vegetables, with the qualification already noted of sugar inputs to fruit canning.

Table 13 summarises the processing costs estimated on the basis of the schedules. (Note that no costs are included for the raw vegetables themselves: the estimates are of the additional costs attributable to preservation.) Of the three main methods, drying is evidently the cheapest and canning the dearest, with freezing occupying an intermediate position. The direct comparison of in-plant processing costs is however unduly favourable to freezing, because subsequent costs in the cold chain are obviously very high. A hint of these extra costs is given by the inclusion of transport costs at the foot of the table. Part of the increase in relative cost this entails for freezing is due to the larger scale of the project;

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[1] The source for the solar dryer is McDowell, op. cit., supplemented by privately communicated information from UNICEF officials. For the source of data on the wood-fired dryer, see the case study on fish preservation.

[2] For example, the manning levels assumed for the large canning plant are 1.3 x manning per can per hour observed in developing country beer-canning lines. See also the case study on fish preservation.

[3] Ngoddy, op. cit.

the average assumed transport distances are 400 km for freezing and 200 km for the large canning and drying projects. However, a substantial part is also due to the higher cost of refrigerated transport per tonne-km.[1] Yet the transport cost differential gives only a hint of the total premium to be added to in-plant freezing costs, which is likely to be quite substantial.[2] Even so, the final costs of freezing are unlikely to be as high as those of canning. On the other hand, the disadvantage of freezing include the absence of electricity supplies in rural areas, the insecurity of the cold chain, and the need for a substantial household capital investment, viz. a refrigerator. A poor family may be able to afford a few kilos of canned vegetables per annum but not US$120 or so for a domestic refrigerator. Because of this high initial cost, frozen foods are cheaper than canned, only to those people who can afford to eat substantial quantities of them.

On the other hand, the costs of canning are vastly greater than those of drying.[3] High canning costs are largely due to the costs of cans themselves, US$305 per tonne of prepared vegetable input. Although canning preserves food well and has Althe advantage (at least vis-à-vis freezing) of being practicable on a small scale, it is unfortunately a very expensive method of preservation.

Turning for a moment to the size of projects, there are no marked economies of scale. In canning, these economies are insignificant at low wages and only moderate at high wages. In drying, the assumption of high wages gives a cost advantage to the larger of the two "modern" projects over the smaller, but in any case both have far higher costs than the small drying projects, in particular the very small solar dryer which has the lowest costs of all.

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[1] Normal road transport: 4¢ per tonne-km; refrigerated road transport: 6.5¢ per tonne-km. No allowance has been made for the weight of packaging materials for any of the three projects.

[2] For example, it has been estimated that the cost of extending the shelf life of food with a refrigerator is 0.4¢ per lb-day; "Proceedings of an International Symposium on Food Preservation by Irradiation", op. cit., p. 270. Thus, every day the frozen product remains in the shop or home (supposing the household can afford a refrigerator in the first place) adds almost US$9 a tonne to preservation costs.

[3] This result confirms the similar conclusion of Ngoddy (Ngoddy, op. cit.).

Cost differentials such as those observed in table 13 are so great that where the processing of a basic foodstuff is concerned, they must render the least-cost technique "appropriate", unless other considerations - employment generation, energy use, nutrition for example - weigh very powerfully against it.

The differential employment opportunities offered by the various projects, although not insignificant, are not sufficiently large to affect the balance of judgement. Non-managerial employment per million tonnes of prepared input ranges from 5,926 jobs for continuous belt drying, to 12,500 for solar drying, 23,210 for small-scale canning, and up to 33,333 for modern tray drying.[1] As regards energy consumption, the least-cost technique makes no demands on energy sources other than sunlight itself. It may be noted however that if the wood-fired dryer must be used in its stead, the fuel requirements would be substantial, over 420,000 tce per million tonnes of prepared input. At first sight indeed, drying compares unfavourably with canning in respect of energy consumption. The average tce required per million tonnes of input is 335,000 for the three non-solar drying projects, 75,000 for the canning projects. But, as is well known, the energy content of canned foods resides mostly in the can itself: one estimate[2] translates into 1,440,000 tce per million tonnes of input as the energy content of cans, versus 394,000 tce for plastic bags used for packaging dried or frozen products. Thus, although there is a case for attempting to improve the thermal efficiency of simple wood-fired dryers where in those countries in which the climate does not permit the effective use of the solar dryer, there are still no grounds for supporting canning as an energy-saving technique.

There remains, finally, the issue of nutrient retention. Vitamins can be lost both before and after "preservation". The larger the processing plant, the further afield it must gather its raw material, and the more complex becomes the problem of delivering the raw product, still "fresh", for preparation and processing. This is a disadvantag that smaller projects - including of course the solar dryer - do not have. On the other hand, small projects have their own disadvantages. In canning, besides its high costs, there may be a problem in obtaining the pure or chlorinated water required for the process. In drying, there is the question discussed above of nutrient retention during storage. The problem can be

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[1] As noted above, the manning requirements for modern tray drying may be somewhat overstated.

[2] Cans 3880 Kw-hr per ton of canned output, plastic bags 1,360 Kw-hr per ton of frozen output. See Astrom, op. cit.

exaggerated: the reader may recall the comments of O'Brolchain, and the favourable conclusion of Ngoduy that nutrient levels were "acceptable". In view of its very low costs, solar drying - even in its present form - may therefore be considered the appropriate technique for preserving fruits and vegetables.

This is not to say, however, that further low-cost technical improvements are to be neglected. In particular, the possibility may be considered of packing the dried products from small-scale dryers in plastic bags which would then be stored inside cement jars. The bags might themselves be sealed to exclude ambient moisture, by a simple heat-sealing device, perhaps a suitably shaped metal tool heated over a cooking fire.

4. Milk processing

Milk contains significant quantities of all the major bulk nutrients - carbohydrates, proteins and fats. This is hardly surprising when we recall that the milk of each mammalian is a complete food for the infant animal. Table 14 gives the approximate bulk nutrient contents of the milk of the cow and the buffalo, the two principal milk producers in the developing world.

Table 14: Typical contents by weight of selected whole milks

Animal	% Water	% Fat	% Protein	% Lactose (milk sugar)
Cow	87.0	3.9	3.5	4.9
Indian buffalo	82.7	7.4	3.6	5.5
Egyptian buffalo	82.1	8.0	4.2	4.9

Source: "Encyclopedia Britannica: Macropedia, Vol. 5", article on "Dairying and dairy products", Chicago, 1974 edition.

Whole milk may of course be drunk as it is but is eminently suitable for processing into derivatives. Cream is artificially fat-concentrated milk; its complement is skim milk, from which almost all fat has been taken in the making of cream or butter, a derivative of cream consisting of 80 per cent fat and 20 per cent water. Butter may be processed further into ghee (clarified butter), which is 100 per cent fat and is widely used for cooking. Whole milk may also be made into cheese, a concentrate of fat and protein, leaving a residual, whey, which is usually fed to animals. Either whole or skim milk may be dried, and whole milk may be concentrated by evaporation, with or without the addition of sugar, to form respectively sweetened condensed milk and evaporated milk. Whole milk and skim milk can also be reconstituted, the latter from its dried form alone, the former usually from dry skim milk plus butter oil, a 100 per cent fat product identical in composition to ghee. Finally,[1] whole raw milk and skim milk may be pasteurised or even sterilised to remove micro-organisms and to increase storage life.

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[1] The range of milk products is by no means exhausted by the partial list given here. Further products include yoghurt, ice cream, and kumis (fermented mare's milk).

Considerable amounts of milk and milk products are produced in the developing world, as table 15 shows. The table also indicates a rather heavy geographical concentration in a group of developing countries in Southern Asia and the Middle East (and in Argentina, a temperate developing country long associated with cattle). In these countries, too, a higher than average proportion of the fresh milk is processed into the major milk products.

Given the diversity of milk products, some concentration on a limited range is essential. Attention is accordingly focused on the technology and costs of milk pasteurisation and butter-making projects based on local fresh ("raw") whole milk, although some broader comments are offered on the costs of milk products.

Technology of milk pasteurisation and butter/skim milk production

Table 16 is a flow chart of a typical process for pasteurising and packing whole milk, with the additional possibility of using some of the pasteurised whole milk to make butter and skim milk. The latter may be packed and sold in liquid form immediately after its production; or it may be dried and sold in its dry form; or the dry product may be held in cold storage until it is required for sale in liquid form, at which time it is reconstituted and packed. This option is useful during lean periods of the year for raw milk production and is assumed in the analysis below for the alternative project in which butter is produced.

Process details may vary considerably. For example, milk homogenisation (achieved by forcing the milk through tiny holes which break up the butterfat globules) is optional, as also is the pasteurisation and salting of butter. There are various methods of drying skim milk, of which the steam-heated drum dryer is probably the simplest; and of pasteurising milk, which may be effected by steam or hot water heating or by infra-red radiation.[1] In addition, the liquid milk may be packed in a variety of containers, for example returnable glass bottles, throw-away rigid plastic bottles, cardboard cartons, or plastic bags. The last option is assumed in the subsequent analysis, since it is the cheapest unless very good recovery and re-use rates can be achieved for glass bottles.

Perhaps of greater significance than the above alternatives are the conditions under which dairies must

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[1] <u>Sterilisation</u>, which allows storage of milk for long periods, is a different procedure which exposes the raw milk to much higher temperatures (ca. 130°C).

operate. Typically, they receive milk every day of the year, perhaps twice a day following morning and evening milkings, but they do not achieve a high utilisation rate over a 24-hour period. Also, efficient raw material delivery and packed product despatch - usually in the dairy's own trucks - are vital, since both raw and pasteurised milk spoil rapidly in high ambient temperatures. Finally, it is of course essential to secure a sufficient supply of raw milk. This may seem an elementary point, but dairies in developing countries are often grossly under-utilised because they have over-estimated available milk supplies, or because they cannot or will not pay high enough prices to ensure adequate supplies.[1]

Economic comparison of milk-processing projects

Table 17 presents summary schedules of inputs and outputs in four milk-processing projects of widely varying scale. At the largest scale, which implies a very large project by developing world standards, two variants are considered. The first uses a fifth of its milk input in making butter and skim milk; the latter then is dried, stored, and later reconstituted and sold in liquid form. The second variant, like the two smaller projects, simply pasteurises and packs all its raw whole milk input. The schedules are largely based on data privately communicated by Swiss and French dairies and equipment manufacturers, although use has also been made of UNIDO profiles of dairies in developing countries.[2]

The technology used in the large and medium projects is standard, but the small project uses an integrated set of equipment developed by an equipment manufacturer in France, a country which abounds in very small-scale dispersed dairies. It is designed for largely manual operation by a handful of people, and the equipment may even be mounted on a truck if desired. It has a further interesting feature, pasteurisation by direct infra-red irridation of the milk. This obviates any need for a steam-raising boiler, but on the other hand increases the unit's reliance on electricity supplies, which

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[1] See, e.g., ILO (1976), "Economic transformation in a socialist framework", ILO, Addis Ababa, Technical Paper No. 4, "Dairy industry", for problems in Somalia; and S.M. Wangwe (1975), "The problem of under-utilisation of capacity in industry: A case study of the Mara dairy industry", University of Dar es Salaam, Econ. Res. Bur. Paper 75.4, Dar es Salaam.

[2] UNIDO, "Food processing industry", UNIDO Monograph on Industrial Development No. 9, UN, New York, 1969, pp. 44-48.

may be unreliable or even (in more remote developing country areas) unavailable. All the projects are assumed to pack their pasteurised milk in plastic bags, and to collect and deliver milk in their own trucks.[1]

Table 18 presents costings for the projects. A raw milk input price of 20 cents per litre has been assumed, based on Indian price levels, and NPVs have been calculated on the basis of a 25 per cent mark-up - to 25 cents per litre - for pasteurised whole milk.[2] This is a "test" mark-up, used to determine whether or not milk-processing plants can be profitable while not raising too much the price of a "basic" foodstuff.

The table indicates that they cannot: all the projects make losses, which are particularly heavy at high wages. Nor is the incorporation of butter and skim milk production into large projects a profitable venture. The combined revenue from butter and skim milk is actually less than would be obtained by simply pasteurising and selling the whole milk. In combination with the higher costs entailed by the addition of butter-making and packing lines and milk-drying equipment, this results in heavy losses for butter/skim milk production: negative NPVs of US$3,010,000 at low wages and US$3,685,000 at high wages.[3] The "break even" butter prices (those producing zero NPV at a 10 per cent discount rate) would be US$2.72 at low wages and US$2.89 at high wages; implying price increases of 36 per cent and 44 per cent respectively, over the US$2 assumed. It would certainly be technically easy to incorporate butter making (though not skim milk drying) even at the smallest project scale, but, in view of its unprofitability at the large scale, no further analysis was carried out.

Even if milk pasteurisation alone is considered, large projects have no very impressive cost advantages over small ones. The processing costs per litre of pasteurised milk (covering, as usual, the 10 per cent real return on investment implied by the 10 per cent discount rate) at the three project scales are, in US cents:

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[1] At the small scale, one truck is required; at the medium scale, ten; at the large scale, with a significantly larger catchment area, 90.

[2] Butter is priced at US$2 per kg., and liquid skim milk at 15 cents per litre.

[3] These losses would be higher still if the energy costs of drying milk were included but, as noted in table 17, no satisfactory allowance could be made for these costs.

Small plant		Medium-scale plant		Large-scale plant	
Low wages	High wages	Low wages	High wages	Low wages	High wages
6.5	9.0	8.3	11.0	6.0	7.5

At low wages in particular, the small project compares quite well on costs with the large one, with the medium-scale plant emerging as a high-cost alternative. It is possible moreover that the costs of the small project have been over-stated, and those of the large one understated. Labour productivity for the small project has been assumed at less than half French levels; and at such a small scale an economy in energy costs could probably be effected (if with some increase in investment costs) by the incorporation of a diesel electric generator, which would have the additional advantage of releasing the plant from dependence on restricted and unreliable mains supplies. On the other hand, the labour productivity assumed in the large project, while considerably below European levels, is much higher than that indicated by the UNIDO profiles, which also suggest a somewhat higher machinery investment cost than is assumed here.[1]

However it is probable that a more important disadvantage of the large project is its very scale, with the accompanying problems of finding an area with sufficient raw milk supply and then organising its uninterrupted collection and transport. These problems are not insuperable; even larger dairy projects than that analysed here are successfully operated in developing countries, notably the well-known Gujerati co-operative in India.[2] But India is a traditional milk-producing country with a high population density: in other developing countries, unless very careful attention is paid to potential milk supply and raw milk pricing policy, the most likely result of

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[1] UNIDO, op. cit., p. 48, shows, for an Indian milk products plant of about 140,000 litres per day capacity, direct production labour of 831 people, versus 245 assumed here; though some of the difference may be explained by the greater complexity of the Indian plant, together with its two-shift operation of some portions. That part of its equipment necessary for milk pasteurisation and packing is valued at 9 million Rs. in 1964 replacement terms. Allowing for inflation, this translates to about US$3.3 million, versus US$2.12 million assumed here.

[2] "Encyclopedia Britannica", loc. cit. The Amul dairy, based on a milk producers' co-operative supplying buffalo milk, receives 500,000 litres per day, sending 200,000 of these daily to Bombay, over 300 km. to the south.

establishing a large dairy project is chronic and massive under-utilisation due to a shortage of raw milk input. A vicious circle of causality may thus be set in train. Because it is under-utilised, the project has high unit processing costs which its management may attempt to cover by paying the milk producers low prices while charging high prices for its output. Rather than pay such high differentials, the public will buy raw milk from the producers direct, thus further exacerbating the supply problem of the dairy.[1] It is worth noting in this connection that halving the assumed utilisation (in terms of daily raw input) of the large project would result in a near-doubling of its unit processing costs, to about 10 to 12 cents a litre at low and high wages respectively.

In most circumstances therefore, it seems that if milk pasteurisation is to be attempted in the developing countries, small projects are most appropriate. Besides their basically competitive and quite possibly lower costs, they may provide slightly more jobs (about 9,600 non-management jobs per 1 million tonnes of raw milk input per annum, versus about 6,800 for large projects) and consume considerably less energy (76,600 tce per 1 million tonnes raw milk versus 136,100 tce for large projects), at the cost of higher requirements for fixed assets (US$124 million vs. US$89 million). They have of course the additional advantage of possible dispersion into rural areas.[2]

There must however be some doubt as to whether an extensive milk-processing industry, whatever its technology, is appropriate in many developing countries. It is significant that while the share of the developing countries in 1976 world cereal production is 48 per cent and of root crop production 60 per cent, their share of milk production is only 21 per cent.[3] Milk and milk products are, relatively speaking, luxuries in developing countries. In the recent survey of Kabul households already cited, milk was not a recorded item of consumption for the lowest-income group. For the next lowest group, it was recorded for 22 per cent of households, for the group above that, only for 33 per cent of households. Only in the highest

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[1] Precisely this cycle was diagnosed in Somalia; ILO (1976), loc. cit.

[2] The diesel electric generators this would probably entail would still further increase project fixed asset requirements: but mains supplies are of course not without their own heavy fixed investments, even though these are not within the dairy industry.

[3] "FAO Production Yearbook" (1976), loc. cit.

of the four income groups was milk drunk in every household, and only in one of 50 households - that with the second-highest per capita income in the whole sample - was consumption of butter recorded.[1]

The main reason for this "luxury" status of dairy products is unquestionably that they are very expensive. In India, for example, ghee (clarified butter) is double the price of its substitute based on vegetable oils, vanaspati.[2] This price ratio exceeds even the corresponding difference found in Europe between butter and margarine. Nor is milk itself a cheap source of nutrients. The solid bulk nutrient content of a litre of liquid whole cow's milk is about 120-125 g. At a milk price of US$0.25 per litre of pasteurised milk, this implies a price per tonne of bulk nutrient of US$2,000 or more, whereas most dry cereals are priced in the range US$150-300 per tonne. Moreover, 25 cents per litre is a relatively inexpensive price for cow's milk. The end-1977 price for whole milk in the UK was 38 cents per litre; in Somalia, 53 cents per litre.[3]

Milk might perhaps be prized for its protein or fat content. But the price ratios of ghee to vanaspati and of butter to margarine indicate that butterfat is an expensive fat source. Moreover, an imputed price of protein in milk may be calculated by valuing the fat content at vanaspati prices, and the lactose at the price of sucrose (common sugar). It is assumed that a litre of whole cow's milk costs 25 cents and contains 35 g of protein, 39 g of fat and 49 g of lactose. The fat is valued at US$1,300 per tonne, and the sugar (lactose) at US$500 per tonne, in accordance with July 1977 Indian retail prices.[4] The imputed price of milk protein is then US$4,970 per tonne, which compares very unfavourably even with the price of meat, at about US$1,000 per tonne.[5] A similar calculation for dry skim milk sourced in the developed countries shows an

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[1] "Survey of 50 Kabul households", op. cit.

[2] Government of India, "Monthly abstract of statistics", table of all-India average retail prices. July 1977 prices, US$ per kg: ghee, 2.61; vanaspati, 1.32.

[3] Retail prices: UK, personal observation; Somalia, ILO (1976), loc. cit., 1976 price for raw whole milk on the open market, increased by 3 per cent to allow for local price inflation.

[4] Government of India (1977), loc. cit.

[5] ibid., loc. cit.

imputed protein price of US$2,200 per tonne, even though the skim milk price is 1976 ex-Netherlands[1] and no allowance is made for inflation or for freight costs to the developing countries and distribution costs within them.

Thus, at market prices, the mass consumption of milk cannot be recommended as a cheap source of nutrients. Under farming or cultural systems where the keeping of milk cattle has little opportunity cost, or is sanctioned by religion, their milk is of course to be welcomed and used as a supplement in rural nutrition. But the deliverate encouragement of commercial milk production should be recognised for what it is: an encouragement of luxury consumption of a costly source of nutrients,[2] which has a high cost in terms of alternative production of cheaper foods or cash crops generating income and employment for the agricultural population.

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[1] "FAO Production Yearbook" (1976), section on prices. Export price of dry skim milk US$1,060 per tonne. Nutrient contents per kg: fat, 8 g; lactose, 523 g; protein, 359 g; "Encyclopedia Britannica", 1974, loc. cit.

[2] The mass pasteurisation of milk might perhaps be advocated on medical grounds, i.e. improving the health of the people, and subsidised on that basis. An unrecovered processing cost of 6 to 10 cents implies however a massive subsidy, which would bring no benefits to a large proportion of the very poor. Moreover, the investment costs would be very large when compared to the rather meagre health budgets of most developing countries.

5. Fish preservation

In terms of calories, fish provides less than 0.2 per cent of world food requirements, but it accounts for about 20 per cent of the animal protein in the human diet.[1] The world catch in 1975 was 70 million tonnes, an amount that was no greater than it had been in 1970. However, the catch used for human consumption rose during the interval by 11 per cent to 49 million tonnes. A further 6 million tonnes are estimated to be caught annually by subsistence fishermen.[2]

More than nine-tenths of the total catch came from salt water.[3] Thus, in the absence of fish preservation, access to this important protein source is very restricted in inland areas. This is particularly true in the developing countries, in which communications between the coastal fishing areas and the interior are unlikely to be as rapid and easy as they are in developed countries, and high ambient temperatures accelerate the spoilage of fresh fish. Much fish is in fact preserved: in 1975, 8.1 million tonnes were smoked, dried or salted, and 7.2 million tonnes were canned.[4]

Fish canning in developing countries is often thought to be almost exclusively for export to the developed countries, on the model of the large Moroccan export industry. Several Latin American countries, however, can large quantities of fish without a correspondingly large export trade: for example, Mexico's 1975 canned sardine output was 58,000 tonnes, whereas exports of all fish products were only 1,000 tonnes;[5] Moreover, a study of basic needs in Swaziland listed "tinned pilchards" among the items of a "minimum daily diet".[6]

It is therefore worth while to consider the possibility that canning fish for domestic consumption is or may become a widespread activity in developing countries, and to compare its appropriateness with that of fish curing, a technically simple

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[1] Borgstrom, G. (1973), "World Food Resources", Intertext, New York.

[2] FAO Yearbook of Fishery Statistics (1975), Vol. 41.

[3] Borgstrom, op. cit., pp. 83-96.

[4] FAO Yearbook of Fishery Statistics, op. cit.

[5] ibid., tables E1-2 and E2-1.

[6] Szal, R. and Van der Hoeven, R. (1976) "Inequality and basic needs in Swaziland", WEP Working Paper, ILO, Geneva.

set of processes including drying, salting and smoking. Cured fish may be kept for several weeks after they are caught, even in tropical climates, so that canning and curing are both technically able to conserve a valuable animal protein supplement for consumption in inland areas of developing countries. A comparison of the two methods is given added point by the recently-increased productivity of "traditional" coastal fishing following the adoption of small outboard motors and tough synthetic fibre nets.[1]

Fish preservation technology: smoke drying and canning

In traditional smoke drying, the fresh fish is placed above a wood fire, where it dries and cooks, acquiring a smoky flavour. In primitive drying chambers, the process is hard to control, wastage rates are high, and the product's subsequent durability and price are often low. However, simple design improvements at low investment cost have been shown to sharply increase yields and product quality.[2] Tropical fish may thus be uniformly smoke dried in simple wood-fired "ovens" - cabinets made of brick and wood and housed in sheds - with minimal losses, over a cycle which is determined largely by experience but is of the order of 15 hours. Batch sizes range up to almost 300 kg of fresh fish input, and the final weight of the dried product is about one-third of the fresh weight.[3] After cooling, the smoke-dried fish may be packed in boxes for despatch to market.

As with fruit and vegetables, it is possible to can fish on a very small scale, but the typical fish cannery in developing countries as elsewhere is a large-scale mechanised enterprise with a high investment cost and a high rate of daily utilisation, but often working only for a limited season of the year according to the availability of fish. The catch may be pumped directly from the holds of large fishing vessels into the cannery, after which the canning process differs only in detail (for example, the fish is "cooked" before the can is sealed) from that already described in the study of fruit and vegetable preservation.

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[1] FAO (1971), "Equipment and methods for improved smoke drying of fish in the tropics", Fisheries Technical Paper No. 104, FAO, Rome.

[2] FAO (1971), op. cit.

[3] ibid.

Economic comparison of three fish-preservation projects

Table 19 presents summary schedules of three projects, two smoke-drying fish on a small scale, and the third a large fish cannery. They are based, as regards smoke drying, on the FAO study of improved smoke-drying techniques cited above;[1] as regards canning, on the same UK sources as the study of fruit and vegetable preservation, checked against a USAID "profile" of a sardine cannery,[2] and (for manning levels) a study of developing country breweries.[3]

In the cannery, each kg of small fresh fish is assumed to be converted into a net can content of 1 kg, of which 0.65 kg is the edible portion of the fish, 0.12 kg is edible (coconut/groundnut) oil, and 0.03 kg is salt. In smoke drying, every kg of (small to medium-sized) fresh fish is converted into 0.33 kg of dried product. This contains the entire edible portion of the fish, which in turn would be (on a fresh weight basis) 0.80 kg per kg of the original fresh fish. Thus, each kg of "net can contents" is equivalent to 0.85 kg of fresh weight of edible fish, and each kg of dried fish is equivalent to 2.40 (3 x 0.80) kg of fresh weight of edible fish.

Table 20 presents the comparative cost and revenue analysis for the three projects. As with fruit and vegetable preservation, small-scale drying is much cheaper than canning, with the slightly larger (B) project lower cost and more profitable than the single-oven (A) variant. The cannery is even more (about four times per tonne of edible fresh fish weight) profitable than the (B) project; this results from the

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[1] ibid. The investment, labour and energy requirements for the larger of the smoke-drying projects were adopted above, for costing purposes, as the requirements for the wood-fired vegetable-drying project in the study of fruit and vegetable preservation. The process details are of course not identical, but it was thought that this would provide a fair approximation of the fixed asset, labour and energy costs of wood-fired vegetable drying.

[2] USAID (1967), "Canning sardines", Industry Profile No. 67376, Government Printing Office, Washington, D.C.

[3] Keddie, J. and Cleghorn, W.H., "Brewing in developing countries", Appendix III, Scottish Academic Press, Edinburgh (forthcoming, 1978).

very high price of canned fish.[1] If cost prices per tonne of edible fresh fish equivalents are calculated for the cannery and the smoke-drying (B) project at low fresh fish prices, with the costs of edible oil and salt excluded from the cannery costs, the following pattern is observed.

Cost prices, US$ per tonne, of edible fresh fish

	Smoke drying (A)	Smoke drying (B)	Cannery
Low wages	286	269	677
High wages	342	290	689

These prices may be compared with the price per tonne of edible fresh fish inputs, US$218 for the smoke-drying projects and US$205 for the cannery. The processing costs of canning are clearly much greater than those of drying; as with fruit and vegetable preservation, the cost of cans alone (US$353 per tonne of edible fresh fish) accounts for much of the differential.

There can be little doubt that smoke drying is the appropriate technique of fish preservation for distant inland markets. Where preservation for later local consumption is concerned, the solar dryer previously described would almost certainly be appropriate. It can be used for drying fish but it is not known whether fish so dried would be preserved over long journeys in boxes. Thus the technique has not been considered in this case study.

With respect to energy consumption, the same considerations apply as were discussed in the study of fruit and vegetable preservation; there is little point in repeating the discussion based since the actual figures are only marginally different. The same conclusion emerges that although efforts to increase the thermal efficiency of wood-fired drying are to be welcomed, canning is a much more energy-intensive technique.

Smoke drying also provides greater employment opportunities. Smoke drying (A) projects require, per million tonnes of edible fresh input, 46,300 non-management workers; smoke drying (B) projects require 23,100; and canneries 9,000.

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[1] The "low" preserved fish prices per tonne of edible fresh fish are US$1,090 for canned fish as opposed to only US$362 for smoke-dried fish. No "high" price regime is known for canned fish, since canneries tend to operate on the basis of large-scale low-cost fish supplies. The "alternative" NPVs show the profitability of drying at high prices.

To these differentials may possibly be added a premium, since smoke drying has lower investment costs,[1] and the savings in this respect might be used to create jobs in other industries or sectors.

With all these advantages - much lower cost prices, lower energy consumption, lower investment costs, higher direct employment - smoke drying is to be strongly preferred over canning as a method of preserving fish and thus providing a welcome cheap protein supplement to inland diets in developing countries. Even where conditions permit large-scale fisheries with geographically concentrated landings, the catch may be processed by a cluster of small smoke-drying enterprises adjacent to the fishing harbour rather than by a large cannery.

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[1] Investment costs, in US$ per million tonnes of edible fresh fish input, are: for smoke drying (A) projects, 55.6 million; for (B) projects, 34.1 million; and for canneries, 80.5 million.

6. <u>Beer brewing</u>

The last of these case studies deals with the brewing of beers, and in particular with lager, the predominant type of European-style beer. It will be news to no-one that beer is primarily consumed as an intoxicant, and an over-solemn discussion of its nutritional role would be out of place.

Nevertheless, European-style brewing is a substantial food processing industry in developing countries. Apart from the stricter Moslem nations, few among them are without lager breweries, although consumption per capita is still much lower than in developed countries.[1] The brewing of 100 million hectolitres of beer of the strength usually found in developing countries requires an input of about 1.8 million tonnes of grains, mostly malted barley, which usually entails a considerable import bill in hard currencies. The 1974 ex-brewery value of European-style beer production in the developing market economies has been estimated at US$4,500,000 net of excise taxes, which probably provide an almost equal sum as government revenue.[2] Moreover, the typical brewery of European-style beer is a large modern production unit using several million US$ of almost exclusively imported equipment. Such breweries are usually found in the large cities, where they often pay even higher wages than other large modern plants. Lastly, the industry has been growing rapidly in recent years, with an estimated annual increase of output of 8.3 per cent between 1963 and 1972 in the developing market economies.[3]

The above remarks refer to European-style beers - predominantly lager - based on malted barley ("malt") and bittered with hops. The term "beer" may however be used to cover all fermented drinks based on foodgrains, and there are in the developing world many "traditional" beers brewed from local grain, notably sorghum, millet and maize. These beers are most often made on a very small scale, although large-scale

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[1] The total production of European-style beer in the developing market economies in 1974 has been estimated at 100 million hectolitres (a hectolitre is 100 litres, or approximately 0.1 tonnes); Keddie and Cleghorn, "Brewing in developing countries", op. cit. For comparison, West German production was 87 million hectolitres in 1973, "The growth of world industry", 1973 Edition, UN, New York, 1975.

[2] Keddie and Cleghorn, op. cit.

[3] ibid.

commercial production is also practised in southern Africa.[1] They are very different in appearance and texture from lager,[2] a clear sparkling drink from which great care has been taken to remove even the protein content of the original malt.[3] In contrast, the traditional processes leave the whole nutrient content of the foodgrain in the beer, often including even the grain husks, which in lager brewing are filtered out and sold to local farmers as animal feed. The principal disadvantage of the traditional beers is their short shelf life. Unlike lager, they are sold (and consumed) while still fermenting, and must be drunk within a few hours or days of sale before the uncontrolled fermentation produces an unacceptable taste.

The discussion below will concentrate mostly on lager brewing, but some attention will be paid to one variant of traditional beer.

Brewing technology

European-style beer - lager for present purposes[4] - is brewed in a lengthy and complicated process which may be summarised here only briefly. The malt and "adjunct" foodgrains (typically processed maize) are milled and mixed with hot water to convert the grain starch into sugars. The grain husks are then filtered off, and the filtrate boiled with hops, which give the beer its bitter flavour. The resulting "wort" is again filtered, cooled, and collected in vessels, to which yeast is added to convert the sugars into alcohol. After this fermentation stage, the beer is transferred to other vessels for "conditioning" in cold storage; this removes the residual protein along with harsh flavours. It is then carbonated, and filtered again before it is ready for bottling, the normal packaging process in developing countries.

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[1] Novellie, L. (1968), "Kaffir beer brewing: ancient art and modern industry", Wallerstein Laboratories Communications, 31, 17-29.

[2] A European brewer in East Africa once commented upon a local variant to the author thus: "It's not really beer at all - more like liquid food".

[3] To leave the protein would result in a "haze" in the beer.

[4] The differences between the process for brewing lager and those for other European beer variants are relatively minimal. For a discussion of stout - the other principal European beer found in developing countries, see Keddie and Cleghorn, op. cit.

In the bottling hall and its associated stores, new and returned bottles are taken from delivery vehicles in crates or cardboard cartons, stored empty, unpacked, filled with beer and sealed, passed through steam or hot water to pasteurise the beer, then labelled, packed again in crates or cartons, stored full, and despatched in delivery vehicles.

The brewery also requires various services: steam, for boiling the wort and pasteurising the bottled beer; refrigeration for cooling the wort, and maintaining low temperatures during fermentation and conditioning; and others, including electricity, engineering maintenance, and a laboratory to provide the precise process and quality controls needed.

From this brief description, it will be apparent that European-style brewing requires considerable technical expertise. Nevertheless, there is a wide range of technical choice in most sections of the brewery. Fork-lift trucks or manual methods may be used for handling of brewing materials and bottles in the stores; pure malt, or a mixture of malt and maize "grits", may be made used as brewing materials; vessels may be made of stainless steel or of cheaper materials, and the conditioning period may be long or short; in bottling, wooden crates or cardboard cartons may be used as bottle containers, and many bottling hall operations may be either mechanised or performed manually.

The production of "traditional" beers, even on an industrial scale, permits many simplifications of the lager-brewing process described above; simpler wort production; a smaller and less refrigerated set of fermentation and conditioning vessels; the omission of pasteurisation, and also of packaging itself, the beer being delivered in tanker trucks; and less skill in general required for a product which is less susceptible to unacceptable flavour and aroma changes caused by minor changes in raw materials or processing procedure.

Economic comparison of brewery projects

Tables 21-23 describe the seven brewery projects selected for comparison. Three scales of output are considered, the largest of which is large by the standards of most developing countries: the medium scale is perhaps more typical of lager breweries in such countries. The small scale, which still implies a substantial industrial enterprise, is reserved in this analysis for the production of "corn beer", a variant of traditional beer brewed in East Africa from millet and maize. Projects at the two larger scales are assumed to brew lager.

At both the smaller scales, production is assumed to double after four years of project life, thus simulating in some degree the rapid growth in output a developing country brewery may expect. However, at the largest scale projects are conceived as "replacement investments" for existing smaller breweries, and therefore work at full production from the start of their lives. After achieving full production, all the lager projects work at high utilisation rates, but for the small corn beer project a more relaxed schedule is assumed.

At each of the larger scales, three lager brewing technologies are considered. "Turnkey" technology is typical of many breweries erected recently in both developed and developing countries.[1] "Least-cost" technology represents the narrow range of technologies previously found to be least-cost at the scales considered.[2] "Low-cost job-creation" technology parallels least-cost technology except in bottling operations, where very considerable substitution of labour for equipment is assumed. At the small scale, the corn beer single technology considered is based on an amalgam of an industrial project observed in East Africa, and the tanker truck delivery system practised in southern Africa.

Table 23 presents summary schedules of inputs and outputs for the seven projects. They are based on a study of brewing and brewing technology co-authored by the present writer,[3] which in turn was based on direct observations of many operating commercial breweries in developing countries.

Table 24 presents the results of the cost and revenue analysis of the seven projects. All of them are highly profitable at either low or high wages, with lager tending to be more profitable than corn beer. At the medium project scale, least-cost lager technology shows an NPV of US$16,114,000 at low wages, almost five times that of the corresponding NPV of the corn beer project, which operates at one-quarter the scale; and the large lager projects are more

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[1] The term "turnkey" recognises the widespread practice of delivering entire factories (usually incorporating developed country technology lock, stock and barrel) in working order into the hands of developing country customers who have nothing more to do - at least initially - than to walk in at the front door of their new asset.

[2] Keddie and Cleghorn, "Brewing in developing countries", op. cit.

[3] ibid.

profitable still.[1] However, lager projects are not always more profitable than corn beer. The use of turnkey technology at the medium scale reduces NPVs particularly sharply, and after the scale adjustment at 4:1 is made, the turnkey project may be seen to be much less profitable than the corn beer project, especially at high wages.

Whatever the comparative profitability of lager however its positive NPVs rest on extremely high prices: an initial price of US$51 per hectolitre is assumed, as opposed to US$21.1 for corn beer. When excise taxation and trade margins are allowed for, this ex-brewery lager price implies a retail price of approximately 80 to 90 cents per large bottle of 660 ml capacity. At developing country wage levels, lager beer is clearly a "luxury" product to be drunk, except by the rich, at the risk of depriving one's dependants of the satisfaction of more basic needs. Even at its least costly - in large projects using least-cost technology at low wages - the ex-brewery cost price of lager covering a 10 per cent return on investment is US$25.9 per hectolitre, which may be compared with the cost price of US$12.6 per hectolitre for corn beer, also at low wages. Since a hectolitre of either type of beer is based on about 18 kg of food grains, the minimum processed costs per tonne of these grains are US$1,440 in lager and US$700 in corn beer, before any allowance is made for excise taxes or trade margins. Moreover, as indicated above, in lager brewing much of the nutrient content of the original grains is removed by the process.

Although beer is not generally consumed for nutritional reasons, it is arguable firstly that a cheaper variant than lager should be promoted to satisfy the demand for intoxicants; and secondly that if the large-scale production of a luxury like lager is to be tolerated, catering to the tastes of the well-off when the basic needs of the poor have not been met, then such toleration should only be on the basis of some reasonably equitable sharing of the benefits of lager production with the poor. The low-cost job-creation technology illustrates the most practicable method, namely the provision of large-scale employment in lager breweries, primarily in bottling operations. Table 24 shows that this is commercially feasible, and that even at high wages the cost premia under existing conditions are only moderate and cannot be taken to indicate an inappropriateness of technique. This is particularly true, because a basic foodstuff is not involved; and because, given present technology transfer practices, the

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[1] The scale adjustment factor for large versus medium projects is about 1:6 to allow for different patterns of output growth.

cost premia should be measured not over the costs of least-cost technology but instead, over those of the much more expensive turnkey alternative,[1] which spreads benefits largely among the malt and equipment suppliers of the developed world rather than among the poor and unemployed in the developing countries. Reference to table 22 will show that the differential employment provided by low-cost job creation over turnkey technology is 1,904 at the large project scale, which translates into 190,400 jobs at the estimated 1974 production of 100 million hectolitres in the developing market economies. The low-cost job-creation technology also makes considerable savings in investment costs, and possibly some energy savings also.[2]

Corn beer production, with its simpler process, has less direct employment potential than lager brewing, but permits a further reduction in fixed asset costs. The corn beer project consumes more energy than the lager projects, but this is due entirely to its smaller assumed scale rather than to any greater energy intensiveness of corn beer as a product.[3] Because corn beer is based on traditionally cultivated local grains, its production may also offer greater indirect employment opportunities in agriculture than lager. The malt in lager is most typically imported from developed countries, and if grown locally is likely to be purchased from the larger-scale commercial farmers.

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[1] Which is indeed often __more__ expensive than low-cost job-creation technology - for example, at low wages at both the medium and large project scales.

[2] Initial investment costs are not presented in this case study, since the differing patterns of output and capacity growth would make comparisons across scales misleading. Investment costs are, however, about 60-65 per cent of fixed asset costs for each project (the remaining 35-40 per cent being attributable to replacement and upkeep). On this basis, it is clear that low-cost job-creation technology permits considerable investment savings over either least-cost or turnkey technology.

No __detectable__ change in energy consumption across technologies was apparent from the observations (Keddie and Cleghorn, op. cit.), but the less mechanised technology is likely to economise slightly on energy.

[3] Direct energy consumption, in tce per million hectolitres of beer, is 18,365 in small corn beer projects, 17,090 in medium-scale lager projects, and 12,110 in large lager projects. Though large projects have an advantage in this respect, it is not of much significance on the national scale of energy consumption.

Corn beer thus seems a more appropriate product than lager in developing countries. Care should be taken however in its promotion on an industrial scale, since corn beer is a substantial household industry. For example, in several African countries, its production on a very small scale may provide the principal means of support for single women. Industrial-scale corn beer production might reduce them to destitution, at least in and around the urban areas the larger enterprises are most likely to serve. If corn beer is to be encouraged on an industrial scale, it should be primarily aimed at reducing the consumption of lager, on which really prohibitive excise taxes might also be levied.

If on the other hand it is not thought desirable to cut lager production sharply, then at least this industry, which by no stretch of the imagination can be said to contribute substantially at present to the basic needs of the poor, should be made labour intensive along the lines of the low-cost job-creation technology presented above. Until this is done, lager brewing will continue to epitomise - without any compensating advantages to the poor - the inappropriate features of the "transfer" model of industrialisation criticised in Chapter 1. The product, of European origin, is brewed in large urban projects, to standards of taste and clarity only recently achieved in Europe. Its retail price per bottle is often a significant fraction of the daily remuneration of even the brewery's own relatively highly paid workers. High brewery wage scales set the trend for other modern plants, and tend to attract into the crowded cities more migrants than they can safely house or industry can employ. The brewing materials must frequently be imported from developed countries; so also is most of the expensive machinery used. Such machinery tends to have been designed for saving labour, so that the brewery provides relatively few jobs. Thus lager breweries produce a luxury product, contribute little to local agricultural employment, provide few jobs and those all in towns, and consume large amounts of foreign exchange and investible funds. But though inappropriateness may be epitomised by lager breweries, it will readily be recognised that similarly inappropriate features of the "transfer" model have been evident in the other case studies presented in this chapter.

CHAPTER 3

Appropriate technology for foodgrain storage

In the previous chapter, the paramount importance of grains in the food supply of the developing world was noted. Like most crops, grains are harvested only once or twice per year; being staple foodstuffs they are thereafter consumed in relatively small daily quantities. In the interim they must be stored, the stocks thus formed constituting an essential barrier between the poor and mass starvation. Although grains are readily dried to the 12-14 per cent moisture content needed for reasonable stability in store and do not need the more elaborate preservation techniques required for "perishable" foodstuffs, care must be taken in their storage for the months between one harvest and the next. Conditions vary between one crop and another, and also according to location and climate,[1] but generally grain is susceptible to loss of weight and quality from, inter alia, rodents, insects and moulds. A degree of protection from such pests, and also from moisture, must be afforded by all storage structures.

The extent of grain losses in storage is often thought to be very high in developing countries. It has even been claimed that improved storage methods would raise food supplies by as much as 40 per cent without a single extra hectare being brought under cultivation.[2] However, when discussing losses a clear distinction must be made between total "post-harvest" losses and storage losses proper. Estimates of the former range up to 60 per cent of the standing grain at harvest time, but losses in store are estimated at only one-sixth of this total.[3] A rough average figure of 5 per cent loss, ranging in

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[1] Greeley, M. (1978), "Appropriate rural technology: recent Indian experience with farm-level foodgrain storage research", Food Policy, Feb. 1978.

[2] McDowell, J., op. cit.

[3] Weitz-Hettelsater Engineers (1972), "Rice storage, handling and marketing: report to the Government of Indonesia", Kansas City, USA. Weitz-Hettelsater report "high" and "average" estimates of grain losses in Asian developing countries. The pertinent figures are (as % losses): "high", total post-harvest, 60; storage, 10; "average", total post-harvest, 23.5; storage, 4.

some cases up to 10 per cent or more, seems the most reasonable assumption on presently available evidence.[1] The developing countries cannot expect miracles overnight by improving grain storage methods, and measures to improve food supplies by increasing production are still very much in order.

On the other hand, the question of the appropriate technology for grain storage remains important. Losses of 5 per cent of 697 million tonnes of grain[2] are not to be sneezed at; and the choice of storage technology may moreover have effects on losses in transport to and from the stores, which may be as great as or greater than storage losses themselves.[3]

Even a moderate increase in food supply consequent upon improved storage methods is to be welcomed, particularly if the poor are the principal beneficiaries. Improving their nutrition, besides bettering their health and happiness, might also increase their productivity, both immediately and - for children - in later life, thus permitting them to help themselves. The examination of the distribution of benefits is therefore particularly important in discussing increases in effective grain supply. If for example such increases are achieved by techniques beyond the reach of the small producer, he may find himself worse off than before, in so far as prices fall without any increase in <u>his</u> production or stored surplus. Or he may not be helped in his relations with the local trader/moneylender, to whom he is often in debt and must sell a large proportion of his crop at harvest time, only to buy it back at higher prices in the "hungry" pre-harvest season.[4] On the consumer side, all developing countries have substantial

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[1] Weitz-Hettelsater, loc. cit.; Greeley, op. cit., who uses 5 per cent, reporting on a project which investigated the matter intensively in the field, and reports two other field studies indicating losses of "4-7 per cent"; and Adams, J.M. and Harman, G.W., "The evaluation of losses of maize stored on a selection of small farms in Zambia" (1977), Tropical Products Institute, London, who report 2-6 per cent losses with the better traditional methods, ranging up to 13 per cent as less care is taken.

[2] 1976 production of cereals in the developing world: see table 3.

[3] Weitz-Hettelsater, loc. cit., report "high" estimates of combined losses during transport to and from storage of 15 per cent, and "average" estimates of 3.5 per cent.

[4] A good introductory account of the trader/moneylender system, and of the operation of developing country grain merchants in general, may be found in Hall, D.W. (1970), "Handling and storage of food grains in tropical and subtropical areas", FAO, Rome, Chapter 10.

populations in urban areas dependent on rural grain supplies; many of them have large grain-deficit rural areas as well - often specialising in meat or export cash crop production.[1] In these areas, the principal requirements for meeting the needs of the poor are low storage costs, and the discouragement of technologies which concentrate control of the bulk grain supplies and thus introduce opportunities for monopoly profiteering.

Besides maintaining or improving the incomes of the poor and reducing the cost of their basic foodstuffs, the choice of appropriate grain storage technology may generate significant employment opportunities in erecting as well as operating the storage structures; in processing any increased supplies of grain they may preserve; and perhaps also indirectly by saving investment funds, or generating demands for labour-intensive products through an increase in the incomes of small grain producers. Most of these effects are difficult to quantify but their likely significant magnitude should always be kept in mind. Because grain production and trade is basic in developing economies, the numbers of people affected by any change in its structure are likely to be very large. For example, if the entire 1976 rice harvest of China, India, Indonesia and Bangladesh were to be processed by the wooden "chakki", the employment implied would be 15.86 million jobs, contrasting rather sharply with the 1.07 million required for milling the same amount of paddy with small mechanised mills at the "high" utilisation rate.[2]

To summarise: although storage losses of grain can be exaggerated, appropriate grain storage technology may be very important in meeting the basic needs of the poor, through an increase in their incomes, a reduction in the costs of the most basic of all foodstuffs, and the provision of employment opportunities. However, the importance of these factors varies with the storage level considered: farm or village local storage, or larger-scale urban or "national" storage - the discussion below will therefore focus successively and separately on these two levels.

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[1] An analysis of such areas and the consequent requirements for rice transport and storage in Sierra Leone may be found in D.S.C. Spencer et al., op. cit.

[2] See Case Study 1, table 5, in Chapter 2; 1976 paddy production for the four countries named was 228,520,000 tonnes, "FAO Production Yearbook" (1976), table 11.

Appropriate storage technology at the local level

In India, 60-70 per cent of the stock of food grain is estimated to be stored in small local stores, whether owned by farmers or by local merchants.[1] The proportion is probably similar in many other developing countries. Most of this grain is stored in "traditional" structures made very cheaply from local materials: stone, clay, bamboo, straw, and the like. As noted above, loss rates in such stores are not very high, yet they may be reduced still further by low-cost improvements in design, which provide for better protection against pests and moisture. The improvements and the building materials used vary with the local circumstances.[2] An example may be given from Zambia, where the improved method involves shelling the maize kernels from the cob and storing them in a crib that has been plastered with dried mud inside and out. More traditional methods store the maize on the cob in unplastered stores.[3]

The most basic calculation in the evaluation of such improvements is balancing the value of the grain they save against the increased costs of erecting and servicing the improved store. Such calculations have been made in two recent research projects, in Zambia and in India, with positive results.[4] Adams and Harman concluded that if the improved technique considered was a plastered crib used to house "treated" (i.e. with insecticide) shelled maize, then:

> The "most likely" ratio of costs to benefits where storage was currently in the form of untreated shelled grain was 1:2.4 and where storage was currently as (unselected) cobs with husks attached 1:1.6 ....[5]

Adams and Harman decline to generalise their results. One of the main purposes of their study was to develop a

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[1] Greeley, op. cit.

[2] Two useful technical guides are: German Agency for Technical Co-operation (1975), "West African Seminar on the Volunteer Role in Farm- and Village-Level Grain Storage", Cotonou, Dahomey; and Lindblad, L. and Duber, L. (1976), "Small-farm grain storage", ACTION/Peace Corps/VITA, Washington, D.C., USA.

[3] Adams and Harman, op. cit.

[4] ibid.: and Greeley, op. cit.

[5] Adams and Harman, op. cit.

methodology for further evaluations in other localities, and they pay very careful attention to the measurement and evaluation of losses both of weight and of quality, and to the time spent in maize-shelling, treating, and crib plastering. In their field area, they found the most valuable benefits to be increases in the quality of stored grain, and the principal costs to be the imputed value of the farmers' time. They were very conscious that costs and benefits might vary widely in other areas from their own estimates.

On the other hand, evidence that their estimated ratios (which indicate a useful, though by no means sensational, surplus of benefits over costs) might be typical of the results to be expected from village-level improvements in storage technique comes from the Institute of Development Studies/Indian Grain Storage Institute study reported by Greeley. A number of improved designs of traditional South Indian bamboo (gade) and straw (puri) stores were developed, and one improved gade and one improved puri subjected to cost benefit analysis, along with a metal storage bin developed in collaboration with an FAO/UNDP team.

In this analysis, the savings were assumed to be of weight only, and the cost of building the structures could be evaluated at the market prices charged by local artisans and manufacturers. The bin and the improved gade were assumed to provide full protection and to save 5 per cent in weight losses. The improved puri was assumed to save 3 per cent. The calculated benefit-cost ratios were unfavourable for the bin (0.67:1) but favourable for the lower-cost improved gade and puri (1.39 and 1.46 respectively). All these ratios are probably slight understatements, since no allowance appears to have been made for the alternative costs of continuing to use the unimproved techniques.[1]

Greeley concludes that either the improved gade or the improved puri would seem to be appropriate techniques, but points out that local circumstances may vary widely, and has serious reservations about the ability of official extension networks to promote such unmechanical, semi-traditional improvements effectively. Adams and Harman give their own twist to a similar theme by pointing out that extension officers are hard-pressed and might better spend their limited time in helping farmers increase production rather than cutting down on storage losses. Such a reservation may be justified under existing conditions but is open to the retort that, in

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[1] Even where it assumed that the unimproved structures were already in place, they would entail costs of upkeep and (probably) replacement within the time horizon of the analysis.

the interests of the rural poor, there ought to be so many extension officers that some of them could give their attention to promoting storage improvements with present benefit-cost ratios of 1.6 to 2.4:1.

It seems likely that village-level storage improvements are worth persevering with, particularly where, as in the Indian case, employment of the poor is generated alongside benefits to the store-owner. The employment potential of labour-intensive processing of the increased paddy supply has already been noted; and Greeley notes that construction of puris is normally done by low caste groups. Such a pattern of increased employment seems possible in densely-populated societies where specialisation of labour has a long tradition.

There is another possible advantage of low-cost improved stores. Because they are cheap and effective, they may help the smallholder to keep his produce at harvest time rather than sell it to a trader/moneylender and perhaps buy it back later at a higher price. No doubt the chief reason for such transactions is the indebtedness of the smallholder, which would have to be eroded by parallel measures such as the provision of credit by agricultural development banks, but the improved store would slightly strengthen his hand, particularly if it gave him the chance to increase his income by improving the size and marketability of any surplus he could retain for sale. It would also benefit consumers by tending to reduce the concentration of grain supplies in the pre-harvest season.

Appropriate technology at the urban or national level

At the local level, the consumer of grain is often also the producer, and the determination of appropriate technology becomes more complicated accordingly. At the urban or national level (hereinafter called the urban level) the poor are primarily grain consumers, and their interests are clearer, viz. low costs of storage, coupled if possible with employment opportunities and the discouragement of monopoly or near-monopoly control of grain supplies.

The choice of technology on the larger scales required at the urban level is basically between silos of steel or concrete and warehouse storage in bags ("bagged storage"). Silos are better adapted to the grading and storage of a few varieties of grain in an environment in which moisture and temperature can be precisely controlled, but bagged storage is also capable of minimising losses with careful management: both techniques, for example, are used in large breweries in developing countries.

Table 25 presents summary schedules of input requirements for the two techniques at two commercial scales. In both cases, storage only is considered. It is assumed that the grain is brought to the storage facility in bags and is also despatched in bags. In the interval, it is (in the case of silos) emptied out of the bags and mechanically shifted into the silos - which may be of concrete or steel construction - via a bucket-and-chain elevator. When despatch is desired, valves are opened at the bottom of the silos to permit refilling of the bags. In the case of bagged storage, the bags are stacked up manually in piles inside the store, shifted around by hand from time to time to keep the grain in condition, and eventually unstacked again by hand prior to despatch.

The schedules are largely based on the study of breweries cited in the previous chapter.[1] In the matter of investment costs for silos, however, that study was only one of the sources used.[2] From these sources, it was not possible to detect economies of scale in silo construction. Nor could different costs be attributed with certainty to concrete as opposed to steel construction, though in the costings presented in table 26 a separate high cost assumption is included for concrete silos, which seemed from some of the evidence available to be the more expensive of the two types. The costings are based on the same set of standardised prices as was used in Chapter 2.

Although economies of scale are apparent in table 26 for both technologies, they are not significant except at high wages, and even then they would not be conclusive in areas of low population density. The differential one-way transport distance required for equalising the costs of silos at the two scales is only 270 km with road transport charged at 4 cents per tonne-km; it would of course be less if greater losses were assumed on longer journeys. It will be recalled that Weitz-Hettelsater reported high transport losses to and from stores and, in areas of difficult communication, estimated economies which took no account of such losses could well prove illusory.

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[1] Keddie and Cleghorn, op. cit.

[2] The others were Weitz-Hettelsater, op. cit., and "Seven-Year Plan, 1975/76 to 1982/83", Ministry of Planning, Government of Afghanistan, Kabul. In addition, Hall, op. cit., whose investment estimates were discarded as low-lying outliers, was used for setting realistic levels of utilisation and throughput. The schedules assume two harvests of grain annually.

The question of scale of storage facilities is of course intimately connected, via transport costs, with the particular circumstances of location and size of deficit and surplus areas. A more generally significant result emerging from the costings is the much lower costs of bagged storage which appears at both scales and both wage levels. It is possible that silos, with their more precisely controlled storage environment, would have some small advantage over bagged storage in the matter of losses. But it is very unlikely indeed that this would overcome the high cost premia presented in table 26. For example, with paddy priced at US$185 per tonne, at the smaller scale (and using the lower cost assumption for silos), the losses with bagged storage would have to be 9.2 per cent greater than with silos for the costs of the two techniques to be equalised at low wages; and similar figures apply to the other combinations of scale and wage level.[1] Recalling that normal loss figures even in unimproved traditional village-level stores are of the order of 5 per cent, such differential losses for bagged storage against silos appear quite incredible and there can be little doubt that it is much the lower cost technique.[2]

Bagged storage provides other benefits besides permitting the passing of lower storage costs on to urban consumers. Silos are likely to be large-scale facilities, permitting both the exercise of monopoly power in grain sales and the ready grading of the grain to secure high prices, practices which are probably not in the interests of the urban poor. Furthermore, large-scale silos are often mis-sited and therefore under-utilised, thus further raising their storage costs. Bagged storage also provides more direct employment: 2,060 jobs more per million tonnes throughput at the smaller scale considered and 2,800 more at the larger scale. It also effects very considerable savings in investment costs, of the order of US$100-150 million per million tonnes throughput. Moreover, much of the investment expense in silo projects is spent on

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[1] An additional cost of the silos would be their higher energy consumption as a mechanised technique. This is not allowed for in the costing for want of any precise data, but it is worth noting that Hall (Hall, op. cit.) budgets a fuel and light cost of US$0.67 per tonne throughput. At end-1977 prices, this would be approximately US$1.4 per tonne throughput.

[2] On the other hand, Greeley's results imply a storage cost of only US$3.60 per tonne throughput in the improved gade, at 1976 Indian prices. It therefore seems likely that Hall's surmise (Hall, op. cit.) that storage methods using local materials would be cheapest is in fact well-founded.

imported items: about 60 per cent or more of it goes on foreign exchange,[1] not on creating the local jobs in construction which might be generated by investing the saved funds in less capital-intensive technologies in other industries. With all these advantages, bagged storage must be considered the appropriate technique for storing grain at the urban level.

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[1] Weitz-Hettelsater, op. cit., 58 per cent and 61 per cent; "Seven-Year Plan, 1975/6-1982/3", op. cit., 67 per cent.

CHAPTER 4

Policy issues related to technological choice in food processing and storage

Summary of results

The foregoing chapters have amply demonstrated the existence of alternatives to the large-scale "modern" technologies implied by a "transfer" model of industrialisation or development. They have also shown that it is possible to evaluate such alternatives in systematic comparisons with the large-scale technologies. Moreover, in these comparisons it is frequently the alternative technologies that emerge as more appropriate.[1]

However, they cannot be typified - for example, as "intermediate" or "labour-intensive" - nor do they possess a uniform set of advantages which is apparent in each activity. There is not often a fortunate coincidence of high employment-generating capacity with cost minima under existing conditions, further bolstered by high profitability, low energy consumption, and superior nutritional status of the final product. The determination of appropriateness usually requires a judgement of the advantages which are crucial in a particular activity, given the opportunities presented by the various technologies. The advantages offered by the appropriate technologies therefore vary from one food processing activity to another. It may be useful at this stage to attempt a brief review of the results obtained in Chapters 2 and 3.

In _rice milling_, small powered mills are the least cost technique, cheaper than either large mills or manual techniques; and the rubber roller variant of the small mill

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[1] These results are paralleled elsewhere, both within and outwith the food processing sector. For other industrial sectors, see in particular "Technology and employment in industry", Bhalla (ed.), op. cit., _World Development_, 9/10 (1977), op. cit., and also J. Keddie and W.H. Cleghorn, "Brick manufacture in developing countries", Scottish Academic Press, Edinburgh (forthcoming). For the food processing industries, see "Technology, Employment and Basic Needs in Food Processing", Baron (ed.), ILO (forthcoming), and for the sugar industry R. Alpine, A. Barclay, F. Duguid, and J. Pickett, various papers given at the UNEP/UNIDO Seminar on "The implication of technology choice in the African sugar industry", Nairobi, 1977, and also Garg, op. cit.

attains the highest profitabilities of any of the techniques, because it is at least as capable as the large mills of producing "fine" rice. These results are disturbing, because the labour-intensity of the small powered mills is hardly any greater than that of their large counterparts: thus their supersession of manual techniques poses great problems of unemployment or diminished income among the rural poor in major rice producing countries. Although manual techniques are much more costly at high wage levels, their disadvantage under the low wage regime is less marked. They must continue to be judged appropriate in the major Asian rice economies unless and until an effective method is found of fully compensating those whose labour is displaced by the introduction of the small powered mills.

If they are especially well managed, large mechanised bread bakeries offer higher profits and lower costs to their owners than smaller labour-intensive bakeries. However, the latter are competitive with the normal run of large bakeries, and they offer significant employment opportunities, which may provide a means of sharing with the poor the benefits of producing bread, a semi-luxury product by the standards of many developing countries. The small bakeries are therefore more the appropriate technique. However, they are relatively energy-intensive, and R and D on means to reduce their fuel consumption at low investment cost should be accorded a high priority.

Of the three major methods of fruit and vegetable preservation, drying is found to have the lowest costs. Canning is a very high cost technique, largely owing to the cost of the cans themselves, while freezing must bear the costs and uncertainties of a long "cold drain" up to the point of consump ion. Drying is thus the appropriate technique, as a low cost method of preserving fruit and vegetable nutrients through off-harvest seasons. From the standpoint of the poor, it is also of interest that the lowest costs are provided by small-scale drying projects, which may be set up at the village level. It is their low costs that make them attractive, for they are not particularly labour-intensive, and nutrient retention, though acceptable, poses some difficulties. Where climate does not permit their direct reliance on solar radiation, attention might profitably be paid to improving their fuel economy, but even at present levels of fuel consumption, drying is probably less energy-intensive than canning or freezing.

In milk processing, small-scale plants are slightly more labour-intensive and consume less energy than large plants. They also compare well with the larger plants in the matter of processing costs, particularly if the likelihood of low utilisation rates of the latter is recognised. However, processing entails a very substantial cost whichever technique is used, and it is doubtful whether an expansion of commercial milk production should be encouraged: milk and milk products are expensive sources of calories, fats and protein, and are certainly luxury items in many developing country environments.

Fish preservation offers a valuable opportunity of supplementing diets in inland areas from a cheap protein source. Drying is a much cheaper preservation technique than canning, and may be reliably practised in small plants with simple equipment which are also considerably more labour-intensive than large canneries. Such plants therefore represent the appropriate technique.

In beer brewing, at least two options are available. European-style beer - typified by lager - is a high-cost luxury by the standards of most developing countries, relying heavily on imported equipment and materials and providing little employment either directly, or indirectly by providing markets for indigenous small farmers. It may therefore be appropriate to promote cheaper beers based on materials that can be supplied by local agriculture. Alternatively, the potential of lager brewing for generating significant direct employment might be fully exploited. This could be done at relatively low cost to the brewery owners, and (like labour-intensive bakeries) might represent an appropriate way of providing the poor with some benefit from the production of a high-income product.

Finally, miracles of greatly increased grain supply cannot be expected from improvements in food grain storage. Nevertheless, technical improvements at low investment cost using local materials and labour constitute appropriate investments in storage at the village level. Besides increasing food supplies, they may provide construction employment and increase the incomes of small farmers who can afford to invest in them. They probably also provide cheaper storage than the appropriate technique at the urban or national level, bagged storage in warehouses. Bagged storage is in its turn considerably cheaper than its urban alternative, silos, saving on investment cost and probably also foreign exchange costs and offers slightly more direct employment.

The advantages offered by appropriate techniques are thus various, as also is the character of the techniques themselves. In rice milling, bread baking, fish preservation and lager brewing they are labour-intensive, and offer significant opportunities for the maintenance or generation of employment. However, these opportunities show little association with cost minima. Lager and bread are high cost products; and under present conditions the labour-intensive techniques, like those in rice milling, are not actually least-cost although their cost premia are - under the low wage regime at least - rather slight. Low cost is however the <u>principal</u> characteristic and advantage of the appropriate techniques in fruit and vegetable preservation, fish preservation, foodgrain storage, and (if the cheaper alternatives to lager are preferred) in beer brewing.[1] These techniques offer cheaper supplies of processed or preserved food to the poor, but with no guarantee of significant employment generation. However, too static a view should not be taken. Given good planning, and the political will without which the best of planning cannot achieve much, their low costs could enable them to capture large markets, their frugal use of investment funds would permit their rapid expansion and still leave potential for complementary investments in agriculture; and agriculture and industry could together provide increased employment stemming from these developments.

<u>Policy issues</u>

However, the attractive potential of the alternative technologies should not induce a blindness to the difficulties of realising it in practice. It is a sobering reflection that not one of the appropriate technologies can be said unequivocally to be the most profitable, and that present conditions are perhaps conducive to the rapid spread of only one of them, small labour-intensive bakeries. In the other activities studied here, the appropriate technologies suffer

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[1] The variety of advantage found in appropriate techniques of food processing extends beyond the activities studied in this paper. In sugar processing, the open pan sulphitation technique may be judged appropriate on account of the large number and geographical dispersion of the jobs it generates, but it may have higher processing costs than the large-scale vacuum pan technique. On the other hand, unless an unreasonably high premium is placed on rural employment, large-scale coconut oil processing plants would appear to be more appropriate than small ones, because they enjoy definite and considerable economies of scale without very serious labour displacement. In contrast to both these cases, the main issue in maize milling technique is probably neither cost nor employment generation, but nutrition: the appropriate small-scale technique retains more of the nutrient value of the maize in the milled product than do the large mills producing "sifted" meal. For discussions on these and other activities, see especially the chapter by Keddie and Cleghorn in Baron (ed.), op. cit.

from the competition of alternatives which offer higher profits or slightly lower costs; or promise to be difficult to promote because of a scarcity of motivated people with the requisite technical knowledge and skills.

On the other hand, all of the appropriate techniques are already "in place" in the developing countries, whence indeed came most of the data required to quantify and cost them in this paper. In their present form, they are still susceptible of improvement, particularly through reductions in energy consumption. However, what is now primarily needed is (to borrow a metaphor from agriculture) "extensive" rather than "intensive" development of technology - that is a much wider application of existing appropriate techniques, rather than technical improvements in them. The two methods are not of course contradictory, for an intensive development (for example, the solar dryer) will often aid the spread of the improved technique. The distinction is made to highlight a point of priority, and also to emphasise that technical change is not the only method of implementing the expansion of appropriate technology.

A strategy for implementation will now be outlined. This necessarily embraces, firstly, the controls needed to create a favourable environment for appropriate technology to flourish, and secondly the "promotional" measures designed to encourage its widespread application within that environment. The object of controls would be to discourage the flow of investment funds and skills into the build-up of inappropriate technologies that do little or nothing for the poor. In some developing countries, the most effective single immediate control might be to cut off the demand for such technologies at its source by effecting a direct redistribution of income to the poor. This would probably lead, for example, to a sharp drop in demand for canned or frozen fruits and vegetables, butter and pasteurised milk, canned fish, lager, and possibly even carefully graded grain. However, significant direct redistribution is in most cases a pipe dream. It would neither be politically acceptable nor of itself an adequate solution to the problem of mass poverty. What is needed is a change in the path of development such that its further benefits go as a first priority to those whose basic needs are not yet met; and, for this, measures which are both less direct and more dynamic are required.

Probably the most effective method of discouraging investment in inappropriate technologies is to tax them, or otherwise control their profitability. In the first instance, high tariffs might be levied on imports of substantial items of machinery and equipment, in sharp opposition to the prevailing practice of levying low or zero tariffs. This might be supplemented by similarly high tariffs on essential imported raw or packing materials - for example, malt and hops for lager, or cans for fruit, vegetables, or fish. These measures might prove insufficient discouragement, particularly in large developing countries with the resources for domestic production of the items usually imported elsewhere: India and Nigeria are good examples. Further support to the above measures might therefore be given by controlling product prices, either by levying high excise taxes on the inappropriate products, or - probably more effectively - by preventing price increases in times of general inflation, thus progressively eroding the profitability of the technologies to be discouraged. Since the squeeze thus instituted would lead to eventual lay-offs of employees, it is only fair that parallel compensatory measures be taken, for example retraining such employees for jobs in more appropriate industrial activities.

In certain cases, an alternative approach might be taken, illustrated in this paper in the case study of beer brewing. There it was suggested that an acceptable sharing with the poor of the benefits of lager brewing might be achieved by insisting that its technical possibilities for labour intensity be exploited, thus providing significant employment opportunities. With this approach, the authorities would need to be guided by norms for labour intensity in their negotiations with the project owners, and they would also need to know whether the approach was likely to prove fruitful in a particular industry.[1] There is thus a strong case for the establishment in finance, industry or planning ministries, of "technology search and appraisal units" whose job it would be to keep an up-to-date body of knowledge on the range of imported and domestic technologies in the more important industries. They might also advise, on the basis of cost estimates, on appropriate tariffs for machinery and raw materials in the various industries; and search for previously neglected appropriate technologies which can then be promoted by government.

Appropriate technology could sometimes be promoted by fiscal measures. For example, labour-intensive small bakeries might be assisted by allowing them a rebate on flour used. Other policies might be financial in nature, for example the liberal provision of loans to small food processing firms and potential local suppliers of appropriate equipment for them. But such measures are unlikely to be effective on their own. More direct "physical" policies are called for. In some cases, these might support "intensive" development of appropriate

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[1] It is unlikely to be so, for example, in large-scale grain milling.

technologies through technical R and D.[1] As already noted, the fuel economy of small bakeries and wood-fired dryers merits improvement at low investment cost. Other technical developments might improve the quality of the output of present technologies. One already suggested here is a small sealing device for plastic storage bags to protect dried fruits and vegetables from atmospheric moisture. Another possibility is further development of the "chakki" hand rice mills. In the rice milling case study, the present wooden chakki was found to be only slightly more costly at low wages than the small mechanised mills, although the quality of its output was uncertain. If improvements could slightly increase its productivity or render it capable of consistently producing high yields of "medium" or "fine" rice, it might arrest the present displacement of manual by mechanised techniques.

In all cases of "intensive" development, the aim should be the preservation or expansion of the employment and incomes of the poor, rather than the encouragement of small-scale units per se. Small-scale projects are not necessarily appropriate: the rubber roller and Engelberg mills are found in small rural or urban projects, but displace scarcely less workers than the large multi-stage rice mills. Greeley has similar criticisms of the FAO/UNDP-developed metal grain storage bins. Although small scale and used at the local level, their construction creates little employment for the poor.[2]

However useful appropriate "intensive" development may be, it will not normally obviate the need for promotion of "extensive" development - the rapid spread of existing appropriate techniques. It is here that the most determined efforts should probably be made, in bread baking, fruit and vegetable preservation, fish preservation, foodgrain storage, and possibly also milk processing. Where the appropriate technology is not initially or primarily suitable for commercial application, as in grain storage improvements and the drying of perishables for local consumption, the promotion may be effected most usefully by an expansion of "extension services", whether these are now primarily concerned with agriculture or with health. Since agriculture is normally accorded a higher priority than health services in developing

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[1] However, present developing country systems for R and D may often be ill-adapted for this task. For a critical case study of one country's system see the chapter by Kaplinsky in Baron (ed.), op. cit.

[2] Greeley, op. cit. Other disadvantages are of course their unfavourable benefit cost ratio and relatively high cost. The latter deters their adoption by the poorer farmers.

countries,[1] an expansion of the personnel, training, and functions of agricultural extension services may be the most fruitful approach.

The distinction between commercial and non-commercial applications cannot be maintained too rigidly, as the discussion of village-level grain storage showed. Likewise, dried perishables might increasingly be marketed as an alternative to reservation for home consumption. But where production for market means an investment of a few thousand US$ and the employment of several people (as with small bakeries and wood-fired smoke-drying of fish), expanded extension work to villages is no longer adequate. In such cases, training programmes for potential artisans and small businessmen are indicated. Trainees might best be recruited from existing small enterprises. The training given would include commercial as well as technical aspects, and the programmes backed by loans to successful trainees for the purpose of setting up small enterprises. Indeed, the financial institutions might link a new policy emphasis on small loans to participation by loan applicants in such training programmes on a part-time basis, or (for applicants for which this was not thought necessary) at least to their adoption of appropriate technologies.[2] As noted above, advice on specifically appropriate technologies might be sought from government technology search and appraisal units.

The main thrust of both control and promotional measures should probably come within the individual developing countries at the national and local levels. Finally, however, supportive actions at the international level should not be neglected, including direct financial support of appropriate projects by international lending institutions and developed country national aid agencies;[3] provision of direct technical assistance, in the form of advisers to extension services,

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[1] See Morley, D.C. (1973), "Pediatric priorities in the developing world", Butterworths, London, for a brief account of low health service budgets in developing countries.

[2] In rice-producing countries, a fund might be set up for small loans and the training or retraining of loan officers, partly from the proceeds of a tax levied on mechanically-milled rice. Such a tax would slow the decline in employment of hand pounders, who might also be given preference for employment in the new businesses generated by the fund.

[3] In this connection, the recent support by the UK Government of the financing arm of the Intermediate Technology Development Group is greatly to be welcomed.

training programmes and small loan schemes; and indirect assistance, by supplying information on request to national technology search and appraisal units, and carrying out co-operative R and D projects for the further development of existing appropriate techniques.

APPENDIX I

Note on prices and inflation

The prices used in this paper (the more important of which are presented below) are based on multifarious observations of price levels in several developing countries since 1970. As noted in the text, they have been updated to "end-1977" (approximately November 1977) levels. The costing analyses have then been conducted in terms of end-1977 purchasing power and price levels, that is in "real" terms without any further inflation assumed. This procedure is reasonable if it can be assumed that all the principal prices will, at least approximately, rise at identical inflation rates throughout the project lives; in such a case all the price relatives will remain constant. Investigations made in some previous studies of choice of appropriate technology in developing countries have indicated that such an assumption is broadly warranted,[1] though in particular cases - the price of lager beer for example - "real" price declines (that is, declines relative to the general run of prices) may be expected.

Note on working capital charges

With the discounted cash flow (DCF) method of evaluation and costing, working capital charges are most consistently allowed for by assuming "leads" or "lags" in the streams of payments for various inputs and outputs. If for example revenues are collected 30 days on average after raw materials are paid for, the accompanying working capital charges are allowed for by lagging the revenue stream 30 days behind the raw material payments stream. With a 10 per cent discount rate, this has the effect of reducing the present value of the project-life revenue stream by approximately 0.8 per cent, and this reduction - which is of course paralleled by a reduction in project NPVs - constitutes an allowance for working capital charges.

The above is an extremely simplified account of the leads/lags procedure: for a fuller exposition, see Keddie and Cleghorn, "Brewing in developing countries", op. cit.

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[1] Keddie and Cleghorn, "Brewing in developing countries", op. cit.; and "Brick manufacture in developing countries", Scottish Academic Press, Edinburgh (forthcoming) by the same authors.

Most of the leads and lags assumed in the case studies in this paper are quite short, 0 to 15 days. The major exception is lager brewing, where many raw materials have to be imported, and the brewery also usually gives several weeks' trade credit to its customers. Thus, in the lager-brewing projects, raw materials are assumed to "lead" the other inputs by 140 days, whereas sales revenue is assumed to "lag" 40 days behind the other inputs.

APPENDIX II

IMPORTANT PRICES USED IN CASE STUDY PROJECT COSTINGS

(Most prices have been slightly rounded)

A, Inputs not specific to individual case studies.

INPUT	UNIT	UNIT PRICE (USD - 1977 US $)
Land - Rural	M^2	9.25
--Urban	M^2	18.50
Buildings - Factory	M^2	98.0
- Store	M^2	78.0
- Open-sided Shed	M^2	35.0

Labour - 8 hour shift, 240 - 300 days per year (Including fringe benefits).

	LOW WAGE REGIME			HIGH WAGE REGIME		
	Traditional	Other Modern	Brewery	Traditional	Other Modern	Brewery
EXPATRIATES	40,000	40,000	40,000	40,000	40,000	40,000
LOCAL MANAGERS	2,300	2,300	2,300	11,300	11,300	11,300
SKILLED	925	925	1,330	3,125	3,125	4,350
LOW SKILL	190	290	580	870	1,275	2,490

Fuel Oil	Litre	0.14
Diesel Oil	Litre	0.17
Wood	Tonne	14.5
Electricity	Kw - hr	0.045, first 100,000/month 0.035, additional consumption
	Additional Annual Charge per KVA	58.0
Water	M^3	0.93, first 200,000/year 0.31, additional consumption
Road Transport	Tonne - Km	0.04
Salt	Tonne	75.0
Plastic Bags and Sachets	1kg/litre capacity	0.01

B. Inputs and outputs specific to particular case studies.

(1) RICE MILLING

Paddy	Tonne	184.0	
Polythene bags	100kg capacity	1.56	
Coarse rice	Tonne	269.0	
Medium rice	Tonne	300.0	
Fine rice	Tonne	353.0	

(2) BREAD BAKING

Wheaten flour	Tonne	324.0	
Other material inputs	Various, per tonne flour	22.1	
Wrappers, plain	Unit	0.012	
Wrappers, luxury	Unit	0.017	
		Wholesale	Retail
Wheaten Loaf	0.4kg., approx.	0.176	0.190

(3) FRUIT AND VEGETABLE PRESERVATION

Cans	500g capacity	0.119	
Carboard Cartons	20 x 500g capacity	0.42	
Cement Jars	200 litre capacity	2.00	
Refrigerated Road Transport	Tonne-km	0.065	

(4) MILK PROCESSING

Raw milk	Litre	0.20	
Plastic Butter tubs	200g capacity	0.028	
Pasteurised Full Milk	Litre	0.25	
Liquid Skim Milk	Litre	0.15	
Butter	Kg	2.00	

(5) FISH PRESERVATION

Raw fish, Smoke Dried Fish	See notes to Table 20 in text		
Canned Fish	See notes to Table 20 in text		
Edible Oil	Tonne	800.0	
Baskets for Raw Fish	30kg capacity	3.9	
Boxes for Smoke Dried Fish	30kg capacity	15.6	
Carboard Carton	24 x 400g or 48 x 200g capacity	0.38	
Cans	400g capacity	0.102	
Cans	200g capacity	0.078	
Labels for Cans	100	0.58	

(6) <u>BREWING</u>

Malt	Tonne	381.0
Maize	Tonne	151.0
Maize Grits	Tonne	205.0
Millet	Tonne	214.0
Hops	Tonne	3,710.0
Bottles	660ml capacity	0.163
Wooden Crates	12 x 660ml capacity	1.11
Carboard Cartons	12 x 660ml capacity	0.38
Insulated Cellar Buildings	M^2	217.0
Lager, net of duty	Hectolitre (= 100 litres)	51.0 (initial)*
Corn Beer, net of duty	Hectolitre (+ 100 litres)	21.1

* See note, to Table 24

TABLE 1.

CASE STUDIES CHOSEN FOR THIS CHAPTER

Classified in Terms of Basic Nutritional Needs

Basic Nutritional Category	Sub-Category	Examples	Chosen for this Chapter
CARBOHYDRATE (Energy Producing Foods)	STARCHY FOODS Cereals	Wheat Millet Rice Maize	1. Rice Milling 2. Bread baking (wheat)
	Tubers	Potato Cassava	
	Fruit	Plantain	
	Oils and fats	Oilseeds Animal Fats Dairy Products	4. Dairy Products
	Sugar	Beet/cane Sugar	
PROTEIN (Body Building Foods)	ANIMAL PROTEIN	Meat, Fish Milk	5. Fish Preservation 4. Dairy Products
	Vegetable Protein	Peas, Soya Groundnut	
VITAMINS, MINERALS (Essential in small amounts)	Leafy Vegetables Fruits	Cabbage Orange Apple	3. Fruit and Vegetable Preservation
OTHER (Water source, stimulants, depressants, etc.)		Beer, Tea, Coffee Soft Drinks	6. Beer Brewing

These categories are not exclusive. They refer to the main characteristics of each food stuff.

TABLE 2.

Contributions of Various Types of Food to Calorie, Protein and Fat Intake, per Person per Day, Average of Three Developing Countries [a]

	Calories[b]	Protein, Grams	Fat, Grams
Energy Producing Foods			
Cereals	1195	28.8	8.8
Other Starchy Foods	177	2.0	0.5
Oils and Fats	94	-	10.8
Sugar	249	0.3	-
Animal Protein			
Meat, Fish, Milk	184	16.0	15.0
Vegetable Protein			
Pulses, Nuts, Seeds	110	6.0	3.8
Fruits	46	0.5	0.4
TOTAL	2055	53.6	39.3
(% of all food intake)	(99%)	(98%)	(99%)

a. Source: FAO Food Balance Sheets, 1971. Averages of data for Colombia, Phillipines, Zambia, 1964 - 6.

b. 1 (nutritional) Calorie = 1,000 calories = 4,200 joules

TABLE 3.

Total Production of Main Types of Foodstuffs in the Developing Market and Asian Centrally Planned Economies, 1971 and 1976.[a]

Type of Foodstuff	Production in Millions of Tonnes	
	1971	1976
Cereals	606	697
Root Crops	311	337
Fruit and Vegetables[b]	307	352
Sugar (Centrifugal, Raw)	40	47
Vegetable Oils	22	26
Nuts, Tea, Cocoa, Coffee	9	8
Milk	80	91
Eggs	7	8
Meat	35	40

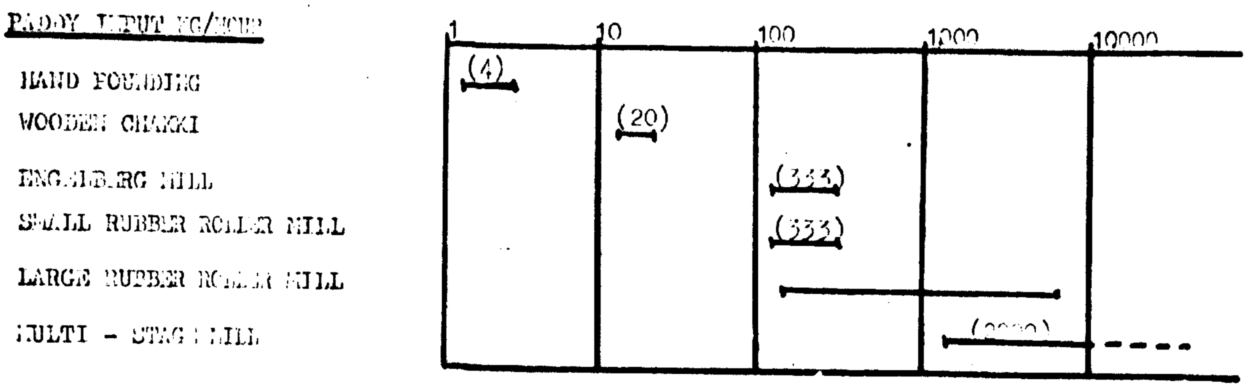
a. Source: FAO Production yearbook(1976), Table 8

b. Including pulses and melons.

TABLE 4.

A SELECTION OF RICE-MILLING TECHNOLOGIES

(horizontal bars indicate approximate ranges of output)



(Figures in brackets indicate the representative paddy input rates chosen for the techniques selected for comparative costing).

TABLE 5

Summary schedules of inputs and outputs for five rice-milling technologies (excluding storage and drying)

SCALE: kg/hr PADDY	4	20	333	333	1 x 2,000
PROCESS TYPE	Hand pounding	Hand milling	Small mechanical mill	Small mechanical mill	Large mechanical mill
LAND: buildings, m^2	12	20	40	40	450 + 200 storage
SITE total, m^2	20	30	100	180	1 900
EQUIPMENT TYPE:	Postle and mortar - husker	Wooden "chakki" - husker	Engelberg steel roller mill - tandem husker/ polisher	One-pass (Japanese) rubber-roller mill - husker/separator/ polisher	Multi-stage mill - (thresher)/husker/ separator/polisher plus accessories
UTILIZATION: days/year	240	240	240	240	240
Hours/day) High rate	) 6	6	) 8.0	8.0	12.0
Hours/day) Low rate	)		) 4.0	4.0	6.0
TOTAL LABOUR: 1/					
Managers	-	-	-	-	1
Skilled: High utilisation	-	-	-	-	6
Skilled: Low utilisation	-	-	-	-	3
Low skill: High utilisation	-	-	-	-	18
Low skill: Low utilisation	1	2	3	3	9
ENERGY:					
Diesel HP installed	-	-	15	15	Not specified
Fuel oil, litres/year: High utilisation	-	-	4 800	4 800	60 000
Fuel oil, litres/year: Low utilisation	-	-	3 000	3 000	30 000
RAW MATERIAL INPUT:					
Paddy: kg/hr	4	20	333	333	2 000
: tonnes/year) High utilisation	) 5.76	28.8	) 640	640	5 760
: tonnes/year) Low utilisation	)		) 320	320	2 880
OUTPUT: Rice, tonnes/year					
High/Low yield) High utilisation	) 3.97/	19.9/	429	438	3 860/3 570
High/Low yield) Low utilisation	) 3.57	17.9	215	219	1 930/1 785
By-products	-	-	Not specified	Not specified	Not specified (US$3.05 per tonne of paddy milled) 2/
Milling out-turn, % (Corresponding to output alternatives specified above)	69% coarse 3/ 62% coarse	69% coarse 62% coarse	67% medium	68.5% med. or fine	67% med. or fine 62% med. or fine

1/ The "traditional" wage scale is used for all projects except the large mechanical mill, where the "other modern" scale is used.

2/ Collier et al., op. cit., (updated). If the by-products were 100 per cent bran at 8 per cent by weight of paddy, it would imply a bran price of US$38 per tonne.

3/ "Coarse", "medium" and "fine" represent different grades of rice "quality", (degree of polish, percentage broken kernels.

TABLE 6

COMPARATIVE REVENUES AND COSTS, 5 RICE MILLING TECHNOLOGIES

(10 - year present values, US $ x 1,000 (END-1977), 10% Discountrate)

Losses are shown in Brackets

PROCESS		HAND POUNDING	WOODEN CHAKKI	ENGELBERG MILL		ONE-PASS RUBBER ROLLER MILL		MULTI-STAGE MILL	
UTILISATION RATE				LOW	HIGH	LOW	HIGH	LOW	HIGH
REVENUES	High yields	6.5	32.9	402	805	411	822	3621	7242
	Low yields	5.9	29.4	N/A	N/A	N/A	N/A	3354	67[illegible]
COSTS :	Paddy	6.3	31.4	349	697	349	697	3174	6349
	Storage Bags[1]	-	-	-	-	-	-	57	113
	Fixed Assets	0.6	1.0	11	11	18	18	225	225
	LABOUR: Low wage	1.2	2.4	2	3	2	8	47	80
	High wage	5.[illegible]	10.7	11	16	11	16	129	328
	ENERGY: Fuel oil	-	-	5	5	5	5	32	64
	TOTAL COSTS: Low wage	3.6	34.7	364	716	374	725	3535	[illegible]
	High wage	12.2	45.9	373	729	381	756	3697	7078
NET PRESENT VALUES (NPVs)	High yield Low wage	(1.5)	(1.8)	38	89	39	99	86	417
	High yield High wage	(5.6)	(10.2)	29	76	30	86	(66)	164
	Low yields Low wage	(2.1)	(5.2)	N/A	N/A	N/A	N/A	(182)	(117)
	Low yields High wage	([illegible].3)	(13.6)	N/A	N/A	N/A	N/A	(334)	(370)
SENSITIVITY TO REVENUE ASSUMPTIONS (high utilisation rate only); *(yields and wages as before)* Assume 'Fine' rice price For rubber roller and multi-stage mill (NPVs as above)		N/A	N/A	N/A	N/A	N/A	241 218 N/A N/A	N/A	1681 14[illegible] 1074 822
INITIAL INVESTMENTS IN US $ FIXED ASSETS		445	980	9650	9650	13700	13700	191,700	191,700

1. Each used 5 times
2. In all tables, "N/A" indicates "Not applicable".

TABLE 7.

LIST OF CORE+ STAGES FOR BREAD BAKING

Stage		Labour-intensive	Mechanised
1.	Mix	Hand	Electric mixer
2.	Work (knead)	Hand	
3.	Ferment	Uncontrolled environment*	Controlled environment
4.	Mill	Knead by hand	Dough brake
5.	Cut	Hand	Automatic
6.	Weigh	Hand	Automatic/partly automated
7.	Mould	Hand	Electric moulder
8.	Pan	Place in tin by hand	Automatic
9.	Ferment	Uncontrolled environment	Controlled environment
10.	Bake	Manual handling	Automatic handling
11.	De-pan	Remove from tin by hand	Automatic de-panning
12.	Cool	Uncontrolled environment	Controlled environment
13.	(Slice)	(Hand)	Electric slicer
14.	Wrap	Hand	Automatic

+ The ancillary handling stages may of course also be performed by either labour-intensive or mechanised means, e.g. the packing and despatch of bread.

* "Uncontrolled environment" = incomplete isolation or control of temperature and humidity during fermentation.

TABLE 8

SUMMARY SCHEDULE OF INPUTS AND OUTPUTS FOR THREE BAKERY PROJECTS

SCALE: Loaves per year	1,000,000	1,000,000	12,500,000
PROCESS TYPE	Labour intensive	Partly mechanised	Mechanised
LAND: buildings, m^2 site total, m^2	160 320	320 640	1,320 2,640
EQUIPMENT TYPE:	manual process; wood-fired oven	Mechanised mixed and slicing, otherwise manual; wood-fired oven	Entire process mechanised; oil-fired oven
ESTABLISHMENT LABOUR:[1] 8-hour shifts, 300 days/year equiv.			
: management	1	1	1 (expatriate)
: skilled/administrative	2.4	2.4	12
: low skill	24	19.2	48
ENERGY: electricity, KW-hr/year	-	18,000	820,000
: fuel - wood or fuel oil/year	378 tonnes wood	378 tonnes wood	196,000 litres fuel oil
RAW MATERIAL INPUTS:[2]			
Wheat flour, tonnes/year	360	360	4,500
PACKAGING MATERIALS: wrappers/year	1,000,000	1,000,000	12,500,000
OUTPUT:			
Loaves per year (each containing 0.36 kg flour)	1,000,000	1,000,000	12,500,000

1. Bakeries actually work 360 days a year. All the projects work two shifts, but the shift length for the mechanised bakeries is ten hours, i.e. 20 hours a day for two shifts. "Traditional" scales are paid in the smaller projects; the "other modern" scale is paid in the larger project.

2. Other inputs include sugar, water, etc. These are costed as a block, US $ 22.1/tonne flour input.

TABLE 9

COMPARATIVE REVENUES AND COSTS FOR THREE BAKERY PROJECTS

(30 - year present values, US $ 1,000 (END-1977), 10% Discount Rate)

Losses are shown in brackets()

SCALE : Loaves / year	1,000,000	1,000,000	12,500,000
PROJECT TYPE	MANUAL	PARTIALLY MECHANISED	MECHANISED
REVENUES	1,660	1,660	21,484
COSTS : Raw materials	1,177	1,177	14,534
Packing materials	109	109	2,017
Fixed assets	32	97	915
LABOUR : Low wage	86	78	726
High wage	375	336	1,296
ENERGY : Wood or fuel oil	51	51	25
Electricity	-	13	514
TOTAL COSTS : Low wage	1,455	1,316	18,722
High wage	1,745	1,782	19,302
NPVs : Low wage	205	136	2,7[illegible]1
High wage	(85)	(123)	2,1[illegible]1
INITIAL INVESTMENTS (US $) IN FIXED ASSETS	27,800	86,400	795,000

TABLE 10.

PRODUCTION OF PULSES, VEGETABLES, MELONS AND FRUITS IN THE DEVELOPING MARKET AND ASIAN CENTRALLY PLANNED ECONOMIES, 1976 [a]

MAIN CATEGORY	IMPORTANT SUB-CATEGORIES	1976 PRODUCTION (millions of tonnes)	
Pulses		37.8	
	Dry Beans & Broad Beans		16.3
	Dry Peas & Chick Peas		13.2
	Lentils		1.6
Vegetables		159.3	
	Tomatoes		16.1
	Dry onions		8.7
	Cabbages		8.3
	All other FAO-itemised crops		18.8
Melons		17.2	
Fruits		137.9	
	Bananas		37.9
	Citrus fruits		23.4
	Grapes		12.9
	Mangoes		12.8
	All other FAO-itemised crops		15.0
		TOTAL 352.2	TOTAL 185.0 FAO-ITEMISED CROPS

[a] Source : FAO Production Yearbook (1976), Section V .

TABLE 11.

UNIT OF SOME STAGES FOR CANNING, DRYING AND FREEZING OF VEGETABLES.

CANNING	DRYING	FREEZING
Preparation of raw product[a.]	Preparation of raw product	Preparation of raw product
Blanching (with hot water or steam)	Steam scalding or blanching	Blanching (with hot water or steam)
Chopping	Drying (on trays or moving belts)	Packaging (in plastic bags)
Can filling	Packaging (in plastic bags)	Bed freezing
(Exhaust box)		Cold store
Can seaming		¦
Pressure cooking (in boiling water)		(Refrigerated transport)
Cooling		
Drying		
Labelling		

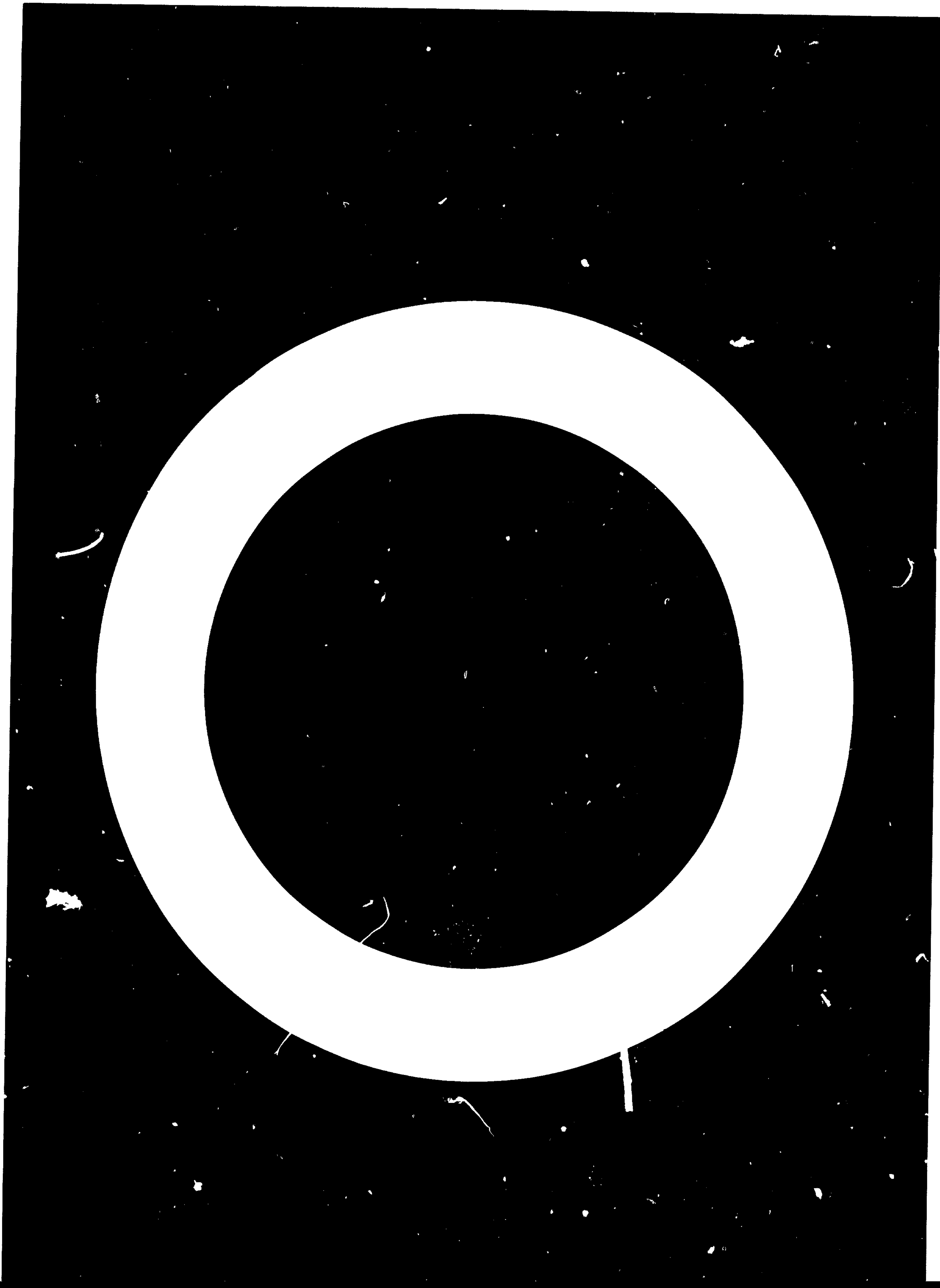
a. Washing, peeling etc.

TABLE 12.

SUMMARY SCHEDULES OF INPUTS AND OUTPUTS FOR 8 VEGETABLE PRESERVATION PROJECTS

SCALE: Prepared vegetable Input, tonnes/year	375	3,375	10,125	20
PROJECT TYPE	Very small Canning Unit	Small Canning Plant	Large Canning Plant	Small Solar Dryer
LAND: Buildings, M^2	200(+50 Storage)	700(+300 Storage)	1,200(800Storage)	-
Site Total : M^2	500	2,000	4,000	20
EQUIPMENT TYPE:	Manual Preparation Blanching, Filling Exhaust Box Seamer, Pressure Cooker, Manual Labelling, Packing and Handling	Manual Preparation Blanching, Filler Steam Flow Injection, Seamer, Retort Cooker, Labeller Manual Handling and Packing	Manual Preparation Blancher, Filler Steam Flow Injection, seamer, Retort Cooker, Labeller, Carton Packer, Fork Lift Trucks	Manual Preparation Mud brick& Polythene Dryer, Storage in Cement jar
UTILISATION: Days/year	250	250	250	200[2]
Hours/day	8	16	16	8[2]
LABOUR[4] Managers	1	2	4	-
Skilled	1	6	16	-
Low Skill	4	22	46	4[2]
ENERGY: KW-hr/year	10,000	75,000	200,000	-
Fuel oil/wood (Litres/Tonnes/year)	20,000/-	140,000/-	380,000/-	-/-
WATER: M^3/year	2,400	22,000	65,000	Negligible
RAW MATERIALS: Fresh vegetables Tonnes/year	500	4,500	13,500	26.7
OTHER MATERIALS: Salt Tonnes/year	5	45	135	-
PACKING MATERIALS: Plastic bags (Sachets) 1kg/year	-	-	-	-
Cans 500g	758,000	6,818,000	20,452,000	-
Cartons 20 x 500g	37,500	337,500	1,012,500	-
200litre cement jars	-	-	-	13.3
OUTPUTS:				
Canned Vegetables (net contents of can/including 40g water per can	480	4,320	12,960	-
Dried Vegetables	-	-	-	4
Frozen Vegetables	-	-	-	-

1. Only total fixed asset investment cost estimated (US $ 9,500,000)
2. Use for duration of hot sunshine (6 hours needed only). Labour need is intermittent.
3. Work in practice may be spread over a longer period (12 hours).
4. Wages are paid at 80% of "Traditional" scales in the two small drying projects, at "Traditional" scales in the smallest canning project, and at "Other Modern" scales in the remaining projects.
5. Not known in detail. U.K. cold storage costs of US $90 per tonne - year taken, and average storage level of 10,000 tonnes assumed, for costing purposes.
6. 1% losses of cans in process.
7. Each jar lasts three years.



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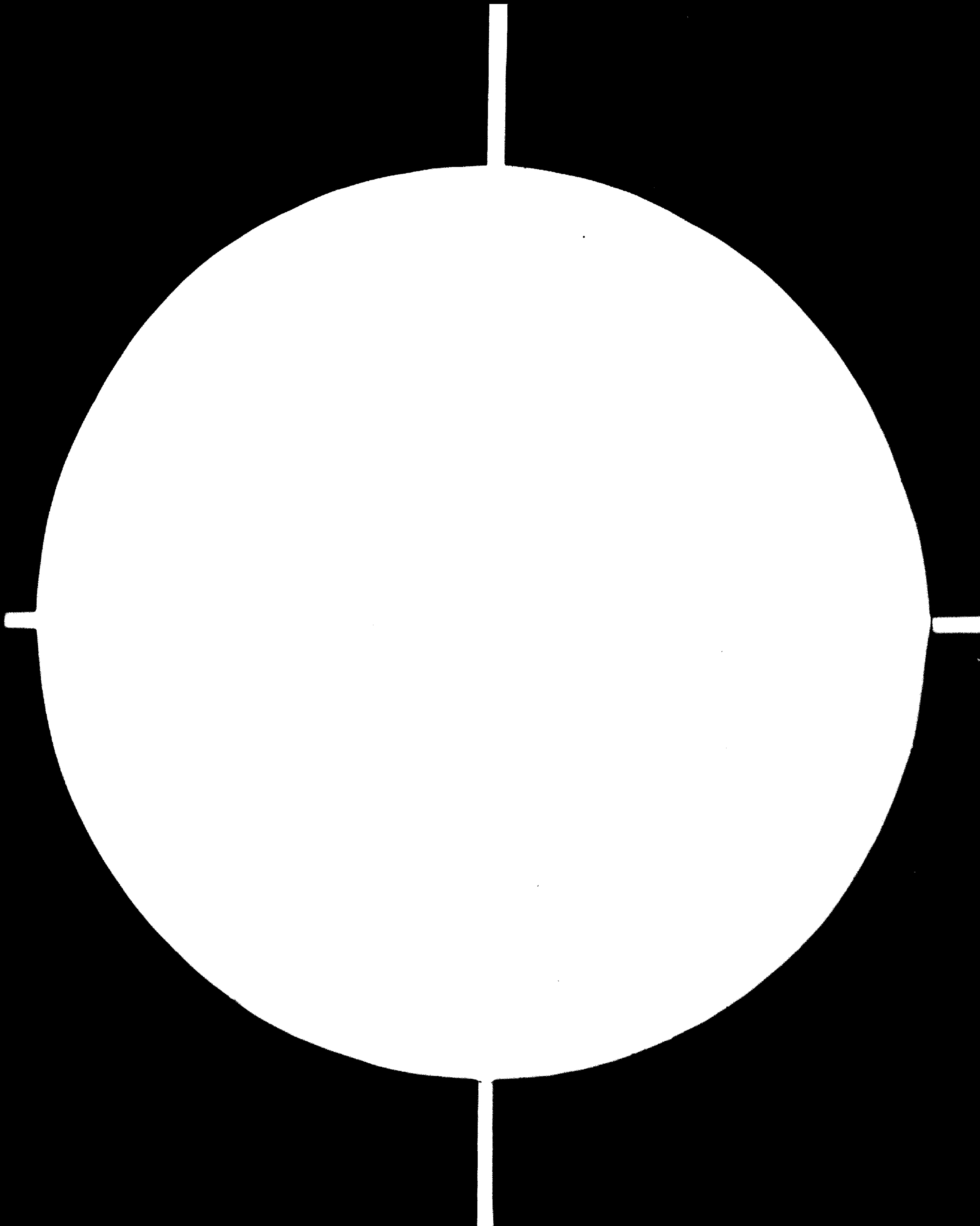

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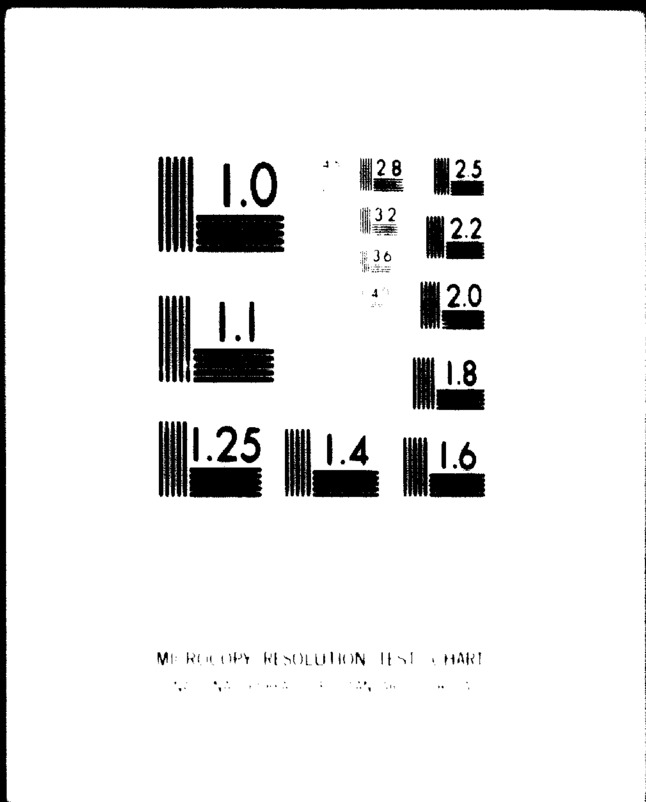

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Table 12 contd.

216	4,500	10,125	42,000
Wood Fired Tray Dryer	Modern Tray Dryer	Continuous Belt Dryer	Freezer, Packing Plant, Cold Store
60(+12 Storage)	800(+200 Storage)	1,600(+400 Storage)	Not Specified
144	2,000	4,000	-
Manual Preparation, Drying Trays over Pit in Shed, Wood Fired, Manual Packing in Plastic Bags	Largely Manual Preparation, Blancher Dryer manually loaded &unloaded Conditioner, Bag Packer, Manual Handling	Mechanised Preparation Blancher Continuous Belt, Dryer, Conditioner, Bag Packer, Fork Lift Trucks	Mechanised Preparation & Packing, Freezer, Refridgerated Cold Store
200[3]	250	250	250
8	24	24	16
-	4	4 (1 expatriate)	20 (4 expatriates)
1	20	15	16
3	130	45	240
-	720,000	1,800,000	NOT SPECIFIED[5]
-/152	600,000/-	1,800,000/-	
300	20,000	50,000	
288	6,000	13,500	56,000
-	-	-	-
43,200	900,000	2,025,000	42,000,000
4,320	90,000	202,500	4,200,000
-	-	-	-
-	-	-	-
43.2	900	2,025	-
-	-	-	42,000

TABLE 13 *

COMPARATIVE PROCESSING COSTS FOR 8 VEGETABLE PRESERVATION PROJECTS

(15 - year present values, US $ x 1,000 (END-1977) 10% Discount rate)

PROCESS AND TECHNOLOGY TYPE	CANNING			DRYING				FREEZING
	Largely Manual	Semi-Automatic	Mechanised	Solar	Wood Fired	Modern Tray Dryer	Continuous Belt Dryer	Mechanised
SCALE: Prepared Vegetables Input Tonnes/year	375	3,375	10,125	20	210	4,500	20,125	42,000
PROCESSING COSTS:								
Packing materials	1,033[1]	9,303[1]	27,907[1]	0.244	17.1	355	801	16,608
Fixed Assets	56	415	851	0.282	7.3	878	2,187	13,110
LABOUR: Low wage	31	126	590	0.290	9.4	499	564	2,459
LABOUR: High wage	132	523	1,486	1.328	35.7	2,093	1,364	6,396
ENERGY: Wood or fuel oil	21	150	404	-	17.1	639	1,916)	
ENERGY: Electricity	5	37	102	-	-	312	729)	6,845
WATER	17	156	458	-	2.1	141	354)	
TOTAL PROCESSING COSTS Low wage	1,163	10,177	30,312	0.816	53.0	2,824	6,551	39,022
TOTAL PROCESSING COSTS High wage	1,271	10,581	31,208	1.854	79.3	4,418	7,351	42,959
PROCESSING COSTS: (US $ per tonne of Prepared input) Low wage	408	397	394	5.4	32.2	82.5	85.0	122.2
PROCESSING COSTS: (US $ per tonne of Prepared input) High wage	446	412	403	2.2	48.3	129.0	95.4	134.5
PROCESSING COSTS FOR LARGE PROJECTS INCLUDING TRANSPORT COSTS (US $ per tonne of Prepared input) Low wage	N/A	N/A	404	N/A	N/A	N/A	86.6	148.2
PROCESSING COSTS FOR LARGE PROJECTS INCLUDING TRANSPORT COSTS (US $ per tonne of Prepared input) High wage	N/A	N/A	413	N/A	N/A	N/A	97.0	160.5
INITIAL INVESTMENT COSTS IN FIXED ASSETS (US $)	47,000	307,000	612,000	235	5,900	699,000	1,602,000	9,500,000

[1] Includes salt, about 0.3% of total costs for this heading.

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* Table 14 is on page 35

TABLE 15

PRODUCTION OF MILK AND MAJOR MILK PRODUCTS IN THE DEVELOPING MARKET AND ASIAN CENTRALLY PLANNED ECONOMIES, 1976[a]

(in million of tonnes)

PRODUCT	TOTAL, ALL DEVELOPING COUNTRIES	APPROX. WHOLE MILK EQUIVALENT[b]	TOTAL INDIA PAKISTAN, EGYPT TURKEY, ARGENTINA.	APPROX. WHOLE MILK EQUIVALENT
Whole cow milk, fresh	58.1	N/A	18.5	N/A
Whole other milk[c], fresh	32.9	N/A	24.5	N/A
Total fresh whole milk	91.0	N/A	43.0	N/A
Butter and Ghee	1.31	(26.2)	0.89	(17.7)
Cheese	1.46	(13.1)	0.59	(5.3)
Dry Whole Milk	0.23	(1.7)	0.09	(0.7)
Condensed/evaporated milk	0.80	(2.4)	0.24	(0.7)
	N/A	(43.4)	N/A	(24.[illegible])

a. Source: "FAO Production Yearbook" (1976), Section V.

b. Approx: Conversion ratios for processed milk products:

Butter and Ghee	20 : 1
Cheese	9 : 1
Dry whole milk	7.5 : 1
Condensed, Evaporated milk	3 : 1

(Based on "Encyclopedia Britannica", loc.cit).

c. About 70% Buffalo milk, remainder from sheep and goats.

TABLE 16.

FLOW CHART FOR MILK PASTEURISATION AND BUTTER/SKIM MILK PRODUCTION.

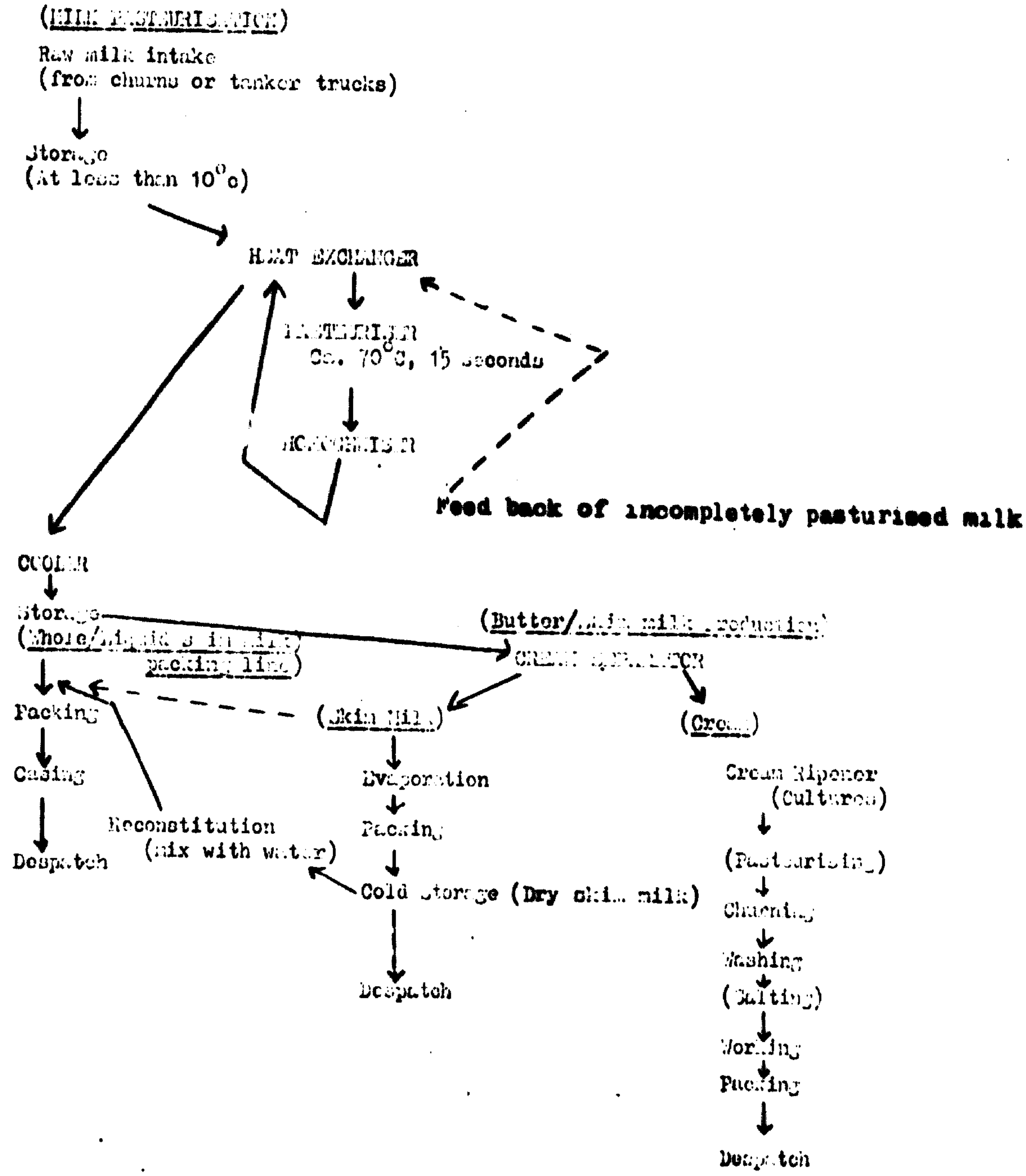

TABLE 17.

SUMMARY SCHEDULES OF INPUTS AND OUTPUTS FOR 4 MILK PROCESSING PROJECTS

SCALE: LITRES/DAY RAW MILK	2,000	20,000	150,000	150,000
PROJECT TYPE	MILK PASTEURISING	MILK PASTEURISING	MILK PASTEURISING, BUTTER AND SKIM MILK PRODUCTION	MILK PASTEURISING
LAND: Buildings, M^2	50(+35 trucks, storage)	800(+450 trucks storage)	3800(+4000 trucks, storage)	2700(+3900 trucks, storage)
Site Total, M^2	170	2,500	15,500	13,000
EQUIPMENT TYPE	Infrared Pasteurisation Semi-automatic Packing of milk in plastic bags.	Pasteurisation by steam heating, Automatic Packing of milk in plastic bags.	Pasteurisation by steam heating, Mechanised Buttermaking and packing, Artificial Dryer for Skim milk, Automatic Packing of Milk and skim milk in plastic bags.	Pasteurisation by steam heating Automatic Packing of milk in plastic bags
UTILISATION: days/year	365	365	365	365
hours/day	5	5	5 (7 for butter and skim milk)	5
LABOUR[1]: Managers	1	← not specified[2]	→	→
Skilled	2	30	160	145
Low skill	5	77	251	225
ENERGY: Kw/hr/ year	150,000	1,200,000	6,000,000	5,400,000
Diesel oil/fuel oil (litres/year)	8,000/-	125,000/400,000	1,500,000/2,500,000[3]	1,500,000/2,250,000
WATER: M^3 / year	3,600	36,000	270,000	243,000
RAW MATERIAL INPUT: litres/year	730,000	7,300,000	54,750,000	54,750,000
PACKING MATERIALS: Plastic bags/1 litre year	730,000	7,300,000	54,000,000	54,750,000
Plastic butter tubs/year (200g)	-	-	2,737,500	-
OUTPUTS:				
Pasteurised full milk litres/year	730,000	7,300,000	43,800,000	54,750,000
Liquid skim milk litres/year	-	-	10,200,000	-
Butter, kg/year	-	-	547,000	-

1. Wages are paid at "other modern" scales in the small and medium projects and at 110 of "other modern" scales in the large projects.

2. Management costs estimated at an addition of 50% to other labour costs.

3. No allowance is made for the very substantial fuel consumption in drying skim milk, since no reliable estimates of this were available.

TABLE 18.

TABLE OF COMPARATIVE COSTS AND PROFITS, 4 MILK PROCESSING PROJECTS
(15-year present values, US $ × 1000 ([illegible]-1977) 10% discount rate)
Losses are shown in Brackets ( )

PROJECT		Small Milk Pasteurising Plant (A)	Medium Scale Milk Pasteurising Plant (B)	Large scale Milk Pasteurising, Butter and Skim Milk Plant (C)	As (C) without Butter and Skim Milk
REVENUES	Milk	1,38[illegible]	13,880	83,264	104,080
	Skim milk	-	-	11,659	-
	Butter	-	-	[illegible],329	-
TOTAL REVENUES		1,3[illegible]3	13,[illegible]80	103,250	104,080
COSTS:	Raw milk	1,110	11,102	[illegible]3,275	83,275
	Packing materials	[illegible]6	355	4,690	4,164
	Fixed assets	175	1,[illegible]74	10,999	10,572
LABOUR:	Low wage	42	572	2,517	2,273
	High wage	163	2,131	9,518	8,399
ENERGY:	Diesel and fuel oil	10	576	4,4[illegible]8	4,200
	Electricity	104	[illegible]51	5,010	2,709
WATER		25	254	1,580	1,422
TOTAL COSTS:	Low wage	1,472	15,534	11[illegible],540	108,416
	High wage	1,613	17,193	117,340	114,542
NPVs	Low wage	(8[illegible])	(1,704)	(7,290)	(4,33[illegible])
	High wage	(230)	(3,313)	(14,090)	(10,462)
INITIAL INVESTMENT IN FIXED ASSETS (US $)		91,000	321,000	5,2[illegible]3,000	4,7[illegible]6,000

TABLE 19.

SUMMARY SCHEDULE OF INPUTS AND OUTPUTS FOR 3 FISH PROCESSING PROJECTS

SCALE: Input of fresh fish per year	54 (A)	216 (B)	8,640
PROJECT TYPE	Smoke Drying	Smoke Drying	Canning
LAND: Buildings m^2	30(+6storage)	60(+12storage)	1,000(+500storage)
Site total, m^2	72	144	3,000
EQUIPMENT TYPE:	Manual Process wood fired "Altona"[1] type oven	Manual Process wood fired "Altona" type oven	Manual preparation tables, Continuous cooker, can washer, can packer, can oiler, can sealer, sealed can washer, can dryer, can labeller, carton packer, boiler, ancillary equipment, fork lift trucks.
UTILISATION: Days/year	200[2]	200[2]	300
Hours/day	8[2]	8[2]	16
LABOUR[3]: Managers	-	-	4 (1 expatriate)
Skilled	1	1	18
Low skill	1	3	48
ENERGY: kw-hr/year	-	-	200,000
Fuel oil/wood (Litres/Tonnes/year)	-/38	-/152	420,000/-
WATER: m^3/year	-	-	63,000
RAW MATERIAL INPUT: Tonnes/year	54	216	8,640
OTHER MATERIALS: Edible oil Tonnes/year	-	-	1,040
Salt, Tonnes/year	-	-	260
PACKING MATERIALS: 200g cans/year	Baskets and boxes (30kg capacity) for Fresh and dried fish		14,400,000
400g cans/year			14,400,000
Labels/year			28,800,000
Carboard cartons/year			900,000
OUTPUTS: Tonnes/year			
Dried fish	18	72	-
Canned fish (net contents of can)	-	-	8,640
Equivalent edible weight of fresh fish	45.2	172.8	7,345

1. A simple oven design, widely used, for example, in Portugal.

2. Spread in practice over a longer period (12-15 hours), according to the oven cycle.

3. Wages are paid at 80% of "traditional" scales in the smoke drying projects, and at "other modern" scales in the canning project.

TABLE 20.

COMPARATIVE COSTS AND REVENUES FOR 3 FISH PRESERVATION PROCESSES

(15-year present values, US $ 1000 (END-1977), 10% Discount rate)

PROCESS	SMOKE DRYING (A)	SMOKE DRYING (B)	CANNING
SCALE: Tonnes of fresh fish per year.	54	216	8,640
REVENUES[1]	114.2	456.8	60,676
COSTS: Raw Materials[1]	72.6	290.5	17,920
Packing Materials	7.1	29.3	23,896
Fixed Assets	3.2	7.3	881
LABOUR: Low wage	7.0	9.4	597
High wage	24.9	35.7	1,471
ENERGY: Wood or fuel oil	4.3	17.1	446
Electricity	-	-	102
WATER	-	-	446
TOTAL COSTS: Low wage	94.2	353.7	44,288
High wage	112.1	380.0	45,162
NPVs Low wage	20.0	103.1	16,3[illegible]8
High wage	2.1	76.8	15,514
ALTERNATIVE NPVs[2] Low wage	72.6	313.6	N/A
High wage	54.7	287.2	
INVESTMENT COSTS IN US $ FIXED ASSETS	2,400	5,900	592,000

1. Assuming "Low" fish Prices..........

2. Assuming "high" fish Prices...........

US $ per tonne	"low"	"high"
Fresh fish	174	394
Smoked dried fish	670	2025
Canned fish	925	N/A

TABLE 21.

OUTLINE PRODUCTION SCHEDULES FOR THREE BREWERY PROJECT 'SCALES'[1].

PROJECT SCALE	SMALL	MEDIUM	LARGE
PRODUCT TYPE	CORN BEER[2]	LAGER BEER[3]	LAGER BEER[3]
Life of Project: years	30	30	30
Output: Years 1-4	25,000 Hectolitres/ year	100,000 Hectolitres/ year	1,000,000 Hectolitres/ year
Years 5-30	50,000 Hectolitres/ year	200,000 Hectolitres/ year	1,000,000 Hectolitres/ year
Utilisation rate: 8hr shifts per 24 hrs			
BREWHOUSE - years 1-4	1 (short shift)	2	3
years 5-30	1	3	3
CELLARS - years 1-4	3	3	3
years 5-30	3 (capacity doubles in year 4)	3 (capacity doubles in year 4)	3
BOTTLING - years 1-4	1 (short shift)	2	2
years 5-30	1	2 (capacity doubles in year 4)	2
Economic life of equipment:			
BOTTLING HALL EQUIPMENT	15 years	10 years	10 years
MOST OTHER EQUIPMENT	30 years	30 years	30 years

1. Source: Keddie and Cleghorn, op.cit.

2. A traditional beer of southern Africa, based on millet and maize. The strength of such beer is equivalent in raw material terms to that of 1,048° OG lager ("standard" strength for the purposes of this case study.

3. European type of beer, 1.048° OG ("standard" streng , as above).

TABLE 22

Alternative technologies for three brewery project scales *

PROJECT SCALE	SMALL	MEDIUM OR LARGE		
TYPE OF BEER	CORN BEER	LAGER	LAGER	LAGER
TYPE OF TECHNOLOGY	Simplified process (see text page 99)	"Low cost job creation" technology	"Least cost" technology	"Turnkey" technology
RAW MATERIAL INTAKE AND STORAGE	Manual handling; storage in bags	Manual handling; storage in bags	Fork-lift trucks; storage in bags	Fork-lift trucks; concrete silo storage
BREWHOUSE AND RAW MATERIALS	Stainless steel vessels; 75% maize, 25% millet	Iron vessels; 65% malt, 35% maize grits; whole hops	Iron vessels; 65% malt, 35% maize grits; whole hops	Stainless steel vessels; 100% malt; hop extracts
CELLARS	Aluminium vessels; 24-48 hours fermentation	Iron vessels; 18 days fermentation and conditioning	Iron vessels; 18 days fermentation and conditioning	Stainless steel vessels; 36 days fermentation and conditioning
BOTTLE STORES AND BOTTLING HALL	None (Bulk shipment of product) stainless steel bulk delivery tanks	Manual handling; unpalletised stores; manual uncrating, labelling, crating; semi-mechanised bottle washing and pasteurising; mechanical filling and sealing	Fork-lift trucks; palletised stores; manual depalletising uncrating crating and palletising; mechanical pasteurising; small mechanical bottle washers; mechanical bottle filling and sealing; high speed labellers	Fork-lift trucks; palletised stores; manual depalletising and palleting; mechanical uncrating and crating; large mechanical bottle washers; mechanical pasteurising, bottle-filling and sealing, high speed labellers
SERVICES	Central steam boiler; small refrigeration plant	Central systems - steam, refrigeration, etc.	Central systems - steam, refrigeration, etc.	Central systems - steam, refrigeration, etc.
	-	Spent grain drying (no yeast drying)	Spent grain drying (no yeast drying)	Spent grain drying (no yeast drying)

* The summary descriptions of these technologies do not cover all the (45) stages of the process, for which, however, full provision has been made in the costings.

TABLE 23

Summary schedules of inputs and outputs for seven brewing projects
(Source: Keddie and Cleghorn, op. cit., Appendix 3)

PROJECT TYPE AND SCALE: HECTOLITRES/YEAR	25— 50 000 Small corn-beer project	100— 200 000 Medium-scale lager brewing project			1 000 000 Large-scale lager brewing project		
PROCESS TYPE	Simplified process	"Low cost" job-creation technology	"Least-cost" technology	"Turnkey" technology	"Low cost" job-creation technology	"Least-cost" technology	"Turnkey" technology
LAND: Buildings, m²	500 brewery 100 stores	4 450 brewery 2 300 stores	4 050 brewery 2 100 stores	4 850 brewery 1 650 stores	14 300 brewery 14 400 stores	12 000 brewery 10 600 stores	13 500 brewery 8 200 stores
SITE total, m²	1 200	15 200	12 700	13 700	59 700	46 600	46 200
EQUIPMENT:	See table 22	See table 22	See table 22	See table 22	See table 22	See table 22	See table 22
LABOUR: Management⁺	(Not specified here: the substantial management input is included in total costs; see Keddie and Cleghorn, ibid.)						
: Skilled labour	13.5*	70**	77**	77**	226	252	254
: Low skill labour	26*	545**	154**	173**	2 517	595	587
ENERGY: Kw-hr/year***	56 000	2 240 000	2 240 000	2 240 000	11 220 000	11 220 000	11 220 000
: fuel oil, litres/year***	580 000	1 780 000	1 780 000	1 780 000	5 700 000	5 700 000	5 700 000
WATER: m³/year ***	25 000	400 000	400 000	400 000	2 000 000	2 000 000	2 000 000
PRINCIPAL MATERIAL INPUTS: per year*** : Brewing	<u>Maize</u>: 675 tonnes <u>Millet</u>: 225 tonnes	<u>Malt</u>: 2 340 tonnes <u>Maize grits</u>: 1 260 tonnes	<u>Malt</u>: 2 340 tonnes <u>Maize grits</u>: 1 260 tonnes	<u>Malt</u>: 3 600 tonnes	<u>Malt</u>: 11 700 tonnes <u>Maize grits</u>: 6 300 tonnes	<u>Malt</u>: 11 700 tonnes <u>Maize grits</u>: 6 300 tonnes	<u>Malt</u>: 18 000 tonnes
: Packaging	-	<u>Bottles</u>: 4 800 000 <u>Wooden crates</u>: 170 000	<u>Bottles</u>: 4 800 000 <u>Wooden crates</u>: 170 000	<u>Bottles</u>: 4 800 000 <u>Cardboard cartons</u>: 1 260 000	<u>Bottles</u>: 24 000 000 <u>Wooden crates</u>: 850 000	<u>Bottles</u>: 24 000 000 <u>Wooden crates</u>: 850 000	<u>Bottles</u>: 24 000 000 <u>Cardboard cartons</u>: 6 300 000
OUTPUTS: Hectolitres/year	CORN BEER 25 000 years 1-4 50 000 years 5-30	LAGER 100 000 years 1-4 200 000 years 5-30	LAGER 100 000 years 1-4 200 000 years 5-30	LAGER 100 000 years 1-4 200 000 years 5-30	LAGER 1 000 000 years 1-30	LAGER 1 000 000 years 1-30	LAGER 1 000 000 years 1-30

* Notional manning figures, for costing purposes only, but approximating the levels likely to be found in practice.
** Manning figures in the medium projects represent operation at full production (i.e. years 5-30). In years 1-4, manning levels ....
*** At full production.

information not legible in original text submitted by the author

TABLE 24.

COMPARATIVE REVENUES AND COSTS FOR 7 BREWERY PROJECTS.
(30 - year present values, US $ × 1000 (MID-1977), 10% Discount Rate)

SCALE: Hectolitres/ year	25 - 50,000		100 - 200,000		1,000,000		
PRODUCT	CORN BEER	LAGER	LAGER	LAGER	LAGER	LAGER	LAGER
TECHNOLOGY TYPE	Simplified Project	'Low cost Job Creation'	'Least Cost'	'Turnkey'	'Low cost Job Creation'	'Least Cost'	'Turnkey'
REVENUES[1]	8,[illegible]	60,3[illegible]	60,399	6[illegible],[illegible]	371,[illegible]11	371,[illegible]	[illegible]71,[illegible]
COSTS: Raw Materials	1,[illegible]1	[illegible],973	[illegible],975	12,[illegible]76	59,[illegible]75	59,[illegible]75	[illegible]
Packing Materials	-	[illegible],215	8,215	1[illegible],222	47,[illegible]	47,[illegible]	[illegible]
Fixed Assets	[illegible]57	5,232	[illegible],275	11,27[illegible]	19,[illegible]1[illegible]	[illegible],7[illegible]2	[illegible]
LABOUR: Low wage	[illegible]	3,327	1,628	1,622	16,[illegible]	6,[illegible]	[illegible]
High wage	61[illegible]	13,162	6,[illegible]	6,[illegible]35	69,[illegible]	25,[illegible]10	2[illegible],[illegible]
ENERGY: Fuel oil	[illegible]	1,9[illegible]0	1,94[illegible]	1,[illegible]	[illegible],214	6,[illegible]	6,[illegible]
Electricity	[illegible]	1,[illegible]7	1,[illegible]7	1,[illegible]	[illegible]	5,[illegible]	5,[illegible]2
OTHER PRODUCTION COSTS[2]	[illegible]	1,301	1,301	1,163	5,190	[illegible]	2,011
IMPORT & NON PRODUCTION EXPENSES[3]	1,660	12,503	12,503	12,503	76,[illegible]61	76,[illegible]61	76,[illegible]61
TRANSPORT COSTS	125	1,003	1,003	1,003	15,507	15,[illegible]	[illegible]5,[illegible]7
TOTAL COSTS: Low wage	4,[illegible]71	[illegible]	[illegible],285	5[illegible],255	250,[illegible]	2[illegible],[illegible]	[illegible]
High wage	5,[illegible]	[illegible],776	[illegible],756	[illegible]7,6[illegible]	30[illegible],[illegible]	262,[illegible]	[illegible]6,[illegible]75
NPVs Low wage	[illegible]	15,[illegible]	16,11[illegible]	7,1[illegible]	120,75[illegible]	126,[illegible]76	[illegible]
High wage	2,[illegible]	5,[illegible]	11,663	2,7[illegible]	6[illegible],267	108,[illegible]	7[illegible],[illegible]

1. 3 per cent per annum decline in Real sales price throughout project lives assumed for lager: Initial ([illegible] -1977) price for lager US $ [illegible]1.0 per hectolitre.

2. Net of by-product sales (spent grains, pressed yeast etc.)

3. Mostly administration and promotional, but including management salary costs.

TABLE 25.

TABLE OF INPUTS FOR TWO GRAIN STORAGE TECHNOLOGIES AT TWO COMMERCIAL SCALES

SCALE	"SMALL"		"LARGE"	
MAXIMUM STORAGE LEVEL, TONNES	1,080		7,680	
NORMAL OPERATING STORAGE LEVEL, TONNES (90% of maximum)	970		6,900	
ANNUAL THROUGHPUT, TONNES (1½ x normal storage level)	1,455 250 days/year		10,350 250 days/year	
UTILISATION	24 hour/day (except intake/dispatch 8 hours/day)		24 hour/day (except intake/dispatch 8 hours/day)	
TECHNOLOGY	Bagged Storage	Silos	Bagged Storage	Silos
LAND: Buildings, M^2 Site Total, M^2	635 1,270	N/A 340	4,520 9,040	N/A 1,940
EQUIPMENT/PROCESS	Manual Stacking/ Unstacking	Bucket and chain Elevators, Screens, and Silos[1]	Manual Stacking/ Unstacking	Bucket and chain Elevators, Screens, and Silos[1]
LABOUR[2]: Skilled Low skill	3 9	3 6	6 38	3 12
(Including Differential Labour for Stacking/Unstacking)	(3)	N/A	(17)	N/A

1. 10% overcapacity on maximum storage levels is allowed for. Installed costs of silos and equipment, US $ per tonne capacity, 245 Concrete silos, 310 (High cost assumption).
2. Only the labour required in storage premises is costed, not hte labour to let the grain on and off them, which is assumed invariant across storage technologies. Labour is paid at the "other modern" wage scales.
3. Based on labour required for manual transfer/stacking, unstacking of crates in breweries (1 man handles 625 tonnes througnput per year); Keddie and Cleghorn Op. cit. Appendix III.

TABLE 26.

COSTS OF TWO GRAIN STORAGE TECHNOLOGIES AT TWO COMMERCIAL SCALES

(30 year present values, US $ x 1,000 (MID-1977), 10% Discount rate)

SCALE	SMALL			LARGE		
TECHNOLOGY	BAGGED STORAGE	STEEL OR CONCRETE	CONCRETE SILOS (High cost assumption)	BAGGED STORAGE	STEEL OR CONCRETE	CONCRETE SILOS (High cost assumption)
COSTS:						
Fixed Assets	95	338	426	677	2282	2878
LABOUR: Low wage	51	42	42	155	51	51
High wage	116	160	160	634	232	232
TOTAL INSTORE COSTS:						
Low wage	140	380	468	832	2341	2137
High wage	291	498	586	1311	2504	3110
TOTAL INSTORE COSTS, US $ PER TON GRAIN PUT THROUGH: Low wage	10.6	27.7	34.1	8.5	24.0	30.1
High wage	21.2	36.3	42.7	15.4	25.7	31.9
	74,000	297,000	374,000	720,000	2,030,000	2,525,000

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