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International Journal of Food Microbiology 75 (2002) 181–187

INTERNATIONAL JOURNAL OF
Food Microbiology

www.elsevier.com/locate/ijfoodmicro

Basic requirements for the transfer of fermentation technologies to developing countries

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Received 28 December 2000

Abstract

Traditional small-scale fermentation technologies offer considerable potential for stimulating development in the food industry of developing countries in light of their low cost, scalability, minimal energy and infrastructural requirements and the wide consumer acceptance of fermented products in these countries. Efficient transfer and adaptation of these technologies is, however, often limited by inadequate basic scientific knowledge of the processes involved and the lack of appropriate biological inoculants and process controls for these technologies. Basic infrastructures, such as suitably equipped laboratories with consistent working conditions, a constant supply of good quality water and reliable power supplies, are critical elements of a minimal technology base for transfer and adaptation of these technologies. Building the institutional capacity in developing countries to facilitate research and development geared toward a better understanding of the technologies applied in small-scale traditional fermentations is essential, as is the encouragement of governments to formulate supportive national policies, which promote small-scale agro-industrial development. Socioeconomic considerations play a critical role in the successful and sustainable transfer and adoption of technologies and their products in developing countries.

Keywords: Small-scale fermentations; Developing countries; Food security; Technology transfer

1. Introduction

The agricultural production sector of developing countries has traditionally been given considerable attention by planners and policymakers, with relatively little focus on the development of agro-industry. Over the years, widespread failure of the survival of medium- to large-scale food-processing enterprises in developing countries has led to growing recognition of the need to foster the development of small-scale food industry. The role of the small-scale food processing as a subsector that can contribute significantly to the development of the rural economy is increasingly being realised (Dietz, 1999).

Small-scale food industry is important for stimulating sustainable development in the rural and peri-urban areas of developing countries and for making food available to the increasing populations in urban areas. It provides a source of income and a means of

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0168-1605/02/$ - see front matter
PII: S0168-1605(01)00705-X

poverty alleviation and contributes to the variety in the diet and to the food security of millions. Small-scale food industry also provides linkages to local suppliers of agricultural raw materials and to income-generating activities such as the manufacture of machinery, packaging and ingredients (FAO, 1997).

Fermentation processes were developed over the years by women in specific communities, in order to preserve food for times of scarcity, to impart desirable flavour to foods or to reduce toxicity. Today, fermentation is still generally practised as a household or village-level technology in developing countries, with very few operations carried out at an industrial level. Table 1 lists examples of products, which are manufactured in the developing world using industrial fermentation processes. Apart from its preservative effects, fermentation is a low-input and appropriate technology with minimal investment requirements, which provides individuals with limited purchasing power, access to safe, inexpensive and nutritious foods. Fermentation adds value and enhances nutritional quality and digestibility through biological enrichment. In addition, it provides dietary enrichment through aroma and flavour production. A diversity of fermented foods, which vary according to staple, geographical area and cultural preference is produced across the globe (Campbell-Platt, 1987; Jones, 1994; Steinkraus, 1996). Fermented foods find wide consumer acceptance in the developing world and contribute substantially to food security in a number of developing countries.

After a brief summary of the potentials of fermentation for developing countries, this paper discusses the current status of small-scale fermentations in developing countries. It then goes on to outline requirements for the successful transfer of these technologies to developing countries, and reviews the role of FAO in contributing to the successful and sustainable transfer of small-scale food-processing technologies.

Table 1
Examples of foods and food additives manufactured using industrial fermentation processes in developing countries[a]

Alcoholic beverages	Wines, beer
Milk and milk products	Cultured milks, yogurts, cheeses
Flavors	Monosodium glutamate, nucleotides
Organic acids	Lactic acid, citric acid, acetic acid
Amino acids	Lysine, glutamic acid
Vitamins	Vitamins A, C and B_{12}, riboflavin
Enzymes	Amylases, proteases, invertases

[a] From Deshpande and Salunkhe (2000).

2. Potential of small-scale fermentations for developing countries

Small-scale fermentation technologies contribute substantially to food safety, food security and nutrition, particularly in regions that are vulnerable to food shortages (Battcock and Azam-Ali, 1998; Onofiok et al., 1996). In addition, they reduce the dependency of urban populations on food imports, and allow farmers to sell their raw materials locally. As an appropriate food preservation technology, the economic and social benefit of applying small-scale fermentation in food preservation contributes to sustainable development in these countries.

3. Status of small-scale fermentation technologies in developing countries

A diversity of fermented products, which include porridges, beverages (alcoholic and non-alcoholic), breads and pancakes, fermented meat, fish, vegetables, dairy products and condiments (Campbell-Platt, 1987; Steinkraus, 1996) are produced from both edible and inedible raw materials in developing countries. These are well documented in an FAO publication series on fermented foods (FAO, 1998, 1999, 2000). Fermented cereals and fermented roots and tubers are in general consumed as dietary staples.

The level and scale of fermentation technologies applied in the production of these foods varies widely in accordance with the wide developmental differences in developing countries. The level of technology applied is highly dependent on the level of technological development and existing institutional support systems within a particular country. Technologies used vary widely from very simple in areas that lack basic infrastructure, to being relatively sophisticated where conditions permit.

A majority of developing countries do not have a supportive economic infrastructure for the development of small-scale food processing. Small-scale food processors in these countries are consequently faced

with a number of complex technical and institutional constraints (Fellows, 1992).

3.1. Technical issues and constraints

Traditional fermentation processes were developed largely as an art, rather than through scientific principles. Although procedures and equipment used by these processes are relatively simple (Ogunmoyela and Oyewole, 1992), microbiological and biochemical aspects of a number of these processes are complicated and not fully understood. Physical aspects of the processes (temperature, relative humidity and level of agitation and aeration) are often poorly controlled, and production techniques are not standardised. In general, processes are of low efficiency, and result in low yields of products of variable quality. Poor hygienic practices and improper handling during post-fermentation processing (e.g. drying), and at the point of sale, render fermented products susceptible to contamination.

The shelf life of a number of fermented products is limited by the unavailability of appropriate technologies for post-fermentation processing treatments such as drying, pasteurisation and refrigeration, which terminate the bioprocesses and consequently extend the shelf life of the fermented product. Inadequate packaging of fermented products in materials such as leaves, vegetable fibres, earthenware pots and newsprint (Fellows, 1992) limits both the shelf life and competitiveness of these products in local markets.

3.2. Institutional issues and constraints

Technical constraints faced by small-scale processors are compounded by a number of institutional constraints. In addition to an inadequacy of governmental policies, which promote and support small-scale food processing, these include insufficient raw materials and infrastructure, limited access to external inputs and limited marketing infrastructure (Dietz, 1999).

3.2.1. Availability of raw materials and physical infrastructure

Agricultural production in most developing countries is seasonal and variable (FAO, 1997). Raw materials are often produced on a small-scale for subsistence rather than for commercial purposes, resulting in low yields. Procurement of consistent supplies of raw agricultural materials for processing consequently poses difficulty. The bulkiness and high perishability of raw agricultural produce, coupled with high transportation costs, underdeveloped road infrastructure and inadequate and inappropriate storage facilities generally dictate that processing be conducted close to the source of agricultural production, during the season of production (FAO, 1997).

Other basic infrastructural facilities such as clean water and reliable energy supplies, which are necessary for the development of any food-processing industry, are not always accessible and available in developing countries. The high cost of utilities and materials often accounts for well over 50% of the cost of production (Table 2).

3.2.2. Access to external inputs

The food-processing sector in many developing countries is generally given low priority by planners and policymakers. Little funding is applied at the national level in support of research and development on food processing and for the adaptation of research results. University, national and regional laboratories are generally poorly equipped, and the research conducted by these institutions is usually poorly linked to local food processing and marketing requirements. Lack of information and networking pose a major hindrance to research and development, since institutions are often dependent on developed countries for

Table 2
Selected food industry indicators (1991–1993)[a]

Country	Materials and utilities (%)	Labour (%)
Industralised		
United States	61.8	8.9
Germany	66.2	10.8
Japan	60.7	12.6
UK	64.8	13.2
Developing		
Ghana	65.0	7.4
Indonesia	64.8	3.7
China	71.0	3.5
Kenya	93.1	1.6
India	89.7	4.2

[a] From UNIDO (1996).

information and technology transfer. Accessibility to books and periodicals is limited by high cost and a lack of foreign exchange, which results in delayed transfer and exchange of information, and in some cases, the duplication of research effort. Operational, business and marketing skills are often very limited and basic knowledge on nutrition and food safety principles is very weak. Training programmes for upgrading these skills are generally very limited and are offered on a sporadic basis with little potential for continuity and follow-up support.

Small-scale processors have little economic power, are usually incapable of supporting research and do not have the resources required to seek technical assistance. They do not generally benefit from technical assistance and support provided to the food-processing sector, and are consequently reliant on extension services, which are usually inadequate both in training and in availability.

Equipment and packaging are difficult to obtain and usually expensive. Poor access to credit, high interest rates, high foreign exchange rates and foreign exchange restrictions, further limit the ability of small-scale processors to invest in equipment and to acquire consumable items.

3.2.3. Marketing infrastructure and marketing systems

Domestic marketing systems in most developing countries are poorly developed. Limited availability of transportation and poor road networks, cause marketing problems in a number of these countries. In addition, the poor image of fermented products in local markets and the lack of market research geared toward their improvement have resulted in these products facing serious competition from imported food products, which are often of inferior nutritional value (Jones et al., 1996; Battcock and Azam-Ali, 1998; Haard, 1999).

4. Critical considerations for sustainable transfer of fermentation technologies

A considerable amount of hard work and commitment is involved in the transfer of technologies to developing countries. FAO's experience with technology transfer to developing countries has shown that individual preferences, rather than technical criteria, dictate the adoption of technologies and their products. Thus, any technology selected for transfer must grow out of the needs and practices of its beneficiary society. The level of technology and tools transferred must conform to both the sociocultural environment and to the resources of the beneficiary country (FAO/WHO, 1996).

A properly coordinated systematic approach for technology transfer to developing countries might constitute a four-phase approach: assessment of the country situation, selection of an appropriate scale and level of technology, implementation, demonstration and dissemination of the technology, and the facilitation of access to the technology (Fig. 1). This four-

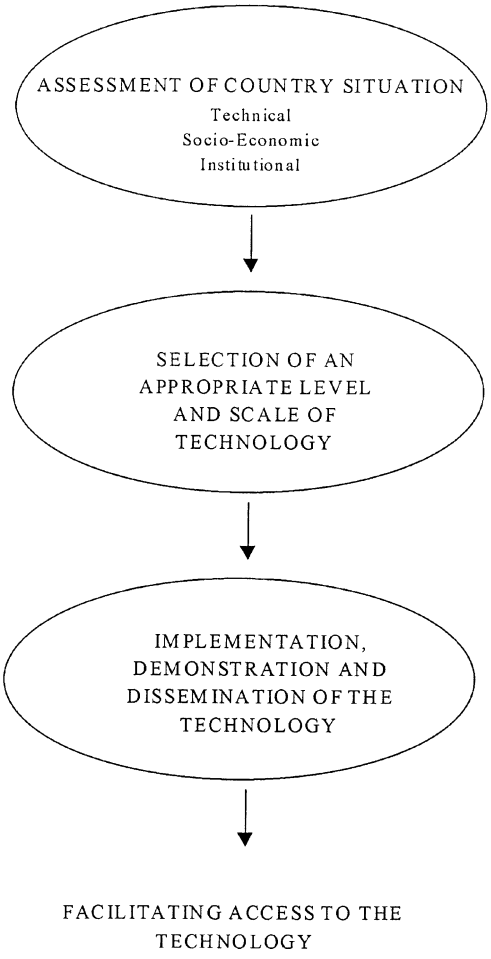

Fig. 1. Four-phase approach to sustainable technology transfer for developing countries.

phase approach must be taken with the objective of being both economically and socially appropriate. The various actors and their roles in technology transfer are summarised in Table 3.

4.1. Assessing the situation within the country

Developing countries are a non-homogenous group, and vary widely in their technical capabilities. Thus, prior to the transfer of any technology to these countries, an assessment of the technical, socioeconomic and institutional conditions within the recipient country is required in order to evaluate the level and scale of the technology to be introduced and the potential for the fermentation technology and its products to be accepted.

4.1.1. Technical and logistical assessments

An assessment must be made of current processing and manufacturing practices within the country, and supporting infrastructure (energy supplies, consistent supplies of clean water) available. In addition, the availability of transportation and road networks must be assessed in relation to sources of raw materials and storage and markets for the finished product.

4.1.2. Socioeconomic assessments

Socioeconomic assessments must be conducted in order to evaluate the level of organisation within the recipient country, cost and availability of labour, consumer purchasing power and the choice and acceptability of fermented foods. Facilities for the hygienic preparation of fermented foods and cultural factors such as the food preparation and storage practices within the country must also be evaluated in order to determine the most suitable type of fermented product for the environment into which it will be introduced (FAO/WHO, 1996).

4.1.3. Institutional assessments

Apart from technical and socioeconomic considerations, institutional factors play a major role in the successful establishment and functioning of small-scale food fermentations in developing countries. Institutional assessments must incorporate an evaluation of the level of education within the country, locally available skills and technical support services, along with an assessment of the capacity for research and development within the country. Government policies are as relevant to the transfer of technology and the provision of incentives for the development of small-scale processing must be assessed. Such incentives might include promotion of the nutritional benefits and food security potential of fermented products and the provision of: specialist advice to small-scale producers of fermented foods; support for the development of technical, business and management skills; direct subsidies or tax holidays for private sector investment in small-scale food fermentations and price policies that allow the small-scale processor to operate profitably. Often, it is necessary to advise governments on the formulation of national pro-

Table 3
Major actors and their roles in the transfer and adoption of fermentation technologies

Executing agency	Government	Processor and researcher
Technical, institutional and socioeconomic assessments	Facilitate the collection of information	Adaptation and adoption of the technology
Advice to government, processor and researcher	Support to research institutions	Application of appropriate quality control and quality assurance measures
Provision of information	Provision of incentives to the food industry	Promotion of sustainable use of the technology dissemination of the technology
Transfer of an appropriate level and scale of technology	Assistance in the dissemination of information	
Provision of training in the use of the technology and in marketing of its products	Provision of infrastructural support	
Facilitating the adoption of the technology	Facilitating access to and dissemination of the technology	

grammes and policies in support of small-scale fermentation technologies, and on rural credit schemes and marketing approaches.

4.2. Selection of an appropriate scale and level of technology

Having thoroughly assessed the needs of the country, and the situation within the country, consideration must then be given to the choice of fermented product and the most appropriate methodology for processing it, within the context of the social and cultural practices of the country. The scale of the technology will depend on the assessed demand for the product, and will in turn govern the size of equipment required.

Emphasis should be placed on self-reliance in the selection of an appropriate technology. Equipment that can be locally maintained, with relatively easy access to spare parts, is general highly desirable. Technologies which utilise locally available materials and skills, or materials and skills that can be procured or developed within the country are most desirable for transfer and adoption in light of the high cost of foreign exchange, limited access to it and the high cost of overseas technical support. These technologies must of course have technical credibility, show a clear benefit in use and conform to production conditions such as water quality and availability, cost and availability of energy, with consideration for overall financial profitability and social and environmental benefit.

An appropriate quality of packaging and some level of quality control must be selected for the product. These should reflect the purchasing power within the target market, while ensuring competitiveness of the product within that market.

4.3. Implementation, demonstration and dissemination of the technology

Once an appropriate level and scale of technology have been selected, it is usually necessary to upgrade the technical, marketing and business skills within the country in order to facilitate implementation and absorption of the technology and its products. This is accomplished by training in the form of workshops, short courses and demonstrations of the technology. Often, a core of skills, which includes information and extension agents, is targeted for training. Demonstrations on both the uses of the fermentation technology and preparation of the fermented product are critical since they can often lead to refinements, which facilitate acceptance and adoptability of the technology, and of the use of the fermented product.

Mechanisms for dissemination of the technology will be determined by the developmental status of the country and the level of education within the country. In some cases, information dissemination can be accomplished through the local media (radio and television), while in others, the use of brochures and printed materials is required. Networking among small-scale processors, scientists, researchers and extensionists also facilitates information dissemination and access to information. Fostering the development of such networks may facilitate information dissemination.

4.4. Facilitating access to the technology

FAO's experience with technology transfer has shown that the adoptability of any technology and its products is highly dependent on the recognition by users of the technology, of a clear benefit in the use of the technology and its products. Once adopted, it may be necessary to facilitate entrepreneurs in acquiring the technology and in the development of both business and product marketing plans. Often, it is necessary to advise entrepreneurs on how to utilise and access credit facilities available within the country.

5. Role of FAO in technology transfer

FAO's focus in supporting the transfer of small-scale food fermentations to developing countries is geared primarily toward building capacity through training designed to upgrade technical, marketing and management skills; providing technical support and advising governments on the selection of appropriate technologies, rural credit schemes and marketing approaches. In addition, FAO provides advisory services to governments on the formulation of national programmes and policies in support of small-scale technologies and fosters technical cooperation among countries. Networking, the provision of technical information and access to technical information and databases are also functions of FAO.

The activities of the Agro-Industries and Post-Harvest Management Service (AGSI) of FAO are geared toward adding value to agricultural produce, the conservation of food, creation of employment, and providing and facilitating access to and exchange of information on issues of relevance to agro-industries and post-harvest. AGSI's main emphasis is on the development of small-scale rural industries based on the use of locally available raw materials. FAO/AGSI's work on fermentation technology currently focuses on assisting developing countries in building and improving traditional fermentation processes, and documentation of fermentation technologies, which are rapidly being lost (FAO, 1998, 1999, 2000). In addition, FAO seeks to promote wider interest in fermentation technology for the enhancement of food security and food safety, for upgrading nutritional standards in impoverished regions and for the prevention of food losses.

6. Conclusions

Not every process or product, which seems technically appropriate for a developing country environment, is workable or adoptable under all conditions. Technical, institutional and socioeconomic assessments at the country level are very important prerequisites to determine the potential for success of a particular technology and its products. Socioeconomic factors, however, play the greatest role in the successful and sustainable transfer and adoption of technologies, and their products.

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