ISSN 1810-0775

Traditional fermented food and beverages for improved livelihoods

FAO Diversification booklet 21

Diversification booklet number 21

Traditional fermented food and beverages for improved livelihoods

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Food and Agriculture Organization of the United Nations
Rome 2011

ISBN 978-92-5-107074-1

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Preface

The purpose of the FAO Diversification booklets is to raise awareness and provide decision support information about opportunities at farm and local community level to increase the incomes of small-scale farmers.

Each booklet focuses on a farm or non-farm enterprise that can be integrated into small farms to increase incomes and enhance livelihoods. The enterprises profiled in the FAO Diversification booklets selected are suitable for smallholder farmers in terms of resource requirements, additional costs, exposure to risk and complexity. The products or services generated by the enterprises are suitable for meeting demand on a growing, or already strong, local market and are not dependent on an export market. However, in this booklet export markets will be considered, because enterprise development, local markets and prices will be influenced by imports.

The main target audience for these booklets are people and organizations that provide advisory, business and technical support services to resource-poor small-scale farmers and local communities in low- and middle-income countries. It is hoped that enough information is given to help these support service providers to consider new income-generating opportunities and how these might enable small-scale farmers to take action. What are the potential benefits? What are farmer requirements and constraints? What are critical 'success factors'?

The Diversification booklets are also targeted to policy-makers and programme managers in government and non-governmental organizations. What actions might policy-makers take to create enabling environments for small-scale farmers to diversify into new income-generating activities?

The Diversification booklets are not intended to be technical 'how to do it' guidelines. Readers will need to seek more information or technical support, so as to provide farmer advisory and support activities relating to the introduction of new income-generating activities. To assist in this respect,

each booklet identifies additional sources of information, technical support and website addresses.

A CD has been prepared with a full series of Diversification booklets, relevant FAO technical guidelines, together with complementary guidelines on market research, financing, business planning, etc. Copies of the CD are available on request from FAO. FAO Diversification Booklets also can be downloaded from the FAO Internet site.

If you find this booklet of value, we would like to hear from you. Tell your colleagues and friends about it. FAO would welcome suggestions about possible changes for enhancing our next edition or regarding relevant topics for other booklets. By sharing your views and ideas with us we can provide better services to you.

Acknowledgements

Gratitude is owed to Doyle Baker, Senior Technical Officer, Rural Infrastructure and Agro-Industries Division, (AGS), FAO, who provided for a detailed technical review on a previous draft version of this booklet. Special thanks also go to Alexandra Röttger, Agribusiness Economist, (AGS), Stepanka Gallatova, Agro-Industry Officer, (AGS), Divine Njie, Senior Officer, (AGS), and Martin Hilmi, Small Enterprise Management and Marketing Consultant, (AGS), for their reviews, inputs and advice on previous drafts of this booklet.

Acknowledgements for the series

Gratitude is owed to Doyle Baker, Senior Technical Officer, Rural Infrastructure and Agro-Industries Division (AGS), FAO, for his vision, encouragement and constant support in the development of the FAO Diversification booklet series. Martin Hilmi managed the development, production and post-production of the series and provided technical support and inputs. Michael Breece undertook the design and layout of the booklets and desktop publishing.

Introduction

Fermented products can play an important role contributing to the livelihoods of rural and peri-urban dwellers alike, through enhanced food security, and income generation via a valuable small-scale enterprise option. There is such a diversity of fermentable substrate available year round, that the activity can provide a regular income. Although harvesting or substrate may be seasonal, fermentation itself is largely independent of weather, and by-products can be recycled into livestock fodder.

Fermentation activities are highly combinable with a variety of other traditional and domestic activities, and can make a particularly important contribution to the livelihoods of women, the disabled and landless poor who, with appropriate training and access to inputs, can increase their independence and self-esteem through income generation.

In the world there are a large variety of fermented foods and beverages with traditional and cultural value. The diversity of such fermented products derives from the heterogeneity of traditions found in the world, cultural preference, different geographical areas where they are produced and the staple and/or by-products used for fermentation. In many instances it is highly likely that the methods of production were unknown and came about by chance, and passed down by cultural and traditional values to subsequent generations. Some of the most popular fermented products derive from grain, fruit and vegetables and are alcoholic-based – most notably and popularly a variety of traditional beers and wines. There are also many fermented food products which are extremely important in meeting the nutritional requirements of a large proportion of the global population. Such products have a long history of production via "kitchen" fermentation, contributing to household nutrition and to important socio-cultural practices.

The origin and rationale of fermentation: Traditions and culture

Together with drying and salting, fermentation is one of the oldest methods of food preservation, and

CASE STUDY 1 **Fermented beverages: A 9 000 year history**

In 2004 a study confirmed that over 9 000 years ago people of the globe were already fermenting beverages. Ancient organic material preserved in pottery jars from the Neolithic village of Jiahu, in Henan province, Northern China, have revealed, via chemical analyses, that a beverage composed of rice, honey, and fruit was being produced at approximately the same time that barley beer and grape wine were beginning made in the Middle East. Additional liquids, dated at over 3 000 years old were also remarkably preserved inside tightly lidded bronze vessels. These vessels from the capital city of Anyang and an elite burial in the Yellow River Basin, dating to the Shang and Western Zhou Dynasties (ca. 1 250-1 000 B.C.), contained specialized rice and millet "wines." The beverages had been flavoured with herbs, flowers, and/or tree resins, and are similar to herbal wines described in the Shang dynasty oracle inscriptions.

Source: Adapted form Science Daily. 2004. 9 000-Year History of Chinese Fermented Beverages Confirmed (Available at http://www.sciencedaily.com/releases/2004/12/041206205817.htm)

embedded in traditional cultures and village life. Fermentation processes are believed to have been developed over the years by women, in order to preserve food for times of scarcity, to impart desirable flavour to foods, and to reduce toxicity (Rolle and Satin, 2002). Today, fermentation is still widely practised as a household or village-level technology in many countries, but comparatively very few operations are carried out at an industrial level (Holzapfel, 2002). As a technology, food fermentation dates back at least 6 000 years, and probably originated from microbial interactions of an acceptable nature (see Case Study 1). Fermentation has enabled our ancestors in temperate and cooler regions to survive winter season and those in the tropics to survive drought periods, by improving the shelf-life and safety of foods and beverages.

The importance of fermentation in modern-day life is underlined by the wide spectrum of foods marketed both in developing and industrialized countries, not only for the benefit of preservation and safety, but also for their highly appreciated sensory attributes. Fermented foods are treasured as major dietary constituents in numerous developing countries because of their keeping quality under ambient conditions - thereby contributing to food security - and because they add value, enhance nutritional quality and digestibility, improve food safety, and are traditionally acceptable and accessible (Holzapfel, 2002, Rolle and Satin, 2002). Fermentation is a low-input enterprise and provides

individuals with limited purchasing power, access to safe, inexpensive and nutritious foods.

Preservation and safeguarding of foods and beverages remain the principal objectives of fermentation, with wholesomeness, acceptability and overall quality, having become increasingly valued features to consumers, especially in rural areas where old traditions and cultural particularities in food fermentations are generally well maintained. The tradition of fermented beverages is long embedded in many cultures, and despite traditional production technologies remaining, there is potential for extension services to introduce some improved methods, particularly those for hygiene and safety. However, it must be noted in this context, despite modern food biotechnology making significant technological advances, limitations in infrastructure and existing low technologies in rural areas of most countries create challenges to keeping abreast of global developments toward industrialization (Holzapfel, 2002) and also importantly in terms of quality and safety of products.

Diversity of fermented products

A diversity of fermented products, including 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 many countries. These are well documented in an FAO publication series on fermented foods (see FAO, 1998, 1999, 2000), and summarised in Box 1, and many are presented as case studies in the section on *Essentials of fermentation*. Fermented cereals and fermented roots and tubers are consumed as dietary staples throughout Africa, Asia, and Latin America, in various forms including breads, porridges, gruels, and pickles.

A wide range of grains, fruit and vegetables are also used to manufacture beverages, both thirst quenching products (mostly non-alcoholic), and those which are generally alcoholic and consumed on special occasions, including festivals. The former include tea, coffee, juices, nectars, syrups, and carbonated soft drinks. In some countries these are also used on special occasions, whereas in others alcoholic beverages, which may or may not be distilled, are preferred (Fellows and Hampton, 1992). In most countries, the market for alcoholic and non-alcoholic drinks is specific with regard to religious and cultural taboos.

BOX 1 **Examples of foods and additives manufactured using industrial fermentation processes in developing countries.**

- Alcoholic beverages, including some spirits, but largely wines and beer
- Milk and milk products, including cultured milks, yogurts, and cheeses
- Flavours, namely monosodium glutamate, and nucleotides
- Organic acids such as lactic, citric, and acetic acids
- Amino acids of lysine and glutamic acid
- Vitamins A, C, B12, and riboflavin
- Enzymes Amylases such as proteases and invertases.

Source: FAO.2000. Fermented grain legumes, seeds and nuts: A global perspective, by S.S. Deshpnade, D.K. Salunkhe, O.B. Oyewole, S.Azam-Ali, M. Battcock & R. Bressani, FAO Agricultural Services Bulletin No.142, Rome

Fermented Foods

Table 1 provides an overview of fermented foods from around the world. The fermentation process of some of these is detailed in the case studies presented in the section on *Essentials of fermentation*.

TABLE 1 **Fermented foods from around the world**

Region and name of fermented products	Type of product
Indian sub-continent	
Acar, Achar, Tandal achar, Garam nimboo achar	Pickled fruit and vegetables
Gundruk	Fermented dried vegetable
Lemon pickle, Lime pickle, Mango pickle	
South East Asia	
Asinan, Burong mangga, Dalok, Jeruk, Kiam-chai, Kiam-cheyi, Kong-chai, Naw-mai-dong, Pak-siam-dong, Paw-tsay, Phak-dong, Phonlami-dong, Sajur asin, Sambal tempo-jak, Santol, Si-sek-chai, Sunki, Tang-chai, Tempoyak, Vanilla,	Pickled fruit and vegetables

TABLE 1 **Fermented foods from around the world** *(Cont.)*

Region and name of fermented products	Type of product
South East Asia	
Bai-ming, Leppet-so, Miang	Fermented tea leaves
Nata de coco, Nata de pina	Fermented fruit juice
East Asia	
Bossam-kimchi, Chonggak-kimchi, Dan moogi, Dongchimi, Kachdoo kigactuki, Kakduggi, Kimchi, Mootsanji, Muchung-kimchi, Oigee, Oiji, Oiso baegi, Tongbaechu-kimchi, Tongkimchi, Totkal kimchi,	Fermented in brine
Cha-ts'ai, Hiroshimana, Jangagee, Nara senkei, Narazuke, Nozawana, Nukamiso-zuke, Omizuke, Pow tsai, Red in snow, Seokbakji, Shiozuke, Szechwan cabbage, Tai-tan tsoi, Takana, Takuan, Tsa Tzai, Tsu, Umeboshi, Wasabi-zuke, Yen tsai	Pickled fruit and vegetables
Hot pepper sauce	
Africa	
Fruit vinegar	Vinegar
Hot pepper sauce	
Lamoun makbouss, Mauoloh, Msir, Mslalla, Olive	Pickled fruit and vegetables
Oilseeds, Ogili, Ogiri, Hibiscus seed	Fermented fruit, vegetable seeds
Wines	Fermented fruits

TABLE 1 **Fermented foods from around the world** *(Cont.)*

Region and name of fermented products	Type of product
Americas	
Cucumber pickles, Dill pickles, Olives, Sauerkraut	Pickled fruit and vegetables
Lupin seed, Oilseeds	Pickled oilseed
Vanilla, Wines	Fermented fruit and vegetable
Middle East	
Kushuk	Fermented fruit and vegetables
Lamoun makbouss, Mekhalel, Olives, Torshi, Tursu	Pickled fruit and vegetables
Wines	Fermented fruits
Europe and World	
Mushrooms, Yeast	Moulds
Olives, Sauerkohl, Sauerruben	Pickled fruit and vegetables
Grape vinegar, Wine vinegar	Vinegar
Wines, Citron	Fermented fruits

Source: Adapted from Cambell Platt,G.1987. Fermented foods of the world-A dictionary and guide, Butterworths, London

Traditional beers and wine

While there are many different types of fermented drinks (see Case Study 2) the most commonly available and best known are beer and wine (see Table 2).

TABLE 2 **Fermented beverages from around the world**

Source	Name of fermented beverage	Name of distilled beverage
Barley	beer, ale	Scotch whisky
Rye	rye beer	rye whisky
Corn	corn beer	bourbon whiskey
Wheat	wheat beer	wheat whisky, Korn (Germany)
Rice	sake sonti	shochu (Japan), soja (Korea)
Juice of fruits, other than apples or pears	wine (most commonly thought of from grapes)	brandy, cognac (France), Branntwein (Germany), pisco (Peru/Chile)
Juice of apples	("hard") cider, apfelwein	applejack (or apple brandy), Calvados
Juice of pears	perry, or pear cider	pear brandy
Juice of sugar cane, or molasses	basi, betsa-betsa (regional)	rum, cachaça, aguardiente, guaro
Juice of agave	pulque	tequila, mezcal
Juice of plums	plum wine	slivovitz, tzuica, palinca
Pomace	pomace wine	grappa (Italy), Trester (Germany), marc (France)
Honey	mead	distilled mead ("mead brandy" or "honey brandy")
Potato and/or grain	potato beer	vodka: potato mostly used in Ukraine, otherwise grain
Milk	Kumis	Araka

Source: FAO.2011. Manufacturing fruit wines-a practical guide, by J. De La Cruz Medina & H.S. Garcia, Rome (Unpublished)

CASE STUDY 2 **Mezcal making in Mexico**

Mezcals are spirits prepared by distilling cooked and fermented agave plants: a tradition which has been passed down from one generation to another for hundreds of years, and takes place in small rustic distilleries or *fábricas*, located close to water sources. Mezcal dates back 10 000 years when baked agaves were the main foodstuff for hunters and gatherers, and the fermented beverage a basic alcohol enslaved Filipinos introduced it in the 16th century. After some escaped and blended with the local population, mezcal became the distinctive indigenous liquor. Some 15 agave species are used in different regions of Mexico and each mezcal is different, both because of the species and because of the tools and processes used in its preparation

Traditionally only men are involved in the production and trading of mezcal, and local distilleries are owned by individuals who have managed to accumulate sufficient capital. Such enterprises can offer local men, who choose to be paid in cash rather than mezcal, sufficient employment and income to prevent seasonal migration in search of paid work. From a case study in Guerrero, Mexico, a group of distillers from 30 communities formed a bottling and commercialization enterprise, and a grower and distiller association, which certifies the mezcal as being of high quality, limited supply, and deriving from a sustainable harvest. The vast majority of community produced mezcal is locally and regionally traded and consumed, but observable increases in demand as a result of trends embracing established traditions and customs, have created new brands providing consumers and connoisseurs with a range of different prices and qualities, from US$25 to US$2 000 per litre.

Source: Adapted from Marshall, E., Schreckenberg, K. & Newton, A. 2006. Commercialization of non-timber forest products in Mexico and Bolivia: Factors influencing success. Research conclusions and policy recommendations for decision-makers, UNEP-WCMC, Cambridge, United Kingdom

Beer

Beer is an ancient beverage: clay tablets describing its brewing process – found in Mesopotamia – date back more than 5 000 years. Sumerians used to prepare "beer bread" out of germinated barley seeds and by crumbling this bread into water, they obtained a liquid called "*sikaru*" which was finally boiled and mixed with a few herbs, resulting in a drink-free of harmful bacteria (FAO, 2009). Over time, different types of starchy plants have been used for brewing, including maize (in South America), soy (in India and Iran), millet and sorghum (in Africa), and rice (in the Far East), but beer production from barley malt is currently the most common brewing process worldwide (FAO, 2009), and forms the basis of industrial brewing which is of particular importance to European countries in transition, including the Balkan States.

Brewing at industrial level requires mashing, which involves the use of hot water to extract the soluble materials from the grains, to produce a liquid called wort, and is carried out in large vessels which may be made of wood or stainless steel. The wort is then boiled, and sometimes hops (which have antiseptic qualities and assist with biological purity) are added. Boiling takes place in a flask-shaped vessel with the neck to carry away the steam and to prevent over-boiling. Prior to adding the yeast (inoculation), the wort is cooled to a lower temperature, depending on the type of beer to be produced, to prevent inactivating the yeast. Fermentation in large vats or food-grade plastic bins generally takes one to two weeks, depending on the temperature at which the bottles are kept. The sugar needed for the fermentation process comes from the transformation of the starch in the grain.

Brewing at farm and village level, which is the focus of the "beers" mentioned in this booklet requires three factors: i) an agricultural commodity, such as millet or sorgum; ii) a source of energy that is controllable, for example a wood fire; and iii) a brewing container, for example pottery. The actual process in general consists of three basic stages – mashing, boiling and fermentation. Case Study 3 illustrates local brewing of banana beer.

CASE STUDY 3 **Making Banana Beer – a popular alcoholic beverage throughout Africa**

Banana beer is a weak alcoholic beverage popular throughout Africa, and is made by fermenting bananas with a cereal flour - often sorghum flour. It is sweet and slightly hazy with a shelf-life of several days under correct storage conditions. In Kenya, banana beer is known as *urwaga*, and in Uganda *lubisi*.

Ripe bananas (*Musa* species) are used as they have a high sugar content which is necessary for fermentation. Preparation involves extracting the juice from peeled bananas, which are unspoiled by micro-organisms or other contaminants. Clean boiled water is added to the extracted juice to dilute the banana juice so that the concentration of soluble solids is low enough for the yeast to ferment the juice. Grinded cereal (sorghum or millet) are lightly roasted over an open fire and then added to the diluted banana juice in a clean bucket. The bucket is covered with a clean lid, and leaft in a warm place to ferment for 18 to 24 hours. The ground cereal improves the colour and flavour of the beer. After fermentation the beer is filtered through a cotton cloth, sterilised with boiling water.

CASE STUDY 3 **Making Banana Beer – a popular alcoholic beverage throughout Africa** *(Cont.)*

Packaging is usually only required to keep the product for its relatively short shelf- life and clean glass or plastic bottles can be used. The product is stored in a cool place away from direct sunlight.

As banana beer is made from raw material that does not undergo any heating or cooking at any stage of the process, the pulp is an excellent substrate for microbial growth – both of the desirable yeasts and the non-desirable spoilage bacteria. The fermentation is brought about by natural yeasts that are present on the banana. Heating or boiling the raw material would kill these natural yeasts and spoil the traditional flavour of the beer. This implies, for important public health and marketing that it is essential that strict attention is paid to cleanliness of the equipment and processing area and to personal hygiene to avoid contamination of the beer with other bacteria that may form acid rather than alcohol. Equipment needs to be sterilised prior to use with boiling rather than chlorinated water, which can affect the fermentation.

Improved method for banana beer

Both hygiene and product quality can be improved by following a typical method for making a fermented beverage, involving the preparation of a wort (which is a boiled starter substrate), addition of a commercial source of yeast, fermentation under controlled conditions (time and temperature), followed by pasteurisation to stop the fermentation. The beer made by this method will have a different taste and appearance to the 'live' beer produced by the traditional method, and it can be bottled and stored, and will be consistent from one batch to the next.

Source: Adapted from Practical Action.2008. Banana beer, The Schumacher Centre for Technology and Development, Rugby, United Kingdom

Wine

Wine making consists typically of fermenting fruit juices and adding yeast, sugar, dextrose or invert sugar (FAO, 2011). Making wine at smallholder level does not require complex equipment and processes, especially those that do not use grapes. However hygiene and safety are paramount in the process, much like beer. However it has to be noted that some fruit wines, for example Palm and Toddy wine, have a very short shelf-life once made, commonly only about a day, and thus limit marketing value and may be more suitable for specific event markets, such as celebrations (weddings, etc.) and festivities (national holidays). Box 2 (Mango wine) illustrates a viable small-scale wine production process that requires commonly non-

BOX 2 **Making mango wine**

For fresh mango marketing the shape and size of the fruits are important. Thus fruits which cannot be marketed as a result of shape and size can be used for producing mango wine. Poor quality raw materials for making the wine will result in poor quality wine that can also be unsafe. Mangos needed for wine production should not be over ripened, free of mould and rot and not badly damaged.

Mangos need to be peeled and cut prior to pulping. Fruits are pulped and then the juice is filtered using a strainer. If sugar content of the juice is too low then sugar can be added. Then the juice is placed in a vessel (made from plastic, wood or stainless steel) for fermentation with a yeast inoculation for 5 to 21 days. The vessel is fitted with an airlock. After initial fermentation the juice is transferred to a larger airtight vessel and then the wine is filtered and funnelled into sterilized bottles and capped for maturing. The mango wine can be aged, but checks need to made on quality and detect any problems with the "instability" of the wine.

Source: Adapted from FAO.2011. Manufacturing fruit wines-a practical guide, by J. De La Cruz Medina & H.S. Garcia, Rome (Unpublished)

marketable raw materials, simple equipment and process, a period of maturation, but provides for a viable marketing option as shelf-life is long.

More "sophisticated" wine making requires still simple facilities and good hygiene practices, but processes involved as slightly more complex. During the first stage, the fruit juice or pulp is mixed with yeast and sugar and held in a fermentation bin for about ten days during the first fermentation stage. Within 48 hours, fermentation becomes vigorous and there is frothing and foaming, and it is important to keep the fermentation vessel closed to prevent bacteria and fungi from infecting the wine. After ten days the fermenting wine is "racked", involving scooping it up together with the solids using a sterilized mug, cup, or jug, and passing it through a sterilized muslin or nylon straining cloth. The wine is transferred into narrow necked fermentation vessels, which may be plugged with wads of cotton wool, or specially-designed vessels fitted with an airlock (known as a demijohn) may be used. Ideally, fermentation is then continued at a temperature of 18°C, and the whole process can take from three weeks to three months, and the end of fermentation can be judged when it is seen that there are no more bubbles rising to the surface. At this stage, the wine is filtered, in order to remove the sediment from the wine

and then syphoned into narrow-necked or food-grade plastic vessels, and stored for the minimum period in the recipe to allow the wine time to clear and mature before bottling. After this period of maturation, the wine is siphoned off into bottles and sealed with a sterilized cork-stopper or screw cap (Fellows and Hampton, 1992).

Market Potential

Fermentation as a diversification enterprise offers many opportunities as a result of their global popularity. Fermented products are part of many social, cultural and consumption patterns, especially regarding fermented beverages. The reduced perishability of many fermented products also offers increased advantages to both sellers and consumers. Demand for fermented products is high, this being especially the case during particular social and cultural events as well as during celebrations, such as weddings. In rural areas markets can be found in close vicinity of farms and in local village markets. Commonly demand is high as many fermented products sold fit in well with social and cultural culinary traditions. Fermented products are seen as having higher value by many consumers compared to other foods and in some instances fermented products are regarded as being delicacies. Fermented products are also convenient for consumers as many of the products do not require refrigeration and this is especially important in hot and humid climates. Rural dwellers are also reassured that the product may be safer to consume then other food and beverages, as a result of fermentation.

Demand for such products is found not only in traditional rural areas, but also in large urban centres as a result of traditions and rural migration. Such products, for example, offer retailers in urban centres to be able to sell products which have a longer shelf-life and are relatively safer to consume then others foods (see also FAO Diversification booklet No. 18 *Selling street and snack foods*). The flux of many daily workers from rural to urban areas, offers, yet another ready market for fermented products as meals can be either bought from rural areas and taken to cities for meals or bought from retailers in urban areas and then sold to daily migrant workers. Some traditional fermented products, for example such as Kefir (fermented milk drink), are also finding ready markets in supermarkets in larger cities. Other fermented products are now being certified with origin-based geographic indication brands.

Small-scale farmers can easily access the many opportunities provided by markets found on farmers' door steps in their local area and in surrounding villages. However, beyond local and village level, market potential of fermented products needs to contend with several pre-requisites including such aspects as larger facilities for production, more ad hoc equipment, consistency and reliability in quality control, labelling, licensing and so forth.

Purpose of the booklet

This booklet is intended to heighten awareness about the potential of fermented foods and beverages as a viable enterprise that can contribute to small-scale farmers' income, building on, and in full respect of, important social and cultural factors. It also looks at how fermented food and beverages contribute to food security through preservation and improved nutritional quality. It highlights the opportunities and challenges associated with small-scale fermentation activities, as well as more formal operations on farm, and different marketing and selling strategies to achieve a successful livelihood diversification option.

Fermentation and sustainable livelihoods

Extending the shelf-life of foods is one of the major objectives of fermentation, with aspects such as wholesomeness, acceptability and overall quality. Fermented foods make a major contribution to dietary staples in numerous countries across Africa, Asia and Latin America and small-scale fermentation technologies contribute substantially to food security and nutrition, particularly in regions that are vulnerable to food shortages (FAO, 1998), see Box 3. In addition, they reduce the dependency of rural and 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. Fermented beverages have also contributed to cultural evolution and preservation, since as far back as 800BC, as illustrated by Box 5.

Food security and cultural importance

Fermentation technologies play an important role in ensuring the food security of millions of people around the world, particularly marginalised and vulnerable groups (see Box 3). This is achieved through improved food preservation, increasing the range of raw materials that can be used to produce edible food products and removing anti-nutritional factors to make food safe to eat. Furthermore, there exist many examples of fermentation by-products which can be safely fed to nutritionally supplement livestock, thereby further strengthening the livelihood system. Well known examples include the by-products of brewing, such as "brewers grains" and dried yeast. These provide a good source of un-degradable protein and water soluble vitamins, but need to be stored cool and fed within a week, or otherwise ensiled, to prolong their shelf-life (FAO, 1999).

BOX 3 **Fermented foods for survival in Sudan**

During the 1983-85 famine in Sudan, relief workers found that people survived by producing specific traditional fermented food products, especially Kawal. An estimated 60 percent of the fermented foods of Sudan are famine or survival foods, and the strong link between fermented foods and food shortages is revealed by the fact that when a family becomes rich a number of fermented foods are no longer prepared. The techniques used are very effective methods of food preservation. The products can be preserved for years through the double action of fermentation itself (which produces anti-microbial acids) and sun-drying. Sudan is probably the hottest and driest country in Africa, and through the years women have made full use of this free solar energy: shade temperatures in the summer reach 45-50 °C and the hot sands outside the shade reach more than 70 °C. Dried and fermented foods together with the seeds and fruits that can be gathered from the wild have saved lives, especially those of children, in times of shortage both past and present.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

Fermentation is a cheap and energy efficient means of preserving perishable raw materials, which is accessible to even the most marginalised, landless, physically incapacitated rural, peri-urban and urban poor. Following harvest, fruit and vegetables, for example begin to deteriorate, especially in the humid tropics where the prevailing environmental conditions accelerate the process of decomposition (see FAO Diversification booklet No. 11 *Growing vegetables for home and market* and FAO Diversification booklet No. 16 *Fruit products for profit*). There are several options for preserving fresh fruit and vegetables including drying, freezing, canning and pickling, but many of these are inappropriate for use on the small-scale: for example, small-scale canning of vegetables can have serious food safety implications given contamination with botulism is a possibility; and freezing fruit and vegetables is not economically viable at the small-scale (Holzapfel, 2002). Fermentation however, requires very little sophisticated equipment, either to undertake or subsequently store the fermented product, and has had a major impact on nutritional habits, traditions, and culture. As such, traditional fermentation still serves as a substitute for refrigeration or otherwise safekeeping of food, and is also directly utilised to make good of edible leftovers (see Box 3).

BOX 4 **Utilising left-overs and by-products in Indonesia**

In Indonesia a variety of waste products are fermented to produce nutritious food products. *Tempe-bongrek* is a protein rich food made in Indonesia by fermenting peanut and coconut press-cake, remaining after oil extraction, and the final product is similar to traditional tempeh produced from the fermentation of soya beans. The production of *tempeh-bongrek* is a mould fermentation, initiated by inoculation of the soaked, acidified press-cake with *Rhizopus* species. The inoculated cakes are placed on banana leaves or plastic sheets in a dark room for about 2 days, and an incubation temperature of 37 ºC is optimal for the mould and prevents the growth of P. *cocovenenans*, which produces *bongkrek* toxin.

Ontjom is produced from waste groundnut press cake, tapioca waste and the solid waste of *tahu. Ontjom* is prepared using a mixed culture of micro-organisms with *Rhizopus* or *Neurospora* species predominating. *Ontjom* is mainly produced in west Java where it is consumed as a side dish in the form of deep fried slices. It forms an important daily food item for the west Javanese, particularly those from the lower income groups. Fresh coconut residue, left over from the production of coconut cream or milk, can be fermented by B*acillus subtilis*, in an alkaline fermentation, to produce *semayi*, which is widely consumed in Indonesia.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

Fermented foods are described as palatable and wholesome and are generally appreciated for attributes, their pleasant flavours, aromas, textures, and improved cooking and processing properties (Holzapfel, 2002). Micro-organisms and enzymes, by virtue of their metabolic activities, contribute to and enhance these characteristics, and through trial and error, traditional skills have been developed for refining fermentation processes (Hammes, 1990). Despite the many nutritional advantages - which surpass western-style fast and processed foods - many fermented products are often associated with the stigma of being a "poor mans" food, and as soon as a family can afford to buy processed foods, it moves away from carrying out home fermentation (Holzapfel, 2002). Where cultural values attached to the fermented food are strong, it is unlikely that there will be an image problem: for example, *kimchi* is considered part of the national heritage in the Republic of Korea: it is a vital ingredient of all meals and as such is a highly valued food (FAO, 1998).

Fermented beverages also have significant cultural importance, and primitive distillates of various ferments were being made in Asia in 800 BC.

Examples included: *Skhou*, in the Caucasus from kefir (mare's milk); *Sochou/Shochu*, in Japan from sake (rice); *Saut/Sautchoo* in China from *tehoo* (rice, millet); *Arrack* in India from toddy (rice with molasses or palm sap); *Arika* by Tartars from koumiss (mare's milk). More recently, from 1 000 AD onwards there are records of forerunners of brandy being produced in Europe, and later in the 15th century, cognac in France and Whiskey in Scotland.

Cultural and social well being:
As is well documented, the indigenous knowledge of producing fermented food and beverages has developed over a long period of time, and age-old indigenous fermentation techniques underpin cultural sustainability in many areas of the world, facilitating the development of nutritious food items which can not only cope with environment conditions, such as inhospitable high altitude areas of the Himalaya (Roy *et al*., 2004), but are an integral component of many indigenous cultures (see Box 5).

Fermentation as an enterprise also and importantly encourages the preservation of cultural tradition related to food security in many countries (see Case Study 4).

BOX 5 **Fermented beverages and cultural evolution**

Recent research suggest the possibility that alcoholic beverages, instead of bread, could have played a more decisive role in causing our ancient ancestors to switch from hunter-gatherers to farmers: the fermentation process was discovered by humans at the beginning of the Neolithic period. Water and alcoholic beverages are refreshing and fill us up, but alcohol versions do even more, containing nutrients, flavours and aromas. They relieve physical pain, can remove harmful alkaloids and kill harmful bacteria, retarding food spoilage. The inherent benefits of alcohol were discovered by experience rather than education: in ancient Egypt, Mesopotamia, China, Rome and Greece, medical practitioners used fermented drinks not only for pain relief, but also to treat a variety of ailments, and alcohol was used to dissolve or dispense medicinal herbs or spices. It is reported that such ancient wonders as the Egyptian pyramids, Incan royal cities and vast irrigation networks were built with labourers amply rewarded with fermented beverages. Instead of being educated about alcohol's antiseptic, anti-oxidant properties, our ancient ancestors seemed to know it had life-extending benefits because they witnessed them first hand. In the 21st century, however, we know that as an addiction it can shorten life or have other negative benefits that help tip the scale between good and bad.

Source: Adapted from Bachelor, R.E. 2010. World's oldest known alcoholic beverage, (Available at http://archaeology.suite101.com/article.cfm/worlds-oldest-known-alcoholic-beverages)

CASE STUDY 4 **Fermented products and changing tastes in Nigeria**

Traditionally in Nigeria fermented foods are a significant proportion of the national diet. However it is now a mixed grill of both foreign and local dishes as per the introduction of imported processed products. These products are sold with relatively high price tags and many Nigerian consumers are willing to pay these prices. Consumers see these products as deriving from decades of research and development in their countries of origin. Almost in contrast, many of the local indigenous fermented foods lack this appeal. Many consumers prefer the imported and exotic food items because of the attractive form, long shelf-life, ease of transportation and other forms of utility which consumers associate with them.

The development of appropriate technologies aimed at upgrading the quality of indigenous Nigerian foods will be indispensable for the growth and survival of the industry.

Source: Adapted from Achi,O.K. 2005. The potential for upgrading traditional fermented foods through biotechnology, African Journal of Biotechnology Vol. 4 (5), pp. 375-380

In addition to improving food security, fermentation can improve the flavour and appearance of food, and in particular, create a meat-like flavour, and for example, over the years, Sudanese women have developed products to replace meat in their diets: such as "*kawal*" fermented wild legume leaves, "*sigda*" fermented sesame press-cake, and "*furundu*" fermented red sorrel seeds (FAO, 1998). The strong flavours of fermented food products can make an otherwise dull, bland, and repetitive diet much more appealing, with fermented vegetables such as pickles and chutneys often used as condiments to enhance the overall flavour of a meal.

Nutritional value

The optimum health and nutrition of individuals is dependent upon a regular and balanced supply of food and water, and when diets are sub-optimal, an individual's capacity for work and achievements is greatly reduced. Availability of food, dietary restrictions and taboos, misconceptions, limited time available for feeding or eating compound to create a group of individuals who are nutritionally disadvantaged. The most vulnerable groups are women, children and weaning infants: approximately 30 percent of women consume less than their daily requirements of energy and at least 40 percent of women world-wide suffer from iron-deficiency anaemia (FAO, 1998).

Foodstuffs:
Fermented foods contribute to about one-third of the diet worldwide (Campbell-Platt 1994), and cereals are particularly important substrates for fermented foods around the globe. Fermentation of both cereals and fruits and vegetables, can make otherwise inedible food stuffs safe, nutritious, and palatable, improving digestibility of protein and carbohydrates, removing natural toxins, and decreased cooking times (see Box 6). Specifically, lactic acid fermented foods are the traditional means for weaning infants in many developing countries, as they improve both food safety and digestibility. By acidifying porridges with lactic acid fermentation, starch is hydrolysed into shorter chains of glucose and dextrose, which reduce the viscosity of the porridge and increase its energy density, helping the child to better meet its energy requirements (FAO, 1998).

Anti-nutritive compounds:
Cereal based diets, including maize, sorghum and millet, contain a number of anti-nutritive factors, including reduced availability of minerals, including calcium, iron, magnesium and zinc, as well as deficiencies in essential amino

BOX 6 **How fermentation processes can result in increased vitamin levels in the final product**

- Sorghum beer in Southern Africa contains relatively high levels of riboflavin and nicotinic acid, which are important for people consuming a high maize diet. Pellagra (a vitamin deficiency disease associated with high maize diets) is unusual in communities in which sorghum beer is consumed. Even children benefit from consuming the dregs which contain relatively little alcohol but are rich in vitamins.
- Palm wine in West Africa is high in vitamin B12, which is very important for people with low meat intake, and who subsist primarily on a vegetarian diet.
- *Pulque* (a fermented plant sap) is an important source of vitamins for the economically deprived in Mexico. The fermentation process involved in *Pulque* production increases its vitamin content. For instance the vitamin content (milligrams of vitamins per 100g of product) of *Pulque* increases from 5 to 29 for thiamine, 54 to 515 for niacin and 18 to 33 for riboflavin (Steinkraus, 1992) during fermentation.
- *Idli* (a lactic acid bacteria fermented product consumed in India) is high in thiamine and riboflavin.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

acids including lysine, tryptophane and methionine, which serve as building blocks for proteins (Holzapfel, 2002). Other anti-nutritive components typical of cereal and legume foods include acids and tannins which can further reduce mineral availability, and further exacerbate malnutrition. However, fermentation may serve to improve the nutritional value and protein quality of food staples, by inactivating naturally occurring toxins, as with cassava (see Box 7). Essential steps in traditional household-level processing, such as soaking, germination and fermentation, may help reduce these anti-nutritive compounds.

Hygiene:

There is some taboo as to how hygienic and safe traditional foodstuffs are produced from small-scale activities. This is sometimes a valid concern, however one which is often overstated, as many fermented foods are inherently safe as a result of low moisture contents or high acidity, as both lime pickle from India and Gundruk from Nepal exemplify (FAO, 1998). Several of the steps in traditional processing are designed in fact to reduce contamination, including boiling, adding salt and sun drying, and in fact, many fermented products have associated medicinal benefits (see the section on *Traditional medicinal value*).

BOX 7 **Removing cyanide by fermentation**

Cassava contains a naturally occurring chemical: cyanogenic glucoside, and when eaten raw or improperly processed, this substance releases potentially fatal cyanide into the body, but correct processing can remove it. The cassava is first peeled (as about 60-70 percent of the poison is in the peel) and then soaked in stagnant water or fermented in sacks for about three days. It is sometimes grated or rasped as this helps to speed up the fermentation process. At the beginning of the fermentation, *Geotricum candida* acts on the cassava, tending to make the product acidic, which finally kills off the micro-organisms as they cannot exist in such a medium. A second strain of micro-organisms (*Cornibacterium lactii*), which can tolerate the acidic environment then take over and by the third day 90-95 percent of the dangerous chemical will have been hydrolysed. The cassava also develops its characteristic flavour. The product is then sieved and the fine starch particles are fried in an iron pan alone over a flame or with some palm oil. During this process most, if not all the remaining toxins are given off. The liquor from a previous fermentation is used as a starter, thereby reducing the period of fermentation to about 6-8 hours.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

Beverages:
Most beverages typically contain a lot of water and while not necessarily adding nutrients to the diet, they importantly help prevent dehydration. Many fruit drinks contain significant sugar adding energy to the diet, and in some cases, provide vitamins and minerals. Alcoholic drinks are judged both in terms of flavour and the stimulant effect they produce, and in many countries alcohol production is strictly controlled by government agencies and it may be difficult to obtain the necessary permits to produce such beverages legally (Fellows and Hampton, 1992).

Non-alcoholic
A wide range of drinks can be manufactured from pulped fruit or juice, and many are drunk without the addition of other ingredients, and others are diluted with sugar syrup. For simplicity, fruit drinks can be divided into two groups:

- Those that are drunk immediately after opening, requiring no preservative if processed and packaged properly;
- Those that are used little by little from bottles which are stored between use, and therefore contain a certain amount of permitted preservatives to have a long shelf-life after opening.

Alcoholic
Typically, alcoholic beverages have no nutritional value, but are consumed and associated with cultural traditions or for the effect they instil! The most common examples of alcoholic beverages are fruit or cereal based wines, and beers, usually made from cereal.

Benefits to small-scale farming systems

A fermentation enterprise fits very well into small-scale farming systems. The cost of entry to such an enterprise is minimal and commonly uses produce from the farm and does not interfere with farm production and labour as most of the job in fermentation is done by micro-organisms. Fermentation utilizes micro-organisms for the transformation of raw materials into useful products (FAO, 2000). It is a viable way for smalls-scale farmers at kitchen level enterprise to use produce that has not been sold or may not be acceptable to sell in terms of physical and visual quality, for example the shape and size of fruits. Importantly it can use raw materials from other processes

BOX 8 **Making vinegar from pineapple**

In preparing peeled pineapples a considerable amount of waste can be generated. This waste is mainly composed of the peel and some parts of the fruit itself. Placing the peelings and waste fruit in containers of water and adding sugar and yeast and letting it sit for about eight days will provide vinegar. The vinegar is of a distinct, light pineapple flavour and can be used in the same way as other vinegars.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

(see Box 8) and farm by-products, for example rice husks. In some instances fermented products and it's by – products can be used to enhance livestock nutrition and improve their health, thus reducing risks of sickness and mortality and reducing veterinary costs.

Fermentation of livestock waste has proven to be an excellent source of energy for many small-scale farmers producing, for example, gas for cooking in the homestead (see FAO Diversification booklet No. 15 *Pigs for prosperity*). Residues of such fermentation processes can also be applied to soil as fertilizer.

Adding value

A fermentation enterprise involves the farmer moving further down the food supply chain and adding value to farm produce and its by-products. It can potentially increase the selling price and income to the farmer, compared to the sale of fresh commodities and extends produce shelf-life. Fermentation often results in the production of nutritional enriched, very stable food products from low-value carbohydrate and protein substrates (FAO, 2000). It can improve the flavour, aroma, texture and appearance of food as well as making food more palatable (FAO, 1998). It also provides different products to be sold with differing flavours increasing and expanding the farmer's portfolio of products. This value addition is also relatively easy in a kitchen-scale enterprise because the "processing technologies" are not too complex and are within the reach of many small-scale farmers' knowledge.

Employment benefits

Fermentation enterprises are employers of many millions of people in the world. Fermentation enterprise that are considered to be industrial set ups process, prepare,

package, market and in some cases brand products and employ many thousands of people. However in comparison, the majority of employment comes from small-scale fermentation enterprises that employ one or two people, commonly members of the same family. Traditional and small-scale fermentation enterprises have a good employment record, especially in remote areas, even where access to sophisticated equipment is limited. For example in sub-Saharan Africa more than 60 percent of the workforce is employed in the small-scale food processing sector (see Box 9). As a result of increased and continual popularity of fermented products', such small-scale enterprises potentially have the capacity of generating even more widespread employment options.

Typically a small-scale enterprise that is set up on farm will provide employment benefits for those in the immediate family: a farmer's wife, sons and daughters. They will find ready employment on their door step and will have the opportunity to increase their knowledge in fermentation practices, thus becoming competent and skilled in a profession. Moreover if subject to training in fermentation processes, process management, quality control, business matters and so forth their capacity will increase as new knowledge will be gained and will have more transferable skills should the need arise.

Such an enterprise may also create indirect employment benefits by possibly requiring other inputs not found on farm, for example sugar and thus contribute to the employment

BOX 9 **The global importance of employment from the fermented food sector**

In Asia fermented food preparation is a widespread tradition, and *Kimchi* (fermented cabbage) is the major food product of the Republic of Korea. Soy sauce (fermented legume) is economically important from Indonesia to Japan, with over a billion litres produced each year in Japan alone, over 2 000 million litres in the Republic of Korea, and over 150 million in Taiwan. More than 560 000 tonnes of *miso* (fermented legume product) is produced each year in Japan, and in Latin America, fermented cereal products, alcoholic drinks, and fermented milk products, are three of the most important sectors of the economy.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin No. 134, Rome

of others. In terms of marketing, transport may need to be rented and/ or market fees paid to be able to sell the fermented products in a village or town weekly market and this will also indirectly provide employment benefits to others in rural and remote areas.

Financial rewards

A fermentation enterprise requires little if any capital to start the business at kitchen level and compared to initial investments made can provide for numerous financial rewards. Fermentation is a value adding activity and hence can provide more money to the farm family then just selling commodities. It also uses farm produce more efficiently as commodities that cannot be marketed, by-products and other left-overs from farm activities can be successfully used in the fermentation enterprise, provided that they are safe and have acceptable quality levels for consumption. Fermentation also reduces costs as commonly it decreases the need for cooking and thus fuel requirements. In some cases fermented products are ready in only a few days and thus enable the conversion of raw materials, time and money investment into potentially saleable products within a short cycle.

A more regular supply of money is ensured to the farm family as a fermentation enterprise can operate on a more regular basis then the usual harvest-sales cycles common to farming. In the case of selling directly to consumers, for example at village level, will enable the farmer to have more profit and sell at lower prices then if intermediaries were involved. The fermentation enterprise can also offer a range of diverse products, enriching the product offering to consumers, but also allowing more opportunities for a farmer to make more sales and hence potentially earn more money.

The more options that are available to sell produce that originates from the farm the greater is the reduction in marketing risks and potentially the greater the increase in income. Diversified and increased income sources enable a greater sense of security, a safety net in hard times, a good source of money for savings or re-investment in the enterprise, as well as more purchasing power for the farm family.

Being in direct contact with consumers, for example at village level, allows farmers to be knowledgeable about them and their likes and dislikes. This information may provide more accurate estimates of which fermented products are

liked more and those which are liked less. This will provide a farmer with what are the potential opportunities of earning income from providing certain fermented products. This will enable better production planning, less waste, reduction in costs and potentially making only products that have a good demand and thus increase the likelihood of selling and earning income. Moreover by meeting with customers regularly can help develop a farmer's local sales network.

It has to be clear that the level of investment in a fermentation enterprise will be commensurate with its earnings. A kitchen- fermentation enterprise investment is small and consequently so will be the income. However this can be seen as a 'stepping stone' initiative, and by re-investing some of the income in the enterprise, it can then grow to become a micro-scale processing enterprise. This clearly means that along the way more money needs to be invested, but also more money will be made.

Gender development

Fermentation activities undertaken on farm represent an important economic opportunity in particular for women. A fermentation enterprise has little or any entry barriers for women as it has low start-up costs, does not require the possession of particular assets, and nor is it sufficiently physically demanding. Women are traditionally knowledgeable of fermentation processes as passed down for generations from mothers to daughters. The processing side of the enterprise requires low labour inputs, which means that it is highly combinable with domestic responsibilities such as childcare and allows flexible hours. On the marketing side of the enterprise it enables women to leave the homestead to earn income for the farm family, but also and importantly for themselves. This provides women with more independence, become more confident, interact with other women, allows for business and other social relations to develop and overall gives them more status and a greater say in a family, as well as improved status in the community. Earnings made can provide for family needs, for savings as well as a safety net in case of abandonment and widowhood.

Marketing carried out by women introduces them to new knowledge from interactions with different types of people, including customers, other vendors and suppliers and so forth. Managing the

enterprise will by necessity require minimal literacy and numeracy. This will encourage those women who are illiterate to become literate and if need be can pay for it as a result of enterprise earnings. Moreover the needs for new skills as an enterprise expands its operations may make participation in training programmes on basic quality and safety, for example, more palatable to women's families and provide more incentives as it may be seen as a way to increase family income.

In countries where social, cultural or religious traditions impede women from leaving the homestead women can still play an active part in a fermentation enterprise. They can work from the homestead, organize operations and have an active role in decision-making. This can enable them to have far more of say in the financial matters of the enterprise and enhance their role in the family homestead.

Traditional medicinal value

In many communities around the world there are traditional beliefs that some fermented foods and beverages have medicinal value. Some studies have demonstrated that the beneficial bacteria contained in fermented foods support and help the digestive system assimilate food, providing for better nutrition and thus increase the effectiveness of the immune system. Other studies have found that fermentation increases acidity of foods and inhibits spoilage and can rid the food of poisonous bacteria. Certain lactic acid bacteria and moulds have been found to produce antibiotics and bacteriocins (FAO, 1998). Fermented foods have also been found to have protective effects against the development of cancer (FAO, 1998). Further fermented foods have also been found to be beneficial for preventing commonly found infant ailments (see Box 10).

BOX 10 **Children and fermented foods**

A study conducted in the United Republic of Tanzania showed that children fed with fermented gruels had a 33 percent lower incidence of diarrhoea than those fed unfermented gruels, owing to the inhibition of pathogenic bacteria by lactic acid forming bacteria (Svanberg, 1992).

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

Essentials of fermentation

A variety of plant materials are globally fermented to supplement diet with more digestible and nutritive foodstuffs, to make foods safer, tastier and easier to preserve. Such materials are usually locally grown, collected or purchased, and as such fermentation activities are suitable for everyone including farmers with limited land, as well as rural landless, and or urban households. At a household level, fermentation activities are compatible with other farming, horticultural and domestic activities and in some cases, even produces a useful by-product, for example nutritious fodder for poultry and other livestock.

At an enterprise level however, access to sufficient, suitable and locally-sourced fermentation substrate is the key determinant to whether fermentation activities are likely to be successful and sustainable. 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, consequently making procurement of consistent supplies of raw agricultural materials somewhat difficult (Rolle and Satin, 2002). 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).

What's involved: Key steps in fermented foods and beverages

Fermentation is the "slow decomposition process of organic substances induced by micro-organisms or enzymes, of plant or animal origin", and the changes caused by fermentation can be both advantageous and disadvantageous (FAO, 1998). Fermentation in food processing is essentially the conversion of carbohydrates to alcohols and carbon dioxide or organic acids using yeasts, bacteria, or a combination thereof, under anaerobic conditions. Fermentation usually implies that the action of micro-organisms is desirable, and the process is used to produce alcoholic

beverages such as wine and beer. Fermentation is also employed in preservation techniques to create lactic acid in sour foods such as sauerkraut, yogurt, or vinegar. As such, where controlled, fermentation is a relatively efficient food preservation process which gives beneficial results, and is therefore a highly appropriate technique for use in developing countries and remote areas where access to sophisticated equipment is limited (see Box 11).

Fermentation skills and techniques

Fermentation activities are not labour intensive and can be undertaken as an additional livelihood activity which fits around other tasks. People with physical disabilities are fully capable of accomplishing most of the necessary tasks in most fermentation activities, even if some modifications in construction, equipment and tasks are required. Fermentation can also be a feasible livelihood activity for chronically ill or weak people, who may benefit from working, particularly in rural settings, in a cooler, shaded environment with minimal physical exertion, in contrast to the more arduous work input often associated with other agricultural horticultural products.

Many societies have considerable traditional knowledge and skills which is a critical component for successful fermentation activities. Additional overarching qualities deemed useful

BOX 11 **The most common groups of micro-organisms involved in food fermentations**

- **Bacteria** - The most important bacteria in desirable food fermentations are the lactobacillaceae which have the ability to produce lactic acid from carbohydrates. Other important bacteria, especially in the fermentation of fruits and vegetables, are the acetic acid producing acetobacter species;
- **Yeasts** - Like bacteria and moulds, yeasts can have beneficial and non-beneficial effects in foods, and the most beneficial yeasts for desirable food fermentation are Saccharomyces, playing roles such as the leavening of bread and the production of alcohol and invert sugar;
- **Moulds** are also involved in the food processing industry, both as spoilers and preservers. Nearly all food fermentations are the result of more than one micro-organism, either working together or in a sequence, but growth is generally initiated by bacteria, followed by yeasts and then moulds.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

for successful fermentation, include the ability to carry out procedures on time, be attentive to detail, vigilant about hygiene and food safely, and, where trade is involved, to have a basic understanding of marketing, particularly logistics, pricing, product presentation, and have good public relation skills.

The level of fermentation sophistication is highly related to the level of technological development and existing institutional support systems, within a particular region or country. Technologies used vary widely from very simple in areas that lack basic infrastructure, to being relatively complex or refined where conditions permit. A majority of developing countries do not have a supportive economic infrastructure for the development of small-scale food processing (Rolle and Satin, 2002).

The process for achieving fermentation differs considerably depending upon the product. A variety of food is globally fermented, including beans, grains, vegetables, fruits, honeys, dairy, fish and meats. The primary benefit of fermentation is the conversion of sugars and other carbohydrates, e.g., converting juice into wine, grains into beer, carbohydrates into carbon dioxide to leaven bread, and sugars in vegetables into preservative organic acids.

Safety and quality

Traditional fermentation processes are typically uncontrolled and dependent on micro-organisms from the environment, or the fermentation substrate, to initiate it, and as such can result in products of low yield and variable quality. However, fermented foods are treasured as major dietary constituents in numerous developing countries primarily because, if done correctly, fermentation improves safety in a traditionally acceptable way, and extends food keeping quality under ambient conditions (Holzapfel, 2002). Furthermore, what is sometimes referred to as variability in quality, is however actually a consequence of using different processes to suit individual preferences, and some problems of variability could be at least in part overcome, by using well selected starter cultures (FAO, 2004). Fermentation is generally considered to improve the hygienic quality and safety of foods, but if it fails, spoilage may result and pathogens survive, thereby creating unexpected health risks in food products which would otherwise be considered safe. Quality, safety and acceptability of traditional fermented foods may be significantly improved through the use of starter cultures selected on the basis of multifunctional considerations (Holzapfel, 2002).

Use of a starter culture to kick-start fermentation:

Experience has shown that back-slopping (inoculating the materials to be fermented with residue from a previous batch), accelerates the initial phase of fermentation. In many traditional processes, starter cultures are not purchased, but an effective means of achieving a similar goal, is to recycle material from a previous successful batch which helps initiate a new process, shorten the fermentation process, and reduce the risk of fermentation failure. Spontaneous fermentations – in the absence of back-slopping or a starter culture - have been applied for millennia and identified through trial and error, and much small-scale fermentation in developing countries is still conducted this way. However, it takes longer and can be associated with a high risk for failure (Holzapfel, 2002). (See Box 11 and Case Study 5 for the opportunities and challenges of using a starter culture, and some examples of different cultures from around the world.) A starter culture may be defined as a preparation or material containing large numbers of variable micro-organisms, which may be added to accelerate a fermentation process, and when adapted to the substrate, a typical starter improves control of the fermentation process and predictability of its products (Holzapfel, 1997).

■ *Overview of fermented fruits and vegetables from around the world*

There are many examples worldwide of fermented foods and beverages, which are specific to the region and culture from which they come. Below are some examples of different products arising from bacterial, yeast and mixed traditional fermentation techniques.

Bacterial fermentation

There are a variety of traditional fermented foods products from bacterial fermentation, including pickled fruits and vegetables, including olives, beetroot, cabbage and other leafy vegetables. Pickling, using lactic acid bacteria, is still carried out at a domestic level but industrial scale processes have been developed for the production of most types of pickles. Local pickling is undertaken by storing prepared vegetables in a weak brine solution, by dry salting, or by allowing the vegetables to ferment without salt (see Case Study 6).

CASE STUDY 5 **Examples of traditional starter cultures around the world**

Some of the oldest traditions of starter culture preparation and distribution are to be found in the different regions of Asia, and this is particularly true for the mixed-culture dough inocula, such as the ragi-type starter cultures which have been used for centuries in the production of a variety of sweet and sour alcoholic beverages and pastes (Lee and Fujio, 1999, Steinkraus, 1997; Tamang, 1998). Although ragi production does not incorporate the use of specialised equipment, ragi formulations are maintained proprietary by manufacturers. Powdered ragi from a previous batch is sprinkled as an inoculum over the paste prepared from rice flour and water and moulded into balls which are placed on bamboo trays and either covered with muslin cloth (Malaysia) or with ferns (Himalayas). Microbial growth takes place over a two to five day period under ambient conditions, during which gradual desiccation of the rice balls occurs. Slow drying during the rainy season, results in large numbers of Mucor and Rhizopus spp.

In some countries of the Near East (Egypt, Iraq) and North Africa dried kishk or laban beer is used as an inoculum for kishk and kuschuk production). Relatively little information is available on starter culture traditions in sub-Saharan Africa, however, the use of back-slopping approaches for inoculation are widespread in that region. One example of a preserved starter is the inoculation belt, typical of Ghana and some countries in West Africa. The inert surface of the belt or woven rope, which consists of flax of hennep, facilitates the preservation of essential micro-organisms during drying and storage. Bakers yeast is used worldwide in bread baking. It is also applied in brewing and the production of wine at the household level. Bakers yeast is commonly used in the fermentation of sorghum and other cereal beers in Africa (Holzapfel, 1989).

Source: Adapted from Holzapfel, W. H. 2002. Appropriate starter culture technologies for small-scale fermentation in developing countries, International Journal of Food Microbiology, Vol. 75, 197– 212.

CASE STUDY 6 **Processing lime pickle**

Lime pickles are produced in Asia, Latin America and Africa, and particularly popular in India, Pakistan and North Africa. The pickle is made from pieces of lime packed in a salty, spicy liquor, like a semi-solid gravy, and is brownish red in colour with yellow or pale lime peels, which have a sour and salty taste. It is eaten as a condiment with curries or other main meals, and if processed well, the product can be kept for several months.

CASE STUDY 6 **Processing lime pickle** *(Cont.)*

Preparation of raw materials
Only fully ripe limes without bruising or damage should be used, and all limes need to be washed in clean cold water, and drained. The limes are then dipped in hot water (60-65 °C) for about five minutes, and cut into pieces in order to expose the interior and allow salt to be absorbed more quickly.

Processing
The prepared limes are covered with a brine solution, causing the water to be drawn out of the pieces by osmosis. It is important to ensure that the surface is covered with juice, and left for 24 hours, and if necessary, the fruits should be pressed down to hold them below the liquid. Once the limes have been placed in the brine, there is a rapid development of micro-organisms and fermentation begins. Following fermentation, the limes are dried in the sun, for two or three days, until the skin becomes brown.

Packaging and storage
The limes are mixed with spices and oils according to local taste and tradition, and the pickle can be packed in small polythene bags and sealed or in clean jars and capped, keeping well if stored in a cool place.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

CASE STUDY 7 **Cocoa Powder – from Africa, Latin America and Asia**

Raw material preparation
Cocoa beans are the seeds of the cocoa plant (*Theobroma cacao*): the pods are cut from the cocoa tree, and the beans removed. Only fully ripe and undamaged beans should be selected, and it is important that the beans are processed quickly.

Processing
It was formerly believed that cocoa beans were fermented to remove the pulp, but a good flavour in the final cocoa or chocolate is dependent on good fermentation. Fermentation is carried out in a variety of ways but all depend on heaping a quantity of fresh beans with their pulp and allowing micro-organisms to produce heat (Beckett, 1988). The majority of beans are fermented in heaps although better results are obtained using boxes, which result in a more even fermentation. Fermentation lasts from five to six days, during the first day the adhering pulp is liquified and drains away with the temperature rising steadily, and chemical changes cause the temperature to

CASE STUDY 7 **Cocoa Powder – from Africa, Latin America and Asia** *(Cont.)*

rise in excess of 50 °C which kills the beans, allowing enzymes and substrate (mainly amino acids and carbohydrates) to mix freely. Fermentation changes the appearance of the beans from pinkish in colour with a covering of white mucilage, gradually darkening, and once their colour becomes a more uniform orange-brown and they are only slightly sticky, they are ready for drying out in the sun or in industrial dryers. After cleaning the beans they are roasted, which can be quite a technical process, ideally requiring an even heat of 120 – 150 ºC over 90 minutes to produce even roasting, and then cooled quickly to prevent scorching. These roasted "nibs" are ground into a powder in a plate mill, and some of the cocoa butter is removed to make powder – up to 90% for low fat powder! Extrusion, expeller, or screw presses are used in the cocoa industry to remove the cocoa, and the cake from the mill is ground in a hammer mill to produce the cocoa powder. The process is identical for the manufacture of chocolate, until roasting which happens at a lower temperature, and then various other processes take place to make the cocoa paste.

Storage:
As cocoa powder picks up moisture from the air, it needs to be protected especially in humid climates, and lidded tins or sealed polythene bags should be used.

Source: FAO. 1998. Fermented fruits and vegetables: A global perspective, by M. Battcock & S. Azam-Ali, FAO Agricultural Services Bulletin N.134, Rome

Mixed fermentation
Mixed fermentation is where there is no single dominant micro-organism, and products include various vinegars, cocoa products, coffee, and tea (enzyme fermentation only). Cocoa powder production is detailed below in Case Study 7.

Yeast fermentation
There are many examples of popular beers and wines, made from the yeast fermentation of various plant parts, which are consumed across Asia, Africa, and Latin America. For example, "*pulque*", a milky, slightly foamy, viscous acidic beverage is the national drink of Mexico, and can be distilled to make "*mescal*". It is obtained by fermenting "*aguamiel*" – the name given to the juices of various cacti (*Agave atrovirens* and *A. americana*). Another well known example is bamboo wine, or "*ulanzi*", made by tapping the young bamboo shoots during the rainy season, and fermenting the sap to produce a clear, whitish

drink with a sweet and alcoholic flavour. The bamboo shoots should be young to achieve a high yield of sap: the growing tip is removed and a container fixed in place to collect the sap. As always, collection containers should be clean to prevent contamination of the fresh sap (which can produce off-flavours), and the raw material is an excellent substrate for microbial growth and fermentation usually starts immediately after collection. Bamboo wine fermentation can take between five and twelve hours depending on the strength of the final product desired. As is often the case, the shelf-life is short, at only a day or two, but may be extended a little, if stored under refrigerated conditions (FAO, 1998).

Toddy and palm wine are other alcoholic beverages made by fermenting the sugary sap from various palm plants – a process which is easy to do with the correct yeasts, temperature and processing conditions. Throughout the world, alcoholic drinks are made from the juices of locally grown plants

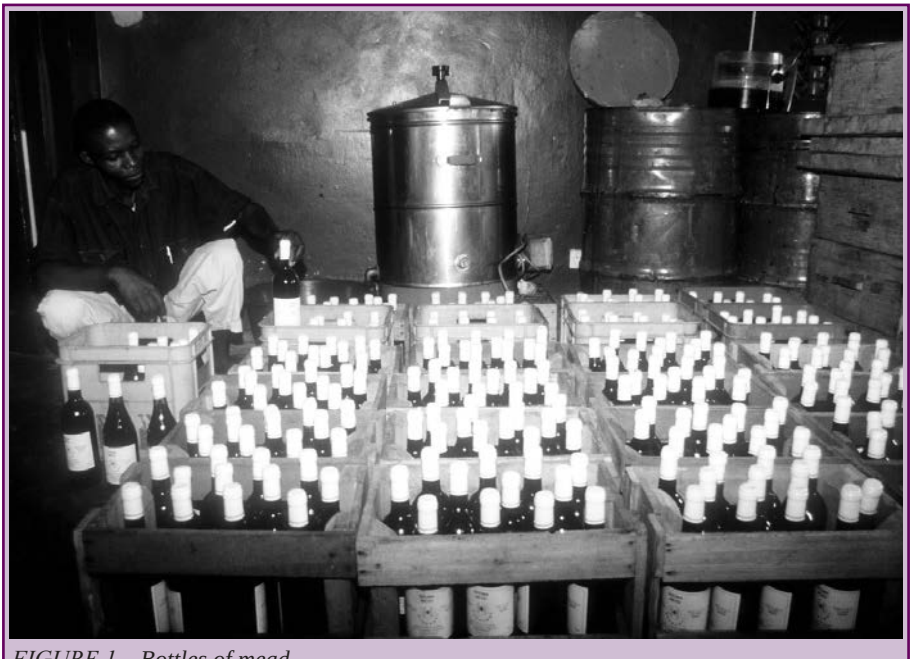


FIGURE 1 Bottles of mead
(Photo: FAO/19183/M Marzot)

FIGURE 2 Mead on sale
(Photo: FAO/19182/M Marzot)

including coconut palm, oil palm, wild date palm, nipa palm, raphia palm and kithul palm. The terms toddy (see Case Study 8) and palm wine are both used to describe similar alcoholic drinks – the terminology varies from country to country. Palm wine refers to the fermented sap, collected from the trunk, of other palms including raphia (*Raphia hookeri* or *R. vinifera*) and the oil palm (*Elaeis guineense*). See Case Studies 4 and 10 for detailed examples of Palm wine and Asai wine. Case study 9 details Chicha, another fermented palm fruit beverage, but which is more similar to beer.

Figures 1 and 2 show the product of yeast fermentation, "mead", an ancient honey-based fermented beverage, which is closer to a wine than a beer, given its elevated alcohol content (10 – 18 percent proof!). It takes longer than beer to ferment, some several months, and at a higher temperature than beer (70°F - 80°F).

CASE STUDY 8 **Palm Toddy – made from fermented flower sap**

Toddy

Toddy is an alcoholic drink made by the fermentation of the flower sap from a coconut palm (Cocus neusifera). It is white and sweet with a characteristic flavour, containing between 4 and 6 percent alcohol, but has a short shelf life of about 24 hours, unless refrigerated.

Principles of processing and preservation

A natural fermentation takes place due to yeasts that are present in the sap and those that are added from a previous batch of toddy (back-slopping). The sugar in the sap is partly fermented to alcohol, which helps to preserve the product. The collecting pots should not be washed out, and that way they retain a small amount of starter culture for future fermentations. However, it is important to ensure that they, and the fermentation vessels are kept clean and do not become contaminated by other bacteria.

Raw material preparation

The sap is collected by slicing off the tip of an unopened flower, which should be clean and free from infection or mould, and they can be used until they cease to provide sap or become infected. The sap oozes out and is collected in a small pot tied underneath.

Fermentation

By retaining a small amount of toddy from the previous days batch, will start the fermentation. The collecting pots are emptied into a larger vessel and the fermentation continues for six to eight hours.

Packaging and storage

The product is usually packaged into clean glass or plastic bottles, and should be kept in a cool place away from direct sunlight. It is not usually stored, but sold immediately or transferred to a refrigerator to extend its shelf life for one or two days. Toddy can be distilled to make a brandy-like spirit (known as Arrack in Sri Lanka). However, distillation requires a special licence and is banned in some countries, so a check with local authorities beforehand is essential.

Source: Adapted from Azam-Ali, S. 2008.Toddy and palm wine, fermented plant saps, Practical Action Technical Brief, Rugby, United Kingdom

CASE STUDY 9 **"Chica" a latin American fermented palm fruit beverage**

"*Chica*"a fermented drink, similar to beer, and popular throughout much of Latin America is made from the fruit of the *Bactris gasipaes* palm, which is harvested once a year. The fruit is peeled, cooked mashed and fermented. Traditionally, and until today, the fruit was preserved mainly in an ensiled form for out of season consumption, and is still stored in trench silos made in the ground. A month after being covered over it is ready for consumption, or can be stored until the next harvest. This fermented material

was consumed mixed with water as a cool drink, and traditionally carried wrapped in leaves during journeys, then diluted in water.

FIGURES 3 & 4 Preparing chicha, a locally produced fermented drink made from Bactris gasipaes fruit. Ecuador
(Photo: FAO/CFU 000845/R Faidutti) (Photo: FAO/ CFU 000846/R Faidutti)

CASE STUDY 10 **Açaí "wine"**

The assai or açaí fruit is highly valued throughout the Amazon, as a juice, or as a "wine" (which is not traditionally fermented!) The dark purple juice is an important and popular dietary complement, and is extracted from the small round fruit, after soaking the seeds in water to soften the thin outer shell. The seeds are then squeezed and strained to produce a tasty, dense purple liquid which is commonly served ice cold with sugar and tapioca flour. It is a nourishing and refreshing beverage: açaí berries are amongst the most nutritious foods of the Amazon, rich in B vitamins, minerals, fiber, protein and omega-3 fatty acids, and reported to harness antioxidant, antibacterial, and anti-inflammatory properties, and cardiovascular system benefits. Assai is considered to have the best nutritional value of any fruit on earth!

FIGURES 5 & 6 Processing assaí palm (Euterpe oleracea) wine ("vinho de açaí").
(Photo: FAO/ CFU 000627/ R Faidutti) (Photo: FAO/ CFU 000629/ R Faidutti)

FIGURES 7 & 8 Selling assaí palm (Euterpe oleracea) wine ("vinho de açaí"). Brazil (Photo FAO/ CFU 000631/ R Faidutti) (Photo FAO R Faidutti CFU 000630)

Overview of fermented grains and cereals from around the world

Important cereal crops worldwide include wheat, rice, maize, barley, sorghum, oats, millet and rye. Cereals have a variety of uses as food: wheat and rye are suited to the preparation of leavened bread, while cereals in general cooking are used either directly in the form of grain, flour, starch, or as semolina, etc (see Box 12). Another common use of cereals is in the preparation of alcoholic drinks such as whiskey and beer (barley; sorghum), vodka (wheat), American bourbon (rye), Japanese sake (rice), etc (FAO, 1998).

A variety of unique, indigenous fermented foods are also produced from cereals, across the globe. An estimated contribution of about one-third is made to worldwide diets by fermented foods, and cereals are particularly important substrates for these, in addition to providing staples in the Indian subcontinent, in Asia, and in Africa (Campbell-Platt, 1994). As discussed earlier, fermentation causes changes in food quality indices including texture, flavour, appearance, nutrition and safety, and benefits may include improvement in palatability and acceptability by developing improved flavours and textures; preservation; enrichment of nutritive content by microbial synthesis of essential nutrients and improving digestibility of protein and carbohydrates; removal of anti-nutrients; and decreased cooking times.

Africa

The main cereals grown in Africa are maize, rice, sorghum and millet. Cereals are more widely utilized as food in African countries, than in the

BOX 12 **Examples of fermented foods made from different cereal substrates using Lactobacillus and different yeasts**

wheat-based foods- *bouza, kishk*
rice-based foods - *busa*
maize-based foods - *ogi, bread, kenkey*
millet based foods - *kunuzaki*
sorghum based foods - *pito, ogi, bogobe, kisra, burukutu, kisra, injera*
barley based foods - *beer*

Source: FAO. 1999. Fermented Cereals: A global perspective, FAO Agricultural Services Bulletin No. 138, Rome

developed world, providing the vast majority of calories and contributing substantially to dietary protein intake. A majority of traditional cereal-based foods consumed in Africa are processed by natural fermentation, and these are particularly important as weaning foods for infants and as dietary staples for adults: examples include a mixture of gruels (*ogi, mahewu, burukutu, pito, uji*), doughs (*kenkey, agidi*), and breads (*kisra, injera*). (FAO, 1999).

In addition to the many fermented foods made from fermented cereals, there are also numerous beverages, some of which are highlighted below in Table 3.

TABLE 3 **Alcoholic beverages produced from cereals in Africa**

Product name	Area of Production	Substrate	Starter
Burukutu	Ethiopia Nigeria (north)	Guinea corn and cassava	Yeasts and lactic acid bacteria
PitoKaffir beer	Northern Ghana	Guinea corn and maize	
Busaa (maize beer)	Nigeria (Bendel) Ghana	Kaffir corn (or maize)	Moulds, yeast and Lactobacillus sp.
Malawa beer	South Africa	Maize	Lactobacillus spp. and yeasts
Zambian opaquemaize beer	East Africa Uganda	Maize	Yeasts and Lactobacillus spp.
Merissa	Zambia	Sorghum	Candida krusei
Seketeh	Sudan	Sorghum	Yeast
Bouza	Nigeria (south)	Maize	Lactic acid bacteria, acetic acid bacteria
Talla	Egypt	Wheat or maize	Unknown
Kishk	Ethiopia Egypt	Sorghum Wheat and milk	Unknown Unknown Lactobacillus spp., yeasts and Bacillus spp.

Indigenous fermented foods are produced at the household level in a majority of African countries, and as such represent an accessible option for increasing food security and through trade, a contribution to household income. It is however expected that increasing industrialization and urbanization trends in these countries may necessitate some scaling up of production of fermented foods of consistent quality. The scope for improving such household activities would likely involve the following steps:

- Isolating and identifying the micro-organism involved in fermentation, determining it's role, and select for improved traits;
- Improve quality and quantity of fermented foods by manipulating environmental factors (temperature, moisture content, aeration, pH, acidity etc);
- Improvement in the quality of raw materials used in the production of fermented foods.

Following the successful implementation of the above steps, it may be appropriate to explore the production of fermented products under laboratory conditions (FAO, 1999). This of course would be subject to enabling policy and infrastructural environments, and extensive technical and financial external support.

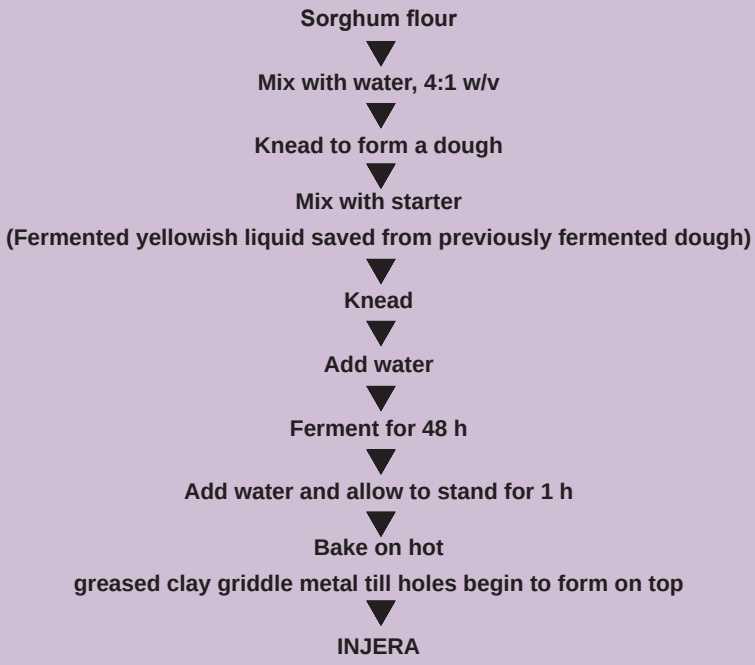
Asia- Pacific Region

The consumption of rice as a staple food, and the high population density which limits animal husbandry practices in this region, has resulted in a typical food processing technology - cereal fermentation with moulds – where fermentation starters (referred to as *chu* in Chinese) are commonly prepared from the growth of moulds on raw or cooked cereals.

Indigenous fermented foods may be classified in many ways: according to the raw materials used; the major type of fermentation taking place; the usage of the product; and the district of production, but in general, fermented products are classified according to use and type of fermentation e.g. alcoholic foods and beverages, vinegars, breads, fermented porridges and snacks, and lactic acid fermented fish products. The most important fermentation products of cereals in the Asia-Pacific region are

CASE STUDY 11 **Making "*injera*" from fermented sorghum bread, Ethiopia.**

Injera is the most popular baked product in Ethiopia with a very sour taste, and is the undisputed national bread of Ethiopia. The baked product, depending on the locality of production in Ethiopia, is referred to as '*bidena*"in Oromigua, '*taeta*' in Giragigua, and '*solo*' in Walaytigna. The sorghum grains are dehulled manually or mechanically and milled to flour which is subsequently used in the preparation of injera.



Flow diagram for the preparation of injera

Three types of injera are distiguishable: (i) thin resulting from mixing a portion of fermented sorghum paste with three parts of water and boiling to yield a product known as 'absit'' which is, in turn, mixed with a portion of the original fermented flour (ii) thick injera, which is reddish in colour with a sweet taste, is a 'tef' paste that has undergone only minimal fermentation for 12-24 hours; (iii) *komtata*-type injera, which is produced from over-fermented paste, and has a sour taste. The paste is baked or grilled to give a bread-like product. Yeasts are the major micro-organisms involved in the fermentation of the sweet type of injera.

Source: FAO. 1999. Fermented Cereals: A global perspective, FAO Agricultural Services Bulletin No. 138, Rome

acids and alcohols, which are both flavour compounds and food preservatives, and serve as an important source of nutrients (FAO, 1999).

Asian beer utilizes rice with moulded starters as the raw material, and the clear products generally referred to as *shaosingjiu* in the People's Republic of China, chongju in the Republic of Korea and *sake* in Japan, contain at least 15 percent alcohol - and are designated as rice-wine. The incubation period and brewing process length for rice wine varies from two days to one month, and wine is generally made when the temperature is lower, in the autumn (see Figure 9). By contrast, cereal-beers which are abundant in micro-nutrients including B vitamins which are formed during fermentation, are brewed at higher temperatures (20ºC) for a few days (FAO, 1999).

Ancient fermentation methods also produce rice vinegar, rice-wine filtercake vinegar and malt vinegar, particularly in Northeastern Regions. Vinegars from tropical fruits (coconut, sugar cane and pineapple) are more commonly prepared in Southeastern countries (FAO, 1999). Indigenous processes for the preparation of vinegars are natural or spontaneous fermentations brought about by the growth of *Acetobacter* on alcoholic substrates under aerobic conditions, and traditionally poor quality rice-wines were used to produce low-grade household level vinegars.

In addition to beverages, many different types of fermented foods are produced and consumed in the region. Dietary staples consumed throughout this vast region include acid leavened bread, pancakes, noodles, etc. See Table 4 for examples. The storage life of perishable fish and meats is also extended by lactic acid fermentation, with added carbohydrates and salts, in the form of rice, millet, flour and even syrup or sugar. Fermented pork, *nham*, is a popular food in Thailand, consisting of fresh pork meat that is trimmed, minced, mixed thoroughly with salt, rice and seasoning and either wrapped in small banana leaf packets, or stored for several months in wooden barrels.

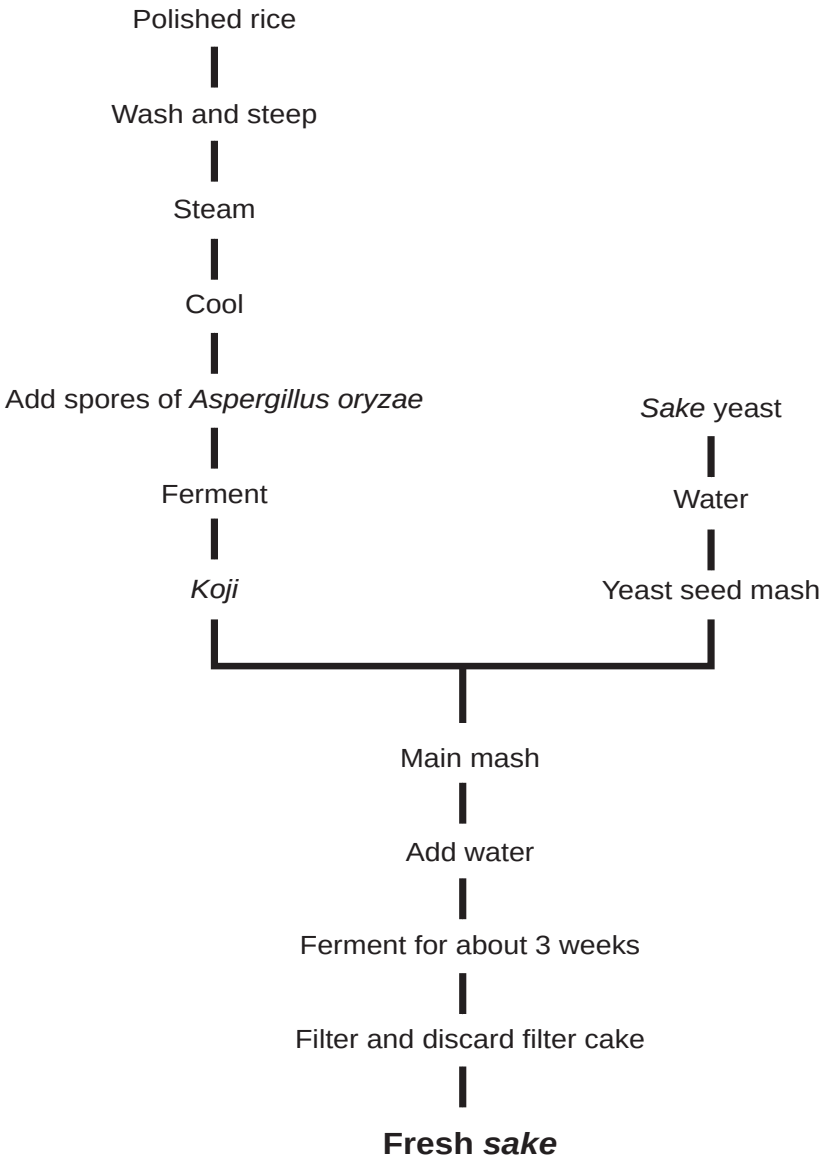


FIGURE 9 Flow chart for the Japanese Sake brewing process

TABLE 4 **Examples of acid-leavened bread and noodles used in Asia-Pacific region**

Product Name	Country of Use	Major Ingredients	Micro-organism	Appearance & Usage
Idli	South India Sri Lanka	rice grits; black gram powder;	*L. mesenteroides* *S. fecalis* *T. candida* *T. pullulans*	
Dosa	India	rice flour; black gram powder;	*L. mesenteroides* *S. faecalis* *T. candida* *T. pullulans*	griddled pancake
Dhokla	India	rice bengal gram	*L. mesenteroides* *S. faecalis* *T. candida* *T. Pullulans*	steamed cake
Jalebies	India Nepal Pakistan	wheat flour	*S. bayanus*	pretzel-like confection
Mantou	China	wheat flour	*Saccharomyces*	steamed cake
Kichudok	Korea	rice, takju	*Saccharomyces*	steamed cake
Puto	Philippines	rice, sugar	*L. mesenteroides* *S. faecalis* *yeast*	steamed cake
Brem	Indonesia	glutinous rice		cake
Mungbean starch	China Thailand/ Korea Japan		*L. mesenteroides* *L. casei* *L. cellobiosus* *L. fermenti*	noodle
Khanomjeen	Thailand	rice	*Lactobacillus sp.* *Streptococcus sp*	noodle
Me	Viet Nam	rice	Lactic acid bacteria	sour food ingredient

(Source: FAO. 1999. Fermented Cereals: A global perspective, FAO Agricultural Services Bulletin No. 138, Rome)

Latin America

Cereal crops, in particular maize which has its origins in Mexico, are very important in Latin America and have been consumed in the fermented form for hundreds of years, principally as alcoholic and non-alcoholic beverages. Throughout Latin America maize has profound religious and magical significance, and in the Andean region, the maize drink "*chicha*" (not to be mistaken with the fermented fruit drink), see Case Study 9, has played a role in fertility rites, and various rain, sun and harvest festivals.

TABLE 5 **Fermented Cereal based foods and beverages consumed in Latin America**

Name	Description	Country
Abati	Alcoholic beverage based on maize	Paraguay, Argentina
Acupe	Beverage based on germinated maize, fermented and sweetened	Venezuela
Agua-agria	Non alcoholic beverage based on ground maize and water	Mexico
Arroz requemado Fermented rice grains Ecuador	Atole Non alcoholic porridge based on maize dough	Mexico
Atole agrio	Non alcoholic porridge based on black maize dough fermented 4-5 days	Mexico
Cachiri	Fermented beverage based on maize, manihot or fruits. It is produced in clay pots	Brazil
Champuz	Fermented beverage based on maize or rice	Colombia, Peru
Chica	Alcoholic beverage based on pineapple, barley steep liquor and black maize dough. It is fermented for 4 days, following which brown sugar, cinnamon and clove are added.	Mexico

TABLE 5 **Fermented Cereal based foods and beverages consumed in Latin America** *(Cont.)*

Name	Description	Country
Charagua	Alcoholic beverage based on “pulque” syrup, chili and toasted maize leaves, heated slowly and fermented	Mexico
Fubá	Germinated maize grains fermented in water	Brazil
Jamin-bang	Bread based on maize fermented for 3-6 days and cooked as a cake.	Brazil
Napú	Beverage based on germinated,ground and fermented maize	Peru
Ostoche	Alcoholic beverage based on maize juice and “pulque”or brown sugar	Mexico
Pozol	Non-alcoholic acidic beverage based on maize liquor. Balls prepared from fermented dough are enveloped in banana leaves	Mexico
Quebranta huesos	Alcoholic beverage based on maize juice toasted maize and pirú fruits (Schinus molle)	Mexico
Sendechó	Alcoholic beverage (beer-like) based on germinated maize and red chili. Dough is resuspended in water, boiled, bestowed, cooled and inoculated with Sendechó	Mexico
Sora	Alcoholic beverage based on germinated	Peru
Tepache	Alcoholic beverage based on maize grains	Mexico
Tesgüino	Alcoholic beverage (beer-like) based on germinated maize	Mexico
Tocos	Dessert based on maize fermented for 2-3 months and cooked	Peru
Zarzaparrilla bark wine	Alcoholic beverage based on maize beer and zarzaparrilla bark	Mexico
Zambumbia	Alcoholic beverage based on toasted barley and water; fermented for 3-4 days, following which brown sugar is added	Mexico

CASE STUDY 12 **Preparation of Pozol, Mexico**

Description: Pozol is a fermented maize dough formed into balls of various shapes and sizes which is consumed by indigenous and *mestizo* populations typically in the Southeastern states of Mexico (Chiapas, Tabasco, Campeche, Yucatan, Veracruz, and Oaxaca). Fermenting pozol balls are diluted with water to produce a whitish porridge which is consumed in the uncooked state as a basic food in the daily diet of large communities. Salt, toasted ground chili pods, sugar, or honey may be added. The beverage prepared from pozol is consumed particularly by low-income individuals during working hours, at meals, or as a refreshment at any hour of the day. The dietary and ceremonial use of pozol is recorded by the Maya culture and continues to be consumed by all social classes.Two basic types of pozol are distinguishable: a traditional-type prepared by the indigenous Indians and a *mestizo*-type, characterized by additional cooking of the dehulled grains. There are records of indigenous groups mixing it with water and honey to reduce fevers, control diarrhea, and even in curing superficial infections and wounds.

Preparation: Pozol is prepared either domestically for consumption or on a small commercial scale according to traditional procedures handed down from generation to generation. 1 -1.5 kg of kernels are obtained by shelling maize cobs, boiled for an hour in a pot containing 1 to 2 litres of calcium hydroxide solution, during which the kernels swell allowing the pericarp to be relatively easily peeled off. The kernels are cooled, rinsed with water, and drained producing a "*nixtamal*" which is ground in a manual metal mill to obtain a coarse dough, and manually shaped into balls. These are then wrapped in banana leaves to prevent drying, and fermented for 1 to 14 days, or more, depending on consumer preference.

Sometimes ground coconut, or ground cacao beans, is added to the dough prior to fermentation.

Source: FAO. 1999. Fermented Cereals: A global perspective, FAO Agricultural Services Bulletin No. 138, Rome

Strategies for successful income generation

Traditional small-scale fermentation technologies offer a reliable and effective way for small-scale farmers to provide opportunities to generate a tradable commodity and contribute to income generation. Furthermore, fermentation offers considerable potential for stimulating development in the food industry in light of their low cost, scalability, minimal energy and infrastructural requirements and the wide consumer acceptance of fermented products in many countries.

Market appraisal

A fermentation enterprise, even at farm household level, requires market demand to be viable. Selling to neighbours, setting up a stall along rural roads and in village markets requires a minimal understanding of what demand there may be for fermented farm products. Researching local demand is a viable method of ascertaining potential demand for products, the likes and dislikes of locals and what may be the most popular products. Such an activity will not eliminate risk in commercial operations, but will reduce the likelihood of making and taking the wrong decisions about, for example, What product to produce? How much to produce? Where to sell? Who to sell to? What prices can be obtained? And so forth.

Market information can be varied, relating to the quantity, quality and price characteristics of particular products in different markets, and is essential for entering new markets and remaining in markets. Information alone however is not sufficient, and those involved in fermentation activities also need to have the capacity to respond to this information. Where demand for produce is high, a lack of information is often less problematic or presents less of a barrier, Where activities are located in remote areas, market intermediaries are often the only source of information between producers and markets, or indeed "market-place".

However when there is a desire or a will to expand kitchen enterprise operations into a more formal processing enterprise it is necessary to conduct a far more in-depth market research. This will provide information on the feasibility of expanding operations

and may well save money in intended investments, such as equipment and machinery that may not work at capacity as a result of lack of consumer demand. Establishing and managing a small processing business involves calculated risk taking so it is important to use tools that provide the information needed to understand and mitigate those risks. The following steps can help in the information gathering process:

- *Conduct a survey – focus on customers not markets*
  Market research typically provides a picture of what the market is like for a product, including information about competitors and likely demand. However the focus needs to be mainly set on consumers. This will provide valuable information on how well a product is likely to do in the market place – providing for the "who, what, where, how and how much" questions and enabling to make more informed decisions regarding enterprise expansion.
- *Test the market*
  Once a consumer survey is completed the next step is to produce a batch of products which will meet the stated expectations of the target group, with a view to learning about how the product is received in terms of acceptable quality, price and selling location: a test market. This allows for modifications to be made if required, but it is worth remembering that changes to the product as a result of customer feedback may not always mean increasing the quality, as the target group may prefer a more standard product at a lower price.
- *Meeting needs better than competitors*
  Markets are not static and even micro-enterprises with good and popular fermented products may soon find them copied. It is important to research what possible competition there may be in the area and find information about what products are been marketed, what prices are being offered, what quantities are being sold and so forth.
- *Location*
  Where products are sold is very important and small-scale farmers needs to ascertain where the best locations to sell their products are. This could be, apart from farm gate sales, setting up a stall on a road side, participating in village markets and/or in town markets, selling

products to retailers and so forth. Knowing where customers are and where they like to buy is an important part of the decision-making process in expanding the operations of a fermentation enterprise.

Marketing strategies

Domestic marketing systems in most developing countries are poorly developed: limited availability of transportation and poor road networks often contribute to marketing challenges. 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 (Rolle and Satin, 2002). In addition, inadequate quality control can adversely effect local demand for products, and is a particular problem for small-scale traditional production. In modern industrial applications, the fermentation equipment and processes are controlled using expensive technology, resulting in a consistent product of a known quality, whereas traditional practises take place in less predictable environments, and can result in mistakes including sour beer and mouldy pickles (Rolle and Satin, 2002).

A successful marketing approach can help households and communities who undertake small-scale fermentation activities, to increase their income status, which in turn creates confidence in their ability to produce marketable fermented goods.

Steps to successful marketing may include:

- Being aware of market demand – in terms of quality, packaging, texture, flavour, volume and prices, etc – through talking to buyers about it;
- Exploring various marketing options for fresh fermented foods and beverages – depending on transport infrastructure - selling directly to local customers, local traders, into local markets, to market intermediaries, regional wholesalers, local restaurants, or even to shops or farmer cooperatives;
- Adding value and increasing the shelf-life of the fermented products by improving processing through drying, pickling, making sauces, extracts, etc, or learning to pasteurize (see Box 13);
- Becoming better organized and collaborating with other

fermented good producers so as to bulk up on volume and the variety of products available, to attract regular traders on the basis of supplying reliable produce;
- Sharing knowledge and experiences with other fermented good producers and, if a problem or constraint is consistent and widespread, collectively source external advice and input;
- Reducing initial capital investment by recycling pieces of equipment and sourcing locally, and sharing costs through informal or formal groupings;
- Identifying existing markets and trading routes, which may include market niches, such as organic fermented products, products for export to "nostalgic" markets (where a significant proportion of the once resident population now reside).

Successful marketing strategies may differ across regions, with transport infrastructure, market accessibility and consumer preferences. They will also require different approaches depending on whether the fermented goods have an extended shelf-life. However whatever marketing system found locally quality control procedures are essential for safe and hygienic products and contribute to the success of a small-scale fermentation enterprise. Appropriate quality control procedures need to be developed and implemented, and importantly, these procedures need to be developed with farmers who must understand and apply them. Food quality has both objective and subjective issues to consider. The objective quality issues are related to the minimum standards of safety and hygiene, while the subjective nature of quality is based on consumer preference. For example, what is acceptable to one customer may not be acceptable to another. It is important to carry out participative research to identify ways to improve the quality control procedures for fermented food products.

Areas of focus may include:

- Selecting good quality raw materials (fermentation substrates);
- Processing under correct conditions (sterile, with good healthy fermenting cultures);
- Ensuring high standards of personal hygiene;
- Ensuring the fermentation and processing areas are sufficiently clean;
- Using appropriate packaging.

BOX 13 **Processing and preserving**

Extracting juice from fresh fruit and vegetables can be undertaken in several ways:

- with a fruit press, fruit mill or hand pulper/sieve;
- by crushing/pulping with a mortar and pestle and then sieving through muslin cloth or plastic sieves;
- by steaming the fruit;
- by squeezing the fruit, as with citrus, using comparatively simple equipment

Pulping

Either the juice or the pulp from fruit is the starting material for the manufacture of soft drinks and wines. Soft fruits, such as papaya and bananas, can easily be pulped by hand or by using a pestle and mortar. A wide range of hand-operated pulpers are available, or if electric power is available, multi-purpose kitchen-scale equipment such as blenders can be used.

Drying

In most cases, any substrate which needs to be dried prior to fermentation, such as "grains", is sun-dried. Treatments such as washing, steeping, milling and sieving are pre-fermentation processing steps applied in the preparation of fermented cereal based "gruels", while milling and sieving are required as pre-fermentation processing steps in the production of dry fermented foods such as bread. Fruits and vegetables are commonly washed, sometimes peeled, sometimes boiled, and then sun dried.

Pasteurization

Liquids such as fruit based drinks and juices may need to be pasteurized if they are to have a shelf-life of more than a few days. Pasteurization involves heating the product to a temperature of 80-90°C and holding it at that temperature for between 0.5 and 5 minutes before filling into clean sterilized bottles. Pasteurization is best carried out over a direct heat in stainless steel pans. Some products can be pasteurized in their bottles. The filled bottles, with the lids loosely closed, are stood in a large pan of boiling water with the water-level around the shoulder of the bottle. The time and temperature required for pasteurization will depend on the product and the bottle size.

Packaging

Beverages have differing needs with regard to storage, but the most pressing need for all beverages is contain them without any leakage. Tables 6 outlines some additional storage requirements, and Table 7 the suitability of different types of container options.

TABLE 6 **Additional storage requirements to address**

	Light	Air	Heat	Micro organisms	Insects
Fruit juice, cordial etc.	some	•		•	•
Beer	•	•	•	•	•
Wine	•	•		•	•
Soft drinks			•	•	•

BOX 13 **Processing and preserving** *(Cont.)*

TABLE 7 **Relative suitability of different types of container options**

	Glass bottle/jar	Metal can	Plastic film/pot/ pouch	Ceramic pot
Fruit juice, cordial etc.	•	Lacquered	•	•
Beer	Coloured	Lacquered	•	•
Wine	•			•
Soft drinks	•	•		

The choice of containers for packaging fermented foods and beverages for small-scale producers is often restricted by what is locally available, and may include leaves, vegetable fibres, earthenware pots and newsprint, but the limitations of these are reduced shelf-life and while acceptable for local consumption, do not help with marketing and product placement in local markets (Rolle and Satin, 2002). Glass bottles are popular medium for packaging beverages, but can be expensive, so many small-scale producers re-use the bottles. To prevent contamination the bottles must be sterilized and cleaned properly, with at minimum a simple hand-held bottle-brushes. The type of closures used depends upon the type of product and its particular use (e.g. for glass bottles does it need to withstand internal pressure from carbonation). Metal 'crown' caps are commonly used for beers and fruit juices, whereas squashes, carbonated drinks and spirits are more frequently packaged using re-sealable metal screw-caps. Wine is preferably sealed with a cork, but plastic stoppers are effective and can cost less (Hampton and Fellows, 1992). There have been many technological advances in the field of packaging materials, and larger commercial manufacturers favour "tetrapak" style of waxed cartons for many beverages, especially fruit juice, on account of their convenience and cost. However, the cost of the equipment needed to form and seal the cartons is prohibitively expensive and presently out of reach for the small-scale producer. Cheaper alternatives as plastic or foil laminated pouches, provided sealed correctly, can be a very convenient way of packaging. (Hampton and Fellows, 1992).

Other equipment

Small-scale fermenting enterprises do not need expensive equipment and some may be shared between producers. Wine and beer making requires little specialist equipment, but all equipment used should be of food grade and thoroughly cleaned before use.

BOX 13 **Processing and preserving** *(Cont.)*

TABLE 8 **An overview of the types of processing equipment which may be required**

Processing stage	Equipment
Juice pulping/extraction	Fruit press or Pulper/juicer, knives
Mashing	Fermentation bins
Mixing	Mixers
Boil, and or sterilizing equipment	Boiling pans, large metal drums
Fermentation	Fermentation bins/jars, plastic bucket
Filter	Filters, filter presses, sieves, strainers, cotton cloths
Carbonation	Carbonating equipment
Filling into bottles	Liquid fillers Funnel
Pasteurize	Open boiling pan, Steam jacketed pan, Pasteurizer

Marketing channels

For small-scale fermentation activities, which aim to market and sell their goods, there are typically a few principal marketing routes. These may include:

- selling directly to consumers either at the farm gate or local market;
- sell to an agent who then sells onto either local or more distant markets;
- belong to a cooperative or another producer organization, which offers easy market linkages to both local and distant markets.

The domestic market has many advantages over export including: easier to respond to requirements and develop appropriate products; lower price to the consumer as fewer distribution costs; ability to fulfil orders for a closer market more quickly and easily in the absence of complicated documentation and restrictions (associated with export); payment should be quicker; and products are usually subject to less competition (Millard, 1995).

Local networks

Cultural and social assets are important for determining the direct

and indirect benefits of all livelihood activities, but are especially important for the sustainable trade and marketing of fermented products. Households undertaking small-scale fermentation for trade can strengthen their market position through organization and association with other households to share techniques, contacts and costs. However, in addition to the informal and formal contacts which individuals have which reduce vulnerability and strengthen access to a variety of supporting resources and business and technical information, "cultural know how" is *embedded* in, and indigenous tradition often *inherent* for successful fermentation. Many societies possess considerable traditional knowledge and skills, without which it would not be possible to successfully produce and importantly market many of the fermented foods and beverages the world over.

■ *Organization for the enterprise*

The ability of individuals or a community to organize itself for trade is influenced by numerous factors including existing social cohesion, the presence of other kinds of community organization, and the presence of charismatic leaders who can motivate people to action. External support can be extremely helpful in establishing or strengthening organizations and social networks.

Good organization of both individuals and producer groups can increase knowledge and technical capacity, and reduce vulnerability and risk. Effective organization can also help achieve consistent qualities of fermented products and larger more appropriate volumes. Furthermore, operating on a "larger economy of scale" can collectively help share the burden of costs, such as transport, which may overcome the challenges of trading bulky, perishable goods with limited shelf-lives. Organization may take various forms, including community partnerships, and community collaboration with companies, or organizations which provide credit and technology.

Where successful, organization can help small-scale producers of fermented products in several ways, including:

- improving product quality (including grading), quantity (including consistent quantities), and diversification;
- providing more cost-effective transportation and overcoming large distances to the point of sale;

- accessing market information and acting upon market intelligence, thereby increasing the ability to negotiate with other actors in the market chain;
- promoting the product, e.g. at different markets, and product fairs.

Summary

The following points summarise some key factors which can contribute to the sustainability of fermentation activities and strengthen their contribution to secure livelihoods:

- **A good understanding of the fermentation process,** usually based on traditional knowledge - but may also be acquired or improved through external support - allowing producers to provide consistent and predictable quantities and qualities of fermented products, thereby attracting buyers more easily.
- **Effective communication and good relationships** between producers and buyers are important to ensure effective information flows about quality sources of substrate, starter cultures, equipment, etc.
- **Identification of a reliable level of market demand.** Most agricultural, horticultural, and other natural resources market chains are demand driven, and establishing new chains can be challenging. The general level of market development in areas where fermented goods are promoted is an important factor determining their market potential.
- **Ability to innovate,** by introducing new or improved fermentation techniques, cultures, and or products, is important to the sustainability of trade. External actors, like NGOs, are particularly important in supporting innovations which can be vital to maintain trade.
- **Length of marketing chain** can influence the resilience of any trade, and may be greatest for shorter chains.
- **High levels of transparency,** both in setting prices and in defining the rules of trade, is often linked to the concentration of market power and good producer organizations may help overcome this. The price received by producers should reflect their production costs, including labour.
- **Organization** can help fermentation activities to be more resilient to external shocks,

and markets may also be made accessible by community organization. Such organizations can also help with training, capacity building and improving fermentation techniques, thereby assisting in empowering poorer and more marginalised producers.

Support services to promote fermented foods and beverages

Public policy

The food-processing sector in many countries is generally given low priority by planners and policy-makers, with little national funding in support of research and development on food processing, and for the adaptation of research results. Furthermore, 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 (Rolle and Satin, 2002). Consequently, institutions are often dependent on developed countries for information and technology transfer

In the small-scale fermentation sector, operational, business and marketing skills are also often limited, and basic knowledge on nutrition and food safety principles weak (Rolle and Satin, 2002). The sector is typically reliant on extension services which are usually themselves under funded and unable to deliver adequate training, or help facilitate access to equipment and packaging, or sources of credit, which further limit the ability of small-scale processors to invest in their livelihood activities. As such, there is a need for governments - in countries where traditionally fermentation plays a significant role in food processing – to directly or indirectly through funding extension services - support the consistent delivery of training programmes on nutrition and food processing, accompanied by follow-up support, specifically to small-scale processors who would otherwise have no resources to seek technical assistance.

More generally, many of the fundamental prerequisites for enabling small-scale producers to improve their livelihoods through agricultural, horticultural and small business activities are public goods, such as roads, electricity, telecommunications, rural markets and other infrastructure. Public investments therefore have an impact on people's capabilities to carry out activities, and investment in rural education, health, transport and communication infrastructure, and skills development, will impact on individual capabilities. As

their capabilities increase, so does efficiency, while costs, risks and vulnerability diminish.

Possible government interventions to support fermentation activities at the policy level include:

- implementing livelihood support policies which provide cross-sectoral support to agriculture, natural resources, and development sectors, enabling rural and urban food processors alike to implement diversified and sustainable livelihood strategies;
- developing specific policies to provide clear support and guidelines on how to improve and maintain small-scale food processing quality, safety, and standards;
- developing policies to help small-scale producers promote trade of their fermented beverages and foods, through branding and other mechanisms;
- developing legislation to prevent irresponsible consumption of alcoholic beverages, and recognising that while policy support for the traditional beverage sector is required for livelihood based enterprise diversification, there is a need to regulate it and protect people who could directly or indirectly be adversely affected by it;
- developing incentives for lending institutions to invest in small or community run businesses, through the provision of basic accountancy and marketing training, and make credit provision accessible for small-scale farmers to get started.

Technical training

Traditional fermentation processes were developed largely as an art, rather than through scientific principles, and although procedures and equipment used by these processes are relatively simple, microbiological and biochemical aspects of a number of these processes are complicated and not fully understood (Ogunmoyela and Oyewole, 1992). Even with simple, small-scale fermentation, some physical aspects such as temperature, relative humidity and level of agitation and aeration, are often poorly controlled and production techniques are not standardised (Rolle and Satin, 2002).

There is a need in particular to provide training as to good hygiene practices which prevent contamination, and on how to improve fermentation efficiency to deliver consistently acceptable

outputs in terms of quantity and quality. It may also be possible to increase shelf-life through training in appropriate technologies which include more efficient drying, or undertaking pasteurization and/or refrigeration, which stop the fermentation, and consequently extend the product's shelf-life. Improved knowledge on adequate packaging of fermented products, in more appropriate materials than purely leaves, vegetable fibres, earthenware pots and newsprint, would also help extend shelf-life, and better place the product in a wider market place.

Business skills development

Education is accepted as an important factor in determining people's capacity to engage in income-generating activities, and it can have a significant impact on successful fermentation activities. Even for trading at local level, basic bookkeeping and numeracy skills are often required, and personal characteristics – including self-confidence, a willingness and ability to experiment and take risks, and attention to detail - are all useful qualities amongst fermented goods producers.

More enhanced entrepreneurial skills are required where small-scale entrepreneurs wish to "grow" their fermentation activities beyond local trade, into a small business. Such skills may include bookkeeping; planning and administration; management of supplies of fermentation materials and equipment, as well as fermentation substrate and starter cultures; managing packaging requirements; meeting legal requirements; logistical coordination of transport and distribution, as well as marketing and negotiation skills. One of the more successful methods to acquire business acumen and practice has found to be the "learning-by doing approach" where trainees are not only taught theory, but importantly apply it during the training to real world situations.

Financial Services

Small-scale food and beverage fermentation for local trade, requires minimal financial assets to undertake. Financial resources will however become more important as the size of an enterprise scales-up to produce outputs that can be reliably traded for income, and thereby needs access to technical support and more refined methods to operate more efficiently. For example, external funding can be used to provide more high technological

equipment, facilitate information and exchange visits, and provide training to expand cultivation skills. The types of credit available vary between countries, but central and local governments, some private organizations, and cooperatives are normally good sources for establishing small-scale enterprises. Although food biotechnology has been used for a long time in much of the developing world, it may require a change of image, as well as the availability of funds, to become more commercially viable (FAO, 2004).

■ *Technology transfer*

Efficient transfer and adaptation of technologies is often limited by inadequate basic scientific knowledge of the processes involved, a lack of appropriate starter cultures, and process controls for 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 (Rolle and Satin, 2002).

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, with individual preferences, rather than technical criteria, dictating the adoption of technologies and their products (Rolle and Satin, 2002). Thus, any technology selected for transfer must grow out of the needs and practices of its beneficiary society and the level of technology and tools transferred must conform to both the socio-cultural environment and to the resources of the beneficiary country (FAO/ & WHO, 1996).

Every country, region, and producer and processor community varies in technical ability, and before facilitating any technological transfer, it is prudent to undertake a systematic approach for technology transfer to developing countries. This might include the following stages:

- a technical, socio-economic, and institutional capacity assessment of the country situation is required to evaluate the type and scale of technology which would be appropriate to introduce;
- selection of an appropriate scale and level of technology - in deciding how best to support

small-scale fermentation based activities, it is sensible to assess current processing and manufacturing practices, the supporting infrastructure (energy and clean water supplies, transportation and road networks in relation to sources of raw materials and storage and markets for the finished product), and evaluate levels of education, locally available skills and technical support services, along with an assessment of the capacity for research and development within the country and relevant government policies and incentives;

- implementation, demonstration and dissemination of the most appropriate technology, within the context of the social and cultural practices of the country;
- and the facilitation of access to the technology (Rolle and Satin, 2002).

See Case Study 13 which details successful approaches to technological transfer.

CASE STUDY 13 **Improving access to technology through training and information dissemination**

Once appropriate technologies have been selected, it is usually desirable to increase the wider technical, marketing and business skills to facilitate implementation and absorption of the technology and its products. This is often achieved through training in the form of workshops, short courses and demonstrations - on both the uses of the fermentation technology and preparation of the fermented product which can lead to refinements which increase product acceptance and ultimately activity success. The most effective dissemination approach depends upon individual communities and countries, and their levels of education and infrastructure. Use of local media (radio and television) may be appropriate in some cases, while in others, brochures and printed materials may be more effective. Networking among small-scale processors, scientists, researchers and extensionists also facilitates information dissemination and access to information.

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.

CASE STUDY 13 **Improving access to technology through training and information dissemination** *(Cont.)*

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, and helps to support the establishment of technical information networks and databases.

Some of the activities of the Rural Infrastructure and Agro-Industries Division (AGS) focus on 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. One of AGS's main emphasis is on the development of small-scale rural industries based on the use of locally available raw materials. AGS'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.

Source: Rolle, R.. & Satin, M. 2002. Basic requirements for the transfer of fermentation technologies to developing countries. International Journal of Food Microbiology Vol 75, pp. 181– 187.

Future priorities and research:
FAO (2004) makes the following recommendations for an integrated approach to the development of small-scale / traditional fermentation, which includes raw material preparation, fermentation monitoring\control and product recovery:

- improved commercialization of food production – where small-scale producers could supply their products to expanded markets – is a better option than "industrialization" of food production, based on a highly capital- and labour-intensive transformation of production processes. As such, many markets for fermented food products from several countries could be developed which

could be national, regional or international;

- development of small-scale rural-based processing industries (which do not require substantial capital investment) in developing countries, thereby improving employment and income prospects through the introduction of simple biotechnology techniques, skills, equipment and technologies into the rural areas;
- effective and appropriate capacity building through improvements in teaching curricula of further and higher education to emphasise biotechnology and its application, and an improvement in research and learning facilities.

Advisory roles

The documentation of the benefits of fermentation and fermented products are not well disseminated: awareness creation, capacity building, training and establishment of food processing units might help in popularizing these technologies (FAO, 2004).

In summary, the following steps may be considered when planning a programme of assistance to rural and peri-urban small-scale fermentation initiatives:

- the provision of specialist advice on scaling up and improving small-scale fermentation activities;
- support to document the processes responsible for fermented food and beverage transformations, and help identify how best to improve traditional fermentation efficiency, to ensure yields and product qualities are more consistent, and safe;
- support for the development of appropriate and necessary technical, business and management skills;
- setting up pilot demonstrations in villages, towns, etc;
- support – where needed - the selection or development of more productive microbial strains, and or provide access to starter cultures at an affordable price, along with the know-how to take advantage of them;
- develop information – for dissemination via the internet, radio and as hard copies - for commonly fermenting products and poorly understood processes, such as pasteurization;
- conducting "field days" on practical methods of fermentation;

- providing practical advice on successful marketing and business strategies;
- assistance in establishing fermentation cooperatives, where individuals or communities are interested, in order to improve access to finance, capacity building, and better market links.

Opportunities and challenges

Opportunities do exist to scale up and improve the efficiency of some fermentation activities, but any interventions to promote livelihood activities should be carefully planned and culturally sensitive, and take into account what assets and resources are available. Successful activities require good organization, and working in joint ventures or partnerships with regional agro-industries, universities or wholesalers can help reduce vulnerability and risk for small-scale producers, and provide access to training and other forms of support. Any displacement of traditional foodstuffs in developing countries, with technologies developed in more affluent countries, may result in centralised production, distribution problems, less local involvement in food processing, less employment in some areas, less nutritionally adequate substitutions in raw materials, displacement of traditional arts, loss of unique local know-how, and dependence on importation of equipment and materials and may otherwise not meet local needs as fully as traditional fermented products.

The agricultural production sector of developing countries has historically been given more attention by planners and policy-makers than the development of agro-industry, but as a result of the widespread failure of many medium to large-scale food-processing enterprises in developing countries, there is a growing recognition of the need to foster the development of small-scale food industry (Dietz, 1999). As a sub sector it has the potential to significantly contribute to the development of the rural economy.

The current low technical fermentation approach is somewhat associated with poor hygiene, improper post-handling fermentation (poorly dried, not pasteurized or refrigerated) which can render products susceptible to contamination and a limited shelf-life. Likewise, many small-scale producers package their fermented products in locally available materials which, while acceptable for local consumption, are often unfavourable for prolonging shelf-life or being attractive at point of sale. However, in addition to the

technical constraints facing small-scale processors, are a number of institutional constraints, including an inadequacy of governmental policies to promote and support small-scale food processing; a sometimes insufficient raw material supply; inadequate infrastructure typically associated with rural poor areas; and limited access to external inputs and technical support (Dietz, 1999).

■ *Public policy: Regulations and laws*

There exists a responsibility to ensure an effective means is in place to regulate and encourage sensible consumption, and protect those who could be indirectly or directly adversely affected by alcohol consumption. This may take the form of community norms and rules, or be more formalised such as legislation, and will vary across cultures and countries. There are many examples of public laws and educational policies to prevent abuse in existence today, and include minimum drinking age; what is permissible to do under the influence of alcohol (*vis* a *vis* opertating machinery, driving a vehicle, etc); restricting sales through taxation or more specifically at certain periods of time or events; and improving knowledge of the potential effects via warning labels and consumer awareness campaigns.

In addition to legislation pertaining to consumption, producers of traditional fermented beverages are also being increasingly obliged to meet various legislative requirements. These may take various forms including taxes and "certification of origin". In the case of Mexican Mezcal, for example, there is a requirement for the product to originate from one of seven named states in Mexico which has had a significant impact on local producers, pushing small-scale distillers out of business or into clandestine production (Marshall, Schreckenberg and Newton, 2006).

■ *Safety and quality*

The challenges of implementing measures to safeguard safety and quality in the real world are numerous. There is a notable role for tailored public and indeed private support for ongoing training and education as to the importance of quality and standards not only for successful trade, but also in terms of social responsibility.

■ *Gender issues*

Small-scale fermentation represents a suitable and empowering income

generating option, in particular for the more vulnerable or marginalised members of society, such as women, because it can be combined with traditional domestic duties, is undertaken at home, and is not physically demanding. The gaining of new skills can help increase financial independence and self-esteem. However, there exist many societies where traditions exclude or deem inappropriate, female participation in fermentation activities, in particular the consumption or sale of alcoholic beverages. See Case Study 2, where the production of mezcal is an exclusively male activity, and how during harvesting and distilling periods, labour for other livelihoods activities comes largely from women and children.

People with disabilities

As fermentation activities are not generally labour intensive, many can be undertaken as complementary livelihood activity which fits around other tasks. People with physical disabilities are fully capable of accomplishing most of the necessary tasks in most fermentation activities, even if some modifications in construction, equipment and tasks are required. As such it is an accessible option for people with disabilities, provided specialist training and adaptation are considered, where necessary.

Enterprise sustainability

Various factors combine to challenge the sustainability of any business, but those of particular relevance to small-scale fermentation enterprises, and need to be addressed during the development of a business plan include:

- under-developed business management and other technical skills and entrepreneurial characteristics;
- poor market and technical knowledge, resources and planning skills;
- inadequate financial management;
- lack of confidence and assertiveness in selling or negotiating, and an absence of trusting relationships and networks with suppliers and retailers;
- little recognition of opportunities for product diversification;
- inadequate hygiene and quality assurance and poor understanding of quality requirements by consumers;
- poor production planning;

- lack of capital for expansion;
- and use of inappropriate technologies for the desired market.

The difference in nature of these factors means that different approaches and types of support for each are needed. Some constraints will be largely addressed by providing training and information resources, however, the high cost of training can be prohibitive and a way forward can be to identify and train selected trainers who can then design and implement local training programmes in a way that is affordable and meets the time constraints of the enterprises. Other approaches to supporting enterprise sustainability may include longer-term initiatives such as the creation of networks involving Government institutions, NGOs and private sector, and undertaking advocacy work to make policies more enabling and supportive, and then implement training in targeted phases, once needs have been fully identified.

Selected further reading

Achi,O.K. 2005. The potential for upgrading traditional fermented foods through biotechnology, *African Journal of Biotechnology* Vol. 4 (5), pp. 375-380**.**

Agar, J. 1999. Marketing for the Local Market, *Small Enterprise Development* Vol. 10 No. 4.

Bachelor, R.E. 2010. *World's oldest known alcoholic beverage*, (Available at http://archaeology.suite101.com/article.cfm/worlds-oldest-known-alcoholic-beverages).

Cambell Platt, G. 1987. *Fermented Foods Of The World – A Dictionary And Guide*. Butterworths, London**.**

Dietz, M.H. 1999. The potential of small-scale food processing for rural economies, *Courier* 174, pp. 89–92.

FAO.2011. *Manufacturing fruit wines-a practical guide*, by J. De La Cruz Medina & H.S. Garcia, Rome (Unpublished).

FAO. 2010. *Meat processing technology*, Bangkok.

FAO. 2009. *Barley Malt Beer*, Agri-business handbook, FAO, Rome**.**

FAO. 2004. *Biotechnology applications in food processing: can developing countries benefit?* FAO Electronic Forum on Biotechnology in Food and Agriculture (Available at http://www.fao.org/biotech/logs/C11/summary.htm).

FAO. 2000a. Fermented Grain Legumes, Seeds and Nuts: A Global Perspective, *FAO Agricultural Services Bulletin* No. 142, Rome**.**

FAO.2000b.Grain legumes, seeds and nuts: rationale for fermentation. Fermented Grain Legumes, Seeds and Nuts: A Global Perspective, *FAO Agricultural Services Bulletin* No 142, Rome.

FAO. 1999. Fermented Cereals—A Global Perspective, *FAO Agricultural Services Bulletin* No 138, Rome.

FAO. 1998. Fermented Fruits and Vegetables—A Global Perspective, *FAO Agricultural Services Bulletin* No. 134, Rome**.**

FAO. 1997. *The agro-processing industry and economic development. The State of Food and Agriculture*, Rome, pp. 221–265.

FAO. 1996. Value added products from beekeeping, *FAO Agricultural Services Bulletin* No 124, Rome.

FAO. 1995a. Fruit and vegetable processing, *FAO Agricultural Services Bulletin* No 119, Rome.

FAO. 1995b. *Sorghum and millets in human nutrition*, Rome.

FAO. 1993. *Rice in human nutrition*, Rome.

FAO. 1992. *Maize in human nutrition*, Rome.

FAO. 1990a. The technology of traditional milk products in developing countries, *FAO Animal production and health paper* No. 85, Rome.

FAO. 1990b. *Roots, tubers, plantains and bananas in human nutrition*, Rome.

FAO. 1985. *Small-scale sausage production*, Rome.

FAO. 1977. *Cassava processing*, Rome.

FAO& WHO. 1996. *Fermentation: assessment and research*, Report of a Joint FAO/WHO Workshop on Fermentation as a Household Technology to Improve Food Safety, 11 – 15 December, 1995, Pretoria, South Africa, WHO/FNU/FOS/96. pp. 1-79.

Fellows, P. & Hampton, A. 1992. *Small-scale food processing - A guide for appropriate equipment*, Intermediate Technology Publications, Rugby, United Kingdom.

Hui, Y.H. 2004. *The handbook of food and beverage fermentation technology*, Taylor & Francis, New York, United States of America.

Hammes, W. P., Brandt, M. J., Francis, K. L., Rosenheim, J., Seitter, M. F. H., & Vogelmann, S. A. 2005. Microbial ecology of cereal fermentations, *Trends in Food Science & Technology* 16, pp. 4–11.

Hammes, W.P. 1990. Bacterial starter cultures in food production, *Food Biotechnology* 4, pp.383– 397**.**

Holzapfel, W. H. 2002. Appropriate starter culture technologies for small-scale fermentation in developing countries, *International Journal of Food Microbiology*, Vol. 75, pp. 197– 212.

Holzapfel, W.H. 1997. Use of starter cultures in fermentation on a household scale, *Food Control* 8, pp. 241–258**.**

Jones, A. 1994. The ancient art of biotechnology, *Food Chain* Vol. 13, pp. 3–5.

Marshall, E., Schreckenberg, K. & Newton, A. 2006. *Commercialization of non-timber forest products in Mexico and Bolivia: factors influencing success. Research Conclusions and Policy Recommendations for Decision-makers*, UNEP-WCMC, Cambridge, United Kingdom.

Millard, E. 1995. *Export marketing for a small handicraft business*, Oxfam/ Intermediate Technology Publication, Rugby, United Kingdom.

Motarjemi, Y. 2000. The impact of small-scale fermentation technology on food safety in developing countries, *International Journal of Food Microbiology* 75, pp. 213-229.

Practical Action. 2008. *Banana Beer: Technical Brief*. (Available at http://practicalaction.org/practicalanswers/product_info.php?cPath=28_41&products_id=68&osCsid=pfba17e488u13jiqvnlihnh5a4&attrib=1).

Rolle, R. & Satin, M. 2002. Basic requirements for the transfer of fermentation technologies to developing countries, *International Journal of Food Microbiology* Vol 75, pp. 181– 187.

Roy, B., Prakash Kala., Nehal, C., Farooquee, A. & Majila, B. S. 2002. *Indigenous Fermented Food and Beverages: A Potential for Uttaranch*al, J. Hum. Ecol., 15, pp. 45-49.

Steinkraus, K.H. 1996. *Handbook of Indigenous Fermented Foods*, Marcel Decker, New York, United States of America.

Sources of further information and support

The Food and Agriculture Organization of the United Nations (FAO)

An important source of information on fermented foods and beverages can be found in a vast range of publications.
http://www.fao.org/documents/en/docrep.jsp

Food and agricultural industries
http://www.fao.org/ag/ags/food-and-agricultural-industries/en/

Post-Harvest management
http://www.fao.org/ag/ags/post-harvest-management/en/

Information Network on Post-harvest Operations (INPhO)
http://www.fao.org/ag/ags/ags-division/en/

Practical Action
Technology Briefs
http://practicalaction.org/practicalanswers/index.php?cPath=28_41

Notes

Small-scale on-farm fermentation enterprises are important both for stimulating sustainable development in rural and peri-urban areas of countries, and for making food available to the increasing populations in urban areas. It can play an important role in strengthening livelihoods of millions of people and reduce their vulnerability to poverty, through both income generation and by making an important contribution to dietary variety and food security. Small-scale on-farm fermentation enterprises also provide linkages to other income generating activities such as the manufactures of equipment, packaging and other ingredients that may be required for fermentation.

This booklet is intended to heighten awareness about the potential of fermented foods and beverages as a viable enterprise that can contribute to small-scale farmers' income. It provides information to decision-makers at policy-level and those involved in development programmes about opportunities, markets and technical support required for such a diversification enterprise.

ISBN 978-92-5-107074-1 ISSN 1810-0775

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I2477E/1/11.11