1. INTRODUCTION

Fermented foods provide a major contribution to the diet in all parts of the world. A number of food fermentation processes including those that yield cheese, yoghurt, sausages, pickles, sauerkraut, soya sauce, bread and beer have been extensively investigated and accurately documented. But, many other foods prepared by the action of bacteria, yeasts and moulds on plant materials have been neglected, mainly because they are almost totally unknown outside their native countries (Hesseltine and Wang 1980).

A food is considered fermented when one or more of its constituents have been acted upon by microorganisms to produce a considerably altered final product acceptable for human use (van Veen 1957). Traditional fermentation processes are those which have been used for centuries, even before it was recorded in history (Hesseltine and Wang 1980). Most of these processes were developed long before the existence of microorganisms was recognized (Wang and Hesseltine 1981).

Ever since man started hunting and gathering food to organized food cultivation, preservation in the forms of drying, salting and fermentation was developed (Campbell-Platt 1987). Descriptions of fermented foods go back as far in time as inscriptions are available. The Egyptians, Sumarians, Babylonians and Assyrians knew about the use of barley to produce alcoholic beverages; a cuneiform inscription on a Babylonian brick from 2800 B.C. gave a recipe for the production of barley wine (Borgstrom 1968).

Records of soya sauce and also miso production in China go back to around 1000 B.C. with the transfer of knowledge of these production processes to Japan occurring around 600 A.D. (Yokotsuka 1985). Early Europeans were known to be making flat sour-dough bread from rye in 800 B.C. Around 100 B.C., there were 250 bread bakeries operating in Ancient rome (Pederson 1979). Accounts of using dahi (curd) throughout India, dadhanvat (milk product) and kali (fermented rice) in southern part of India and panir (milk product) in Punjab are as old as 2000 B.C. (Om Prakash 1961). Records of dosa and idli go back to 1100 A.D. (Gode 1955). The history of using bhat bajraka (bajra flour product) in southern India, rabdi (maize flour product) in Rajasthan and rasgulla (milk product) in Bengal is found in 1500 A.D. (Pathak 1970). As soon as man started collecting milk from animals, sour milk bacame an item in his diet. Accounts of production of fermented dairy products can be found in early Sanskrit and Christian works, while recipes of soury fermented milks were given in Roman times around 200 A.D. (Oberman 1985).

The essential objectives of developing traditional fermentation technology were to carry over supplies from the time of plenty to those of want. It transpires an essence of knowledge and wisdom, gained by experience and based on trial and error. People might not be able to explain what is going on during storage and processing in terms of scientific language, but they certainly know what they have to do to get the desired product (Dietz 1984). The fermentation techniques pass as a trade from older to younger generations in the families; and in some regions of India, the hereditary nature of the profession preparing fermented foods is not only encouraged

but also protected by tradition or secular means (Batra and Millner 1976). These methods were based on interdependent factors, such as available raw materials, climate, available energy source, topography, culture and religion.

Traditional fermented foods form the basic components of the diet, and provide major nutrients to the people of many countries where hunger and malnutrition accompany poverty. With increase in population and paucity of protein sources, inexpensive and easy-made traditional fermented foods are becoming popular even in the developed countries.

The growth and activity of microorganisms play an essential role in controlling the whole environment and ecosystem, of which food supply is only a part. Microorganisms are responsible for the biochemical changes which occur during fermentation (Campbell-Platt 1987). Typically, the microorganisms used are those present in or on the ingredients and are selected by adjusting the fermentation condition (Hesseltine and Wang 1980). Microorganisms bring about specific transformations of the substrates for which traditional fermented foods are prized for the following advantages:

1. Microorganisms produce desirable enzymes: during miso production, both protein of soya bean and starch of rice are hydrolysed by the enzymes produced by *Aspergillus oryzae* (Hesseltine and Wang 1967).
2. Microorganisms destroy undesirable components: during tempe preparation, trypsin inhibitor is inactivated by *Rhizopus oryzae*, and factors causing flatulence are eliminated (Hesseltine 1983a).
3. Fermented foods provide dietary variety where choice of food is limited (Hesseltine 1965). Masking of any undesirable flavour or

production of any improved flavour of the fermented foods helps to overcome the monotony of eating local plant products (Hesseltine 1979). In many fermentations using soya beans, the undesirable beany flavour is replaced by a pleasant, nutty flavour (Hesseltine 1983a).

4. Many of the fermented foods are preserved without refrigeration or other energy-intensive operations because of reduction of pH and production of organic acids by lactic acid bacteria (Hesseltine 1979). Presence of antimicrobial agents, often produced by the fermenting microorganisms, prevent the growth of toxin-producing bacteria (Hesseltine 1983a).

5. Fermentation enhances nutritional value. Many microorganisms synthesize vitamins: in tempe, the levels of niacin, riboflavin and cyanocobalamine are increased (van Veen and Steinkraus 1970). In soya idli, in addition to these vitamins, an increased level of amino nitrogen and free sugar was found (Ramakrishnan 1979).

6. Fermentation increases digestibility of the product: during tempe and natto production, proteins are broken down to amino acids (Hayashi 1977; Steinkraus 1983a).

7. Fermentation may change the physical state of a product: in tempe, loose soya bean flakes or cotyledons are bound together to make a solid cake which when cut resemble non-textured bacon slices. In making soya sauce, components of solid substrates are digested by the koji enzymes into more soluble compounds resulting in a tasty liquid product (Hesseltine 1983a).

8. Fermentation produces colour to the product: in making angkak, dehulled rice is fermented with *Monascus purpureus* which imparts a brilliant purple-red water-soluble colour (Beuchat 1978); this

product is used in colouring meats and rice wine (Hesseltine 1983b).

9. Fermentation may produce alcohol: a number of rice fermentations including tape of Indonesia and lao-chao of China are carried out by amylolytic filamentous fungi in combination with alcohol-producing yeasts (Wang and Hesseltine 1981).

10. Some of the traditional fermented foods require less energy than conventional processes. Generally, the lactic acid fermentations are low-cost processes, and often little or no heat is required in them. Thus, they are fuel-efficient (Steinkraus 1983b).

11. Some traditional fermented foods have medicinal uses. In Russia, koumiss, a fizzy alcoholic beverage made from horse's, donkey's or camel's milk, has been used widely in treating pulmonary tuberculosis (Kosikowski 1977). Kvass, an alcoholic beverage of Russia made from rye or wheat bread, affords protection to the digestive tract against cancer (Wood and Hodge 1985).

12. Some of the traditional fermented foods are sun dried. Then, they can be transported easily from one place to another (Hesseltine 1979).

13. Traditional fermented foods have been prepared since prehistoric time and, therefore, are culturally acceptable. Most Indian Hindus eat only non-animal foods. Hence, products made from cereals and legumes are acceptable (Hesseltine 1979).

Darjeeling, with an area of 3075 km² and a population of 1,335,618 (Census of India 1991b) is a district of West Bengal in India. Excepting Siliguri, the three other subdivisions of this district including Darjeeling, Kalimpong and Kurseong are hilly (commonly, Darjeeling hills), inhabiting 70% of the district population. Sikkim, a tiny Himalayan state of india, with an area of 7096 km² and a population of 403,612 (Census of India 1991a)

lies north to Darjeeling hills (Fig. 1). It comprises four districts including East, West, North and South. Topographically, culturally and ethnically, people of Darjeeling hills and Sikkim, comprising of mostly the Nepalis, the Bhutias and the Lepchas, have remarkable similarities.

The food habit of a region is, to some extent, reflected in the pattern of food production. The staple crop in these regions is maize (*Zea mays* L.) followed by paddy (*Oryza sativa* L.) which is cultivated mostly in the lower altitudes of both Darjeeling hills and Sikkim. Depending on the altitude, wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and finger millet (*Eleusine coracana* Gaertn.) are cultivated. A variety of legumes including soya bean [*Glycine max* (L.) Merrill] and black gram [*Vigna mungo* (L.) Hepper] are also grown. The main vegetables cultivated during autumn and winter are 'rayo' [*Brassica rapa* L. ssp. *campestris* (L.) Clapham var. *cuneifolia* Roxb.], mustard [*Brassica rapa* L. ssp. *campestris* (L.) Clapham] and radish (*Raphanus sativus* L.). In the low-altitude areas, different varieties of bamboo are grown; some of them, when young in monsoon, are edible. Table 1 shows the area and annual production of some of the crops commonly used as substrates for preparation of traditional fermented foods of these regions.

Besides agriculture farming, cattle rearing is common for milk, milk products and meat. Goat, pig and sheep rearing, usually for meat, is also common. In the northern parts of Sikkim, bordering arid Tibetan plateau and in the north-eastern parts of Darjeeling hills, at an altitude of $\geq$4000 m, yak rearing is common for the

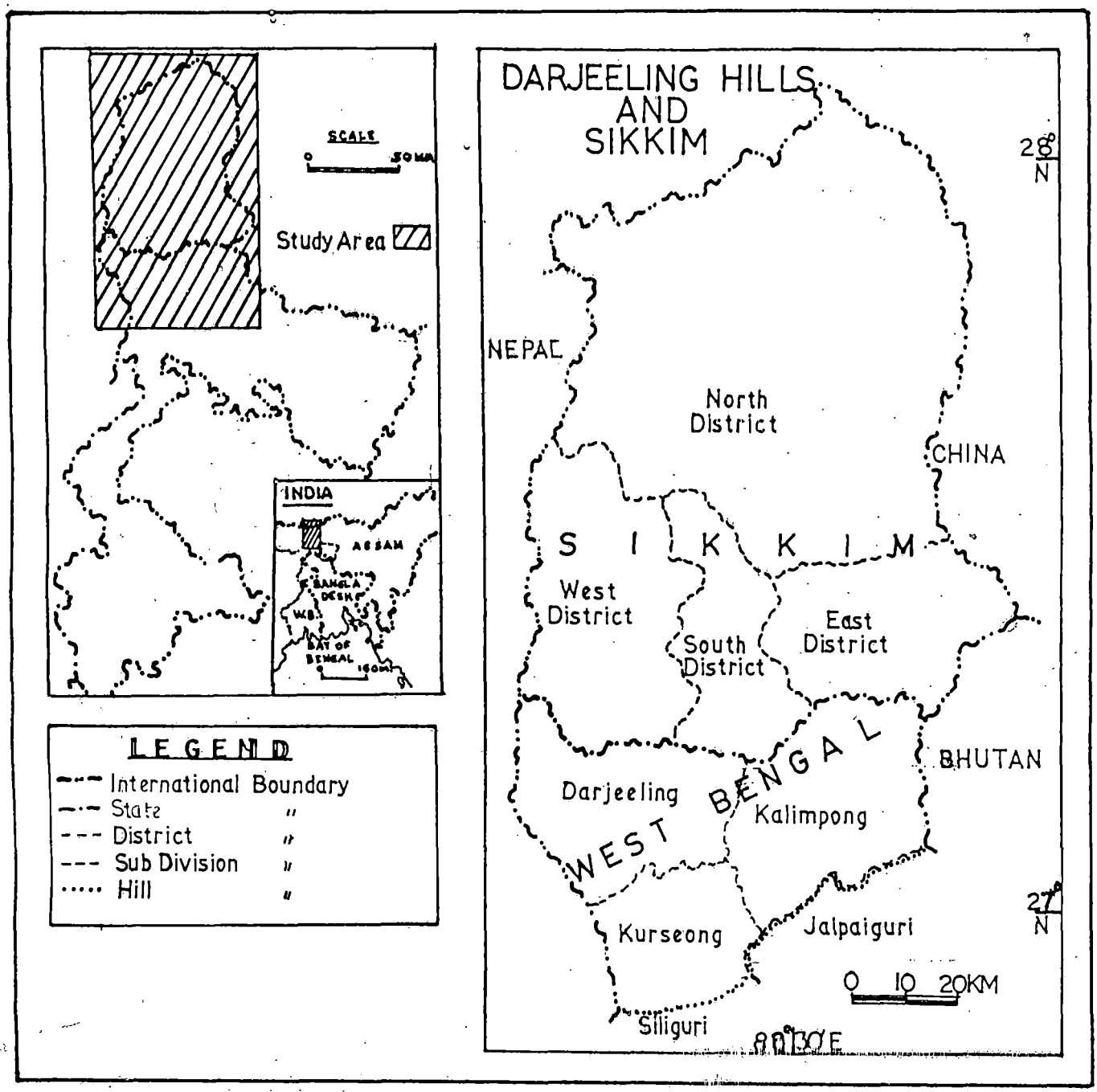

Fig. 1. The location map of Darjeeling hills and Sikkim

Table 1. Area and production of some of the agricultural produces of Darjeeling hills and Sikkim in the year 1990-91, used for the preparation of traditional fermented foods

	Darjeeling hills[a]			Sikkim[b]		
Agricultural produces	Area (ha)	Production (t)	Cultivar	Area (ha)	Production (t)	Cultivar
Rice	9,1Ø7	15,637	Local: Adday, Ramtulsi, Jhapaka; Improved: C1 531Ø, Kalimpong 1	18,61Ø	25,3ØØ	Local: Adday, Dormali, Dutkali; Improved: Giza 14, Pusa 33
Soya beans	392	255	Local: yellow brown	4,68Ø	7,6ØØ	Local: yellow brown; Improved: Bragg, Gyalab
Leafy vegetables	243	1,944	Local	400	3,ØØØ	Local
Radish	398	1,463	Local: Tibetan mula, muli, Japanese white	300	1,8ØØ	Local: Tibetan mula, muli, Japanese white

[a]Source: Office of the Principal Agricultural Officer, Government of West Bengal, Darjeeling

[b]Source: Department of Agriculture, Government of Sikkim, Krishi-Bhawan, Gangtok

same purpose. However, the use of meat is a taboo to some of the Hindus inhabiting these places.

Fermentation of vegetables, cereals, legumes, dairy products and meat has been pracised in these regions since a long time. These fermented foods provide basic diet as staples, adjuncts to staples, condiments and beverages for the people of these regions. Some ethnic groups are economically dependent upon these fermented products. Despite rapid urbanization, traditional fermented foods still have ethnic importance and are essential items in their diet. Solemnizing marriages, and even worshipping the Gods and Goddesses by offering fermented beverages are traditional practices still common among some ethnic groups of these places.

The traditional fermented foods of these regions include kinema (soya bean product), masayura (black gram product), gundruk (leafy vegetable product), sinki (radish tap root product), mesu (bamboo shoot product), khalpi (cucumber product), shel roti (rice preparation), dahi, kachcha churpi, dudh churpi, churpi (all dairy products), sukako masu (meat product), murcha (starter culture), jnard (finger millet product) and raksi (rice beer).

The production of these foods has remained a traditional family art practised in homes in a crude manner. Consequently, the production has not increased substantially, the quality is not consistent and the shelf-life is short. In order to scale-up their production, it is necessary to modernize the production style and optimize the process conditions. In order to know how the preparation could be modernized, it is necessary to know the scientific basis of fermentation. This will shorten production time, guarantee

improved and consistent flavour and nutritional value, increased shelf-life, and this in turn will increase their general acceptibility.

Most of these traditional fermented foods were not even so far documented. The present investigation is an attempt to bring some light into these obscure yet important foods. It aims to study the traditional methods of their preparation, modes of consumption, ethnic values, and microbial and selected biochemical associations in some of them. The information obtained will provide relevant background data for the development of improved fermentation technology.

Strategies proposed to be adopted for accomplishing the above objectives are:

1. Obtaining information in as much details as possible on the methods used by the local people to prepare the foods, modes of consumption and ethnic value of various traditional fermented foods;
2. Studying proximate composition and isolating dominant microorganism(s) of some foods;
3. Optimizing traditional process parameters;
4. Studying succession of microflora and selected biochemical parameters;
5. Testing each of the isolates or combinations thereof by producing the native product in the traditional way;
6. Characterizing the proven producing strain(s) in order to identify their taxonomic status; and
7. Improving the foods by using selected pure culture strain(s) to replace the mixture with undesirable ones now in use.