# REVIEW OF LITERATURE

There are two major types of cereal-based fermented products: (1) Alcoholic food beverages and (2) Non-alcoholic foods. Majority of alcoholic food beverages are prepared using mixed cultures with co-existence of filamentous moulds, yeast and lactic acid bacteria in the form of flattened ball, dry-cake like starter, mostly in Asia (Nout and Aidoo, 2002; Dung *et al.*, 2006). Consumption of rice as a staple food in Asia has resulted in a traditional cereal fermentation with moulds and yeasts (Haard *et al.*, 1999). Varieties of traditional non-alcoholic cereal-based fermented foods are mostly prepared and consumed in Africa as staple foods (Oyewole, 1997; Nout, 2001; Blandino *et al.*, 2003). Cereal-based fermented gruels are generally used as naturally fortified weaning foods for young children in Africa (Nout, 1991; Efiuvwevwere and Akona, 1995; Tou *et al.*, 2007).

Table A shows a comprehensive list of more familiar cereal-based fermented products of the world. Review of available literature on some common cereal-based fermented foods across the world has been mentioned below.

**Table A. More familiar cereal-based fermented products of the world**

| Fermented Product | Substrate | Nature and use | Country | Reference |
|---|---|---|---|---|
| *Ben-saalga* | Pearl millet | Fermented gruel; complementary weaning food | Burkina Faso | Tou *et al.* (2007) |
| *Bhaati jaanr* | Rice | Alcoholic, sweet-acidic paste; staple food | India, Nepal, Bhutan | Tamang and Thapa (2006) |
| *Dosa* | Rice and black gram | Shallow-fried, thin crisp pancake; staple food | India, Sri Lanka | Soni and Sandhu (1990) |
| *Enjera* | Tef flour, wheat | Sour, leavened, pancake-like bread; staple food | Ethiopia | Gashe (1985) |
| *Idli* | Rice and black gram | Soft, moist and spongy, sour flavour cake; breakfast food | India, Sri Lanka | Reddy *et al.* (1981) |
| *Jalebi* | Wheat flour | Crispy, deep fried pretzels; confection snack | India, Nepal | Batra (1986) |
| *Kenkey* | Maize | Acidic, maize dumpling, steamed; staple food | Ghana | Halm *et al.* (1993) |
| *Kisra* | Sorghum | Thin pancake bread; staple food | Sudan | Elkhalifa (2000) |
| *Kodo ko jaanr* | Finger millet | Mild-alcoholic, acidic beverage | India, Nepal, Bhutan | Thapa and Tamang (2004) |
| *Lao-Chao* | Rice | Sweet taste with fruity aroma; dessert | China | Wang and Hesseltine (1970) |

| Fermented Product | Substrate | Nature and use | Country | Reference |
|---|---|---|---|---|
| *Mahewu (Magou)* | Maize | Sour, non-alcoholic beverage; drink | South Africa | Gadaga *et al.* (1999) |
| *Masa* | Rice/millet or sorghum | Shallow fried millet or sorghum flour cake; snack food | Nigeria | Efiuvwevwere and Ezeama (1996) |
| *Mawè* | Maize | Sour-dough, porridge or steamed bread; staple food | Togo and Benin | Hounhouigan *et al.* (1991) |
| *Ogi* | Maize, sorghum, millet | Starchy-cake, porridge; staple food | Nigeria | Onyekwere *et al.* (1989) |
| *Puto* | Rice | Rice cake; breakfast and snack food | Philippine, China | Kelly, *et al.* (1995) |
| *Rabadi* | Barley, maize, wheat, pearl millet | Cereal flour with buttermilk; staple food | India | Gupta *et al.* (1992a) |
| *Sourdough bread* | Rye, wheat or mixed flour | Acidic-tasting aerated bread, staple food | Europe and South America | Brandt (2007) |
| *Tapé* | Rice or cassava | Sweet-sour paste with an alcoholic flavour; staple food | Indonesia | Ko (1982) |
| *Tarhana* | Wheat, milk products, vegetables | Crushed wheat boiled in milk, stored as dry biscuit; consumed as soup | Turkey | Erbas *et al.* (2006) |
| *Togwa* | Sorghum, millet, maize, cassava | Food beverage; drink | Tanzania | Mugula *et al.* (2003a) |

***Ben-saalga***

*Ben-saalga* is a popular fermented gruel produced from pearl millet in Burkina Faso, which is frequently used as complementary foods for infants and young children in Africa (Tou *et al.*, 2006). The processing steps for this food include: washing (optional), soaking of grains (first fermentation step), grinding and sieving of the wet floor, settling (second fermentation step), and cooking (Blandino *et al.*, 2003). These processes were chosen according to their potential ability to favour partial starch hydrolysis (pre-cooking and addition of malt) and also to promote rapid acidification by lactic acid fermentation (back-slopping) to improve hygienic conditions (Nout *et al.*, 1989). The soaking step was mainly characterized by alcoholic fermentation whereas lactic acid fermentation occurred during the settling step (Tou *et al.*, 2006). Glucose and fructose were the main substrates observed for lactic acid fermentation during the settling step; however unbalanced fermentation led to the hypothesis that starch hydrolysis products may also serve as substrates for lactic acid fermentation (Tou *et al.*, 2006).

In the combining cooking and addition of malt process combination, the start of fermentation was considerably

delayed due to the marked reduction in natural microflora during cooking (Tou *et al.*, 2007). Some species of LAB isolated from *ben-saalga* produced bacteriocin (Omar *et al.*, 2006). The dry matter content of *ben-saalga* is very low (Guyot *et al.*, 2003).

***Bhaati jaanr***

*Bhaati jaanr* is an inexpensive high calorie mild-alcoholic beverage prepared from the steamed glutinous rice, consumed as a staple food beverage in the Eastern Himalayan regions of Nepal, India and Bhutan (Thapa, 2001). It was revealed that *Saccharomycopsis fibuligera* and *Rhizopus* spp. play the important roles in saccharification process of rice in *bhaati jaanr* fermentation (Tamang and Thapa, 2006).

***Dosa***

*Dosa* is a light, shallow-fried, thin crisp pancake, made from finely grounded rice and dehulled black gram in South India (Steinkraus, 1983). *Dosa* batter is very similar to *idli* batter, except that both the rice and black gram are finely grounded. Bacteria alone or in combination with yeasts were

found to be responsible for the fermentation of *dosa* and ordinarily the microorganisms developed during the initial soak and fermentation are sufficient to bring about the fermentation (Soni *et al.*, 1986). Overall increase in batter volume, microbial load, total nitrogen, soluble proteins, reducing sugar and decrease of pH has been noted after 30 h fermentation of *dosa* (Soni *et al*, 1985). The combination of *Saccharomyces cerevisae* and natural bacterial flora was found to be the best microbial factor for standardizing the dosa fermentation (Soni and Sandhu, 1989a).

***Enjera***

*Enjera (Injera)* is thin soft bread, with numerous eyes, or gas holes, baked in Ethiopia from the cereal tef (*Eragrotis tef*) and eaten at nearly every meal with meat, vegetable or legume stew, with each person eating two or three per day (Gashe, 1985). Stewart and Getachew (1962) isolated fungi including *Pullaria, Aspergillus, Penicillium, Rhodotorula, Hermodendrum, Candida guilliermondii* and a number of unidentified bacteria from samples of *enjera* batter. Gashe *et al.* (1982) reported the initial fermentation was carried out by gram-negative aerogenic rods such as *Enterobacter, Hafnia,*

*Citrobacter, Klebsiella, Escherichia* and *Proteus. Streptococcus, Leuconostoc* and *Lactobacillus* develop during fermentation lowering the pH below 4.0 (Gashe *et al.*, 1982). *Leuconostoc mesenteroides* has been reported from *enjera* (Oyewole, 1997). Yeasts appeared in all stages of *enjera* fermentation but disappeared later due to decrease in pH of the product (Gashe, 1985).

***Idli***

*Idli* is an acid-leavened and steamed cake made by bacterial fermentation of a thick batter made from coarsely ground rice and dehulled black gram (Veer *et al,*, 1967). *Idli* cakes are soft, moist and spongy, sour flavour, and are eaten as breakfast in South India. *Idli* makes an important contribution to the diet as a source of protein, calories and vitamins B-complex, compared to the raw unfermented ingredients (Reddy *et al.*, 1981). Though, lactic acid bacteria mostly pediococci, lactobacilli and enterococci, are predominant microflora in *idli* (Thyagaraja *et al.*, 1992), yeasts have also been reported in *idli* mostly *Saccharomyces cerevisiae, Debaryomyces hansenii, Hansenula anomala, Torulopsis candida* and *Trichosporon beigelii.*from (Soni and

Sandhu, 1989b, 1990, 1991). Addition of yeasts in *idli* fermentation contributes to leavening and flavour development and results in enhanced contents of thiamine and riboflavin (Soni and Sandhu, 1989a). However, the presence of yeasts can interfere with acidification of the batter since the yeasts utilize a portion of the fermentable sugars that otherwise would be used for production of lactic acid supplementation of the batter ingredients (Venkatasubbaiah *et al.*, 1985; Steinkraus, 1996). The riboflavin content decreased due to the presence of *Streptococcus faecalis* (Veer *et al.*, 1967). The predominant microorganism responsible for souring as well as for gas production was found to be *Leuconostoc mesenteroides* (Mukherjee *et al.*, 1965). *Idli* batter obtained from the hotels and restaurants showed yeast participation in leavening process in addition to *Leuconostoc mesenteroides* (Venkatasubbaiah *et al.*, 1984). During *idli* fermentation the volume, total acid and soluble solids increased whereas the pH, total nitrogen and soluble nitrogen decreased (Steinkraus *et al*, 1967).

***Jalebi***

*Jalebi* is a traditional Indian crispy sweet, deep fried pretzels made from wheat flour and eaten as confection snack food (Chitale, 2000). The batter is prepared by mixing wheat flour with curd and then fried in oil and the fried *jalebi* are taken out from the pan and soak in sugar syrup immediately for 4-5 hours (Batra, 1986). LAB *Lb. fermentum, Lb. buchneri, Lb. bulgaricus, Streptococcus lactis, S. faecalis, S. thermophilus,* and yeasts *Saccharomyces bayanus, S. cerevisiae* and *Hansenula anomala* have been reported from *jalebi* (Batra and Millner, 1974; Soni and Sandhu, 1990). The pH decreases from 4.4 to 3.3 and there is a 9 % volume increase in the batter while both amino nitrogen and free sugar decreases during fermentation (Ramakrishnan, 1979).

***Kenkey***

*Kenkey* is a popular fermented maize product of Ghana which is acidic, dumpling like, wrapped in leaves or maize cob sheaths, and usually steamed, eaten as a staple food with soup (Amoa and Muller, 1976; Halm *et al.*, 1993). *Leuconostoc mesenteroides, Pediococcus acidilactici* and *Lactobacillus fermentum,* and yeast *Geotrichum candidum*

were reported from *kenkey* (Christian, 1970; Halm *et al.*, 1993). *Kenkey* dough containing LAB was used successfully to accelerate the fermentation time (Nche *et al.*, 1994). Decrease in endogenous activity of protease and carbohydrates were recorded when soaking temperature was raised to 60° C (Nche *et al.*, 1996). The lysine availability in *kenkey* increased during soaking, cooking and fermentation of maize and maize-cowpea doughs (Nche *et al.*, 1995). The incorporation of aflata into the dumpling prior to fermentation using starter dough, shortened the fermentation time in *kenkey* (Nout *et al.*, 1996). LAB are mainly responsible for acidification in *kenkey* (Nche *et al.*, 1995).

***Kisra***

*Kisra* is a thin pancake like fermented bread made from whole sorghum flour and it is the staple food of Sudan served regularly for at least in one of the three meals of the day (Elkhalifa, 2000). The general procedures practiced by most of the housewives are as follows: a thick paste (*ajeen*) is prepared by mixing approximately 60 parts of flour and 40 parts of water. The *ajeen* is left to stand fermenting for approximately 12-24 hour in an earthenware container, by

which time it develops a sour taste. The hot plate on the fire is rubbed with a damp oily cloth before spreading the batter. Now the women swiftly spread the batter into a very thin layer using a 4-5 inch strip of a dry piece of palm leaf in very quick and smooth sideways movements. In less than 1 minute, the *kisra* is done and ready to peel off (Dirar, 1992).

*Kisra* made from sorghum has 11.3 %, 14.1 % and 12.6 % of protein content respectively (Elkhalifa, 2000). The predominant microorganisms in *kisra* are *Lactobacillus* sp., *Acetobacter* sp. and *Saccharomyces cerevisiae* (Steinkraus, 1996). Mohammed *et al.* (1991) reported *Pediococcus pentosaceus, Lb. confusus, Lb. brevis, Erwinia ananas, Klebsiella pneumoniae, Enterobacter cloacae, Candida intermedia, Debaryomyces hansenii, Aspergillus* sp., *Penicillium* sp., *Fusarium* sp., and *Rhizopus* sp.

***Kodo ko jaanr***

*Kodo ko jaanr* is the most common fermented mild-alcoholic beverage prepared from dry seeds of finger millet (*Eleusine coracana*), by using a mixed cultures locally called *marcha* in Sikkim, the Darjeeling hills and North East hills in India, Nepal, Bhutan and Tibet in China (Tamang, 2005a).

*Kodo ko jaanr* contributes to the mineral intake in daily diet of the local people (Thapa, 2001). Because of high calorie, ailing persons and post-natal women consume the extract of *kodo ko jaanr* to regain the strength. Population of yeasts and LAB was detected at the level of $10^7$ cfu/g and $10^5$ cfu/g, respectively. Yeasts consisted of *P. anomala, S. cerevisiae, C. glabrata, Saccharomycopsis fibuligera,* and LAB consisted of *P. pentosaceus* and *Lb. bifermentans* in *kodo ko jaanr* samples. Microorganisms necessary for fermentation of finger millets into *kodo ko jaanr* are supplemented by *marcha,* a traditional mixed starter culture (Thapa and Tamang, 2004).

Thapa and Tamang (2006) studied the microbiological and physico-chemical changes during fermentation of *kodo ko jaanr* and found that *Saccharomycopsis fibuligera* and *Rhizopus* spp. play the dominant role in saccharification process of *kodo ko jaanr* fermentation breaking starch of substrates into glucose for ethanol production.

***Lao-chao***

*Lao-chao* is a popular Chinese fermented food with sweet taste and fruity aroma, made from rice by using *chiu-yueh* or *peh-yueh* as starters (Wang and Hesseltine, 1970). It

is served as a dessert and is also a traditional diet for new mothers who believe that it helps them regain their strength. Wei and Jong (1983) reported the presence of *Rhizopus*, *Amylomyces*, *Torulopsis*, and *Hansenula* in *lao-chao*. Pure culture fermentation method of *lao-chao* was developed by Wang and Hesseltine (1970) and showed that good fermented rice was made when a mold, *Rhizopus chinensis* NRRL 3671, and yeast, *Endomycopsis* (*Saccharomycopsis*) sp. NRRL Y7067, used as inocula instead of a commercial starter.

***Mahewu (Magou)***

*Mahewu (Magou)* is a traditional, sour, non-alcoholic maize beverage popular among the Bantu people of South Africa and Zimbabwe (Steinkraus, 1996; Gadaga *et al.*, 1999). *Mahewu* contains about 8 to 10 % solids and has a pH of about 3.5 with a titratable acidity of 0.4 to 0.5 % (lactic acid) (Schweigart and de Wit, 1960; Schweigart *et al.*, 1960). LAB associated with *mahewu* are *Lb. bulgaricus Lb. delbrueckii, Lb. acidophilus* and *S. lactis* (van der Merwe *et al.*, 1964, 1965).

***Masa***

*Masa* is a popular shallow fried fermented product which is obtained through fermentation of rice, millet or sorghum and is widely produced in Northern Nigeria (Efiuvwevwere, and Ezeama, 1996). The product or a comparable product is known as *kisra* in Sudan (Dirar, 1993). Whereas these products generally have a sour-sweet quality due to a wide range of microorganisms, some variations exist in the fermentation parameters such as fermentation time, formation paste or slurry (ratio of water to flour or grain), addition or exclusion of *Kanwa* and baking or frying temperatures (Steinkraus, 1983; Dirar, 1993). A wide range of microorganisms was isolated during the early stage of *masa* fermentation between 0-6 hours with *Bacillus* spp., *Lactobacillus* spp., *Saccharomyces* spp., *Enterobacter* spp., *Aspergillus* spp., *Penicillium* spp., and *Rhizopus* spp. being the dominant organisms (Efiuvwevwere and Ezeama, 1996). As the fermentation progresses beyond 8 hours, *Enterobacter* spp., *Aspergillus* spp. and *Penicillium* spp. disappear while *Lactobacillus* spp., *Saccharomyces* spp. became dominant with few *Bacillus* spp. occurring (Efiuvwevwere and Ezeama, 1996).

***Mawè***

*Mawè* is a sour-dough fermented food prepared from dehulled maize of Togo and Benin (Hounhouigan *et al.*, 1991). *Lactobacillus* spp. constitute the majority of the strains of LAB involved in *mawè* fermentation and others were *P. pentosaceus, P. acidilactici* and *Leuc. mesenteroides* (Hounhouigan *et al.*, 1993b). The titratable acidity of home made and commercially produced *mawè* ranged from 1.2-1.4 % and pH (4.2), protein, fat, fibre, and ash of home produced *mawè* were found to be little higher than commercially produced *mawè* (Hounhouigan *et al.*, 1993c). Fermentation significantly increased the swelling and thickening capabilities of *mawè* (Hounhouigan *et al.*, 1993a). Aflatoxins and fumonisins that occur in maize, was studied through the traditional processing of naturally contaminated maize in *mawè*, where overall reduction of mycotoxin level was more significant during the fermentation (Fandohan *et al.*, 2005).

***Ogi***

*Ogi* is a traditional African fermented starch cake processed from maize, sorghum, and millet grains by soaking in water, followed by wet milling, sieving, further

fermentation, and decantation (Onyekwere, 1989). *Ogi* is also known as *akamu* by the Hausas of Nigeria (Akingbala *et al.*, 1987). The predominant microorganism involved in the fermentation of maize during *ogi* processing is *Lb. plantarum* (Banigo and Muller, 1972). Moulds associated with the surface microflora of the fermenting maize in *ogi* are *Cephalosporium, Rhizopus, Oospora, Cercospora, Fusarium, Aspergillus* and *Penicillium,* but these moulds are eliminated within 6 hour of steeping (Akinrele, 1970). Olukoya *et al.* (1994) developed an improved 'ogi' named 'Dogik' by using a starter culture of *Lactobacillus* with antimicrobial activities against some diarrhoeagenic bacteria, including *Salmonella, Shigella, Campylobacter, Aeromonas, Pleisiomonas, Escherichia coli, Yersinia enterolytica* and *Vibrio cholera.*

***Puto***

*Puto* is a fermented rice cake consumed as a breakfast and snack food in the Philippines and is generally served with grated coconut; it is closely related to Indian *idli* except that it contains no legume (Sanchez, 1996). *Leuconostoc mesenteroides* has been reported to be the predominant organisms in *puto* (Cooke *et al.*, 1987). However, Kelly *et al.*

(1995) reported other three species *Leuc. citreum, Leuc. pseudomesenteroides, Leuc. fallax* along with *Leuc. mesenteroides* subsp. *mesenteroides.* During *puto* fermentation, the yeasts and microaerophilic bacteria increased in number with time where the predominant organism was always *Leuc. mesenteroides,* followed by *S. faecalis* and then *S. cerevisiae* (Rosario, 1987). The prevalence of *Leuc. mesenteroides* in *puto* was 45 % to 89 % of the total microbial population and was responsible for most of the acid and gas production (Sanchez, 1996). It was found out that the yeast along with *Leuc. mesenteroides* played an important role in leavening the batter for *puto* (Tongananta and Orillo, 1996).

***Rabadi***

*Rabadi* is a fermented cereal-based food of North-West India (Gupta *et al.*, 1992a). It is prepared by mixing flour of wheat, barley, pearl millet or maize with buttermilk in an earthen or metallic vessel and then allowing the mixture to ferment in the open sun for 5-6 hour in the hot summer, and after fermentation, it is boiled, salted to taste and consumed (Gupta *et al.*, 1992a). *P. acidilactici* (3.6 x $10^5$/g), *Bacillus* sp.

($1.1 \times 10^6$/g), and *Micrococcus* sp. ($7.9 \times 10^5$/g) were reported from *rabadi* (Ramakrishnan, 1979). Phytic acid content decreased during *rabadi* fermentation (Mahajan and Chauhan, 1987; Gupta *et al.*, 1992a). *Rabadi* fermentation of barley flour-buttermilk at 30° C, 35° C and 40° C for 6 hour, 12 hour, 24 hour and 48 hour lowered pH, enhanced titratable acidity but did not change fat and total mineral (Gupta *et al*, 1992b).

Single as well as mixed culture fermentation of pearl millet with yeast (*S. cerevisiae* or *S. diastaticus*) and LAB (*Lb. brevis* or *Lb. fermentum*) was developed for utilization of pearl millet by fermentation (Khetarpaul and Chauhan, 1990a,b). Fermentation of pearl millet with pure cultures of yeast and lactobacilli has been found effective method for improving its nutritive value: increased bioavailability of minerals (Khetarpaul and Chauhan, 1989); improved starch and protein digestibility (Khetarpaul and Chauhan, 1990a); increased total soluble sugar, reducing and non-reducing sugar content with decrease in starch (Khetarpaul and Chauhan, 1990b); elimination of anti-nutrients (Khetarpaul and Chauhan, 1991a); and brought an improvement in biological utilization (Khetarpaul and Chauhan, 1991b).

***Sourdough* bread**

Sourdough bread is acidic-tasting aerated bread, made from rye, wheat or mixed flours of Europe and South America (Campbell-Platt, 1987). Sourdough fermentation is a mixture of flour, water and salt and if kept at room temperature, it will undergo a natural fermentation that involves the growth of indigenous yeasts and LAB (Brandt, 2007). The microbial ecology of these fermentations has been well studied, leading to the recognition that *Saccharomyces cerevisiae* is the principal yeast of most bread fermentations (Jenson, 1998). Gas ($CO_2$) production causes expansion and leavening of the dough, ultimately affecting bread texture, density and volume (Hammes *et al.*, 2005). Some of the $CO_2$ dissolved to form carbonic acid. Ethanol produced by the yeast, yeast enzymes that affect cereal proteins and carbonic acid, influence the rheological properties of the dough again impacting on final bread texture and structure (Hammes and Ganzle, 1998). The principle requirements of the strains are rapid production of $CO_2$ from maltose and glucose, and generation of good bread flavours (Decock and Cappelle, 2005). There is significant physiological, biochemical and genetic diversity in strains of *S. cerevisiae* used for bread production (Jenson, 1998). In

some cases, species other than *S. cerevisiae* could offer better functionality in some criteria such as *Torulaspora delbrueckii* and *Kluyveromyces thermotolerans* are used to prepare frozen dough breads (Alves-Araújo *et al.*, 2004).

Many breads, especially in European countries, are still produced by traditional processes where no commercial strains of baker's yeast (*S. cerevisiae*) are added (Hammes and Ganzle, 1998). Dough fermentation is conducted by indigenous yeasts and LAB, and the resultant products are generally called sourdough breads because they have higher contents of lactic acid and acetic acid due to the bacterial growth (Hammes *et al.*, 2005; de Vuyst and Neysens, 2005; Rehman *et al.*, 2006). San Francisco sourdough bread falls into this category (Romano *et al.*, 2006). Various studies have been conducted in recent years to understand the microbial ecology of this fermentation (Viljoen, 2006). While indigenous *S. cerevisiae* is still prominent in many of these fermentations, the presence of other yeasts are significant and these include *S. exiguus, Candida milleri, C. humilis, C. krusei* (*Issatchenkia orientalis*), *P. anomola, P. membranifaciens* and *Yarrowia lipolytica* (Paramithiotis *et al.*, 2000; Gullo *et al.*, 2002; Foschino *et al.*, 2004; Veinocchi *et*

*al.*, 2004). These yeasts have evolved to grow in temperature with LAB of these doughs, including *Lb. sanfranciscensis* (unique to these eco-systems), *Lb. plantarum,* and various other species *of Lactobacillus, Pediococcus* and *Leuconostoc* (Hammes *et al.*, 2005). Commercial starter cultures of these yeast-bacterial combinations are now available (Decock and Cappelle, 2005). Growth of *Pichia burtonii* produces visible, white or chalky discoloration (Legan and Voysey, 1991).

***Tapé***

*Tapé* is a sweet-sour paste with an alcoholic flavour, prepared from glutinous rice or cassava or other cereals by using starter *ragi* in Indonesia (Ko, 1982). A combination of *Aspergillus rouxii* and *Saccharomycopsis burtonii* reduced total solids by 50 % in 192 hour at 30° C, which raised the crude protein in tapé ketan by 16.5 % (Cronk *et al.*, 1977). Suprianto *et al.* (1989) reported that *Saccharomycopsis fibuligera* produced mainly α-amylase, and *Rhizopus* sp. produced glucoamylase in tapé fermentation and found that liquefaction was not caused by amylases of *Saccharomycopsis* even though it produced high activity of ∝-amylase.

***Tarhana***

*Tarhana* is a traditional Turkish fermented food made with wheat, milk products, various vegetables and spices using yoghurt bacteria and baker's yeast as culture and is commonly consumed as soup (Erbas *et al.*, 2006). It is prepared in biscuit form for storage after boiling the crushed cereal in fermented milk and dried (Daglioglu, 2000). During fermentation, count of *Lactobacillus* spp. decreased from 6.4 to 5.4 Log cfu/g and count of total mesophilic aerobic bacteria decreased from 6.4 to 5.9 Log cfu/g with increase in acid content of *tarhana* dough (Erbas *et al.*, 2005a). Changes in water-soluble vitamins were investigated in *tarhana* dough during fermentation, and the contents of riboflavin, thiamine, niacin, vitamin $B_6$ and folic acid increased significantly (Cartel *et al.*, 2007). The free amino acids in *tarhana* increased significantly during fermentation and storage (Erbas *et al.*, 2005b).

***Togwa***

*Togwa* is a Tanzanian fermented food prepared from sorghum, millet, maize or cassava which is consumed as liquid drink by adults and children (Mugula *et al.*, 2003a). During the natural fermentation of *togwa*, the process was predominated by *Lb. plantarum, Lb. brevis, Lb. fermentum, Lb. cellobiosus, P. pentosaceous, Weissella confuse, Issatchenkia orientalis, S. cerevisiae, C. pelliculosa* and *C. tropicalis* (Mugula *et al.*, 2003a). Starter cultures of LAB and yeasts isolated from native *togwa* were tested singly or in combination for their ability to ferment maize-sorghum gruel to produce *togwa* (Mugula *et al.*, 2003b). All species of bacteria showed an ability to ferment the gruel by lowering the pH from 5.87 to 3.24 and increasing the titratable acidity from 0.08 % to 0.30 % in 24 hour, and the yeasts used singly, showed little activity within 12 hour, but lowered the pH to 3.57-4.81 and increased the acidity to 0.11-0.21 % in 24 hour (Mugula *et al.*, 2003b).