J Food Sci Technol (November–December 2012) 49(6):665–672
DOI 10.1007/s13197-011-0474-1

REVIEW

Cereal based functional food of Indian subcontinent: a review

Arpita Das · Utpal Raychaudhuri · Runu Chakraborty

Revised: 1 June 2011 / Accepted: 26 July 2011 / Published online: 5 August 2011

Abstract Due to constant health awareness and readily available information on usefulness of different diet and their direct link with health, the demand of functional food is increasing day by day. The concept of functional foods includes foods or food ingredients that exert a beneficial effect on host health and/or reduce the risk of chronic disease beyond basic nutritional functions. Increasing awareness of consumer health and interest in functional foods to achieve a healthy lifestyle has resulted in the need for food products with versatile health-benefiting properties. Cereal- and cereal component-based food products offer opportunities to include probiotics, prebiotics, and fibers in the human diet. Various growth studies using probiotic Lactic acid bacteria on cereal-based substrates and utilization of whole grain or components as high-fiber foods in developing novel food products lend support to the idea that cereal-based media may well be good probiotic carriers. It is essential that science and traditional knowledge should go together to find mutually beneficial results. In the Indian subcontinent, making use of fermented food and beverages using local food crops and other biological resources are very common. But the nature of the products and the base material vary from region to region.

Keywords Cereal · Functional food · Probiotic · Prebiotics

A. Das · U. Raychaudhuri · R. Chakraborty (✉)
Department of Food Technology and Biochemical Engineering,
Jadavpur University,
Kolkata 700032, India
e-mail: crunu@hotmail.com

Introduction

Functional foods are defined as the food or dietary components that may provide a health benefit beyond basic nutrition. A food can be made functional by applying any technological or biotechnological means to increase the concentration of, add, remove or modify a particular component as well as to improve its bioavailability, provided that component has been demonstrated to have functional effect (Roberfroid 1999). Again, according to Kalra (2003) when food is being cooked or prepared using "scientific intelligence" with or without the knowledge of how it is being used, the food is referred to as "functional food" (Kalra 2003). In recent years, cereals and its ingredients are accepted as functional food and nutraceuticals because of providing dietary fibre, proteins, energy, minerals, vitamins and antioxidants required for human health. Also, cereals can be used as fermentable substances for the growth of probiotic microorganisms (Charalampopoulos et al. 2002). Wheat, buckwheat, oat, barley, flaxseed, psyllium, brown rice and soy products are notified as the most common cereal based functional food and nutraceuticals (Truswell 2002). Cereals are used world-wide as staple foods. A large proportion of the world cereals production is processed by fermentation prior to consumption. The enhancement of attractive flavour and texture, and the improved shelf-life and digestibility as a result of fermentation are important reasons for this (Nout 2009). Recently, the functional food research has moved progressively towards the development of dietary supplementation, introducing the concept of probiotics and prebiotics, which may affect gut microbial composition and activities (Ziemer and Gibson 1998). In this context, this review aims to summarize the production processes and health benefits of some of the most commonly consumed traditional cereal-based fermented and non-fermented food of the Indian subcontinent.

Cereal- a rich source of nutrients

Cereals offer several challenges from nutrition point of view, especially the swelling of their starch upon cooking, the limited quantity and amino acid profile of their protein fraction, and the limited bioavailability of their mineral content due to relatively low mineral levels and the presence of phytic acid and other antinutritional factors that reduce their bioavailability to 5–15% (Nout 2009).

Cereals are grown in over 73% of the total world harvested area and contribute over 60% of the world food production providing dietary fibre, proteins, energy, minerals, and vitamins required for human health. Possible applications of cereals or cereal constituents in functional food formulations could be use as fermentable substrates for growth of probiotic microorganisms, especially lactobacilli and bifidobacteria or as dietary fibre promoting several beneficial physiological effects. It can also serve as a prebiotic due to their content of specific nondigestible carbohydrates or as encapsulation materials for a probiotic in order to enhance their stability (Charalampopoulos et al. 2002). Increasingly, whole grain is becoming one of the favored choices as a probiotics delivery vehicle. This is mainly because the formulations of probiotics with whole grain products offer consumers both probiotics and whole grain benefits, e.g., non-digestible carbohydrates, soluble fibre, phytochemicals, and other bioactive components (Marquart and Cohen 2005).

Cereals as functional food and nutraceuticals

Strong epidemiological evidence has clearly demonstrated that whole-grain cereals protect the body against age-related diseases such as diabetes, cardiovascular diseases and some cancers (Chatenoud et al. 1998, 1999; Venn and Mann 2004). This may be due to the fibre and micronutrients in the outer layer and germ fractions of the grain acting together to combat oxidative stress, inflammation, hyperglycaemia and carcinogenesis. Whole-grain cereals also contain micronutrients such as vitamin E, folates, phenolic acids, zinc, iron, selenium, copper, manganese, carotenoids, betaine, choline, sulphur amino acids, phytic acid, lignins, lignans, and alkylresorcinols, which all may have potential antioxidant effects (Slavin et al. 1999). Antioxidant micronutrients in whole-grain cereals are given in Table 1. Dietary fibre is one of the major phytochemicals present in cereals, upon water solubility it can be divided into two categories. Water-soluble fraction (soluble fibre) consists mainly of nonstarchy polysaccharides such as beta glucans and pentosans (arabinoxylan). Soluble fibre is known to decrease serum cholesterol, postprandial blood glucose, and insulin levels in humans (Edge et al. 2005). Water-insoluble fraction (insoluble fibre) consists of lignin, cellulose, hemicellulose (water-insoluble arabinoxylan). The Comparison of total dietary fibre content in cereal grains are shown in Table 2.

Rice

Protein quality of rice surpasses that of wheat and corn while it is just inferior to oats. Also, rice protein is hypoallergenic and contains good quantity of lysine. Thus it may act as a suitable ingredient for infant food formulations while adding variety to the restricted diets of children with food allergies (Burks & Helm 1994, Gurpreet and Sogi 2007). Amino acid profile of rice protein was better than casein and soy protein isolate in fulfilling the amino acid requirements for 2–5 years old children (Wang et al. 1999). Table 3 presents the composition of different varieties of cereals.

Wheat

Whole wheat and wheat bran based cereals are important source of dietary antioxidants. Free and esterified phenolic acids in wheat have the greatest potential to be beneficial to health (Baublis et al. 2000). Wheat antioxidants are mainly concentrated in bran layers and the amount of antioxidants depends largely on the grain variety, with red wheat generally containing higher levels than white wheat (Kim et al. 2006).

Maize

Maize (*Zea Mays*) is one of the important cereals in Asia. It has the largest kernels. Because of its hardness and size, decortication by abrasion is feasible and fine grinding is essential to obtain smooth texture of cooked products (Nout 2009).

Barley

Barley has a high acceptance in human nutrition, when its new functional and nutritional properties are recognized (Bhatty 1999). Barley grain is used as feed, malt, and food. Our ancestors depended on barley as a staple food more than we do now. Barley played an important role in the origin and development of the Neolithic culture. Barley is used as flour, as semolina, and as whole-dehulled grain. A large variety of dishes, including soups, bread, and couscous are made from barley products (Amri et al. 2005). The major component in barley is β-glucan, which is a major component of soluble fibre implicated in hypercholesterolemia, hypoglycemia, and in reducing incidence of chemically induced colon cancer in experimental animals (Bhatty 1999).

Table 1 Antioxidant micronutrients in whole-grain cereals

Cereal type	Tocopherol and tocotrienol (mg/100 g grain)	Folate (μg/100 g grain)	Zinc (mg/100 g grain)	Iron (mg/100 g grain)	Copper (μg/100 g grain)	Selenium (μg/100 g grain)
Wheat	1.4	87	2.6	3.2	369	0.5–74.6
Maize	6.6	110–170	1.7	1.5	240	12.0
Rice	1.9	16	1.6	3.2	288	10.0
Oats	1.8	33	3.2	5.8	422	7.1
Barley	2.2	65	2.8–7.4	2.8–12.8	419–570	7.0
Sorghum	1.1	–[a]	0.3–1.8	1.1–5.7	20–735	13.0
Millet	4.0	–	2.9–6.6	6.9–20	340–610	2.0
Cereal type	Polyphenols (mg gallic acid eq/100 g grain)	Ferulic acid (mg/100 g grain)	Betaine (mg/100 g grain)	Phytic acid (mg/100 g grain)	Carotenoids (μg/100 g grain)	Alkylresorcinols (mg/100 g grain)
Wheat	70–1459	10–198	6.9	906	20–265	28–142
Maize	39–711	177	–	940	969–1300	–
Rice	54–313	30	0.5	890	14–77	0
Oats	9–34	7–30	2.7	900	31	–
Barley	50–196	36–62	–	1070	15–105	4–44
Sorghum	100–2300	9	–	–	20–22	0
Millet	29–47	29	–	–	74–80	9–87

[a] Data not available. (Fardet et al. 2008)

Sorghum

Sorghum is widely grown in the semiarid topics of Asia, and constitutes a major source of carbohydrates and proteins for people living in this region. Although the use of sorghum as human food is widespread, the technology for processing the grains in to consumable product is still far from adequate (Lazaro and Favier 2000).

Millet

Finger millet or Ragi (Eleusine coracana) is an important staple food for the traditional consumers and the people belonging to the lower socio-economic strata in the Indian subcontinent (McDonough et al. 1986). Some of health benefits associated with regular intake of millet foods, such as the hypocholesterolemic, hypoglycemic and antiulcerative characteristics indicate the scope for its utilization by the non-traditional millet consumer also. Since, the anti-nutritional factors of the millet, namely, polyphenols and phytates are mainly concentrated in the seed coat and aleurone layers (McDonough et al. 1986, Ravindran 1991), decortications lowers their contents and as a result improves the bio-availability of the nutrients.

Table 2 Comparison of total dietary fibre content in cereal grains

Cereals	Total dietary fibre (%, db)
Rice	3.9±0.2
Wheat	12
Corn	15
Oats	14
Sorghum	10.7
Finger miller	6.2–7.2
Barley	10

(Source: Charalampopoulos et al. 2002).

Oat

Oats have recently attracted research and commercial attention mainly due to their high content of β-glucan and of compounds with antioxidant activity (Malkki et al. 2004). The health effects of β-glucan as related to cholesterol reduction, improved gastrointestinal function and glucose metabolism would be achieved at a daily consumption level of 10 g oat β-glucan (Malkki & Virtanen 2001). Soluble fibres of oats, in balance with insoluble fibres, perform important roles in the digestive tract and are essential for maintenance of a healthy colon wall and colonic environment, being available for fermentation by "good bacteria" (pro-biotic microbes), and as such exert pre-biotic effects. Soluble fibre-based pre-biotic are becoming increasingly important as health-promoting functional foods (Macfarlane et al. 2006). Soluble fibres are mainly polysaccharides (e.g. beta glucans, arabinoxylans, plant gums) and oligosaccharides (e.g. fructo-oligosaccharides). These soluble materials are not digested in the human stomach and small intestine and survive mainly intact into the colon, at which point they are available for microbial fermentation (Würsch and Sunyer 1997). Antioxidants function is also helping to maintain the stability of processed oat products, and oat can stabilize oils and fats against rancidity (Truswell 2002).

Table 3 Composition of different varieties of cereals expressed as 100 g of edible portion

Parameter	Rice	Wheat	Maize	Sorghum	Millets
Water (%)	12	12	13.8	11	11.8
Protein (g)	7.5	13.3	8.9	11	9.9
Fat (g)	1.9	2.0	3.9	3.3	2.9
Carbohydrates (g)	77.4	71.0	72.2	73.0	72.9
Fibre (g)	0.9	2.3	2.0	1.7	3.2
Ash (g)	1.2	1.7	1.2	1.7	2.5
Ca (mg)	32	41	22	28	20
P (mg)	221	372	268	287	311
Fe (mg)	1.6	3.3	2.1	4.4	68
K (mg)	214	370	284	350	430
Mg (mg)	88	113	147	n.d.	162
Riboflavin (mg)	0.05	0.12	0.12	0.15	0.38
Niacin (mg)	1.7	4.3	2.2	3.9	2.3
Thiamin (mg)	0.34	0.55	0.37	0.38	0.73

SOURCE: Adapted from Severson (1998)

Burkwheat

Buckwheat (Fagopyrum esculentum Moench) is known as a valuable source of protein, and its amino acid composition is nutritionally superior to that of cereal grains (Pomeranz & Robbins 1972). For many years, the cultivation of buckwheat was in decline, yet recently it has been observed to increase because of the health-promoting properties of its grains. Buckwheat grains and other tissues contain numerous nutraceutical compounds (Li & Zhang 2001). The amino acid composition of buckwheat proteins is well balanced and of a high biological value (Kato et al. 2001, Christa and Soral-Śmietana 2008). Buckwheat grains are an important source of microelements, such as: Zn, Cu, Mn, Se (Stibilj et al. 2004) and macro elements: K, Na, Ca, Mg (Wei et al. 2003) with 80% unsaturated fatty acids more than 40% are constituted by polyunsaturated fatty acid (PUFA) (Krkošková & Mrázová 2005). The significant contents of rutin, catechins and other polyphenols as well as their potential antioxidant activity are also of significance to the dietary value (Oomah & Mazza 1996, Wanatabe 1998). Moreover, buckwheat grains are a rich source of TDF (total dietary fibre), soluble dietary fibre (SDF), and are applied in the prevention of obesity and diabetes (Brennan 2005).

Cereal based fermented functional food

Fermentation is one of the oldest technologies used for food preservation. Research has reviled that by the process of fermentation flavor enhancing compounds, useful enzymes and essential amino acids are produced. Some fermentation microorganisms have been found to produce antimicrobial products that lead to safe and long storing of foods. Probiotics are live microorganisms associated with fermentation that, upon ingestion, beneficially affect their host by improving the balance of the intestinal microflora (Kalui et al. 2010). A specific type of mechanism by which probiotics may prevent and treat gastrointestinal disorders is represented in Figure 1. These health enhancing microorganisms bring about fermentation resulting in production of lactic acid and hence commonly referred to as Lactic acid bacteria (LAB) (Holzapfel and Schillinger 2002, Shah 2007). Most of them are generally regarded as safe (GRAS). Common microorganisms used in probiotic preparations are predominantly Lactobacillus species, such as *Lactobacillus acidophilus*, *L. casei*, *L. reuteri, L. rhamnosus*, *L. johnsonii,* and *L. plantarum* and Bifidobacterium species, such as *Bifidobacterium longum*, *B. breve, B. lactis* (Shortt, 1999).

a) Rice based products:

A global interest in rice and its fermented product is increasing due to their calorie value, unique quality characteristics and high acceptability (Steinkraus 1994). In most of the countries, rice is fermented either by using mixed culture(s) into alcoholic beverages, or by natural fermentation into leavened batter formed dough breads which are usually baked or steamed (Yokotsuka 1991).

1. Idli:

Cereal/legume-based foods are a major source of economical dietary energy and nutrients worldwide. Among the fermented food of India, *idli*, a fermented steamed product with a soft and spongy texture is a highly popular and widely consumed snack food in India. Traditionally, the product is made from naturally fermented batter prepared from a mixture of milled rice (*Oryza sativa*) and dehulled Blackgram dhal (*Phaseolus mungo*), the proportion of which varies (Desikachar et al. 1960,

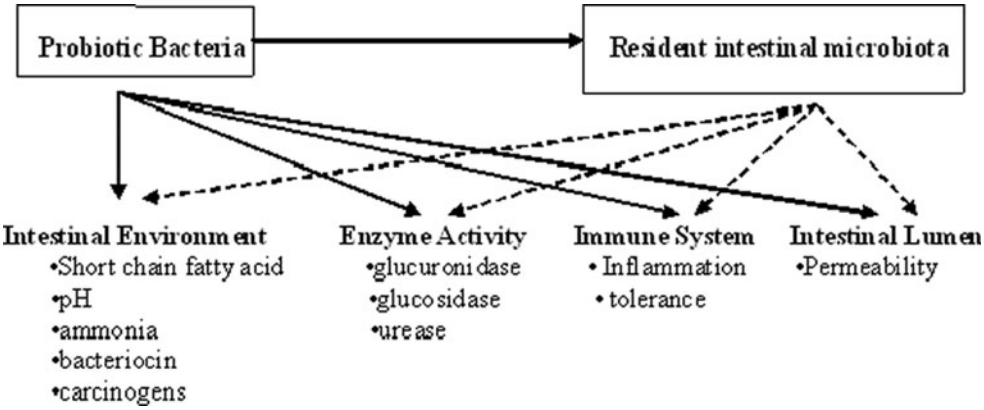

Fig. 1 Mechanisms by which probiotics may prevent and treat gastrointestinal disorders (adapted from Santosa et al. 2006)

Radhakrishnamurthy et al. 1961). The lactic acid bacteria *Leuconostoc mesenteroides, Streptococcus faecalis, Lactobacillus delbrueckii, Lactobacillus fermenti, Lactobacillus lactis* and *Pediococcus cerevisiae* have been found to be responsible for the fermentation process, although *L. mesenteroides* and *S.faecalis* are considered to be the microorganism essential for leavening of the batter and for acid production in *idli* (Purushothaman et al. 1993, Ramakrishnan 1993).

2. Dosa:

   Dosa batter is similar to *idli* batter but the batter is thinner (Steinkraus 1996). After fermentation, the leavened *dosa* batter is baked on hot pan as a thin, crisp pancake and eaten with chutney and *sambar* (Purushothaman et al. 1977). A dosa suspension is prepared by grinding wet rice and black gram separately with water. The two suspensions are then mixed and allowed to undergo natural fermentation, usually for 8–20 h. To make a dosa, the fermented suspension is spread in a thin layer (of 1–5 mm thickness) on a flat heated plate, which is smeared with a little oil or fat. A sol to gel transformation occurs during the heating and within a few minutes, a circular, semi-soft to crisp product resembling a pancake, ready for consumption is obtained (Battacharya & Bhat 1997).

3. Dhokla:

   Dhokla is also similar to *idli*, but black gram is replaced by Bengal gram in the preparation (Battacharya & Bhat 1997). A mixture of rice and chickpea flour is also used as the substrate for the fermentation. As in idli preparation, the fermented batter is poured into a greased pie tin and steamed in an open steamer (Purushothaman et al. 1993, Ramakrishnan 1993). A significant improvement in the biological value and net protein utilisation of dhokla due to fermentation has been reported (Aliya & Geervani 1981, Sands & Hankin 1974).

4. Selroti:

   Selroti is a popular fermented rice-based ring shaped, spongy, pretzel like, deep fried food item commonly consumed in Sikkim and Darjeeling hills in India, Nepal and Bhutan.For the preparation of selroti, local variety of rice (*Oryza sativa* L.) *attey* is sorted, washed, and soaked in cold water for overnight or 4 to 8 h at ambient temperature. Water is then decanted from the rice by using bamboo made sieve called *chalni* and spread over a woven tray made up of bamboo, locally called *naanglo* and dried for 1 h. Soaked rice is pounded into coarse powder in a wooden mortar and pestle known as *okhali* and *mushli*, respectively. Larger particles of pounded rice flour are separated from the rest by winnowing in a bamboo tray. Then the rice flour is mixed with nearly 25% refined wheat (*Triticum aestivum* L.) flour, 25% sugar, 10% butter or fresh cream and 2.5% spices/condiments containing large cardamom (*Amomum subulatum* Roxb.), cloves (*Syzygium aromaticum* Merr.), coconut (*Cocos nucifera* L.), fennel (*Foeniculum vulgare* Mill.), nutmeg (*Myristica fragrans* Houtt.), cinnamon (*Cinnamomum zeylanicum* Bl.), and small cardamom (*Elletaria cardamomum* Maton.), are added to the rice flour and mixed thoroughly. Milk (boiled/unsoiled) or water is added, kneaded into a soft dough and finally into batter with easy flow. Batter is left to ferment naturally at ambient temperature (20–28°C) for 2 to 4 h during summer and at 10–18 °C for 6–8 h during winter. The oil is heated in a cast iron frying pan locally called tawa. The fermented batter is squeezed by hand or metallic serving spoon, deposited as continuous ring onto hot edible oil and fried until golden brown and is drained out from hot oil by poker locally called *jheer* or *suiro* or also by a spatula locally called *jharna*. Deep fried Selroti is served as confectionary (Yonzan Hannah & Tamang Jyoti Prakash 2009).

5. Khaman:

   Khaman is similar to *dhokla*, but it is made entirely of Bengal gram dhal. *Idli, dhokla* and *khaman* are steamed as soon as the batter is leavened and acidified. They are consumed the same day. The acid content retards the growth of food poisoning and food spoilage organisms (Sekar & Mariappan 2007).

6. Ambeli:

   Ambali is a fermented product from ragi [*Eleusine coracana* (L.) Gaertn] *Leuconostoc mesenteroides* (1.6×10^9/gm), *Lactobacillus fermentum* (1.6×10^9/gm) and *Streptococcus faecalis* (8×10^8/gm) have been isolated from fermented ragi. The pH usually decreases from 6.4 to 4.0 and volume increases by about 20%, indicating CO_2 production (Ramakrishnan 1979).

7. Sez:

   The traditional semi-fermented food used by the Bhotiyas in Uttaranchal of India is called *sez.* It is made from rice, and is mostly used as snacks. Earlier, it was a delicacy and was prepared only during certain festivals. In most cases, *sez* is extracted while preparation of rice *jann* (local beer) (Roy et al. 2004).

8. Adai and Vada:

   Adai and vada both are cereal legume based breakfast or snack food in India. Pediococcus, Streptococcus, Leuconostoc are predominant micro-organism required for the fermentation of both the products (Adams 1998, Chavan & Kadam 1989, Harlander 1992, Sankaran 1998, Soni & Sandhu 1990, Blandinob et al. 2003).

9. Bhattejaanr and Anarshe:

   Bhattejaanr and Anarshe both are rice based breakfast in India. Anarshe is sweetened snack food fermented by lactic acid bacteria whereas bhattejaanr is sweet and sour alcoholic paste fermented by *Hansenula anomala* and *Mucor rouxianus* (Adams 1998, Chavan & Kadam 1989, Harlander 1992, Sankaran 1998, Soni & Sandhu 1990, Blandinob et al. 2003).

b) Wheat based fermented food:

1. Balam:

   The beverage jann is prepared using starter material called as balam in Kumaon and balma in Garhwal region of Uttaranchal. It is made up of wheat flour, clove (*Cinnamomum zeylanicum* Nees), elaichi (*Amomum subulatum* Roxb.), kali-mirch (*Piper longum* L.) and leaves of wild chillies and seeds of pipal (*Ficus religiosa* L.). In addition, old balam is also mixed. The mixture is prepared with required amount of water and made into a thick paste. This mixture is pressed between palms to make balam balls of the required size. These are dried in shade and stored for future use (Roy et al. 2004).

2. Jalebi:

   It is a sweetened fermented product made from *maida* (refined wheat flour), *dahi* and water. The fermented batter is deep fat fried in oil in spiral shapes and immersed in sugar syrup for few minutes. This traditional food is prepared during marriage ceremonies and festivals of South India. *Lactobacillus fermentum* (6×10^8/gm),L. *buchneri* (3.2×10^8/gm, *Streptococcus lactis* (6×10^8/gm), S. *faecalis* (6×10^8/gm) and *Saccharomyces cerevisiae* are found in the fermented batter. The pH decreases from 4.4 to 3.3 and there is a 9% volume increase in the batter. Both amino nitrogen and free sugar decrease during fermentation (Steinkraus 1996).

3. Kulcha, Nan and Bhatura:

   Various types of traditional wheat based fermented snack foods like Bhatura (white wheat flour product), kulcha (white wheat flour product), Nan (wheat flour product), are prepared indigenously in India. For the fermentation of those products, mainly *Saccharomyces cerevisiae*, LAB are used (Sanjeev & Sandhu 1990).

4. Kurdi and Taotjo:

   Kurdi is a type of wheat based solid fried chips, whereas taotjo is a kind of condiment made from fermentation of roasted wheat meal by *Aspergillus oryzae*,it is mainly popular in eastern India (Adams 1998, Chavan & Kadam 1989, Harlander 1992, Sankaran 1998, Soni & Sandhu 1990, Blandinob et al. 2003).

5. Soy sauce:

   Soy sauce is a dark brown liquid, made from a blend of soybeans and wheat, that is mainly used as an all purpose seasoning in Japan, China and the Far East countries (Yokotsuka 1993). Soy sauces have a salty taste, but are lower in sodium than traditional table salt. The characteristic aroma and flavour of soy sauce is due to the enzymatic activities of yeasts and some LAB. As soybeans contain high levels of proteins and oligosaccharides, but no significant level of simple sugars, fermentation by lactic acid bacteria and yeasts requires the exogenous saccharifying enzymes supplied by the koji. In general, the pH of the sauce is between 4.6 and 4.8, and the typical salt concentration is 17–19%. Concentration of salt less than 16% can result in the development of putrefactive species during fermentation and age-

ing. On the contrary, levels greater than 19% interfere with the growth of halophilic bacteria such as *Pediococcus halophilus* and osmotic yeasts such as Z. *rouxii* (Beuchat 1983).

Conclusion

In the developed countries, due to large obesity problem and also for maintaining normal and sound health, different formulations and activities are coming up, specially delivering soluble fibres to the consumers via different foods like cereals and cereal products containing antioxidants. Cereals like wheat, maize, rice, oats etc. are now employed in preparation of food that are similar in appearance to conventional food and used in normal diet but have an added advantage of aiding physiological functions along with providing nutrition. Eating habits can drastically reduce healthcare expenditures if individuals were to modify their diets based on an existing knowledge of nutrition. In today's world the development and utilization of different cereal based functional foods is a challenging task. Invention of newer technologies for processing of cereals to improve their nutritional value vis-à-vis their acceptability by the end users will be the focus area in the near future.

References

Adams MR (1998) Fermented weaning foods. In: Wood JB (ed) Microbiology of fermented foods. Blackie Academic, London, pp 790–811

Aliya S, Geervani P (1981) An assessment of protein quality and vitamin B content of commonly used fermented products legumes and millet. J Sci Food Agric 32:837–842. doi:10.1002/jsfa.2740320814

Amri A, Ouammou L, Nassif F (2005) Barley-Based Food in Southern Morocco. In: Grando S, Gomezmacpherson H (eds) Food Barley: Importance, Uses, and Local Knowledge. ICARDA, Aleppo

Battacharya S, Bhat KK (1997) Steady shear rheology of rice blakgram suspensions and suitability of rheological models. J Food Eng 32:241–250

Baublis AJ, Lu C, Clydesdale FM, Decker EA (2000) Potential of wheat-based breakfast cereals as a source of dietary antioxidants. J Am Coll Nutr 19(3):308–311

Beuchat LR (1983) Indigenous fermented foods. In: Reed G (ed) Biotechnology. Food and feed production with microorganisms. Weinheim, Verlag Chemie

Bhatty RS (1999) The potential of hull-less barley. Cereal Chem 76 (5):589–599

Blandinob A, Al-Aseeria ME, Pandiellaa SS, Canterob D, Webba C (2003) Review: Cereal-based fermented foods and beverages. Food Res Int 36:527–543

Brennan ChS (2005) Dietary fibre, glycaemic response and diabetes. Mol Nutr Food Res 49:560–570

Burks AW, Helm RM (1994) Hypoallerginicity of rice protein. In: Presented at the annual meeting of the American Association of Cereal Chemists. Nashville, TN

Charalampopoulos D, Wang R, Pandiella SS, Webb C (2002) Application of cereals and cereal components in functional foods: a review. Int J Food Microbiol 79:131–141

Chatenoud L, Tavani A, La Vecchia C, Jacobs DR Jr, Negri E, Levi F, Franceschi S (1998) Whole grain food intake and cancer risk. Int J Cancer 77:24–28

Chatenoud L, La Vecchia C, Franceschi S, Tavani A, Jacobs DR Jr, Parpinel MT, Soler M, Negri E (1999) Refined-cereal intake and risk of selected cancers in Italy. Am J Clin Nutr 70:1107–1110

Chavan JK, Kadam SS (1989) Critical reviews in food science and nutrition. Food Sci 28:348–400

Christa K, Soral-Śmietana M (2008) Buckwheat grains and buckwheat products—nutritional and prophylactic value of their components—a review. Czech J Food Sci 26:153–162

Desikachar HSR, Radhakrishnamurthy R, Rama Rao G, Kad kol SB, Srinivasan M, Subrahmanyan V (1960) Studies on idli fermentation: Part 1. Some accompanying changes in the batter. J Sci Ind Res 19:168–172

Edge MS, Jones JM, Marquart L (2005) A New Life for Whole Grains. J Am Dietet Assoc 105(12):1856–1860

Fardet A, Rock E, Rémésy C (2008) Is the in vitro antioxidant potential of whole-grain cereals and cereal products well reflected in vivo. J Cereal Sci 48:258–276

Gurpreet KC, Sogi DS (2007) Functional properties of rice bran protein concentrates. J Food Eng 79:592–597

Harlander S (1992) Food biotechnology. In: Lederberg J (ed) Encyclopaedia of microbiology. Academic, New York, pp 191–207

Holzapfel WH, Schillinger U (2002) Introduction to pre- and probiotics. Food Res Int 35:109–116

Kalra EK (2003) Nutraceuticals-Definition and Introduction. Aaps Pharmsci 5(3): Article 25, Submitted: April 15, 2003; Accepted: July 28, 2003; Published: September 3, 2003. DOI: 10.1208/ps050225

Kalui CM, Mathara JM, Kutima PM (2010) Probiotic potential of spontaneously fermented cereal based foods—A review. Afr J Biotechnol 9(17):2490–2498

Kato N, Kayashita J, Tomotake H (2001) Nutritional and physiological functions of buckwheat protein. Re-cent Research Development Nutrition 4:113–119

Kim KH, Tsao R, Yang R, Cui SW (2006) Phenolic Acid Profiles and Antioxidant Activities of Sheat Bran Extracts and the Effect of Hydrolysis Conditions. Food Chem 95:466–473

Krkošková B, Mrázová Z (2005) Prophylactic components of buckwheat. Food Res Int 38:561–568

Lazaro EL, Favier JF (2000) Alkaline debranning of sorghum and millet. American Association of Cereal Chemists 77(6):717–719

Li S, Zhang QH (2001) Advances in the development of functional foods from buckwheat. Crit Rev Food Sci 41:451–464

Macfarlane S, Macfarlane GT, Cummings JJ (2006) Review: prebiotics in the gastrointestinal tract. Alim Pharmac Ther 24:701–714

Malkki Y, Virtanen E (2001) Gastrointestinal effects of oat bran and oat gum: A review. Lebensm WisS Technol 34(6):337–347

Malkki Y, Myllymaki O, Teinila K, Koponen S (2004) Method for preparing an oat product and a foodstuff enriched in the content of beta-glucan. US Patent 6:797–307

Marquart L, Cohen E (2005) Increasing Whole Grain Consumption. Food Technol 59(12):24–31

McDonough CM, Rooney LW, Earp CF (1986) Structural characteristics of Eleusine coracana (finger millet) using scanning electron and fluorescence microscopy. Food Microstruct 5:247–256

Nout MJR (2009) Rich Nutrition from the poorest—Cereal fermentation in Africa and Asia. Food Microbiol xxx:1–8

Oomah DB, Mazza G (1996) Flavonoids and antioxidative activities in buckwheat. J Agr Food Chem 44:1746–1750

Pomeranz Y, Robbins GS (1972) Amino acid composition of buckwheat. J Agr Food Chem 20:270–274

Purushothaman D, Dhanapal N, Rangaswami G (1977) Microbiology and biochemistry of *idli* fermentation, Symposium on Indigenous Fermented Food, Bangkok, Thiland

Purushothaman D, Dhanapal N, Rangaswami G (1993) Indian idli, dosa, dhokla, khaman, and related fermentations. In: Steinkraus KH (ed) Handbook of indigenous fermented foods. Marcel Dekker, New York, pp 149–165

Radhakrishnamurthy R, Desikachar HSR, Srinivasan M, Subrahmanyan V (1961) Studies on idli fermentation II. Relative participation of Blackgram flour and rice semolina in the fermentation. J Sci Ind Res 20:342–344

Ramakrishnan CV (1979) The studies on Indian fermented food. Baroda J Nat 6:1–57

Ramakrishnan CV (1993) Indian idli, dosa, dhokla, khaman, and related fermentations. In: Steinkraus KH (ed) Handbook of indigenous fermented foods. Marcel Dekker, New York, pp 149–165

Ravindran G (1991) Studies on millets: Proximate composition, mineral composition, and phytate and oxalate contents. Food Chem 39:99–107

Roberfroid MB (1999) What is Beneficial for Health? The Concept of Functional Food. Food Chem Toxicol 37:1039–1041

Roy B, Kala CP, Farooquee Nehal A, Majila BS (2004) Indigenous Fermented Food and Beverages: A Potential for Economic Development of the High Altitude Societies in Uttaranchal. J Hum Ecol 15(1):45–49

Sands DC, Hankin L (1974) Selecting lysine-excreting mutants of lactobacilli for use in food and feed enrichment. J Appl Microbiol 28:523–534

Sanjeev KS, Sandhu KD (1990) Indian fermented foods; microbiological and biochemical aspects. Ind J Microbial 30:135–157

Sankaran R (1998) Fermented food of the Indian subcontinent. In: Wood JB (ed) Microbiology of fermented foods. Blackie Academic and Professional, London, pp 753–789

Santosa S, Farnworth E, Jones PJH (2006) Probiotics and their Potential Health Claims. Nutri Rev 64(6):265–274

Sekar S, Mariappan S (2007) Usage of traditional fermented products by Indian rural folks and IPR. Indian J Trad Know 6(1):111–120

Severson DK (1998) Lactic acid fermentations. In: Nagodawithana TW, Reed G (eds) Nutritional Requirements of Commercially Important Microorganisms. Esteekay Associates, Milwaukee, pp 258–297

Shah NP (2007) Functional cultures and health benefits—a review. Int Dairy J 17:1262–1277

Shortt C (1999) The probiotic century: historical and current perspectives. Trends Food Sci Technol 10:411–417

Slavin JL, Martini MC, Jacobs DR Jr, Marquart L (1999) Plausible mechanisms for the protectiveness of whole grains. Am J Clin Nutr 70:459S–463S

Soni SK, Sandhu DK (1990) Indian fermented foods: microbiological and biochemical aspects. Indian J Microbiol 30:135–157

Steinkraus KH (1994) Nutritional significance of fermented foods. Food Res Int 27:259–267

Steinkraus KH (1996) Handbook of Indigenous Fermented Foods. Marcel Dekker, New York

Stibilj V, Kreft I, Smrkolj P, Osvald J (2004) Enhanced selenium content in buckwheat (*Fagopyrum esculentum* Moench) and pumpkin (*Cucurbita pepo* L.) seeds by foliar fertilisation. Eur Food Res Technol 219:142–144

Truswell AS (2002) Cereal grains and coronary heart disease. Eur J Clin Nutr 56(1):1–14

Venn BJ, Mann JI (2004) Cereal grains, legumes and diabetes. Eur J Clin Nutr 58:1443–1461

Wanatabe M (1998) Catechins as antioxidant from buckwheat (*Fagopyrum esculentum* Moench) groats. J Agr Food Chem 46:839–845

Wang M, Hettiarachchy NS, Qi M, Burks W, Siebenmogen T (1999) Preparation and functional properties of rice bran protein isolate. J Agr Food Chem 47:411–416

Wei Y, Hu X, Zhang G, Ouyang S (2003) Studies on the amino acid and mineral content of buckwheat protein fractions. Food/Nahrung 47:114–116

Würsch PF, Sunyer Xavier Pi (1997) The role of viscous soluble fibre in the metabolic control of diabetes. Diabetes Care 20:1774–1780

Yokotsuka T (1991) Nonproteinaceous fermented foods and beverages produced with koji molds. In: Arora DK, Mukerji KG, Marth EH (eds) Handbook of Applied Mycology, vol. 3. Marcel Dekker Inc, New York, p 293

Yokotsuka T (1993) Japanese shoyu. In: Steinkraus KH (ed) Handbook of indigenous fermented foods. Marcel Dekker, New York, pp 511–517

Yonzan H, Tamang JP (2009) Traditional processing of Selroti-A cereal based ethnic fermented food of the Nepalis. Indian J Trad Know 8(1):110–114

Ziemer CJ, Gibson GR (1998) An overview of probiotics, prebiotics and synbiotics in the functional food concept: perspectives and future strategies. Int Dairy J 8:473–479