Chapter 1

Introduction

Millets have been important staples in the semi-arid tropics of India for centuries. Among the several kinds of millets that are grown in the world, the barnyard millet (*Echinochloa frumentacea*), finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), kodo millet (*Paspalum scrobiculatum*) and little millet (*Panicum sumatrense*) assume significance. Millets are good sources of energy, protein, vitamins and minerals (Rao, 1986). Millets proteins are good sources of essential amino acids except lysine and threonine but are relatively high in methionine (Gopalan *et al*., 1997). They are rich source of phytochemical & micronutrients and are termed as "nutria–cereals" (Sehgal and Kawatra, 2003).

The area under barnyard millet (*Echinochloa frumentacea*) cultivation in India is 208600 ha thousands hectares with a productivity of 863 kg/ha (Annon, 2007). The wide adaptation of barnyard millet crop has made its cultivation possible throughout India. Under favourable moisture and temperature conditions, the grain would ripen within 45 days of sowing (Hulse *et al*., 1980). Barnyard millet is a main crop (among millet) of North Western Himalayan Region (NWHR) of India, and is popularly known as *Jhingura*. These crops are less prone to disease and pests in the field and even during storage (Anon, 2001). It is grown with limited water resources and usually without application of any fertilizer or other inputs by a multitude of small–holding farmers in hills. They are often referred to as "poor people's crops" since they are mostly consumed by disadvantaged groups. The height of the plant varies between 50 and 100 cm.

Barnyard millet is three times richer in minerals as compared to wheat and four times richer in fat, seven times richer in minerals and twice richer in calcium as compared to rice (Gopalan *et al.*, 1997). The grains of barnyard millet are low in phytic acid and rich in iron and calcium. In spite of its significant production and rich nutritional values this millet has not found significant place in Indian diet. The major reason for this may be the lack of appropriate post harvest technologies for management of these crops.

Introduction

Development of suitable post harvest processing technologies for barnyard millets is essential to promote its utilization in India where nearly 63% children under five years of age are malnourished (Rhode, 1994).

The barnyard millet grain is utilized after removing the hulls. Some countries are also utilizing hulls of barnyard millet for making organic pillows. Millet hulls are capable of fully supporting the weight of our head and neck without losing their form (http://www.pillowcompany.com/millethull.html, accessed on 22th March 2010). The removal of hull from seed greatly improves the appearance of the product (Deshpande *et al.*, 1982) and enhances the digestibility. In India, barnyard millet crop is harvested at 24 to 26% (db) moisture content in month of October–November and kept under the sun until the moisture content reduces to 12 to 14% (db), followed by staking the harvested crop for 1 to 1.5 months in a threshing yard for loosening the glumes of the grains (Ajisegiri & Sopade, 1990). After that, the dehulling is conventionally done by manual pounding which needs more than 1 h effort for dehulling of 2–2.5 kg grains (Pushpamma, 1989). This operation is time consuming, laborious and uneconomical to the farmers. The dehulling of barnyard millet is difficult because the small sized grains are held much more firmly in the glumes. The mature pericarp consists of two epidermal layers. The cells of inner epidermis are closely compressed against those of the outer part. Barnyard millet has an aleuronic layer thought to contain strongly a cutinized cell wall (Narayanaswami, 1955; Zee and O'Brain, 1971). The dehulling of barnyard millet requires considerable pressure coupled with repetitive impact, and shear (Singh *et al.*, 2003).

The traditional methods of dehulling do not give the desired yield and often result in low quality products (Singh *et al.*, 2003). In dehulling operation, by means of manual pounding, most of the grains get damaged due to repeated impact on them. The mechanized dehulling of barnyard millet will not only reduce the drudgery to the farmers but also give better quality kernels with a higher dehulling rate and lower broken grain. The dehulling, using mechanical dehuller, can be done after 4–5 days of harvesting, which will be saving the time and labour of the millet producers. The machine dehulling will increase the availability of dehulled kernel in the market which will attract the entrepreneurs, flour makers and bakers to utilize this nutritionally important crop for commercial purposes. The increased commercial demand will fetch the farmers good price for their produce, which will be encouragement for the farmers to grow more and more barnyard millet.

In designing of the mechanical dehuller for barnyard millets grains, the rice and barley dehullers played major role of inspiration (Hulse *et al.*, 1980; Reichert, 1982). In abrasive methods of dehulling, abrasions and attrition forces crush the seeds, causing a high proportion of dehulling losses (Gupta & Das, 1999). Various dehulling methods suitable for use in small–scale milling systems, developed by many researchers (Reichert & Youngs, 1976; Reichert *et al.*, 1984) were employed in preliminary trials, and it was observed that the dehulling based on impact and shear principle gave better performance for small seeds as compared to abrasive methods. In order to perform dehulling of seeds under the action of an impact, shear or compression or their combination, many researchers have studied the force deformation characteristics of hull breaking load for various agricultural seeds under quyasi–static compression (Bilanski, 1966; Paulsen, 1978; Liu *et al.*, 1990; Pandey, 1986; Joshi, 1993; Kang *et al.*, 1995 and Gupta and Das, 1999). Information on these aspects of dehulling of barnyard millet grain is lacking in the literature.

The study of engineering, aerodynamic and physical properties of barnyard millet grains and kernels are important and essential for the designing of different components of processing machineries. The shape and size are important in the separation from foreign material and in the design and development of grading and sorting machineries. Rupture force, specific deformation, rupture energy, internal friction, static coefficient of friction and terminal velocity can be used in design and development of the dehuller. Bulk density, true density and porosity, are important factors in designing of storage structures. The dynamic angle of repose of the grains and kernels can be used for designing the bins, silos, hoppers and storage structures. Many researchers have determined the properties of different agricultural produces, like small millet (Baryeh 2002, Subramaniam & Viswanathan, 2007) and caper seed (Dursun & Dursun, 2005). Subramanian & Viswanathan (2007) studied some physical properties, like bulk density and friction coefficient of barnyard millet grain. However, they did not consider other physical, aerodynamic and mechanical properties.

Barnyard millet grain is consumed in a traditional way and almost the entire produce is utilized at the farm or village level. In spite of superior value of grain, the utilization of this millet for food is mostly confined to the traditional consumers and population of lower socioeconomic strata (Malleshi and Desikhachar, 1985). Some millet are even better in protein, oil and mineral content but, their use in the diet is limited because they are difficult to process and lack gluten and grittiness (Malleshi, 1986). Bread, biscuits and cakes are traditionally made from wheat flour. Other cereal flours like rye, barley, sorghum and maize have been used either alone or in combination with wheat flour for bakery product making in various parts of the world. Several studies have indicated the possibility of incorporation of millet flours in wheat flours at various levels. Such composite flours can be used for producing breads, biscuits and other snacks. Kamaraddi & Shanthakumar (2003) reported that substitution of wheat flour with millet flour was possible from 10 to 20% level. The optimum level of addition of barnyard millet was recommended as 20%. The increase of millet blend percentage beyond 20% was not possible, perhaps due to the lack of gluten forming abilities in millets. Gluten is the most important constituent of dough which is responsible for texture of the bakery products. The percentage of millet in the composite flour blend can be increased by adding some external gluten. The glycemic index (GI) of millet is lower as compared to other cereal grains. The increase in percentage of millet will decrease the GI of the composite flour, which might be beneficial for the persons suffering from heart disease, diabetes and hypertension (Srivastava and Singh, 2003).

Tannins present in barnyard millet grain are potent inhibitors of pests and pathogens. It is, therefore, best stored as whole grain. After dehulling of barnyard millet and preparation of wheat-millet composite flour, storage of kernels and composite flours will be the major challenge for the entrepreneurs. The property of food material which influences dehydration, shelf life, and storability is its water sorption characteristics (Labuza, 1968, 1975). Accurate information on sorption characteristics and equilibrium moisture contents of barnyard millet grain and kernel at various relative humidities and temperatures are not available. The shelf life study of wheat-millet composite flours at accelerated condition (90% RH and 40 °C temperature) using different packaging material also needs to be carried out. Usually millet flour is produced when it is needed and is not often stored for long periods, because, it tends to turn rancid. Insect-infested food material showed significant losses in total fat, mineral matter, thiamine and riboflavin (Pant and Susheela, 1977). Use of suitable packaging, can prevent the loss of nutritive value of composite flours, by controlling the degree to which environmental factors connected with processing and storage are exposed to the flour.

Keeping the above points in mind the present project was undertaken to develop a machine & process technology for dehulling of barnyard millet. The study also included the formulation and storage of millet–wheat composite flour and its use in bread. Changes during accelerated storage of composite flours, were also studied and its shelf life was evaluated. The specific objectives of the study were as under.

Objectives

- To analyze important physico–chemical and engineering properties and sorption behaviour of barnyard millet grain and kernel.
- To design and develop a dehulling machine for barnyard millet grain and optimize its operating parameters.
- To optimize pretreatment conditions and process parameters for dehulling of barnyard millet grain.
- To formulate millet–wheat composite flour and study its physico-chemical characteristics.
- To prepare bread from the developed composite flour and evaluate its quality.
- To study the changes during accelerated storage of composite flour and evaluate its shelf life.