INTRODUCTION
1. INTRODUCTION

Extrusion is a multivariable unit operation i.e. mixing, shearing, cooking, puffing and drying in one energy efficient rapid continuous process. Extrusion has become an important technique in an increasing variety of food processes and it has many benefits, including the inactivation of antinutritional factors, versatility, high productivity, low cost, variable product shapes, high quality and production of new food and there are no effluents. Extrusion cooking is a popular means of preparing snack foods and ready-to-eat breakfast cereals using starch-based raw materials (Harper, 1981). Snacks contribute an important part of many consumers in daily nutrient and calories intake (Tetlweiler, 1991). Extrusion cooking is capable of converting soluble globular legume proteins into material having fibrous and chewy texture (Harper, 1981).

Grain legumes are an important source of protein, minerals and vitamins for millions of people in the world, particularly in the developing countries (Singh and Singh, 1992). They improve the nutritional quality of predominantly cereal based diets of large segments of population, as cereal proteins are deficient in lysine (Deosthale, 1984). Legumes can be described as the most potent and valuable source of naturally occurring proteins and carbohydrates (Hulse, 1975). Proteins are essential for growth and carbohydrates are the source of energy for our body. In addition to these, pulses also possess B-complex vitamins and minerals. This necessitates the consumption of pulses in some form or the other. Pulses are grown in appreciable amount in the Bundelkhand region; the milling process yields a sizeable amount of pulses in the form of broken from the pulse mills. The brokens do not find good market and are listed as losses of pulse.
processing, generally disposed of cheaply, only to be used as animal feed or to act as raw material for manufacture of other complementary products.

In recent years, many compounds from food legumes have been shown to cause physiological and biochemical effects, such as pancreas enlargement and growth inhibition in various species of animal (Grant, 1989; Guen et al., 1993; Liener, 1989). These compounds include phytic acid, condensed tannins, polyphenols, protease inhibitors (trypsin and chymotrypsin) and lectins. Moreover digestibility of legume protein and legume starch is limited by the presence of anti-nutrients (Lajolo et al., 1991; Nielsen, 1991; Yadav and Khetrapaul, 1994) and the utilization of pulses in both animal and human nutrition is restricted by the presence of the afore mentioned factors. A wide range of processing techniques could improve the protein and starch digestibilities of legumes and therefore their utilization (Alonso et al., 1998; Conan and Carré, 1989; Frias et al., 1995; Gujska and Khan, 1991; Van der Poel, 1990; Wang et al., 1997). Extrusion has been reported to have caused biggest effect in reduction of protein anti-nutritional factors and appeared to be the most effective, improving both in-vitro protein digestibility and in-vitro starch digestibility (Alonso, 2000).

Millets are small seeded annual cereal grains. These are very hardy crops and can be grown successfully on infertile land. These crops are less prone to diseases and pests in the field and store. Millets in India occupy 0.7 per cent of the total cropped area which is about 1.3 million hectares and is confined to the vast stretches of dry land and hilly area (IASRI, 2006a). Bundelkhand region falls has a semi-arid climate, the land is hilly and dry, and water is scarce. Limitations of soil and irrigation facility makes millet a very
popular crop amongst the farmers of this region, however, poor commercial market for millets yields less returns.

The need to utilize locally grown crops for manufacture of convenient local recipes in the less developed countries has been seriously stressed by international agencies as the most suitable channel for addressing a deepening world food problem (Iwe et al., 2001). The advantages of this approach include the reduction of the inherent food losses associated with food production in the less developed countries; promoting year-round, as opposed to seasonal consumption; providing a greater variety and convenience of uses, especially for roots, by making products with characteristics distinct from those of the raw material; increasing the economic value of the crop to producers and increasing the efficiency of the food delivery system, thus freeing time for other occupations (Wolfe, 1992).

Millets are not only nutritionally comparable but are also superior to major cereals with respect to protein energy, vitamins and minerals. Besides they are rich source of dietary fibre, phytochemicals, micro-nutrients, nutraceuticals, and hence now-a-days they are rightly termed as nutricereals (Desikachar, 1977).

Foods that are high in total dietary fibre (TDF) and soluble dietary fibre (SDF) have been related to decrease in wide spectrum of diseases. The cholesterol lowering effect of SDF in specific foods has been established in animal (Ranhotra et al., 1987) and human clinical studies (Jenkins et al., 1980; Behall et al., 1984; Anderson and Tietyen-Clark, 1986). The relatively higher proportions of dietary fibre of millet grains confer many advantages. Fibre as a component of food will provide several nutritional and physiological benefits, namely, hypocholesterolemic, and hypoglycemic effects, reduced
transit time, minimizing the undesirable fermentation of undigested food component in the gut and binding with toxins and discharging them with stools in colon, in other words it brings down the incidence of colon cancer, constipation and gastro intestinal complications. However, the utilization of millets for foods is still mostly confined to the traditional consumers and population of lower economic strata, partly due to non availability of these grains in ready to use or ready to eat forms (Malleshi and Desikachar, 1985).

Extrusion cooking is being increasingly used to manufacture a diverse range of food products including snack foods and slimming products. Such foods are likely to make significant contribution to the diet of sub groups in the population who may be potentially vulnerable to mineral deficiencies (Hazell and Johnson, 1989). In the extrusion of snacks and other food products, proper control of the extrusion process is of vital importance to the quality of the final product. In cereal-based products, the degree of starch processing is all-important for major quality aspects such as taste, digestibility, texture and appearance. However, the effect of various operational and processing parameters and their interaction on extrudates quality for millet and pulse-broken blend is yet to be studied and established. Extrusion operational parameters such as die head temperature, barrel temperature and screw speed affect the snack quality. In addition to these, the processing parameters like feed moisture content, blending ratio, and flour particle size also play important role in extrudate quality. Proper manipulation of any, some or all the outlined conditions through adoption of well defined experimental design influence ultimate extrudate quality and functionality (Dziezak, 1990). Combine effect of various operational and processing parameters in relation to product quality have not
been investigated and standardized so far. Therefore, a systematic and integrated study considering the effect of various operational and processing parameters has been carried out in this research study, to develop integrated extruded quality models which can then be used to optimize these parameters for best quality of ready-to-eat snack food product.

In view of the above mentioned need, the present study was undertaken with the following specific objectives.

- To study the effect of operational parameters of extruder i.e. die head temperature, barrel temperature and screw speed on extrudates physical properties (expansion ratios and density) and textural properties (crispness, hardness and cutting strength) made out of millet and pulse broken flour blend.

- To study the effect of processing parameters of feed i.e. feed moisture content and blend ratio on the physical properties (expansion ratios and density) and textural properties (crispness, hardness and cutting strength) of extrudates.

- To optimize these operational and processing parameters for developing acceptable quality of ready-to-eat extruded snacks.

- To develop various prediction models for extruder performances under various operational and processing conditions.