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Introduction

Food is one of the basic needs of man, the consumption of which, besides satisfying hunger and promoting growth and energy to the body, enhances friendliness and social warmth. Every society or group has its own conception of food and own history of food habits, rather indigenous, which shape their food culture. Indians have always made a mark in the cuisine world with mouth-watering delicacies that make even a full stomach crave for more. Indian food presents a range of flavours, intense and subtle, as vast as the country itself. Regional influences range from climate and elevation to history and religion. They define cuisines that differ widely, no surprise in a country of more than one hundred million people occupying an area of 3,287,263 sq. km. Unarguably, the strongest influence defining Indian food is religion. Centuries of Hindu practice and the profound belief in reincarnation have resulted in the most delicious vegetarian cuisine to be found in the world. For protein, vegetarians rely on a wide range of legumes. Mixed with grain, boosted by vegetables and dairy products, they provide a wholesome, varied diet. The frontline staple foods of the Indian population are

cereals and legumes which are consumed in diverse forms. One of the important forms of consumption is the fermented one. Majority of the Indian population depends heavily on several indigenous fermented products made from either cereal or legume, or a mixture of both.

Fermented foods are those foods which have been subjected to the action of microorganisms or enzymes so that desirable biochemical changes cause significant modification to the food (Campbell-Platt, 1987). These foods are of great significance because they not only extend shelf-life of foods but also improve their nutritional value and enhance sensory properties. Fermented foods are easy to digest and have increased bioavailability of proteins, carbohydrates, lipids and minerals. Many of the undesirable factors such as toxins, phytates, tannin and polyphenols present in raw foods are detoxified or removed during fermentation. During fermentation, the microorganisms secrete hydrolytic enzymes into the substrate and assimilate some of the fatty acids, amino acids and simple sugars thus liberated. These are then converted to microbial structural components and secondary metabolites. In some cases, the microorganisms are capable of producing pectinases and cellulases, softening the texture of the food and liberating sugars that would otherwise be unavailable to the human digestive system. Hence, fermented foods are expected to be more digestible than their unfermented counterparts.

According to Food and Agricultural Organization, pulses, the food legumes, are 'annual leguminous crops yielding from one to 12 seeds within the pod, harvested for the dry seeds'. This definition excludes seeds that can use for extracting oil, e.g. soybean (*Glycine max* (L.) Merr.), peanut or groundnut (*Arachis hypogaea* L.), and vegetable crops like green pea (*Pisum sativum* L.) and green beans. In India, the word 'pulse' is used to describe the decoated cotyledons of legume seeds. Pulses have been grown by farmers since millennia, and these have contributed in providing nutritionally balanced food to the people of India. The pulses, in order of importance in India, are chick pea or Bengalgram (*Cicer arietinum* L.), pigeon pea or redgram (*Cajanus cajan* (L.) Millsp.), mung bean or green bean (*Vigna radiata* (L.) R.Wilczek), blackgram (*Vigna mungo* (L.) Hepper), cow pea (*Vigna unguiculata* (L.) Walp.), lentil (*Lens culinaris* Medik.) and moth bean (*Vigna aconitifolia* (Jacq.) Maréchal) (Draper, 2006).

Pulses are a quintessential part of Indian cuisine and occupy a prominent place in Indian diets and the agricultural economy. In India, food legumes are recognized as one of the most important sources of edible plant proteins, and virtually all Indians, rich and poor as well as vegetarian and nonvegetarian, consume pulses. Pulses are served at home and in all types of establishments. Most pulses are consumed in shelled and split form. In India, pulses are used to make dal (a gravy-like dish), curries and snacks. Practically, all legumes are consumed only after these are subjected to some forms of processing such as heating, roasting, soaking, sprouting, fermenting, boiling and pressure cooking. All these methods are known to improve their palatability and digestibility, decrease antinutritional factors and convert vital constituents of the pulses into simpler compounds which are ultimately beneficial nutritionally. However, regional preferences exist with respect to pulse consumption. Besides their high nutritional value, pulse crops have unique characteristics of containing and restoring soil fertility through biological nitrogen fixation (Kannaiyan, 1999).

India is the largest producer and consumer of pulses in the world, accounting for about 25% of global production, 27% of consumption, and 34% of food use (Price *et al.*, 2003). Pulses are cultivated in about 23 million hectares in India with production of 12 million metric tonnes build up from an average productivity of 534 kg ha^{-1}. The per hectare productivity of pulses in India is very low when compared to the average productivity of 1494 and 637 kg ha^{-1} in other developed and developing countries, respectively, as well as the global average pulse productivity of 797 kg ha^{-1} (Ramanathan, 2000). India is also a top importer of pulses with an 11% share of world imports (1995-2001), although

imports have only accounted for about 6% of domestic consumption during the same period (Price *et al.*, 2003).

Domestic demand and consumption, however, are much more than the production, mainly because pulses are the major source of protein for a large section of the vegetarian population in the country. India has given food legumes a more important place in its agriculture than most other countries and has the distinction of growing more than 12 types of food legumes on a larger scale (Nene, 2006). Madhya Pradesh is the largest pulse producing State in the country, accounting for about 26% of total production. Other States with significant output include Uttar Pradesh (18%), Maharashtra (14%), Rajasthan (14%), Karnataka (5%), Andhra Pradesh (5%) and Bihar (5%) (Price *et al.*, 2003).

However, pulse production in India has fluctuated widely, leading to a steady decline in per capita availability over the past 20 years. In fact, 15 years ago, the production was 14.3 million tonnes; however the current production has stagnated at around 13 million tonnes a year, while the consumption has been hovering around 17 million tonnes a year. Consequently, the per capita availability of pulses has dropped from 22.5 kg in 1965-66 to 10.6 kg in 2003-04. While the World Health Organization and Indian Council of Medical Research recommended 85 g and 47 g, respectively, per capita consumption of pulse per day to meet the protein requirement. The actual consumption in India, however, is much less i.e., around 30-35 g pulse per capita per day (Surendran and Muthiah, 2000). This situation warrants producing a three-fold increase as that of the current pulse production even to meet the minimum need of protein requirement. Hence, it is a contradiction that India is not only the biggest producer and consumer of pulses in the world, but also the biggest importer. In spite of the reduction in their per capita availability, food legumes are an integral part of the diet of the predominantly vegetarian population of the Indian Subcontinent.

The fact that food legumes provide protein supplement to the diet cereals suggests that the most practical means of eradication of the widespread protein calorie malnutrition, in several areas of the world, is to increase the supply of cereal-pulse mixture for human diets. Although consumption of meat and dairy products as primary sources of protein and calories is common in India, many consumers rely on cereals and pulses and exclude meat products from their diets due to their high cost or for religious reasons. Compared to animal foods, edible legumes have only a secondary nutritional value and low utilization. This has been partially attributed to (i) inherent presence of beany flavour, (ii) prolonged preparation and cooking prior to consumption, (iii) deficiency of sulphur-containing amino acids, particularly methionine, (iv) presence of several antinutritional and toxic factors, including enzyme inhibitors, phytohaemagglutinins, cyanogenic glucosides, lathyrogens, supenins, allergens, antivitamins, favism factors, polyphenolic compounds, phytic acid and flatulence-causing oligosaccharides. Reduction or elimination of these factors would make grain legumes more acceptable as a source of inexpensive nutritious proteins and maximize their utilization in human food.

Indians are credited for discovering the methods of souring and leavening cereal-legume batters. The traditional fermented foods derived from edible legumes form the basic component of human diet across the country. Several legume-based fermented foods are being produced at cottage industry scale, manufactured by employing traditional or technologically less advanced methods using natural microbiota from the staples and the surroundings. Soybean, blackgram and Bengalgram are the principal legumes used in the preparation of a variety of fermented foods in India. They are fermented either separately or in combination with cereals, particularly rice (*Oryza sativa* L.). Many fermented products made of cereal grains and legume beans (mixed preparation) give a high protein content,

and provide a better balance ratio of amino acids, overcoming the danger of lysine deficiency from cereal alone. Legume-based traditional fermented foods have made a significant contribution to human diet. They not only add variety to the human diet, but also serve as an economic source of supplementary proteins for the large human population in developing countries, like India, where a bulk of the population is vegetarian.

Due to her wide variations in agroclimatic features, social behaviour, cultural and religious beliefs, and dietary cultures among the multi-ethnic population, India harbours an excellent source of legume-based indigenous fermented foods. Although some of these, native to different parts of country, have been well-studied and even several of these are scaled-up, there is even no documentation on other lesser known similar legume-based fermented foods indigenous to India.

The present study is an attempt to focus on some of the obscure yet important legume-based traditional fermented foods of India. It aims to study the indigenous methods of their preparation, mode of consumption, ethnic values, and microbial and selected biochemical associations in them. The information obtained will provide comprehensive and systematic studies for the development of improved fermentation technology of some of the legume-based fermented foods of India.

To accomplish these, the following strategies were adopted:

1) Obtaining information on the methods used by the local people to prepare various legume-based traditional fermented foods, their modes of consumption and ethnic values;
2) Studying proximate composition of some selected legume-based indigenous fermented foods;
3) Isolating dominant microorganism(s) from some selected foods;
4) Optimizing traditional process parameters of some selected foods;
5) Studying succession of microbiota and selected biochemical parameters;
6) Characterizing the proven producing strain(s) in order to identify their taxonomic status; and
7) Studying the influence of fermentation on antioxidative activities of substrates of some foods.