1. INTRODUCTION

Indian dairy industry has witnessed rapid progress in the last 3 decades. The milk production during the year 2004 is estimated to be 91.1 million tonnes (Narang, 2004). About 45-50% of the total milk produced is converted into variety of traditional milk products using processes such as heat and acid coagulation, heat desiccation and fermentation. The market for Indian traditional products is estimated to be more than Rs. 6,500.0 crores (Patil, 2004).

Paneer is an important Indian traditional coagulated dairy product that provides sound nutrition, variety, safety, novelty of flavour, texture, portability and profitability to consumers. Mostly small-scale traders and halwais produce this dairy product by traditional methods. The unhygienic condition maintained during manufacture lead to lower shelf-life of these products. The demand for these products is increasing every year. There is a great concern to produce high quality with long life products that requires hygienic modern processing and preservation technologies. The organized dairies in India have to modernize and scale-up the production in order to meet the demand.

Paneer is an acid coagulated dairy product, which is similar to western cottage cheese and Tofu (Soy paneer). In India, paneer production has been largely confined to small non-organized sectors. It is estimated that 1% of the country’s total milk production is converted into paneer and the annual production is estimates at 150,000 tonnes (Aneja et al., 2002). Paneer is mainly used for various culinary preparations. In the last few decades, the popularity of paneer has spread from the north to all over the country. Its growing popularity has led to its integration into the Indian cuisine. Now, it enjoys the status of a national delicacy.

The defects of paneer are mainly associated with microbial growth as well as surface drying. The microflora come from cooling water used for immersing paneer, environmental contamination, equipments, personal involved in processing, packaging materials and storage temperatures. This results in post-manufacturing changes in fat and protein integrity and loss of moisture during storage. Changes in the environmental conditions during storage, transportation, and handling may cause microbial spoilage
and further results in quality and nutritional losses. Pre-and post-process microbial contamination of paneer is a potential safety hazard for consumers and can lead to food poisoning. Other common problem encountered is oxidation and hydrolysis of fat which lead to off-flavours and make product unattractive and unacceptable.

As the dairy and food industries consolidate and distribution chains to grow longer, product processors are being challenged to extend the shelf-life of dairy and food products. As there is no need for formulation changes, manufactures typically prefer to use the traditional processing or packaging techniques rather than use of other preservation technologies or ingredients to extend the shelf-life of product.

Microwave heating is an important novel technique available for thermal processing of food and dairy products. Microwaves (Electromagnetic Waves) when penetrate products, heat is generated instantaneously within the product by friction between water molecules. Now-a-days, conventional thermal ovens are replaced by Microwave ovens in various food processing and preservation operations. This process can be successfully applied to products containing high and intermediate moisture contents. The products with higher moisture, fat and sugar have great affinity to microwave energy and hence heated instantaneously. Compared to conventional heating, microwave heating provides several advantages in terms of voluminous and instantaneous heating that yields products with higher qualities in terms of nutrition, taste, texture, flavour and increased production.

The microwave processing technology is successfully applied in food and dairy industries for blanching, tempering, pasteurization, sterilization, baking, drying, etc. The prospects of microwave processing in the dairy industry need to be investigated extensively. Application of this technique in commercial scale is more confined to western countries. When employing this technology to Indian dairy products, due concern is to be given to the shelf-stability of the products.

Modified Atmosphere Packaging (MAP) is the enclosure of food in a package, inside which the atmosphere is modified by replacement of air with a fixed gas or mixture of gases (nitrogen, carbon dioxide, oxygen etc). Once the gas mixture is introduced, no further control of the gas composition is exercised inside the package
and the composition will inevitably change depending on the nature of the product packaged.

In the traditional food packaging system, product is protected from external environments such as oxygen, water vapor, light and microbial contamination. However, newer packaging techniques, like MAP, Vacuum Packaging (VP) and Active Packaging (AP) do more than just provide protection from outside influences. These techniques reduce physiological changes, respiration rates, oxidation reactions and microbial growth by changing the levels of gases that surround the product. Prudent use of MAP, VP and AP techniques alone or in combination with novel processing technologies such as microwave, pulsed electric field, high pressure processing etc can extend the shelf life of food products, without affecting their nutritional and sensory qualities.

The shelf life of paneer is low and the spoilage is due to surface growth of microorganisms. A greenish-yellow slime forms on the surface and the off-flavours render the paneer unacceptable. The shelf-life of paneer is 1 day at room temperature and 6 days at refrigerated temperature. Several methods like, physical (vacuum packaging, low temperature storage, dehydration, heat sterilization), chemical (brine, chlorinated water, hydrogen peroxide, delvocid, sorbic acid, potassium sorbate antioxidants etc) treatments, use of GRAS (Generally Regarded as Safe) additives have been tried to improve the shelf-life of paneer.

There is no evidence of published literature on the microwave processing, as well as modified atmospheric packaging to increase the shelf-life of paneer, a popular heat and acid coagulated indigenous dairy product that resembles western Quarg and Cottage cheeses. Heating of solid foods by conventional heating method is difficult because of poor heat transfer rate. In such condition, microwave heating is more suitable for dairy products such as paneer, cheese etc. Once the microwaves enter the product, it volumetrically heats it (i.e. each and every particle is heated instantaneously). Hence, the investigation is undertaken to increase the shelf-life of paneer by employing novel processing technique like Microwave processing and Modified Atmosphere Packaging without affecting its physico-chemical, microbiological, sensory properties and rheological characteristics.
Therefore, the proposed investigation has been conducted with the following objectives.

1. To standardize different protocols for the use of continuous microwave processing to improve the shelf-life of paneer.

2. To study the effect of continuous microwave processing on the chemical, microbiological, rheological and sensory quality of paneer during storage.

3. To study the effect of Modified Atmosphere Packaging (MAP) using different gas mixtures and selected packaging materials on the chemical, microbiological, rheological and sensory quality of paneer during storage.

4. To evaluate the effect of microwave exposed followed by modified atmosphere packaging of paneer on the chemical, microbiological, rheological and sensory quality of paneer during storage and

5. To study the cost of manufacture of microwave processed and modified atmosphere packaged paneer.