INTRODUCTION
Biosynthesis (Gr: bios, life; syn, with, together; thesis, a placing) - the synthesis (building up) of complex compounds from simpler substances in a living body (Flood and West, 1991). Technically it is the synthesis of complex molecules using enzymes and biological structures like ribosomes and chromosomes either within or without the cell (Peter and Walker, 1990). The classic complex compounds synthesized by fungi and of industrial significance are potable alcohol from yeasts, citric acid from *Aspergillus niger* and *Candida lipolytica*, gallic acid from *Aspergillus wentii*, flavouring reagents and Penicillin from *Penicillium* spp; enzymes from species of *Aspergillus*, *Penicillium* and *Trichoderma reesei*, gibberellins from *Gibbrella fujikuroi* and ergot alkaloids from species of *Claviceps*. There are several other fungal metabolites, the long list of which is given by Turner (1971). Some of these are of commercial significance or are suggestive so or not, such as the lipids (Weete, 1974; 1980; Lösel, 1988; Weete and Gandhi, 1992), nematoxicants (Guima and Cooke, 1971), gum and resinous materials (Sanborn, 1936), hallucinogenic agents (Wasson and Wasson, 1957; Heim, 1978), pigments and alkaloids (Präve et al., 1987), aflatoxins or mycotoxins (Burnett, 1976; Bilgrami and Verma, 1978), fragrant and flavour enhancers, surfactants, polymers for oil industry, nutritional supplements (such as vitamins
and amino acids), other organic acids, enzymes (useful in food, chemical and pharmaceutical industries), drugs (such as antibiotics and their precursor), steroid derivatives or steroid transformation and foreign protein; and growth hormones, carbohydrate modifications and biologically active compounds such as ascofuranose (antilipidemic) from *Ascochyta viciae*, naematolin (coronary vasodilator) from *Naematoloma fasciculare*, salframine (salivation inducer) from *Rhizoctonia leguminicola*, zearalenone (esterogenic) from *Gibberella zeae*, other miscellaneous compounds such as lysergic acid (ergot alkaloid derivative) from *Claviceps puspali*, Oudenone (tyrosine hydrolyase inhibitor) from *Oudmansiella radicata* and some other compounds obtained through immobilized fungal cells such as adenosine triphosphate (ATP) from *Saccharomyces cerevisiae*, cystidine diphosphate choline from *Hansenula jardini* (Neidleman, 1991) and other genetically engineered products (Berry, 1988).

The different types of fat are stored in fungal biomass (mycelium and spores) during the metabolism. The fat sensu stricto means the esters of fatty acids with glycerol and sensu lato means lipids with heterogenous group of compounds related either actually or potentially to the fatty acids. When liquid the lipids are known as oils. They have a common property of being relatively insoluble in water and soluble in non polar solvents (like ether, chloroform and
The fats, oils, waxes and related compounds constitute the lipid. The lipids are important human dietary constituents not only because of their high calorific value but also because of presence of fat soluble vitamins and essential fatty acids. Lindner (1922) seems to have first given the idea of fat synthesis from fungi. Since then several fungi have been listed oleaginic (Foster, 1949; Weete, 1974 and 1980; Christie, 1982; Ratledge, 1982; Harwood and Russel, 1984; Boulten and Ratledge, 1985; Ratledge and Boulten, 1985; Lösel, 1988; lackie and Dow, 1989; Alfrad et al., 1990; Weete and Gandhi, 1992), with high fat yields. Oleaginous yeasts are the highest fat producers. These include Cryptococcus albidus, Endomycopsis vernalis, Rhodotorula gracilis and Trichosporon pullulans, all of which have been reported to produce about 65% fat with 21 fat coefficient. Among filamentous fungi the highest fat producers are Mortierella isabellina, M. vinacea, Mucor circinelloids and Penicillium spinulosm, which have been reported to yield about 65% or more of the lipids (Ratledge, 1982; Lösel, 1988; Weete and Gandhi, 1992) with fat coefficient not more than 14. Several economic processes have been developed to produce fungal lipids industrially using cheap agricultural wastes and many of the techniques have been patented. Despite all these efforts and fungal fat being nutritionally similar to vegetable oils,
it has not appeared in the market as alternative to vegetable oils mainly because of production economics. Hence the trend has shifted from fungal lipid production to specific fungal lipid products having specific biological activity as precursors to prostaglandins or with surfactant properties (Weete and Gandhi, 1992). Though the trend has shifted from fat production yet it merits serious consideration particularly in India because of acute shortage of animal and vegetable fats and their high input economics. It could supplement the conventional production if not capable of bulk supply through fermentation to cope with the increased demand. Also, despite fungal oil not being developed into a commercially successful product, the fungi still offer considerable promise because of paucity of information on fungi for oleagenity (being less than 0.3% species screened) giving limited indication of their potential for lipid contents/production, both of conventional and normal types. Recently the subject of fungal lipids have been expanded enormously in various directions such as biochemistry, fungal lipid relationship with taxonomy and phylogeny, production of ergosterols or fungal sterols, extra-cellular glycolipids and lipases that have been excellently reviewed by Weete and Gandhi (1992) and Lösal (1988).

The organic acids are usually classified as primary
fungal metabolites (Turner, 1978). Out of all known organic acids as fungal metabolites, only citric acid is fungal synthesised industrially using Aspergillus niger or Candida lipolytica (Arora and Mukerji, 1992), along with few others like glutamic acid biosynthesised by species of Penicillium, A. niger and Acetobacter suboxydans; itaconic acid by Aspergillus terreus; malic acid by Candida rugosa (in China) and Brevibacterium spp. (in Japan) employing immobilized or intact cells; fumaric acid by Rhizopus nigricans, R. japonicus and R. arrhizus with maximum of 60% yield through industrial fermentation which is now stopped because of being expensive (Arora and Mukerji, 1992). The other organic acids though produced in large amounts through fungal fermentation, have not been industrialized because of economic reasons. They have been considered of minor importance and include, itaconic, epoxysuccinic, malic, oxygluconic, propionic, butyric, tartaric, oxoglutaric, fumaric, succinic, pyruvic, oxogalactonic and kojic acids (Buchta, 1983). Recently, the use of the organic acids industrially in the production of concentrated food, beverages, in the preparation of alkyl resins, unsaturated polyester coating compounds, resin adducts and plasticiser (Anonymous, 1958; Doschar et al., 1941) and in pharmaceutical preparations, have increased their demand manifold leaving far behind the rate of their production through conventional methods. This has
necessitated the probe for their synthesis through unconventional methods (fermentations/cell immobilization or through isolated enzymes) to cope with their increased demand. A review of literature reveals that members of mucorales are excellent source of fungal lipids on one hand and of several organic acids on the other hand. Species of *Mucor, Rhizopus, Circinella, Cunninghamamella* (Foster and Waksman, 1939), have been reported to produce fumaric acid, oxalic, 1(+) lactic, pyruvic, formic, D(-) malic, succinic, epoxysuccinic acids in variable amounts along with ethyl alcohol. However, among these only fumaric acid and lactic acids are patented for industrial production. Kanel (1934) reported 38-40% lactic acid yield on the basis of carbohydrate consumed from *R. japonicus*. Ward et al. (1936) reported 62% or more of L(+) lactic acid from *R. oryzae*. About 40-50% of the sugar consumed has been reported to be converted into fumaric acid by *R. nigricans* (Kane et al., 1943; Prescott and Dunn, 1959). A yield of 60% fumaric acid has been reported from *R. arrhizus* (Smith et al., 1974; Buchta, 1983), industrially through fermentation, which was once in operation, but is now abandoned because of expensive technique. The other organic acids are either produced in traces or in insufficient amounts for industrial use.

The review of literature reveals that much less work is reported on the production of succinic acid by fungi than fumaric acid (Buchta, 1983; Arora and Mukerji, 1992). Similarly much less fungi have been screened for oleaginity compared to
Succinic acid is reported to be produced by Rhizopus sp. in mixed fermentation with bacteria (Sasaki et al., 1970). Takahashi and Sakaguchi (1925) and Takahashi and Asai (1933) have reported production of succinic acid by Rhizopus and Mucor species, in principal fermentation of lactic acid and ethyl alcohol, respectively. Hiall (1978) had reported 67% yield of succinic acid from Candida brumptii, but fermentative succinic acid is costlier than synthetic.

In the light of information reviewed above on fungal lipids and organic acids, it seems evident that mucorales are quite potent both for production of fungal fats and the organic acids. Hence only those species of mucorales were selected in this study on which no such work has been reported previously by any worker. These are Absidia corymbifera (Cohn) Sacc. and Trotter and A. spinosa Lendner. However, R. arrhizus Fischer - a highest yielder of fumaric acid and sufficient fat as reported in literature is also included in the study to compare its capabilities of production of these parameters with reported capabilities of this species from other countries by different workers. This work is in continuation with the already reported for other fungi vis a vis production of organic acids and fats from them by my predecessors from this laboratory (Gurpreet, 1987; Ramanjit, 1990; Rawla and Ramanjit, 1990; Savita et al., 1992; Rawla, 1992).