



Review Article

An Overview of Bacterial Lipases and their Enormous Applications

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Abstract | Lipases are reputedly honored as cleavers of fatty compounds that have been recognized from innumerable organisms. Among microbial lipases, the bacterial lipases holds very prominent stance. The specificity of lipases is far-fetched for their point selection and kinds of reactions they undergo on their discernible substrates. Most suitable production plan involves Sub-merged liquid fermentation in fed batch manner using agricultural wastes. Bacterial lipases are preferred due to their extra cellularity, easy step down approach and practicability of increased productions via technological modifications. They have wide-ranging applications in diverse sectors of the food, medical, cosmetic, detergent sectors and in paper industry which establishes their irrefutable noteworthiness.

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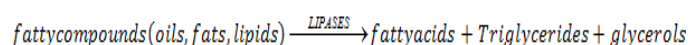
Introduction

Enzymes – The tiny proteinaceous biomachines that come in various orders of forms, shapes, sizes and names; each endeavoring to boost up a certain chemical reaction of our metabolism, work continuously but specifically until a cascade of desired product is acquired without being ended and still available for the next series of reactions.

Word lipases stands for an assembly of catabolic enzymes that principally acts on lipids (a broad category of compounds that are made up of fatty acids possessing an

ester that is hydrolyzed by lipases) to rip them apart setting off lipolysis. They were first recognized from bacterial origin in start of 19th century and with advancement in scientific knowledge they were given an enzyme commission number 3.1.1.3. The digit 3 in beginning shows they belong to serine hydrolases family (Aravindan *et al.*, 2007).

The substrate of lipases is the hydrocarbon back bone of organic fatty compounds and upon catalysis by means of hydrolyzing ester part they engender minor free building blocks of fatty acids in addition to Triglycerides and glycerol.



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The catalytic site of lipases has special arrangement of

amino acids; it begins and ends with Glycine with respective histidine and glutamic acid on sides of middle serine as G-X-S-X-G as described in [Figure 1](#). Analysis of its 3D configuration reveals that it has an oxyanion hole lying about seventy to hundred amino acids in advance of this site and transuding sequence consisting of thirty five amino acids is sited ten to forty spaces forward to this hole. The common molecular weight is 40-50 kilo Daltons ([Kwoun Kim *et al.*, 2004](#)).

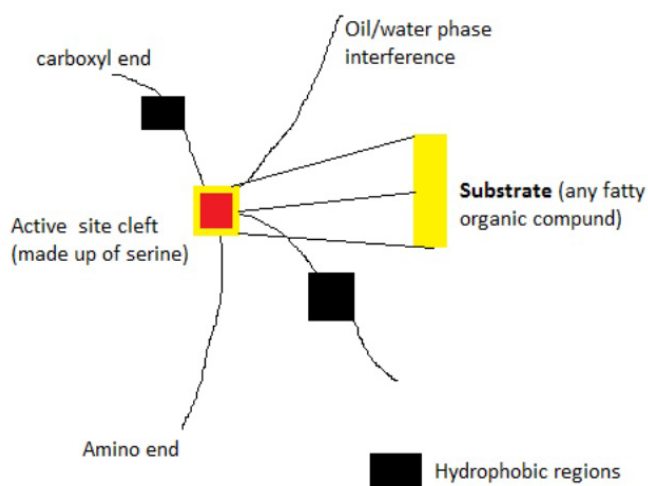


Figure 1: Design of lipase - substrate complex (modified and redrawn from [Aravindan *et al.*, 2007](#))

Concerning their chemical properties lipases are reported to catalyze transesterification, interesterification, esterification, acidolysis, aminolysis, alcoholysis types of chemical reactions, working on wide-ranging substrates with high specificity ([Houde *et al.*, 2004](#)). Lipases illustrate immense point and location selectivity for bond fissure and formulation during catalysis.

Sources

Lipases are universal in origin. They exist in the majority of living organisms, from largest visible human beings to smallest invisible microbial organisms like bacteria. Since the inception of biotechnology, gradually the noteworthy of enzymes and their production has become irrefutable. These enzymes producing organism can be either of fungal or bacterial origin. They are reported as intracellular enzymes in spit and Gastrointestinal tract whereas extracellular liposome within humans. There are grouped according to their Physiological locality. Other than animals, some researchers have also reported presence of lipases in vegetation of bean family ([Gupta *et al.*, 2004](#)).

They are ideally recovered from microbial means through a tone down approach that withdraw lipases after culturing them on a larger scale. Among microbial lipases, lipases gained from fungal sources are favored but the bacterial lipases are also employed up to a greater extent in commercialization because of their extracellular secretion.

[Pandey *et al.* \(1999\)](#), [Jaeger *et al.* \(1999\)](#) has reported following bacterial species which are significant producers of lipases are :ten species of *Achromobacter*, *Acinobacter*, *Alcaligenes*, *Arthrobacter*, Eleven species of *Bacillus*, *Burkholderia*, *chromobacterium*, *Proteus*, five species of *staphylococcus*, nine species of *Pseudomonas*. Out of all, the later is much more reputable for lipases production than anyone else.

Production

For producing lipase on larger scale, starter culture of bacteria are grown in fermentation reactors with addition of growth supporting sterilized medium and monitoring of physical and chemical factors like agitation for appropriate amalgamation, aeration for suitable oxygen supply, pH harmonization via acids and bases, apt temperature and moisture echelon. Medium includes a variety of nutritional elements like carbon, nitrogen, electron donors, hydrogen ions some vitamins and metals ions as coenzyme to accelerate bacterial growth and primary metabolites so that more enzyme production takes place during the growth phase by as secondary metabolites ([Vargas *et al.*, 2008](#)).

According to the amount of water used in fermentor; there are two manners of carrying out fermentation i.e. culturing of microbes in controlled and monitored conditions, first one is called solid state fermentation SSF that is mostly suited for fungal growth or filamentous organisms that necessitate very minute moisture level (water), this process is reasonably cost-effective and trouble-free to control whereas the second is submerged liquid fermentation (SLF) for mushrooming bacterial cells necessitating more moisture level, even though it is pricey but step down approach is unproblematic ([Pandey, 2003](#)).

Many researchers have reported enhanced lipase production employing (SSF) by using agricultural waste as nutritional delivery which reduces the cost effect as well ([Imandi *et al.*, 2010](#); [Vargas *et al.*, 2008](#); [Kempka *et al.*, 2008](#); [Alkan *et al.*, 2007](#); [Mala *et al.*, 2007](#)). Whereas Submerged Liquid Fermentation has been also employed for production ([Thakur *et al.*, 2014](#); [Pinheiro *et al.*, 2008](#); [de Azeredo *et al.*, 2007](#); [Falony *et al.*, 2006](#)). These fermentations manners are drive in batch (taking out the entire product upon completion of session), Fed-Batch (taking out product and inoculating at intermissions) and continuous, in chorus addition of new media and taking out of formed products ([Thakur, 2012](#)). It is common observation that the later approach significantly time saving, less prone to contamination and cheaper. It has proved a 5.67 IU/ml, fold raised yield of lipases ([Li *et al.*, 2005](#)).

Improved production

Since breakthrough of lipases on industrial scale researchers are incessantly working on improving the lipase yield, their distinctiveness of competence through amend-

ments in their properties and existing and novel strains and this all is to be indebted to contemporary biotechnologies. One of most frequent method in this regard is site-directed mutagenesis (monitored mutation induction at specific sites of genome) by means of radiations and chemicals (Bapiraju *et al.*, 2004). More than an one hundred and tenfold enhancement in catalytic performance of lipases from mutant sources as compared to the ordinary source has been achieved using NTG mutation at random locations on DNA have comprehensively converse about better production of lipases via technological manipulation (Shu *et al.*, 2010). They have explained the employment of homologous expression for obtaining twenty three percent additional yields of *pseudomonas* lipases by increasing the number of lipase coding regions introduced in expression vector for replication. Ahn *et al.* (2001) reported manufacturing lipases together with their respective group of proteins in designed recombination gives seventy percent more production. Another policy of getting more lipases is to produce them in absence of lipase slicing entities (proteases) so that more intact enzymes can be recovered (Takahashi *et al.*, 1999). Similarly the insertion of potent transcription maker sequences and coalescing chaperons synthesis has encouraging influences on lipase production (Liu *et al.*, 2006). Additionally, monitoring triplet gene codes for enhanced productions has resulted in much greater yield of lipases (Chang *et al.*, 2006). Adding *acacia gum* in cell growth medium also improves the expression of bacterial lipases (Martinez and Nudel, 2002).

Factors affecting lipase production

Amplified yield of lipase depends on optimization of fermentation conditions. Therefore, factors like carbon and nitrogen sources, temperature, incubation period, pH and agitation speed matter the most (Ugo *et al.*, 2017).

Carbon and nitrogen sources

Most excellent substrates for lipases are various classes of organic compounds like oils, lipids and fats of all sorts. Mostly carbon acts as a limiting factor for the synthesis of lipases. Highest yield of lipases for *B.subtilis* KPL13 was observed with olive oil, tributyrin and glucose respectively when used as carbon source (Veerapagu *et al.*, 2013). Organic nitrogen sources are well suited for increased lipase production. For *P.stutzeri* cotton seeds provide best supply of Nitrogen and carbon respectively (Thakur *et al.*, 2014). *Bacillus spp.* and *Pseudomonas spp.* reveal enhanced growth with use of peptone or alternatively yeast as nitrogen source (Lanser *et al.*, 2002). Peptone was used as nitrogen sources for lipase production (3.7U/ml) from *B.subtilis* KPL13 using peptone (Veerapagu *et al.*, 2013).

Temperature

Temperature significantly affects flourishing of bacteria in fermentation medium. An optimum temperature of 36°C is reported for *Bacillus* and *Pseudomonas* species (Pri-

ya and Reddy, 2015). Thakur *et al.* (2014) have reported 86 Fahrenheit as optimal for maximum lipase output from *P.stutzeri*. While optimum temperature for *P.gessardii* has been reported as 37°C (Veerapagu *et al.*, 2013). Even though lipase producing bacteria belong to mesophilic temperature range they show appropriate growth between twenty to forty five degrees centigrade but with increasing warmth an increase in synthesis is reported, higher temperature at which first-rated growth of bacterial lipase takes place is reported fifty degrees centigrade by Sharma *et al.* (2002).

Incubation period

From smaller laboratory scale fermentation to larger reactor scale production requires incubation; this time varies from various hours to days depending upon the fermentation type and microbe used. Incubation periods are slightly longer in SSF. Imandi *et al.* (2010) has reported 14 days of incubation in SSF reactor with 86F temperature, pH of 6.8 and sixty percent of humidity for optimized production. Whereas incubation period of 3 days was reported for *Bacillus* strains (Priya and Reddy, 2015; Kumar and Valsa, 2007). Mahler *et al.* (2000) has reported an incubation duration of twelve hours works finest for *Bacillus spp.* while an incubation duration of three to four days in case of *Pseudomonas sp.*

Agitation speed

Speed at which reactor media is stirred increase the rate of lipase production as it results in uniformity of substrate distribution, providing more surface area and greater rate of oxygen transfer (Gulati *et al.*, 2000). A range of 110-160 rpm is usually employed by different researchers (Veerapagu *et al.*, 2013). The optimum speed for maximum production by *Pseudomonas* and *Staphylococcus* species has been reported as 160 rpm (Priya and Reddy, 2015; Sirisha *et al.*, 2010).

pH

Bacterial growth is significantly affected by the pH of growth medium, which ultimately influences the products being harbored. Although, bacteria can produce lipases in a pH range from 4-10 but studies have reported that initial pH is much more significant (Ugo *et al.*, 2017). pH 6± 0.5 has been reported for higher yields of lipases from *Bacillus*, *Pseudomonas*, *Klebsiella* and *Corynebacterium* strains (Bharathi *et al.*, 2018). Optimized pH for lipase produced by *P.gessardi* was 7.0 (Veerapagu *et al.*, 2013). In a similar study, pH 7.0 has been stated as optimized for *Bacillus* species (Priya and Reddy, 2015).

Table 1 Summarizing the yields and fermentation modes with respect to bacteria

Table 1: Summarizing the yields and fermentation modes with respect to bacteria.

Bacterial Genus	Mode of Production	Substrate	Enzyme Units (units/ml)	Reference
<i>Pseudomonas luteola</i>	SMF	Olive oil	2059	(Litthauer <i>et al.</i> , 2002)
<i>Pseudomonas Pseudomallei</i> 12Sm	SMF	Hexadecane	69	(Kanwar and Goswami, 2002)
<i>Pseudomonas</i>	SMF	Coconut oil	960	(Rathi <i>et al.</i> , 2001)
<i>Bacillus alcalophilus</i>	SMF	Soyabean Starch Yeast Extract	59.4	(Ghanem <i>et al.</i> , 2000)
<i>Bacillus</i> LBN2	SMF	Ground nut oil	2394	(Bora and Bora, 2012)
<i>Bacillus</i> Spp.(locally collected)	SSF	Mustard Oil cake and wheat Bran	20	(Bokhari <i>et al.</i> ,2013)
<i>Serratia mercescens</i>	SMF	Tributyryn emulsion	380.6	(Abdou, 2003)
<i>Serratia mercescens</i>	SSF	Olive Oil	11.94	(Gupta <i>et al.</i> , 2013)
<i>Acinetobactorradioresistens</i>	SMF	Synthetic (Tween 80)	84.5	(Neelambari <i>et al.</i> , 2011)

Purification

During cultural growth the lipases are secreted extracellularly otherwise intracellularly; either in very last of log or at beginning of the equilibrium phase (Shah and Bhatt, 2011). Depending upon location type of product synthesized. The first step is to take apart the cell biomass (CBM) in case of intracellular product or the supernatant in case of extracellular product from fermentation medium by sedimentation (through settling down the CBM) or flotation, for supernatants or cell pellet ultracentrifuges are used, afterwards mechanical or non-mechanical ways are employed to break cells leading to clarification using filtration and concentrated products are obtained by several techniques like: precipitation via Ammonium Sulphate or solvent and Gel Chromatography. At last final product is preserved through drying and crystallization (Waite *et al.*, 2009).

Shah and Bhatt (2011) has reported the following steps of purification of lipases from *Bacillus spp.* as: cell separation achieved by a centrifugation at 10,000 rpm, 15 min to acquire supernatant and icy acetone precipitation using sixty percent of it for the night and recuperating lipase by subsequent centrifuge as well as drying. Impurities and contaminations were removed by dialysis using forty percent solution of sucrose. For higher resolution cellulose column with pore size of G-100 was used for purifying analyte in an ion-exchange way of chromatography. Use of sepharose column has also been reported by (Nawani and Kaur, 2000)

Characterization

All enzymes are naturally designed to function at some set parameters; which severely influence the effectiveness of enzyme activity. All the factors that affect production of lipase actually characterize the lipases as well. Other factor that contributes to chemical properties and characterization of lipases are:

Metal ions

Lipolytic action of bacterial lipases is observed to be increased as well as decreased by certain bivalent metal ions. Since, certain lipases are metalloenzymes therefore effect of these should be considered (Ugo *et al.*, 2017). Metal ions which cause an augmented performance are calcium and Magnesium while the one which reduce this activity are Zinc and copper (Ran *et al.*, 2015). In the middle of a variety of metal ions tested as inducer of lipases, five Molar concentration of CaCl₂ was found to give highest expression with exposure to air at 0.4 liters per minute at an incubation of 2 days (Thakur *et al.*, 2014). The lipolytic activity of lipases obtained from *P.aeruginosa* was reported to be reduced with high concentrations of metal ions like Hg⁺, Pb⁺², Al⁺³, Zn⁺² and Fe⁺³ (Bakir and Metin, 2016) while it was reported to be increased with Ca⁺² (Borkar *et al.*, 2009).

pH, Metal chelators and Surfactants: The pH of fermentor in which culturing is taking place is very important for regulating the growth of any enzyme, same is true for lipases. Bacterial lipases is most excellently formed at neutral pH i.e. 7.0, although at slightly higher pH upper limit of production is reported but this is critical (Barbaro *et al.*, 2001). Ran *et al.*, (2015) has reported lipase from *Acinetobacter* show excellent catalysis at slight basic pH 8.0 and trivial higher temperature 40°C.

Shah and Bhatt, (2011) have reported an investigation of pH range from strong acidic 4 to moderately basic 10 but the maximum lipolytic activity of lipases was marked at nearly neutral 7.4 at 98.6 Fahrenheit temperature for bacterial lipases from *Bacillus subtilius*. while *Staphylococcus spp.* are reported to work best at weak acidic pH 6. Among inhibitors of their lipolysis capabilities significant was the effect of EDTA and among the agents that arouse this capability were Magnesium and calcium metals. Other substances that affect are some surfactants like Tween and existence of fatty compounds of lipid category (Rathi *et al.*, 2001).

Table 2: Physical and chemical optima of bacterial lipases.

Bacteria	Optimum pH	Optimum temp	Molecular weight	Metal ion effect	Kinetics Km=mM, Vmax= μ M/min, Kcat=S ⁻¹	Reference
<i>Bacillus spp.</i> (lipase gene expressed in <i>E.coli</i>)	7	19.85	Not mentioned	Ca ⁺ activate	Km=66.68 Vmax=400 Kcat=228 Kcat/km= 3.4 \times 10 ⁶	(Masuch <i>et al.</i> , 2015)
Bacillus sp.J33	8	70	45KDa	Inhibited by Hg ⁺	Km=2.5 Vmax=0.4	(Nawani and Kaur,2000)
<i>Bacillus thermoleovorans</i> (BDIT A)	9	60-65	18 KDa	Inhibited by cu ⁺ ,co ⁺ ,Hg	Km=1.82 Vm=12.8	(Lee <i>et al.</i> , 2001)
<i>Bacillus thermoleovorans</i> (BDIT B)	9	60-65	43 KDa	Ca ⁺ ,Co ⁺ ,Mn ⁺ activate	Km=6.24 Vmax=63.3	(Lee <i>et al.</i> , 2001)
<i>Pseudomonas spp.</i>	7	40	Not Mentioned	Ca ⁺ ,Mg ⁺ activate	Km=0.50 \pm 0.05 Vmax=128.16	(kermanshahi <i>et al.</i> 1998)
<i>Pseudomonas Pseudomallei</i> 12 Sm	10	35	143KDa	Ca ⁺ has no effect	Km=178 \pm 12 Vmax=172 \pm 8 Kcat=409 \pm 10 Kcat/Km=2.3	(Kanwar and Goswami,20002)
<i>Pseudomonas spp.</i>	11	90	Not Mentioned	Not Mentioned	Km=40mg/ml	(Rathi <i>et al.</i> , 2000)

Even though colossal research has been done on lipases but only a few articles have discussed the Enzyme kinetics of bacterial lipases, the published data mainly of fungal lipases has been more generous in this regard. Each bacterial lipase catalyzes the specific reaction of its own kind at a specific rate of K_m , V_{max} and K_{cat} numbers as following:

Table 2 abridging the Physical & chemical optima of Bacterial lipases

Applications

Lipases stand amongst the most significant enzymes from biotechnological point of view because of their all-encompassing utilization in most of sectors concerning human beings and quality of their life by sharing five percent of the total enzyme demand (Vakhlu, 2006). Immobilized as well as silcoat enzymes are more ready to lend a hand for large scale applications (Mohamad *et al.*, 2015).

Food sector

Fat monitored quality products: Lipases are capable of boosting interesterification reaction that promises dawdling rancidity, altered melting points, and nutritionally healthier oils with less saturated fat contents that can be adopted more easily for cooking. This type of hydrolysis reaction occurs optimally at 0.9 water to lipase ratio, products diffuse from bulk phase by a water saturated oil phase (Kuo and Gardner, 2002). Sales of such products throughout the globe annually crosses billion.

Flavor enrichment: In common terms flavor enrichment can be described as making edible items more superior in taste and nutrition by the means of definite flavor

enhancers in food industry that is why the gross sale of these agents crosses billions. Lipases are one of these flavor enriching enzymes that can generate the esters by removing water molecules and squeezing the atoms of alcohol and acid together in compact form. Esters are prevalently known for increasing the zest of milk made items and processing of other foodstuffs (Rajendran *et al.*, 2009). For this purpose, out of many esters created are a Hexyl acetate that confer distinctive fruit heady scent, this compound is tasteless and green in color (Shieh and Chang, 2001). Another ester of these category is Hexyl butyrate widely known as Natural flavor enrichment compound made through gentle transesterification of a six carbon alcohol along with tributrin, using lipozyme IM-77 obtained from fungal sources for treatment of edible food and drinking items (Chang *et al.*, 2003).

Baking: In all sorts of bakery items like from cakes, biscuits, cookies to puddings and pie, Eggs are extensively used for their fat content that imparts aromatic flavor and act as a binding, moisture giving and leavening ingredient. Phospholipases (PLs) are used in baking sector for their hydrolytic action whose primary purpose is to improve the quantitative and qualitative aspects of dough, employed in baking. These PLs interact with protein components of eggs like lecithin and act as biocatalyst in their hydrolysis which results in greater emulsifying role and more thermo-resistance to increased temperature (Reimerdes *et al.*, 2004). Increased stability and improved texture of the dough is made with dried egg yolks which were pretreated with Phospholipases A2 as compared to non-treated with these PLs (Zhao *et al.*, 2010).

Dairy trading: Their key intervention in dairy industry

is as hydrolytic agents for dropping the level of fat part of milk as well as to amend the length of fatty acids. Lipases also confer cheesy aroma to manifold cheeses with hastened time of cheese ripening. Customary devices for this purpose are pancreatic glands of animal origin that are mostly bovine tissues. They also possess the competence to substitute the lipases of pre-gastric origin. A large number of dairy products (like butter, curd, cream and fats) are treated by their hydrolytic reactions to attain the desired properties through the process of lipolysis, this generates free TAGs, esters and fatty acids that yield diverse dairy products further. A class of such lipases is reported from a number of bacteria (Rajendran *et al.*, 2009).

Fatty acids which are cleaved and released during this catalysis turn out flavor enriching products most likely beta keto acids and lactones. Addition of lipases in experimental cases is the reason of speeding up the release free fatty acids in contrast to control groups under observation (Rooney and Weatherley, 2001). Enzyme Modified Cheese (EMC) is the revolution that lipases together with pack of other enzymes have brought in dairy industry. According to the preferred aroma needed, cheese without any prior treatment is incubated with particular lipases at amplified temperature ranges to perform catalysis to ensure intense aroma and fat percentages. EMC has tenfold greater fat content than normal cheese (Rajendran *et al.*, 2009).

Commercial tea leaves preparation: The inborn flavor of tea usually drank in Asian countries, comes from the type of plant and mode of preparation employed in processing tea leaves. Starting from picking leaves it involves drying and breakdown of leaves with help of lipases for oxidation and exclusion of water, which is made through the help of lipases due to their hydrolytic capacity (Ferreira-Dias *et al.*, 2013).

Medical sector

Various enzymes are deliberately operated to function preferably in organic media rather than using water this is because extraction of products which are further to be used as drugs become quite laborious and is a lengthy procedure whereas organic reaction media like lipases are handy to use for this purpose since years, in manufacturing drugs because of ease in product recovery and purification. Lipases are employed for multipurpose functions: as non aqueous media and as biocatalysts for leading transesterification, resolution of chiral substrates and compounds with basic amide structure, acetylation, bond making abilities as selective points within drug complexes (Gotor-Fernández *et al.*, 2006).

For drug assembly lipases take part in quickening the transfer of acyl groups between a donor (ester) and acceptor (such as amines) resulting in establishment of racem-

ized products through ping pong course of action (Päiviö and Kanerva, 2013). Successful production of up-to-the-minute category of Profens that fit in to the Non steroidal anti-inflammatory drugs is synthesized with help of these lipases that in their action is more efficient than its parent molecule in S-enantiomer was done in late nineties and revived currently by Zhang *et al.* (2005) with better output. Furthermore now in the field of nanomedicine researchers like (Khan *et al.*, 2017) has demonstrated the dilapidation of artificial polyesters after successful drug administration by lipases of lactobacillus origin. Currently Trousil *et al.* (2017) have shown the improved released of Rifampicin after dilapidation of polymers by bacterial lipases.

Lipases elicit the discharge of Necrosis factors that degrade the growth of abnormally developed cancerous cells (Hasan *et al.*, 2006). Liposome are also extensively investigated and are still an emerging research horizon for the drug transportation and deliverance at targeted sites, they are accompanied with drug together with lipases to shun bio-inactivation and detoxification during the route and within the body of organisms. Streck *et al.* (2016) used mechanism of phase switching for such lipid supported drug transportation through injecting the drug Benznidazole. Nutraceuticals are the derivative compounds of edible sources with eminent therapeutic benefits owing to their diet related favor, are reported to be obtained with help of new lipases of bacterial origin (Jaeger and Eggert, 2002).

Biosensing

The term biosensing was introduced in 1999 and it can be defined as checking the existence or determining the amount of a certain biomolecule with help of a biosensor within living organism for investigating medical reasons (Loo, 2015). Biosensors are combination of a bimolecular probe with quantifying unit that can display results in digital way. This sector has now gained a tremendous legendary in every field influenced by humans and their environment. For health care purposes and routine monitorings lipases are used for tracking Triglycerides (TG) intensity plus the amount of cholesterol and fats within blood (Herrera-López, 2012).

(Califano *et al.*, 2014) has well described the model of silicon supported lipase biosensor that can serve medical purposes well and this model has employed MAPLE technique for settling of lipases. Beside investigation of TG solely in blood this function can also be performed for the same purpose in food sector, rather than determination in biological fluids only. This holds multipurpose applications in improving the quality of edibles. Such a sample based lipases biosensor is developed by (Escamilla-Mejía *et al.*, 2015). In addition to measuring TG and cholesterol lipases bases biosensing can also detect level of some insect killing chemicals like organopesticides via pH fluctuation produced in biosensor meanwhile investigat-

ing samples (Kartal *et al.*, 2007). Recently this has proven useful in measuring many pesticide concentrations within aquatic habitats as a hall mark of water quality and maintaining quality and monitoring ecology of water (Reddy *et al.*, 2014).

Macromolecular science

Massive and heavy weighted large scale polymers, polyesters and biodegradable stuff is manufactured by unification of recurring smaller subsets of molecules. Plastic and fibers are the biggest hallmark of this sector but they are a necessary evil as they are beneficial for mankind on the other hand they are hazardous for our surroundings. To maintain greener environmental conditions degradation of these artificially synthesized products is necessary; this is primarily done with help of decomposers that include fungi and bacteria. They release extracellular enzymes that shatter these macromolecules; these enzymes are lipases in particular as they are catalytic in characteristic. Polyurethane (PAE) and polycaprolactone (PCL) is reported to be degraded by lipases of bacterial origin (Tokiwa *et al.*, 2009).

Biodiesel manufacturing

Compared to the diesel fuel consumed in general, it is renewable, environment friendly and safer to use. Its fundamental ingredients are fatty acids together with methyl esters derived from sources of animal and plant origin. Lipases are engaged in its production because of their ability of carrying out transesterifications as catalysts. Meka and Tripathi (2007) have reported its optimum production with 2% catalyst using 1 ratio of safflower oil with 6 ratio of alcohol acquiescing 96.8% of biofuel. De Regil and Sandoval (2013) have compared the superior quality of lipase aided fuel synthesis with the long-established procedures due to esterifications of fats and alcohols with an overall advantage of unproblematic step down of product. Gog *et al.* (2012) have mentioned eighty to ninety percent better performance of customized bacterial lipases for biodiesel manufacture. Fan *et al.* (2012) has described the dominance of lipases to chemical catalysts in their mode of action without damaging the needed product and biodegradability. In addition to obtaining oils from typical plant sources unusually Algae and microalgae can be utilized for yielding higher product percentages. Taher *et al.* (2011) used immobilized lipases for it and reported them convenient with painless separation as compared to dissolved ones. Du *et al.* (2004) have experimentally achieved ninety four percent yield of biodiesel using Novozyme 435 from crude oil of soyabean.

Making beauty products

Almost every human being uses some kind of cosmetic as beauty making or improving product, the objective of their use maybe different and varies with each individual, but the main thing is their enormous use in our daily lives

in a way to improve ourselves. Beauty products range from general soaps, hand washes and body washes to creams, lotions, perfumes, make up, shampoos and powders. Records show this is very powerful industry whose sales cross billion every year and gradually this accessory has become a necessity of everyone in modern age.

According to the product type these products are mixtures of various categories of chemical components like surfactants, thickeners, moisturizers, antioxidants, preservatives, vitamins, cooling agents, stimulators, conditioners, scrubbing agents, oils and fatty acids along with alcohols. Lipases enzyme serve an active agent in manufacturing these products. They are used to regulate the activities of glands present within the layers of skin whose secretions affect the physical appearance of skin like more oil secretion from sebaceous gland will result in more oily skin furthermore they are also use to tan or whiten the complexion and monitor and intervene in keratinization (Ansorge-Schumacher and Thum, 2013).

For commercial production of these chemical components lipases proves to be the most significant group of enzymes and their immobilized form is most economical as well technically correct to use for this purpose to obtain fatty acids plus ester for sole cosmetic purposes. Commercialized processed involve the use of lipases.

Detergents

Their fat hydrolyzing capacity makes them an excellent part of detergents as stain removers. Alkaline lipases of bacterial origin are of special interest in this regard because alkalinity together with high temperature works best (Cherif *et al.*, 2011) in his post doctoral research has investigated this detergent action of bacterial lipase from *staphylococcus sp.* abbreviated as (SL-1) against various fatty substrates like olive oil, with optimization of pH, temperature and stability to formulate lipase based detergents. Niyonzima and More, (2015) has experimented various bacterial lipases for their lipolytic strokes, when any cloth or crockery item with marks of fats and oils is prone to lipases action it removes the stains by hydrolyzing fats from larger to smaller units along with their detachment from the surface. They have also mentioned that lipases constitute 50 percent of detergents in scientifically up to dated countries as green chemicals. Chauhan *et al.* (2013) has reported 62 percent increased in the efficiency of detergents with incorporation of bacterial lipases. Examination of this action is done in three repeats of washing and exposure to air. The important parameters in these observations are temperature, metal ion's concentration and time of soaking and exposure to detergent plus lipases as an additive (Aehle, 2004).

Paper industry

Paper is used everywhere for a lot of purposes, the

annual production of paper has crossed 28.9 million tons this year, according to the Σ The worlds count. About 50 percent of the waste from every business comes in the form of wasted papers. Owing to its demand and usage wasted papers are recycled again so that raw materials are managed wisely without exhausting them. In making paper and paper products along with recycling the older ones in every process enzymes are used. Lipases are used for deinking and solving pitch problem and since their substrate is glycerol backbone they transform triglycerides to fatty acids that are more water resistant and stable. On the other hand recycling older papers involve removing ink from the previously used papers through hydrolysis by lipases that helps to attain the desired whiteness of papers (Leduc *et al.*, 2011). Lipases are proved to be useful for removing laser ink from printed papers with approximately one percent increment in the whiteness of papers and this removal through enzymes is more effectual as compared to the chemicals used in long-established methods, that involve the use of chemicals (Lee *et al.*, 2013).

Conclusion and Recommendations

Lipases are catabolic enzymes that split lipids and are of multiple origin. Lipases exemplify immense point and location selectivity for bond fissure and formulation during catalysis. Bacterial lipases are although bit expensive but the compensation with their easy step approach, purification and improved production. The specificity of lipases is far-fetched for their point selection and kinds of reactions they undergo on their discernible substrates. Although decades of the precise researches have been devoted to lipases but the potential of this distinctive group of enzymes is yet to be paid and there is a great need to make human beings beneficiary of their services through biotechnology.

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