WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on Multi-Faced Appeal on Fungal Protease in Interdisciplinary Sectors.

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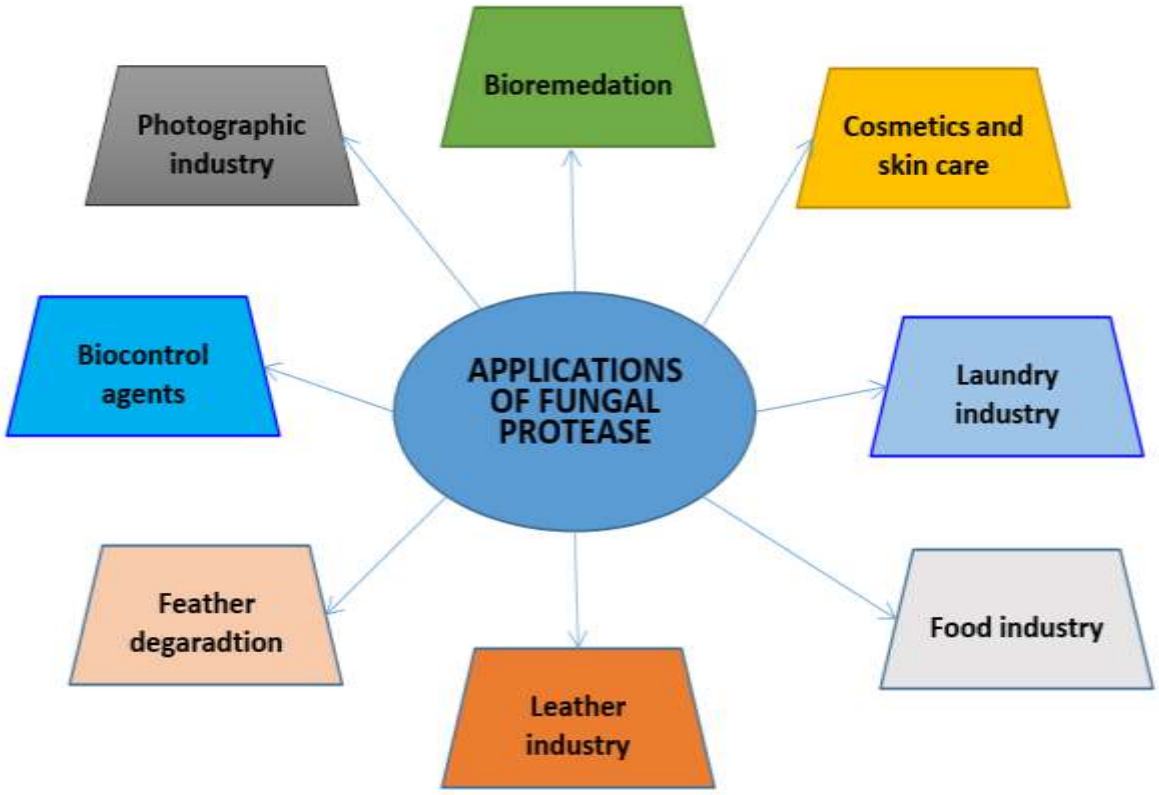
ABSTRACT:

Enzymes, a substance that goes about as an impetus in living creatures, control the rate at which synthetic responses continue without themselves being modified simultaneously. The natural cycles that happen inside all living life forms are synthetic responses, and most are directed by enzymes. Without enzymes, a considerable lot of these responses wouldn't happen at a noticeable rate. Enzymes catalyze all parts of cell digestion, substrate ties to the active site trusted source of a catalyst and is changed over into product. When the product leaves the active site, the enzyme is prepared to connect to another substrate and rehash the cycle. Proteolytic chemicals (proteases) are catalysts that separate proteins. These enzymes are creatures of plants, animals, and microorganisms (bacteria, fungi, and actinomycetes). Fungal proteases are viable, proficient, and appropriate for the overwhelming majority involved in restorative solicitations, modern handling, bioremediation purposes, and rural applications. Other uses of fungal protease are laundry, leather industry, feather debasement, biocontrol, optical focal point cleaners, tannery, deproteinization of prawn shell, counteraction of the rot of trimming oil, food additives, chelating specialists, grain additives, expulsion and corruption of polymeric substances (EPS), evacuation of hairs in buffalo hide, squander treatment, removal of biofilm, degumming of silk, cosmetics (to eliminate glabellar-grimace lines), cheddar making, Meat tenderization, fibrin corruption, visual, silver recuperation from X-beam films, dairy industry, control destructive nematodes, natural product juice, soybean paste, sauce industry, liquor creation, fish handling squanders and prion debasement.

Keywords: Application; Fungal protease; Laundry; Bioremedation; Leather; Food industry.



INTRODUCTION:

Enzymes in the possibility of biotechnology ("gadgets of every age that assemble or alter items or advancements for their motivations utilizing natural or subsidiary norms") [1,2]. Slight advances in the creature or plant tissue or cell protein separation and assembling techniques have worked with the immediate utilization of cleansed catalysts [2]. Biocatalyst chemicals that are fundamental for wellness all makeup natural techniques. Catalysts have for some time been utilized in the creation of an assortment of food items like a lager, wine, vinegar, cheddar, sourdough other applications such as cowhide, cloth, and indigo. Aging strategies for creating normal proteins from explicit species have taken incredible steps over the long haul [3,4]. In the regular reactant reaction the use of the catalyst biocatalyst, free or in solid structures, depends upon the compound determination. In current advances in biotechnology, in sync with strategy necessities, different enzymes were developed and are planned or deliberately planned. various examples have developed particular proteins to complete exceptional synergist responses and component mounted their utilization in settled on bio methods. An enormous wide assortment of catalysts integrates protein designing, biochemical designing, and metagenomics. Different sub-atomic components were utilized to improve the quite generally speaking presentation of little compounds for huge use in heaps of enterprises [4,5].

Peptidases, supposed peptide hydrolases or proteases, are hydrolases that separate peptide securities from different proteins and peptide pieces [6,7]. Protease compounds have for some time been fascinating to numerous scientists. Research on these proteins started in the sixteenth 100 years and has been broadly utilized in the creation and extraction of cheddar and the maintenance of skin. Today, these compounds are utilized in numerous businesses, particularly the material, drug, food, and cleaning ventures [7,8].

Complete protease deals represent over 60% of all modern catalyst deals around the world. Proteases are far and wide in current culture. Proteases are utilized in the cleansers and cowhide businesses, as well as in prescriptions, for example, gastrointestinal and mitigating drugs [8-10]. Microorganisms are an alluring wellspring of proteases since they can be misleadingly developed in huge amounts in a moderately brief time frame utilizing laid-out maturation processes. Microbial antacid proteases overwhelm the worldwide compound market and involve close to 66% of the cleanser business. Screening and portrayal of these proteases from an assortment of sources offer many advantages from both environmental and modern viewpoints [9,10]. It is separated into four classes in light of the component of activity, and soluble protease alone has a wide scope of uses in the cleanser, protein recuperation or calfskin handling solubilization, natural combination, meat mellowing, cleansers, and food ventures all through the protease market. It represents around 89%, Photography, Pharmaceuticals, and Bioremediation [8-12]. Proteins utilized in different ventures, for example, cleansers, materials, paper, and mash make up a significant fragment as 52% of the market stock is held by soluble proteases in the significant portion of the compound market. [11-14].

Protease.

Proteases are far and wide in the natural universe of plants, creatures, and microorganisms [15]. Proteases, likewise called peptidases or proteinases, are a gathering of compounds that perform proteolysis known as the hydrolysis of peptide bonds that interface the amino acids of the polypeptide ties that make up a protein [16]. Be that as it may, the revelation of psychrophilic and thermophilic catalysts, including proteases, has worked on their reactant spectra. As of now, a few proteases have been segregated and recombinantly delivered to catalyze the response in the temperature scope of 50-100 °C and the pH scope of 2-10 [17,18]. Proteases assume significant parts in every single physiological cycle, from the ordinary debasement of proteins as supplements to the guideline of modified cell passing. They are delivered by all living beings that are effectively engaged with metabolic cycles and complex cell articulation pathways [7]. Microbial proteases are turning out to be more significant because proteases extricated from plants and creatures can't address modern issues. Microbial proteases have practically all helpful properties for bioengineering applications and are fundamentally brought about by biochemical variety and simple hereditary control of microorganisms, and their fast development [19].

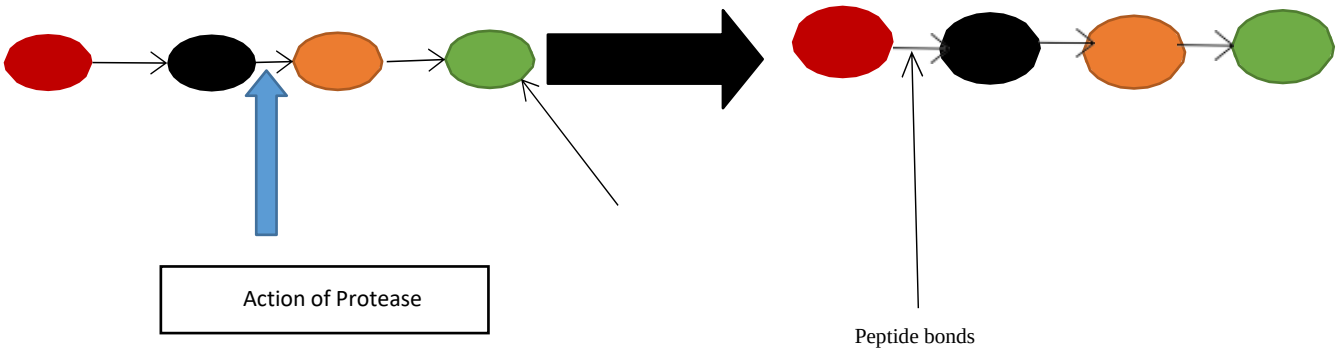


Fig 1: Action of protease on proteins.

Biochemical characterization of protease.

Peptidase (EC 3.4) is a compound that can hydrolyze peptide connections among proteins and peptides. They make up around 2% of all proteins present in a wide range of life forms [20]. The term peptidase is most favored because it is the evident withdrawal of "hydrolysis of peptide bonds" and is likewise the derivation of the multitude of terms utilized. The term peptidase is suggested by the IUBMB Naming Commission and structures an enormous group of compounds that can be partitioned into endopeptidase (EC 3.4.21-99) and exopeptidase (EC 3.4.11-19) [21].

Classification of protease based on site of action.

Peptidases are grouped given three fundamental models: the kind of response catalyzed, the science of the reactant side, and the developmental relationship of essential design [22]. As far as the idea of the synergist response, peptidases are endopeptidases and exopeptidases [24].
Endopeptidase breaks peptide bonds where amino corrosive deposits are inside the polypeptide chain. A remarkable property of endopeptidases lies in their special activity on peptide bonds in the internal districts of the polypeptide chain away from the N-end and C-end. Endopeptidases are separated into four subgroups in light of their synergist component, serine proteases, aspartic proteases, cysteine proteases, and metalloproteases [25].
Exopeptidases divide peptide bonds at the closures (aminopeptidases) and carboxy-terminals (carboxypeptidases) [23]. It is partitioned into aminopeptidases and carboxypeptidases given the site of activity at the N-end or C-end. Aminopeptidase (EC 3.4.14) acts at the free N-end of the polypeptide chain, liberating a solitary amino corrosive buildup, dipeptide, or tripeptide. Carboxypeptidase then acts at the C-end of the polypeptide chain, delivering a solitary amino acids or dipeptide [22-24].

Classification of protease based on functional group present in active site.

The most convincing characterization technique depends on the amino acids engaged with hydrolysis, given which proteases are isolated into six significant gatherings [24,25].

1. Serine Proteases (EC 3.24.21).
2. Threonine proteases (EC 3.4.25).
3. Cysteine proteases (EC 3.4.22).
4. Aspartate proteases (EC 3.4.23).
5. Glutamic corrosive proteases (EC 3.4.19). 6.Metalloproteases (MMPs) (EC 3.4.24).

1. Serine Protease (EC 3.24.21).

Serine proteases, alongside serine, which capacities as a nucleophilic amino corrosive, add to major modern and helpful proteases. In this class of compounds, chymotrypsin/trypsin and subtilisin are monetarily accessible serine proteases [26]. The dynamic site of serine peptidase framed by the reactant group of three is made out of the accompanying amino acids, Ser/His/Asp, yet serine deposits are tracked down in all varieties, yet changed for the place of the essential arrangement. May happen. These abnormal serine peptidases use new synergist sets of three like Ser/His/Glu, Ser/His/His, Ser/Glu/Asp, and are impetuses comprising of Ser/Lys, Ser/His, or the simple presence of the catalyst[24,25].

2. Threonine Protease (EC 3.4.25).

Threonine peptidases have their impetus buildup (threonine) in the district of the N terminal and show a comparative synergist system as in serine and cysteine peptidases which are engaged with the development of a middle of the road acyl compound [26]. In any case, threonine protease is another economically huge protease where threonine (Thr) buildup lies on the synergist site. These proteases have a lot of importance in physiology and proteasome and acyltransferases are traditional models [27].

3. Cysteine Proteases (EC 3.4.22).

The dynamic site of cysteine peptidases comprises the synergist ternion made out of the accompanying amino acids, Cys/His/Asn, where the gathering engaged with the course of catalysis is sulfur of the cysteine buildup [27,28]. Furthermore, cysteine proteases, otherwise called thiol proteases, are vital in modern applications. These proteases perform nucleophilic thiol-related reactant activity on synergist ternions or diads. These proteases are fundamentally tracked down in all organic products, including papaya, pineapple, figs, and kiwi. Cysteine proteases show their true capacity in the poultry business and are a significant meat-beating capacity. Moreover, cysteine proteases have been utilized as remedial proteins to battle viral contaminations [29].

4. Aspartate Proteases (EC 3.4.23).

The aspartic peptidase in the dynamic site has two aspartic corrosive deposits containing the synergist dyad. The movement is identified at acidic pH, because of the presence of these deposits in the dynamic site. Catalysis includes the presence of the water atom [27]. Aspartic corrosive proteases are very unique concerning different proteases as their commitment to keeping up with physiological capacities. Exemplary models are pepsin, cathepsin, and renin, which are significant proteins that keep up with physiology [26-28].

5. Glutamic Protease (EC 3.4.19).

Glutamic corrosive peptidase has a diad comprising of amino acids, glutamic corrosive, and glutamine deposits as its significant dynamic site buildups. In this kind of peptidase, catalysis is intervened by the presence of water atoms [30]. The significant glutamate proteases normally found in contagious species are significant compounds in food handling and present-day therapeutics, for example, antitumor and anticancer specialists [31,32].

6. Metalloprotease (MMP) (EC 3.4.24).

Metallopeptidases have the property of being the presence of metal particle securities associated with the synergist activity of the substrate. Catalysis is intervened by the presence of water particles [27]. Another gathering of proteases, called metalloproteases, has various purposes in drug advancement and utilization of metal particles for catalysis. Because of the wide range of substrate partiality and various protease sources [32].

Classification of protease based on origin.

On the bais of their starting point, proteases can be isolated into various classifications, for example, microbial (bacterial, parasitic, and viral) proteases, plant proteases, animal, and human protease chemicals [33-35]. Microorganisms are viewed as a significant wellspring of proteases since they can be developed in enormous amounts utilizing laid out maturation techniques, are accessible in an exceptionally brief time frame, and give a standard and bountiful stockpile of the ideal item. What's more, microbial proteins have a more extended period of usability and can be put away for quite some time under non-ideal circumstances without huge loss of action [35,36].

Microorganisms are known to create soluble proteases, with the family Bacillus being the most unmistakable source. Different outlandish conditions are the wellspring of various Bacillus species equipped for delivering basic proteases. Various microorganisms having a place with microscopic organisms, parasites, yeasts, and actinomycetes are known to create serine-type soluble proteases [37].

Proteases separated from plants and creatures can't address modern issues, so microbial proteases are turning out to be more significant. Microbial proteases have practically all helpful properties for bioengineering applications and are brought about by biochemical variety and simple hereditary control of microorganisms, and their fast development. Likewise, numerous microorganisms discharge proteases into the outside climate to separate proteins, and their hydrolysis items act as a wellspring of nitrogen and carbon for cell recovery. Because of their fast development, filamentous growths can deliver proteases through maturation processes that utilize an assortment of substrates. This section depicts contagious proteases and features their biochemical properties, creation, and bioengineering applications [38].

Characterization of protease in view of pH.

pH is the main element for all compounds to effectively work. There are three classes of proteases in light of ideal pH.

Acidic protease.

Acidic proteases function admirably under acidic circumstances (pH 2.0-6.0). They are usually delivered by *Aspergillus niger* [39,40].

Basic protease.

Such proteases work productively at unbiased pH (6.0-8.0). basic proteases are created by *Aspergillus carneus, Tricholoma columbetta* and *Fusarium culmorum,* and so forth [40].

Neutral protease.

These proteases are expected in soluble circumstances (pH 8.0-13) for effective working [39-41]. neutral proteases are created by *Trichoderma harzianum, Aspergillus clavatus, A. fumigatus, Penicillium chrysogenum, Conidiobolus coronatus, Fusarium culmorum,* and *Cephalosporium* species [41].

Wellsprings of Commercially Significant Protease.

The huge scope creation of these catalysts was important to satisfy a business need, so a few sources, including growths, were explored. Parasites have different environments, develop pervasively, and produce an assortment of proteins/catalysts for endurance. Among these catalysts, proteases structure a significant class with different compounds like lipase, cellulase, xylanase, and pectinase. In light of their living space, growths are delegated psychrophilic, mesophilic, and thermophilic, and have arisen as possible wellsprings of business chemicals, including proteases [42].

Psychrophile fungus.

The microbial world has been a significant wellspring of different compounds for modern and helpful applications for quite a long time. Bacterial species are at the core of the huge scope of creation of compounds all over the planet [42]. A few remote ocean microbes, for example, *Aspergillus terreus*, *Beauveria brigniartii,* and *Acremonium butyri* can deliver psychrophilic proteases [43].

Mesophilic fungus.

Mesophilic contagious strains can likewise deliver economically accessible protease catalysts for a huge scope. The principal class of mesophilic growths is *Aspergillus candidas, A. Flavas,* and *A.* Fumigartus, which Contributes to more than 25% of proteases created from parasitic sources, including *Meleus* and *A. Niger, A. oryzae, A. sojae, A. Sulfur,* and *A. sydowi.* This assorted biodiversity of organisms produces various sorts of proteases that catalyze various biochemical responses [44,45].

Thermophilic fungus.

Scarcely any eukaryotes can duplicate at high temperatures. Such organisms incorporate thermophilic and thermostable structures, which are for arbitrary reasons recognized in light of their base and greatest temperature development. In such environments, these strains produce heat shock proteins (HSPs) that permit the creature to make due in. Thermophilic proteases are delivered by thermophilic microorganisms, including microbes and parasites, which have a wide scope of business utilization [45,46]. *Thermomyces lanuginosus* developed at 50 °C, was exposed to warm stun at 55 °C for an hour, and afterward presented to 58 °C [47]. Thermophiles, for example, *Canariomyces thermophila, Thermomyces ibadanensis, Talaromyces thermophiles, Myriococcum thermophilum,* and *Dactylomyces thermophiles,* can deliver monetarily accessible proteins, including the proteases that demonstration at high temperatures [43].

Mode of activity of protease.

Proteases have an assortment of properties that digest protein chains into more limited parts by breaking the peptide bonds that interface amino corrosive deposits [48]. Some assault the terminal amino acids of the protein chain called exopeptidase. Others break the interior peptide obligations of a protein called endopeptidase [49]. Proteases separate proteins through a hydrolysis response, which is the expansion of water particles. Proteases ordinarily initiate nucleophiles, which assault the carbon of the peptide bond. When the nucleophile sticks, the carbon-oxygen twofold bond electrons move to oxygen. This tetrahedral moderate contains high energy and proteases by and large balance out this middle of the road. The middle of the road item then, at that point, parts into two sections, delivering two peptide pieces [18].

Application of Fungal Proteases.

1. Fungal protease in Detergent Industry.

Proteases have for some time been utilized in the food business and cleansers. During the twentieth hundred years, the main technique for cleaning textures with catalyst cleansers was created, protected, and sold until the 1960s. The item depended on trypsin, a stomach-related protein created in the mammalian pancreas, however, the item was less fruitful because the compound was not adequately dynamic insoluble media (pH 9.0 or more) [50]. In 1959, the Swiss scientific expert Jaag, who worked for the Gebrüder Schnyder cleanser organization in Swiss brew, fostered another item called Bio40, which contains the most reasonable bacterial protease for modern purposes [50,51]. Proteases are utilized in a wide range of cleansers, including family ones and those used to clean contact focal points and false teeth [50-52].

All cleanser proteases right now available are serine proteases created by Bacillus strains. The benefit of fungal soluble proteases over their bacterial partners is the simplicity of downstream handling to deliver microbial compounds. *Conidiobolus coronatus* produces soluble proteases viable with business cleansers utilized in India [52]. Both family and modern cleansers contain the primary parts of proteases. Organic cleaners are for the most part utilized in industry to clean huge boilers. Not withstanding the poultry business, clinics are one more significant purchaser of organic cleaners [53]. *Streptomyces sp*. CN902, *Myceliopthorasp, Aspergillus clavatus,* and *Actinomycete* MA11 [54]. Basic protease chemicals are utilized in clothing cleansers, yet in addition to family dishwashing cleansers and the definition of office and modern cleansers [55].

Added substances to the principle fixings in cleanser plans. A few business chemicals are temperamental within the sight of blanch and oxidants. This limit can be overwhelmed by utilizing recombinant DNA innovation to create designed catalysts. The basic protease separate showed an ideal temperature of 60 °C and an ideal pH of 11. The protease was hatched with cleanser and oxidant at room temperature for 72 hours. The protease was steady against non ionic surfactants like Triton X100 and Tween 2 (1% focus). The catalyst held 73% of its movement when treated with 5% SDS for 72 hours. This catalyst likewise showed expanded movement when treated with 2.5% sodium borate and 5% hydrogen peroxide [56].

The *G. putredinis* and *T. harzianum* proteases had ideal pH and temperature of 7.0-8.0 °C and 50-60 °C, separately. At 37 °C and 60 ° C, the parent protease was steady for 1 day and 15 minutes, separately, and the combination specialist was steady for 2 days, which was viable in freeing the strain from the fabric for 10 minutes. [57].

2. Fungal protease in leather industry and tannery industry.

Cowhide is a prime product for India in procuring unfamiliar cash and India is the second biggest exporter of natural calfskin on world guide after china. Calfskin making an intricate interaction includes a few unit activities and dehairing and other proteins from the dermis district of crude conceal [58]. Thermophilic parasites have arisen as expected hotspots for cowhide handling alongside bacterial proteases. Further, cleaning of hair and its natural absorption had yielded a few imperative amino acids utilized as dietary enhancement [59]. The utilization of thermostable protease became an essential piece of current calfskin making and thermophilic parasites are the imperative wellspring of such financially huge compounds [60]. In calfskin enterprises,

synthetic compounds are utilized to eliminate hair and other subcutaneous layers. These synthetic compounds caused extreme ecological contamination. A few investigations have proposed that the enzymatic handling of cowhide settle natural issues as well as yield better quality calfskin [61]. The basic circumstances add to the enlarging of the skin permitting access, and the activity of the proteases advances the corruption of elastin and keratin, delivering a milder cowhide utilized essentially for dress and calfskin products. Microbial examinations have shown fruitful utilization of antacid proteases in the calfskin handling of *Aspergillus flavus* and *Streptomyces* [62].

Customary calfskin creating techniques utilize harmful synthetic compounds, for example, sodium sulfide, which expands waste and defilement. The utilization of proteases rather than synthetic substances works on the nature of cowhide and lessens its ecological effect [63]. Soluble protease proteins have a wide scope of purposes in the cowhide business. Different advances like drenching, hair expulsion, pickling, and tanning [62]. Bating plans to eliminate undesirable inter fiber proteins [64]. The outcome is a milder, silkier, more flexible calfskin [65]. Basic proteases segregated from specific microbial sources have been demonstrated to be viable. The principal reason for the bating system is to incite inside detachment of collagen by debasing keratin proteins, uncovering the greatest response surface region on which tannins act [66].

The extracellular serine protease-delivering bacterium was detached from a wastewater test from the Salem sago industry and distinguished as *Graphium putredinis* and *Trichoderma harzianum*. Intergenus-created combination specialist delivered elevated degrees of protease in soybean feast, which changed more tenderly than the parent [65-66].

3. Fungal protease in the handling of keratin waste and chicken plume.

The poultry business is extending quickly, delivering a great many lots of quill squander every year. To deliver huge amounts of keratin results as modern waste all over the planet, they should be utilized lawfully. Synthetic treatment of keratin squander has been pronounced by different scientists as an ecologically damaging methodology since it produces auxiliary toxins. Keratinases delivered by an assortment of microorganisms (microbes and organisms) can be utilized to successfully treat keratin garbage [67-68]. Suggested for the treatment of side-effects containing keratin, *Aspergillus (A.) flavus* accomplishes a double restorative impact [66]. Keratin is an insoluble, sinewy primary protein that is innately abnormal because of its overflow of hydrogen and disulfide bonds. Different vertebrates, like fish, reptiles, birds, and warm-blooded creatures, have conservative keratin in their skin layer and are plentiful, making them the third biggest after chitin and cellulose [69]. Keratin can be isolated into two sorts: α-keratin and β-keratin [68-70]. The capacity of *Aphanoascus fulvescens* and *Chrysosporium articulum* strains segregated from the dirt (Phaesol) to corrupt regular plume keratin. Strains were recognized in light of phenotypic qualities and nucleotide arrangements. The reaction surface technique was utilized to improve culture conditions for the most noteworthy keratolytic movement. The analysis depended on Box-Behnken's plan for losing substrate mass (chicken quills) [71].

A few animal categories are keratinized human and creature tissue parasites that cause dermatophytosis and recognize three species gatherings of earthly dermatophytes. These are Mainly saprophytic species addressed by Trichophyton terrestrial, frequently pathogenic species like *H. Microsporum gypseum* (Bodin), an inadvertently pathogenic species, for example, *H. Microsporum Cookei Ajello* and *Trichophytonajelloi* [72-74]. Keratin squander is wealthy in nitrogen and sulfur-rich proteins. It contains 90% protein, basically keratin, around 15-18% nitrogen, and 2-5% sulfur [75-77]. Keratinase, as different protease, is supposed to make a possible worldwide market. Different gatherings of microorganisms that produce keratinase have been utilized to separate quills [78,79].

Chicken feather | Chicken feather in Fungal protease. | Degradation of chicken feathers.

Fig 2: Feather degardation by fungal protease.

4. Fungal protease in biofilm evacuation.

Biofilm evacuation is troublesome. In a modern climate, both inactivation and evacuation of biofilms are vital. If by some stroke of good luck sterilization is performed without eliminating the connected biofilm, the inactivated biofilm cells can give an optimal climate for additional connection and development, bringing about a complicated grid. Microbial protection from biocides and their negative natural effect is the primary explanation behind searching for elective biofilm in the executives' procedures [80]. The development of biofilms on these macromolecules is a typical lifestyle for microorganisms that join to practically all surface water interfaces and may advance their biodegradation. Biofilm life forms empower the foundation of safeguarded networks that upgrade the reasonability of microbial networks in troublesome conditions [81-83]. A high proteinase substitute was suggested for old *A. Niger* societies in gum arabic (65 ± 5% expulsion proficiency). The other two choices are youthful societies of gelatin. These are high in

pectinesterase and low in proteinase. The best of these are *Trichoderma* arrangements that are likewise rich in cellulose. The ones from *Aspergillus* were likewise moderately wealthy in gelatin lyase. Along these lines, it tends to be inferred that both proteolytic and starch corrupting exercises are appropriate for biofilm expulsion [84-86].

5. Fungal protease in silk degumming.

Degumming of silk includes breaking peptide bonds from sericin, a proteinaceous substance that covers the filaments, either by hydrolysis or enzymatic strategies, trailed by the expulsion of sericin from silk fibroin. Hydrolysis of sericin can be performed under nonpartisan, basic, or acidic circumstances to give four portions, each with various properties. Degumming is generally finished with a soluble arrangement of cleanser and is an unforgiving cycle that likewise goes after the fibrin structure [87]. Enzymatic treatment requires a lot of lower temperatures than customary techniques. Handling silk with catalysts under the above conditions might keep up with the radiance and delicate quality of the silk. Conditions, for example, catalyst fixation, temperature, and handling time have been streamlined to save how much compound. The productivity of this catalyst has been concentrated on in a relationship with weight reduction and muscle shortcoming [88]. In wet silk medicines, degumming and fading are the main pretreatments before coloring to eliminate sericin gum and contaminations from crude silk or texture. This further develops delicate quality, whiteness, retentiveness, and sparkle properties [89]. The synthetic compounds present in wastewater are non-biodegradable, unpleasant to the climate, and cause natural contamination. The degumming system in the silk business includes the evacuation of sericin and normal pollutants from silk fibers, which is typically done in the cleanser and soft drink bubbling cycle [88,89]. Crude silk is mostly made out of fibroin, which is the essential part of silk fiber and records for around 78 to 80% of the complete silk. Sericin, which is a tacky material that gives silk fiber unpleasant and hard feelings, is 22 to 25% possesses Silk [90]. Degumming is the interaction by which sericin is taken out from the fibroin divider to keep up with shine, perfection, and different properties [91]. *Conidiobolus brefeldin* and BOA2 proteases were the best catalysts, which showed weight reduction like the traditional strategy with low compound focuses and in a more limited time. No massive contrasts were tracked down in elasticity or prolongation at the break by enzymatic degumming showing that there was no harm to the fiber [92]. Protease from Aspergillus Saito helps in silk degumming [93].

6. Fungal protease in the visual business by recuperating silver from X-beam.

Silver is a significant modern metal and has applications in adornments, visual film, hardware, flatware, and X-beam film. Silver isn't obliterated during shooting and can be recuperated and reused. X-beams or visual movies contain 1.5-2% (w/w) silver in the gelatin layer. Soluble proteases assume a significant part in the bioprocessing of X-beam films utilized for silver recuperation. X-beam film utilizing soluble protease delivered from the contagious strain *Aspergillus Versicolor* PF/F/107. It was seen that the gelatin layer has deteriorated at 50 °C. what's more, pH was 9.0 in a short time and 0.135 g of silver was recuperated in 0.335% yield [94]. *Conidobolus coronatus* soluble protease eliminated the gelatin layer in 6 minutes at 40 °C and 9.0 pH [95]. Contagious proteases have been widely concentrated because of their incredible assortment. Proteases are disengaged from *Schizophyllum* collective, *Phanerochaete chrysosporium*, *Sporotrichum thermophiles*, *Myceliophthora thermophile*, *Thermomyces ibadanensis*, *Candida mogii*, *Saccharomyces pombe*, *Aspergillus flavus*, and *Neurosporacrass*, and so on [96].

7. Fungal protease in meat tenderization.

The surface and delicacy of meat are quite possibly the main quality attributes for shoppers [97]. Furthermore, it is the still up in the air the physical and biochemical conditions of the protein in the meat are. For the meat of warm-blooded creatures, for example, cows, pigs, and sheep, delicacy is a specific issue. Clients will pay a premium for milder meat. The delicacy of cooked meat is abstractly estimated by the buyer board [98]. Meat tenderizer is a mind-boggling process with a few related sub mechanisms. Corruption of collagen sum and type [99]. The novel aspartic protease quality (RmproA) was cloned from the thermophilic organism Rhizomucor miehei CAU432 and communicated in Pichia pastoris [100].

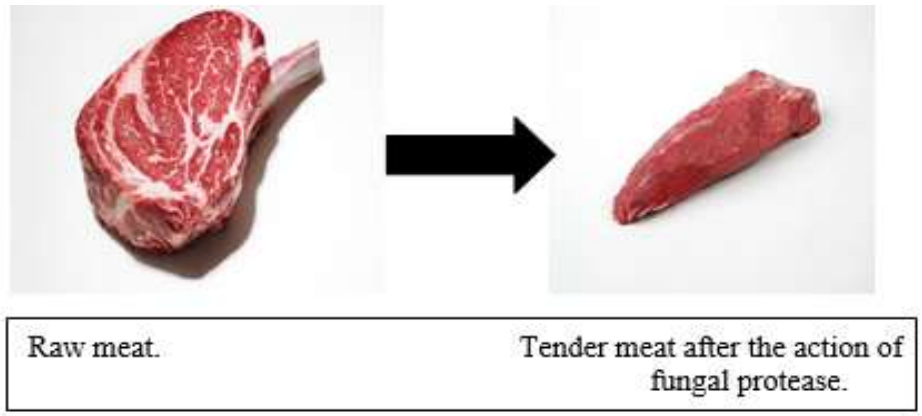


Fig 3: Tenderization of meat by fungal protease.

8. Fungal protease in food industry.

Soluble proteases have been utilized to create nutritious protein hydrolysates. There is a wide range of kinds of protein hydrolysates that can be produced using food proteins. Creation and de-harshness of protein hydrolysates [101]. Proteolytic catalysts are utilized to adjust and control proteins. This further develops solvency, warm dependability, and protection from precipitation in acidic conditions. Protein hydrolysates are likewise utilized as emulsifiers in an assortment of utilizations, for example, salad dressings, spreads, frozen yogurt, espresso flavors, wieners, and lunch get-together meat items. Fish hydrolyzate, a fish hydrolyzate, yields roughly 100 billion tons of fish every year, of which simply 29.5% is changed over completely to fishmeal [102]. Soybean hydrolyzate. Soybeans are a generally excellent wellspring of plant-based protein. Soy protein can be hydrolyzed in two ways: enzymatic hydrolysis and corrosive hydrolysis [103].

The utilization of immobilized compounds in the handling and examination of dairy items seems promising because of the attributes of the dairy framework. Most dairy items are fluid at the handling stage and are nonstop handling frameworks. Cheddar creation has been fostered that can utilize immobilized compounds. What's more, adjustment of milk parts, for example, fat with immobilized catalysts appears to be doable and favorable. Immobilized proteases might help the ceaseless coagulation of milk for cheddar creation. Since the immobilized chemical doesn't stay in the item, it could be feasible to substitute a less expensive, less alluring but more promptly accessible catalyst that isn't regularly financially accessible as a milk coagulation compound [104].

Fungal protease in cheddar making.

Parasitic proteases are principally utilized in the food business, particularly for acidic proteases. acidic proteases can supplant the exercises related to papain, renin, and pepsin, among different capacities. *Aspergillus* and *Mucor* species are the business' most significant wellsprings of contagious proteases. *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus oryzae*, *Mucor pusillus*, *Mucor miehei*, and *Rhizopus* are utilized in the arrangement of oriental food sources, for example, tempeh and mucor, and in the creation of cheddar rather than regular rennet. *M. pusillus*, *M. miehei*, *Penicillium roqueforti*, and Others, for example, camemberti, are significant wellsprings of proteases, which are milk coagulation chemicals [105]. Proteins likewise give milk chocolate confections and buttermilk flapjacks a special flavor [106]. Aniger var. awamori, Endothiaparasitica, *Mucor miehei*, for example, *Rhizopusoryzae* have been enrolled with the FDA and are endorsed for cheddar creation [107-109].

Fungal proteases in brewing and baking.

Proteases are likewise utilized in the pastry shop industry, like gluten, to get ready bread rolls, keeping business cakes from sticking to aluminum machines. Proteases, for example, prolyl endopeptidase from *Aspergillus niger* have been accounted for to corrupt gluten peptides that can endure the acidic climate of the stomach [109].

9. Fungal protease in biopolitics of fleece and textile industry.

One more vital area of business use of proteases is the material business, where enzymatic treatment gives the last rich surface [110]. Silk is the world's most important texture, treated with heat-settling proteases and utilized in an assortment of uses to eliminate gum and different pollutants present in silk from center protein filaments. Silk degumming is a developing industry that utilizes a lot of proteases to deliver excellent silk [111]. Parasitic proteases are likewise popular in the material business to give an exemplary surface by eliminating silk gum and pollution. The use of proteases in the silk business brought about two times the all-out yield of Indian sericulture [112]. The utilization of basic proteases, including sodium chloride and slaked lime, is compelling in eliminating hair from creature skin. Different blends of *Aspergillus* protease and trypsin have been utilized in calfskin handling. The utilization of chemicals has been displayed to work on the surface and nature of calfskin [113,114]

10. Fungal protease in nematode control and biocontrol specialists.

Organisms assume a significant part in natural bioremediation by breaking down contaminations, for example, material colors, mash and paper effluents, calfskin tanning, petrol hydrocarbons, and pesticides. Different kinds of parasites, including Aspergillus niger, have been accounted for to corrupt polychlorinated biphenyls. Trichoderma sp. For fading material colors; Candida sp., Mucor sp., Penicillium sp. what's more, Rhizopus sp. For oil-based goods; for the expulsion of wastewater from the Aspergillus. Acremonium, Carbularia, Pythium for weighty metal obstruction [115]. Fungal nematodes go through two formative stages: nematodes in the host and free-living nematodes that as far as both parasite advancement and its control [116]. Current examinations have explored the utilization of intensity-safe soluble proteases to control hurtful nematodes. Proteases from G550 showed high nematode action against M. incognita under research facility conditions [117].

11. Fungal protease in squander treatment.

Fungal proteases assume a significant part in squander treatment. They can separate different proteinaceous squander from the climate. Poultry and slaughterhouse squander, like plumes and bodies, can be handily debased by fungal proteases [118]. Proteases show the most noteworthy proficiency in the recuperation of silver from x-beam film. X-beam film contains silver in the gelatin layer. Consuming the film to extricate silver makes contamination issues. Proteases hydrolyze gelatin and recuperate silver without pollution [119]. Sinewy proteins, for example, horns, plumes, hair, and nails are plentiful as waste. Microbial-inferred basic protease compounds can be utilized to change over squander into helpful biomass [120]. *Aspergillus tamari* MTCC5152

produces the basic protease created by SSF. Proteases have an assortment of modern purposes. After brooding for 10 minutes at room temperature, complete expulsion of blood stains was seen with a q-tip. This protease can separate the gelatin layer of utilized X-beam film, chitin in shrimp shells, and bloodstains on cotton towels. The complete corruption of gelatin was seen following 2 hours at pH 8.5 at a temperature of 55 °C. Shrimp shell squander is a rich wellspring of proteins like chitin. This waste was treated with a protease chemical to extricate chitin. The subsequent chitin was portrayed by Fourier change infrared spectroscopy examination [121].

12. Fungal protease in medial and parmaceutical industry.

Proteases assume a significant part in the clinical field. Proteases are involved day to day in the therapy of different sicknesses, for example, malignant growth, aggravation, cardiovascular and necrotic injuries [119]. Proteases have been concentrated as an option in contrast to mechanical injury resection (evacuation of dead skin) from consumes [122]. Restorative Use of Proteases The clinical utilization of proteases for symptomatic and remedial objects is very much perceived and a few catalysts have been utilized for a long time. Proteases are essentially associated with the improvement against malignant growth, mitigating, antibacterial, and cluster dissolving specialists. Bacterial and parasitic stains contribute similarly to characterizing the helpful capability of proteases [123].

In the drug business, catalyst inhibitors are one of the primary items that underline the remedial class, and protease inhibitors are one of them. A few classes of interest repress serine, Metallo, cysteine, and aspartic proteases. Serine proteases act against provocative circumstances, for example, asthma and rheumatoid joint pain to deliver anticoagulants that follow up on the coagulation overflow. Among the serine proteinase-creating microbes is a type of *Aspergillus oryzae* [124]. The class of aspartic proteases shows the principal progress in the plan of compound inhibitors by computational methods [123,124].

13. Fungal Proteases in White Biotechnology.

Biotechnology applications in the modern area are described by varieties like red for drug stores, green for farming, and white for modern biotechnology. The term white biotechnology incorporates the development of natural items produced using living cells and their chemicals [125]. White biotechnology incorporates food creation, fermenting and pastry kitchen, cleansers, materials, cowhide, paper and mash, and bioremediation [126]. *Aspergillus niger, A. melleus, A. oryzae, Fusarium spp., Penicillium spp., Rhizopus oryzae, Trichoderma harzianum,* and *T. reesei* has been accounted for to create homologous or heterologous proteins by basic downstream medicines, for example, refinement and recuperation [127].

Table 1: Application of fungal protease.

SLNO	FUNGI	APPLICATIONS	REFERENCE
1.	Aspergillus tamarii	Biotechnological	[128]
2.	Aspergillus	Crackers	[129]
3.	Aspergillus tamarii	Leather processing	[130]
4.	Beauveria felina	Soy protein hydrolysis	[131]
5.	Pencillium griseoroseum	Cheese formation	[132]
6.	Aspergillus oryzae	Biochemical industries	[133]
7.	Trichoderma atroviride	Fruiting clusters of grape crops	[134]
8.	Doratomyces microsporous	Hydrolysis of keratin	[135]
9.	Nemtophagous	Biocontrol agent	[136]
11.	Pectinolytic	Apple juice purification	[137]
12.	Clonostachys rosea	Biocontrol agent	[138]
13.	Trichoderma harzianum	Reducing copper	[139]
14.	Pseudomonas aeruginosa K-187	Deprotonization of crab shell wastes and shrimp	[140]

15.	Rhizopus oryzae	Pharmaceutical	[141]
16.	Aspergillus flavus	Depilation of hides	[142]
17.	Pochonia chlamydosporia	Biocontrol agent	[143]
18.	Phanerochaete Chysosporium	Bioremediation	[144]
19.	Irpex lacteus	Water and soil bioremediation	[145]
20.	Saccharomyces cerevisiae	Pulp bleaching processes	[146]
21.	Chrysosporium keratinophilum	Bioremediation of keratin wastes	[147]
22.	Spilosoma obliqua	Contact lens cleaner	[148]
23.	Acanthameba polyphaga	Contact lens cleaner	[149]
24.	Basidiobolus NCL 97.1.1	Photographic films	[150]
25.	Scytalidium thermophilum	Degumming of silk	[149]
26.	Aspergillus nidulans HA-10	Dairy industry	[151]
27.	Aspergillus oryzae	Baking, food processing, protein modification	[152]
28.	Xylotrophic basidiomycetes	Therapeutic	[153]
29.	Pencillium godlewskii	Detergent formulation	[154]
30.	Chryseobacterium acquatium	Biocontrol and plant growth	[155]
31.	Aspergillus niger	Waste treatment	[156]
32.	Aspergillus sp	Bioremediation process	[157]
33.	Thermoascus aurantiacus	Food industry	[158]
34.	Thermophilic fungi	poultry	[159]
35.	Rhizopus oryzae	Wheat protein hydrolyze	[160]
36.	Leptosphaeria maculans	Agriculture	[161]
37.	Thermostable protease.	Medicine	[162]
38.	Endomopathogenic fungi	Insecticides	[163]

39.	Trichoderma virens	Plant defense response	[164]
40.	Aspergillus oryzae	Meat tenderization	[165]
41.	Nematoloma frowardii	Environmental purpose	[166]
42.	Mucor miehei	Food process	[167]
43.	Aspergillus nidulans	Leather and pharmaceutical	[168]
44.	Myceliophthora sp	Laundry and detergent	[169]
20.	Thermomucor indicae	Dairy industry	[170]
21.	Aspergillus fumigatus	Pharmaceuticals	[171]
22.	Aspergillus nidulans HA-10	Photographic	[172]
23.	Conidiobolus coronatus	Photographic industry (X-ray films)	[173]
24.	Fusarium sp	Dissolving fibrin clot	[174]
25.	Cordyceps sinensis	Degrade fibrin	[175]

SLNO	**FUNGI**	**APPLICATIONS**	**REFERENCES**
51.	Rhizomucor miehei	Meat tenderization	[176]
52.	Trametes cingulata CTM10101	Cleansing process	[177]
53.	Chryseobacterium sp	Food processing industry	[178]
54.	Aspergillus oryzae CH93	Beer Brewing	[179]
55.	Aspergillus niger	Bioremediation and paper	[180]
56.	Aspergillus carbonarius	Brewing industries	[181]
57.	Aspergillus oryzae DRDFS13MN726447	Cheese production	[182]
58.	Pencillium camemberti	Cheese ripening	[183]
59.	Geotrichum candidum	Bioremediation	[184]
60.	Fusarium lateritium	Ethoxylated oleyl cetyl alcohol bioremediation	[185]
61.	Aspergillus oryzae Y1	Soy sauce	[186]

62.	Neocosmospra so.N1	Stain removal	[187]
63.	Beauveria sp.(MTCC 5184)	Silk industry	[188]
64.	Aspergillus tamarii URM4634	Silk industry	[189]
65.	Trichoderma harzianum	Protein hydrolysates	[190]
66.	Rhizomucor miehei	Meat tenderization	[191]
67.	Pleurotus sajor-caju CTM10057	Protein hydrolysates	[192]
68.	Cheotomium globusum	Photographic	[193]
69.	Trichoderma spp.	Photography	[192]

CONCLUSION:

Fungal protease are used in multidisciplinary sectors, nowadays more importance is given to products which are derived from enzymes, which are treated as environmental friendly Mainly the fungal protease enzyme plays a major role in the degradation of protein, using this unique property the protease is used in industries like in laundry where detergent derived from protease are used that can remove the stains like blood, sweat in the cloths. In the leather industry and tannery industry where the protease enzyme is used for the dehairing of skin of animals to manufacture leather, fungal protease has other applications also like in degradation of chicken feather by the action of protease, where the chicken feathers have a major role in environment pollution, also in biofilm removal where biofilm is called as a 'city of microbes. In photographic industries, protease plays a versatile role in the recovering of silver. Also protease plays an important role in food industry like in drinks, and brewing and Fungal protease has a effective mechanism in nematode control.

Fungal protease helps in synthesis of peptides and sequencing, removal of unwanted proteins, for cell culturing, preparation of antibody fragments, structure-function relationships, affinity tag removal, and proteolytic digestion of proteins are all processes that will require a lot of research in the future.

Reference:

1. Li AN et al. Purification and characterization of two thermostable proteases from the thermophilic fungus Chaetomium thermophilum. J Microbiol Biotechnol 2007; 17(4):624-631.
2. Sandhya, C., Sumantha, A., Szakacs, G., Pandey, A., 2005. Comparative evaluation of neutral protease production by Aspergillus oryzae in submerged and solid-state fermentation. Process Biochem. 40, 2689–2694
3. Schoemaker HE, Mink D, Wubbolts MG. Dispelling the myths—Biocatalysis in industrial synthesis. Science 2003;299:1694–1697.
4. Demain AL, Adrio JL. Contributions of microorganisms to industrial biology. Mol Biotechnol 2007;38:41–55.
5. Kirk O, Borchert TV, Fuglsang CC. Industrial enzyme applications. Curr Opin Biotechnol 2002;13:345–351.
6. Barret, A.J. Classifi cation of peptidases. pp. 1–15. In: 1994. Meth. Enzymol., Academic Press, Inc., Califórnia.
7. Turk, B. 2006. Targeting proteases: successes, failures and future prospects. Nature. 5: 785–799.
8. Rao MB, Tanksale AM, Ghatge MS, Deshpande VV. Molecular and biotechnological aspects of microbial proteases. Microbiol Mol Bio Rev 2998;62: 597–635.
9. Kumar, C.; Joo, H.S.; Koo, Y.M.; Paik, S.; Chang, C.S. Thermostable Alkaline Protease from a Novel Marine Haloalkalophilic Bacillus Clausii Isolate. World J. Microbiol. Biotechnol. 2004, 20, 351–357.
10. Zhang, L.X.; An, R.; Wang, J.P.; Sun, N.; Zhang, S.; Hu, J.C.; Kuai, J. Exploring novel bioactive compounds from marine microbes. Curr. Opin. Microbiol. 2005, 8, 276–281.
11. Zhang, L.X.; An, R.; Wang, J.P.; Sun, N.; Zhang, S.; Hu, J.C.; Kuai, J. Exploring novel bioactive compounds from marine microbes. Curr. Opin. Microbiol. 2005, 8, 276–281.
12. Zhang, L.X.; An, R.; Wang, J.P.; Sun, N.; Zhang, S.; Hu, J.C.; Kuai, J. Exploring novel bioactive compounds from marine microbes. Curr. Opin. Microbiol. 2005, 8, 276–281.
13. Gupta R, Beg QK and Chauhan B. Applied Microbiol Biotechnol 2002b;60:381-395.
14. Shanmugam Jayashree , Balumuri Annapurna , Renganathan Jayakumar Tongmin Sa, Sundaram Seshadri , Screening and characterization of alkaline Protease produced by a pink pigmented facultative Methylotrophic (PPFM) strain, MSF 46 ,Journal of Genetic Engineering and Biotechnology 12, 111–120. (2014).
15. Li AN et al. Purification and characterization of two thermostable proteases from the thermophilic fungus Chaetomium thermophilum. J Microbiol Biotechnol 2007; 17(4):624-631.
16. Li AN et al. Purification and characterization of two thermostable proteases from the thermophilic fungus Chaetomium thermophilum. J

Microbiol Biotechnol 2007; 17(4):624-631.
17. Hayashida S et al. Xylanase of Talaromyces byssochlamydoides. Methods Enzymol 1988; 160: 675–678.
18. Lasa I. Thermophilic enzymes and their biotechnological potential. Microbiologia 1993; 9(2):77-89.
19. Puri, S., Q.K. Beg and R. Gupta. 2002. Optimization of alkaline protease production from Bacillus sp. using response surface methodology. Curr Microbiol. 44: 286–290.
20. Polgár, L. 1989. Mechanism of protease action. CRC Press, Inc. USA, Florida. p. 232.
21. Rawlings, N.D. and A.J. Barrett. 1993. Evolutionary families of peptidases. Biochem. J. 290: 205–218.
22. Rao, M.B., A.M. Tanksale, M.S. Ghatge and V.V. Deshpande. 1998. Molecular and biotechnological aspects of microbial protease. Microbiol Mol Biol. Rev. 62: 597–635.
23. Garcia-Carreño, F.L. and M.N. Del Toro. 1997. Classifi cation of proteases without tears. Biochem. Edu. 25: 161–167.
24. Rao YK, Lu S-C, Liu B-L et al. (2006) Enhanced production of an extracellular protease from Beauveria bassiana by optimization of cultivation processes. Biochem Eng J 28:57-66.
25. Polgár, L. 2005. The catalytic triad of serine peptidases. Cell. Mol. Life Sci. 62: 2161–2172.
26. Lbwe, J., D. Stock, B. Jap, P. Zwickl, W. Baumeister and R. Huber. 1995. Crystal structure of the 20S proteasome from the Archaeon T. acidophilum at 3.4 A resolution. Science 268: 533–539.
27. Bayoudh A, Gharsallah N, Chamkha M, Dhouib A, Ammar S, and Nasri M. J Industr Microbiol Biotechnol 2000;24:291–295.
28. Mala B et al. Molecular and Biotechnological Aspects of Microbial Proteases. Microbiol Mol Biol Rev 1998; 62(3): 597–635.
29. Polgár, L. 1989. Mechanism of protease action. CRC Press, Inc. USA, Florida. p. 232.
30. Canevascini G et al. Cellobiose dehydrogenases of Sporotrichum (Chrysosporium) thermophile. Eur J Biochem 1991; 198: 43–52.
31. Fujinaga, M., M.M. Cherney, H. Oyam, K. Oda and M.N.G. James. 2004. The molecular structure and catalytic mechanism of a novel carboxyl peptidase from Scytalidium lignicolum. Proc. Natl. Acad. Sci. 101: 3364–3369.
32. Goldberg A L et al. Proteases of Escherichia coli. Methods Enzymol 1983; 80: 680–702.
33. Govind N S et al. Protease and carotenogenesis in Blakeslea trispora. Phytochemistry 1981; 20: 2483–2485.
34. Gustin J K et al. A substitution at His-120 in the Las A protease of Pseudomonas aeruginosa blocks enzyme activity without affecting propeptide processing or extracellular secretion. J Bacteriol 1996; 178: 6608–6617.
35. Veloorvalappil NJ et al. Advances in Enzyme Research 2013; 1(3): 39–51p.
36. Sawant R, Nagendran S. World Journal of Pharmacy and Pharmaceutical Sciences. 2014; 3(6): 568–579p.
37. Mikhailova R.V. Мікробіоёоãія і біотеõноёоãія 2011. 1(3). 47-61p.
38. Rao, M.B., A.M. Tanksale, M.S. Ghatge and V.V. Deshpande. 1998. Molecular aayoudh A, Gharsallah N, Chamkha M, Dhouib A, Ammar S, and Nasri M. J Industr Microbiol Biotechnol 2000;24:291–295.
39. nd biotechnological aspects of microbial protease. Microbiol Mol Biol. Rev. 62: 597–635.
40. Sawant R, Nagendran S. World Journal of Pharmacy and Pharmaceutical Sciences. 2014; 3(6): 568–579p.
41. Veloorvalappil NJ et al. Advances in Enzyme Research 2013; 1(3): 39–51p.
42. Igarashi H et al. A new method for purification of staphylocoagulase by a bovine prothrombinSepharose column. J Biochem 1979; 86: 1615–1618.
43. International Union of Biochemistry. Enzyme nomenclature. Orlando, Fla: Academic Press, Inc.; 1992.
44. Kasana RC. Proteases from psychrotrophs: an overview. Crit Rev Microbiol 2010; 36(2):134-45.
45. Yike I. Fungal proteases and their pathophysiological effects. Mycopathologia 2011; 171(5):299-323.
46. Monod M et al. Secreted proteases from pathogenic fungi. Int J Med Microbiol 2002; 292(5-6):405-419
47. Cardello L et al. A cytosolic trehalase from the thermophilic fungus Humicola grisea var. thermoidea. Microbiology 1994; 140: 1671– 1677.
48. Wikibooks. Structural Biochemistry/Enzyme Catalytic Mechanism/Proteases. https://en.wikibooks.org/wiki/Structural_B iochemistry/Enzyme_Catalytic_Mechanis m/Proteases. Accessed 12 July 2012.
49. Sharma PM. Nature Environment and Pollution Technology. 2010; 9(4): 707– 711p.
50. Bon, E.P.S. 1995. A tecnologia enzimática no Brasil. Enzitec. 1: 9–14
51. Kumar, C.G. and H. Takagi. 1999. Microbial alkaline proteases: from a bioindustrial viewpoint. Biotechnol. Adv. 17: 561–594.
52. Phadatare SU, MC Srinivasan, and VV Deshpande. Enz Microbial Technol 1993;15:72–76.
53. Maurer KH. Detergent proteases. Curr Opin Biotechnol 2004; 15(4):330-334.
54. Shankar S, Rao M, Laxman RS. Purification and characterization of an alkaline protease by a new strain of Beauveria sp. Process Biochem 2011;46:579–585.
55. Showell MS. Enzymes, Detergent. In: Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation Flickinger MC, Drew SW (eds.). J. Wiley and Sons Inc., New York. 958–971, 1999.
56. Verma A, Pal HS, Singh R, Agarwal S. Potential of alkaline protease isolated from Thermoactinomyces sp. RM4 as an alternative to conventional chemicals in leather industry dehairing process. Int J Agric Environ Biotechnol 2011;4:173–178.
57. S. Savitha, S. Sadhasivam, K. Swaminathan, Feng Huei Lin, Fungal protease: Production, purification and compatibility with laundry detergents and their wash performance, Journal of the Taiwan Institute of Chemical Engineers,Volume 42, Issue 2,2011.
58. Pradeep MR and Narasimha G. Effect of leather industry effluents on soil microbial and protease activity. J Environ Biol 2012; 33(1):39-42.
59. Wang HY et al. Screening and mutagenesis of a novel Bacillus pumilus strain producing alkaline protease for dehairing. Lett Appl Microbiol 2007; 44(1):1-6.
60. Vijayaraghavan P et al. Dehairing protease production by an isolated Bacillus cereus strain AT under solid-state fermentation using cow dung: Biosynthesis and properties. Saudi J Biol Sci 2014; 21(1):27-34.

61. Sawant R, Nagendran S. World Journal of Pharmacy and Pharmaceutical Sciences. 2014; 3(6): 568–579p.
62. Rao, M.B., A.M. Tanksale, M.S. Ghatge and V.V. Deshpande. 1998. Molecular and biotechnological aspects of microbial protease. Microbiol Mol Biol. Rev. 62: 597–635.
63. Kumar, C.G. and H. Takagi. 1999. Microbial alkaline proteases: from a bioindustrial viewpoint. Biotechnol. Adv. 17: 561–594.
64. Zambare VP, Nilegaonkar SS, Kanekar PP. Production of an alkaline protease by Bacillus cereus MCM B-326 and its application as a dehairing agent. World J Microbiol Biotechnol 2007;23:1569–1574.
65. Hameed A, Natt MA, Evans CS. Production of alkaline protease by a new Bacillus subtilis isolate for use as a bating enzyme in leather treatment. World J Microbiol Biotechnol 1996;12:289–291.
66. Ichida JM, Krizova L, Lefevre CA, et al. Bacterial inoculum enhances keratin degradation and biofilm formation in poultry compost. J Microbiol Methods 2001;47:199–208.
67. KORNIŁŁOWICZ-KOWALSKA, T. and BOHACZ, J., 2011. Biodegradation of keratin waste: theory and practical aspects. *Waste Management (New York, N.Y.)*, vol. 31, no. 8, pp. 1689-1701.
68. BOHACZ, J., 2017. Biodegradation of feather waste keratin by a keratinolytic soil fungus of the genus *Chrysosporium* and statistical optimization of feather mass loss. *World Journal of Microbiology & Biotechnology*, vol. 33, no. 1, pp. 13.
69. MCKITTRICK, J., CHEN, P.Y., BODDE, S.G., YANG, W., NOVITSKAYA,

E.E. and MEYERS, M.A., 2012. The structure, functions, and mechanical properties of keratin. *Journal of Management*, vol. 64, pp. 449-468.

70. Bohacz J. (2017). Biodegradation of feather waste keratin by a keratinolytic soil fungus of the genus Chrysosporium and statistical optimization of feather mass loss. *World journal of microbiology & biotechnology*, *33*(1), 13.
71. Korniłłowicz-Kowalska T, Bohacz J. Biodegradation of keratin waste: theory and practical aspects. *Waste Manage.* 2011;31:1689–1701.
72. Kunert J. Physiology of keratinophilic fungi. In: Kushwaha RKS, Guarro J, editors. *Biology of dermatophytes and other keratinophilic fungi.* 1. Bilbao: Rev Iberoam Micol (Suppl.); 2000.
73. Korniłłowicz-Kowalska T. Studies on the decomposition of keratin wastes by saprotrophic microfungi. P. I. Criteria for evaluating keratinolytic activity. *Acta Mycol.* 1997;32:51–79.
74. Onifade AA, Al-Sane NA, Al-Musallam AA, Al-Zarban S. A review: potentials for applications of keratin-degrading microorganisms and their enzymes for nutritional improvement of feathers and other keratins as livestock feed resources. *Bioresour Technol.* 1998;66:1–11.
75. Nam GW, Lee DW, Lee HS (2002) "Native-feather degradation by Fervidobacteriumislandicum AW-1, a newly isolated keratinase-producing thermophilic anaerobe." Archives of Microbiology 178: 538-547.
76. Deivasigamani B, Alagappan KM (2008) "Industrial application of keratinase and soluble proteins from feather keratins." Journal of Environmental Biology 29: 933-936.
77. Mukhopadhyay RP, Chandra AL (1993) "Protease of a keratinolyticstreptomycete to unhair goat skin." Indian Journal of Experimental Biology 31: 557-558.
78. Nam GW, Lee DW, Lee HS (2002) "Native-feather degradation by Fervidobacteriumislandicum AW-1, a newly isolated keratinase-producing thermophilic anaerobe." Archives of Microbiology 178: 538-547.
79. Mah TF, O'Toole GA. Mechanisms of biofilm resistance to antimicrobial agents. Trends Microbiol. 2001 Jan;9(1):34-9. doi: 10.1016/s0966-842x(00)01913-2. PMID: 11166241.
80. Kolter R, Greenberg EP. Microbial sciences: the superficial life of microbes. Nature. 2006 May 18;441(7091):300-2. doi: 10.1038/441300a. PMID: 16710410.
81. Hall-Stoodley L, Stoodley P. Evolving concepts in biofilm infections. Cell Microbiol. 2009 Jul;11(7):1034-43. doi: 10.1111/j.1462-5822.2009.01323.x. Epub 2009 Apr 6. PMID: 19374653.
82. Costerton JW, Stewart PS, Greenberg EP. Bacterial biofilms: a common cause of persistent infections. Science. 1999 May 21;284(5418):1318-22. doi: 10.1126/science.284.5418.1318. PMID: 10334980.
83. Olsson L, Christensen T, Hansen KP, Palmqvist EA. Influence of the carbon source on production of cellulases, hemicellulases and pectinases by Trichoderma reesei Rut C-30. Enzyme Microb Technol 2003;33:612–9.
84. Pontecorvo G, Roper JA, Hemmons LM, Mc Donald KD, Bufon AVJ. The ´ genetics of Aspergillus nidulans. Adv Genet 1953;5:141–238.
85. Blanco P, Sieiro C, D´ıaz A, Villa TG. Production and partial characterization of an endopolygalacturonase from Saccharomyces cerevisiae. Can J Microbiol 1994;40:974–7.
86. Shalini Singh, Robinka Khajuria, in New and Future Developments in Microbial Biotechnology and Bioengineering, 2018.
87. N.V. Padaki, ... R.M. Thirumalesh, in Advances in Silk Science and Technology, 2015.
88. A.K. Roy Choudhury, in Handbook of Textile and Industrial Dyeing, 2011.
89. More, S. V., H. B. Khandelwal, M. A. Joseph, and R. S. Laxman. 2013. Enzymatic degumming of silk with microbial proteases. Journal of Natural Fiber 10 (2): 98–111.
90. H. El-Sayed, S. Mowafi, A.F. El-Fiky, E.M. Khalil. (2022) Low temperature water-saving bio-degumming of natural silk using thermophilic protease. *Sustainable Chemistry and Pharmacy* 27, pages 100681.
91. Freddi, G., R. Mossotti, and R. Innocenti. 2003. Degumming fabric with several proteases. Journal of Biotechnology 106: 101–112.
92. Cavaco-Paulo, A., 1998. Processing textile fibres with enzymes: an overview. In: Eriksson, K.E.L., Cavaco-Paulo, A. (Eds.), Enzyme Applications in Fibre Processing, ACS Symposium Series 687, American Chemical Society, Washington, DC, pp. 180– 189.
93. Choudhary V. Recovery of silver from used X-ray films by Aspergillus versicolor protease. J Acad Ind Res 2013;2:39–41.
94. Shankar S, Rao M, Laxman RS. Purification and characterization of an alkaline protease by a new strain of Beauveria sp. Process Biochem 2011;46:579–585.
95. Johansen C, Falholt P, Gram L. Enzymatic removal and disinfection of bacterial biofilm. Appl Environ Microbiol 1997;63:3724–8.

96. Miller, M.F., Carr, M.A., Ramsey, C.B., Crockett, K.L., Hoover, L.C., 2001. Consumer thresholds for establishing the value of beef tenderness. J. Anim. Sci. 79 (12), 3062–3068.
97. Boleman, S.J., Boleman, S.L., Miller, R.K., Taylor, J.F., Cross, H.R., Wheeler, T.L., et al., 1997. Consumer evaluation of beef of known categories of tenderness. J. Anim. Sci. 75.
98. E. Veiseth, S.D. Shackelford, T.L. Wheeler, M. Koohmaraie
Factors regulating lamb longissimus tenderness are affected by age at slaughter Meat Sci., 68 (4) (2004), pp. 635-640.
99. Casas, E., White, S.N., Wheeler, T.L., Shackelford, S.D., Koohmaraie, M., Riley, D.G., et al., 2006. Effects of calpastatin and m-calpain markers in beef cattle on tenderness traits. J. Anim.Sci. 84 (3), 520–525 [pii].
100. Neklyudov AD, Ivankin AN, Berdutina AV. Properties and uses of protein hydrolysates (Review). Appl Biochem Microbiol 2000;36:452–459.
101. Rebeca BD, Pen˜a-Vera MT, Dı´az-Castan˜eda M. Production of fish protein hydrolysates with bacterial proteases; Yield and nutritional value. J Food Sci 1991;56:309–314.
102. Kristinsson HG, Rasco BA. Fish protein hydrolysates: Production, biochemical, and functional properties. Crit Rev Food Sci Nutr 2000;40:43–81.
103. Coughlan M P and Hale A Me 1981 The ceUulolytic system of Tataromyces emerson[a] identification of the various components produced during growth of cellulosic media; Biochim. Biophys. Acta. 662 145-151.
104. Arima K, lwaski J, Yu S and Tamura G 1968 Milk clotting enzymes from micro-organisms V. Purification and erystallization of Mucor rennin from Mucor pusillus var. Lindt; Appl. Microbiol. 16 1727-1733.
105. Fukumoto J, Tsuru D and Yamamoto T 1967 Studies on mold proteases. I. Puritication, crystallization and sorne enzymic properties of aeid protr162 of Rhizopus chinensis; Agric. Biol. Chem. 31 710-717.
106. Yao W, Zhu J, Sun B, Miller C (2009) Development and optimization of a culture medium for L-lactic acid production by Rhizopus oryzae using crude protein from dairy manure as a nitrogen source. J Environ Sci Health A 44(12):1306–1313
107. Kumar M, Yadav AN, Tiwari R, Prasanna R, Saxena AK (2014) Evaluating the diversity of culturable thermotolerant bacteria from four hot springs of India. J Biodivers Biopros Dev 1:1–9
108. Adrio JL, Demain AL (2014) Microbial enzymes: tools for biotechnological processes. Biomolecules 4:117–139.
109. Cinkotai FF. The size-distribution and protease content airborne particles in textile mill cardrooms. Am Ind Hyg Assoc J 1976; 37(4):234- 8.
110. Nilesh P, Nirmal and R Seeta Laxman. Enhanced thermostability of a fungal alkaline protease by different additives. Enzyme Res 2014; 10:93-103.
111. Gomaa EZ (2013) Optimization and characterization of alkaline protease and carboxymethylcellulase produced by Bacillus pumilus grown on Ficus nitida wastes. Braz J Microbiol 44(2):529–537.
112. Ward OP, Qin WM, Dhanjoon J, Ye J, Singh A (2005) Physiology and biotechnology of Aspergillus. Adv Appl Microbiol 58:1–75.
113. Sahay H, Yadav AN, Singh AK, Singh S, Kaushik R, Saxena AK (2017) Hot springs of Indian Himalayas: potential sources of microbial diversity and thermostable hydrolytic enzymes. 3 Biotech 7:1–11.
114. Deshmukh R, Khardenavis AA, Purohit HJ (2016) Diverse metabolic capacities of fungi for bioremediation. Indian J Microbiol 56(3):247–264.
115. Mansfield LS, Gamble HR, Fetterer RH (1992) Characterization of the eggshell of Haemonchus contortus. I. Structural components. Comp Biochem Physiol 103B(3):681–686
116. Y. Tzean, T.H. Chou, C.C. Hsiao, P.Y. Shu, J.D. Walton, S.S. Tzean
Cloning and characterization of cuticle-degrading serine protease from nematode-trapping fungus Arthrobotrys musiformis.
117. Veloorvalappil NJ et al. Advances in Enzyme Research 2013; 1(3): 39–51p.
118. Sawant R, Nagendran S. World Journal of Pharmacy and Pharmaceutical Sciences. 2014; 3(6): 568–579p.
119. Khardenavis AA, Kapley A, Purohit HJ. Processing of poultry feathers by alkaline keratin hydrolyzing enzyme from Serratia sp. HPC 1383. Waste Manage 2009; 29:1409–1415.
120. Banik RM, Prakash M (2004) Laundry detergent compatibility of the alkaline protease from Bacillus cereus. Microbiol. Res., 159: 135–140.
121. Waites MJ et al. Industrial Microbiology: An Introduction, 1st Edn. Blackwell 2001, London, 109–123p.
122. Leung, D., G. Abbenante and D.P. Fairlie. 2000. Peptidadse inhibitors: current status and future prospects. J. Med. Chem. 43: 305–341.
123. Zimmer, K.R., G.L. Borre, D.S. Trentin, C.W. Junior, A.P. Frasson, A.A. Graeff,
P. Gomes and A.J. Macedo. 2009. Enzimas microbianas de uso terapêutico e diagnostic clinic. Rev. Liberato. 10: 123–137
124. Chambergo FS, Valencia EY (2016) Fungal biodiversity to biotechnology. Appl Microbiol Biotechnol 100(6):2567–2577.
125. Saxena AK, Yadav AN, Kaushik R, Tyagi S, Kumar M, Prasanna R, Shukla L (2014) Use of microbes from extreme environments for the benefits of agriculture. In: Afro-Asian Congress on microbes for human & environmental health.
126. CG Boer, RM Peralta - Journal of Basic Microbiology: An …, 2000 - Wiley Online Library.
127. RK Saxena, R Gupta, S Saxena, R Gulati - Applied mycology and …, 2001 - Elsevier.
128. A Dayanandan, J Kanagaraj, L Sounderraj… - Journal of Cleaner …, 2003 - Elsevier.
129. D Agrawal, P Patidar, T Banerjee, S Patil - Process Biochemistry, 2005 - Elsevier.
130. H Mukhtar, Z Ali, N Riaz - Pakistan Journal of Biological Sciences …, 2004 - agris.fao.org.
131. R Wang, RCS Law, C Webb - Process Biochemistry, 2005 - Elsevier.
132. J Grinyer, S Hunt, M McKay, BR Herbert, H Nevalainen - Current genetics, 2005 - Springer.
133. J Friedrich, S Kern - Journal of Molecular Catalysis B: Enzymatic, 2003 - Elsevier.

134. B Nordbring-Hertz, HB Jansson, A Tunlid - e LS, 2001 - researchgate.net
135. S Singh, R Gupta - 2004 - nopr.niscair.res.in.
136. KQ Zhang, ML Zhao - Journal of Zhejiang University (Agriculture & …, 2004 - en.cnki.com.cn.
137. L Kredics, L Hatvani, Z Antal… - … of plant diseases …, 2004 - publicatio.bibl.u-szeged.hu.
138. YS Oh, L Shih, YM Tzeng, SL Wang - Enzyme and Microbial Technology, 2000 - Elsevier.
139. S Kumar, NS Sharma, MR Saharan, R Singh - Process Biochemistry, 2005 - Elsevier.
140. JM Cardamone - AATCC review, 2002 - search.ebscohost.com.
141. CO Morton, PR Hirsch, JP Peberdy… - Mycological Research, 2003 - cambridge.org.
142. SI de Sousa Fragoeiro - 2005 - dspace.lib.cranfield.ac.uk.
143. Č Novotný, P Erbanova, T Cajthaml… - Applied Microbiology …, 2000 - Springer.
144. T Bulter, M Alcalde, V Sieber, P Meinhold… - Applied and …, 2003 - Am Soc Microbiol.
145. CJ Singh - Mycopathologia, 2003 - Springer.
146. A Anwar, M Saleemuddin - Biotechnology and applied …, 2000 - Wiley Online Library.
147. R Hughes, S Kilvington - Antimicrobial agents and chemotherapy, 2001 - Am Soc Microbiol.
148. SS Ingale, MV Rele, MC Srinivasan - World Journal of Microbiology and …, 2002 - Springer.
149. IH Ifrij, ZB Ögel - Biotechnology letters, 2002 - Springer.
150. P Charles, V Devanathan, P Anbu… - Journal of basic …, 2008 - Wiley Online Library.
151. A Sumantha, C Larroche, A Pandey - Food Technology and Biotechnology, 2006 - Citeseer.
152. OA Kudryavtseva, YE Dunaevsky, OV Kamzolkina… - Microbiology, 2008 - Springer.
153. R Sindhu, GN Suprabha… - African Journal of …, 2009 - academicjournals.org.
154. M Gandhi Pragash, KB Narayanan… - …R Paranthaman, K Alagusundaram… - World Journal of …, 2009 - researchgate.net of microbiology and …, 2009 - koreascience.or.kr.
155. R Paranthaman, K Alagusundaram… - World Journal of …, 2009 - researchgate.net.
156. JM Salgado, L Abrunhosa, A Venâncio… - International …, 2016 - Elsevier.
157. CW Merheb, H Cabral, E Gomes, R Da-Silva - Food Chemistry, 2007 - Elsevier.
158. MM Macchione, CW Merheb, E Gomes… - Applied Biochemistry and …, 2008 - Springer
159. S M'hir, CG Rizzello, R Di Cagno… - Journal of applied …, 2009 - Wiley Online Library.
160. K Keymanesh, S Soltani, S Sardari - World Journal of Microbiology and …, 2009 - Springer.
161. J Synowiecki - African journal of biotechnology, 2010 - ajol.info.
162. RJS Leger, C Wang - Applied Microbiology and Biotechnology, 2010 - Springer.
163. S Djonović, MJ Pozo, LJ Dangott… - Molecular plant …, 2006 - Am Phytopath Society.
164. CT Payne - Ingredients in meat products: properties, functionality …, 2009 - books.google.com.
165. M Ayala, MA Pickard, R Vazquez-Duhalt - Journal of Molecular …, 2008 - karger.com.
166. A Sumantha, C Larroche, A Pandey - Food Technology and Biotechnology, 2006 - Citeseer.
167. P Charles, V Devanathan, P Anbu… - Journal of basic …, 2008 - Wiley Online Library.
168. LM Zanphorlin, FDA Facchini, F Vasconcelos… - The Journal of …, 2010 - Springer.
169. C Merheb-Dini, E Gomes, M Boscolo, R da Silva - Food Chemistry, 2010 - Elsevier.
170. SB Oyeleke, EC Egwim, SH Auta - Journal of Microbiology and …, 2010 - researchgate.net.
171. P Charles, V Devanathan, P Anbu… - Journal of basic …, 2008 - Wiley Online Library.
172. S Shankar, SV More, RS Laxman - Kathmandu university journal of …, 2010 - nepjol.info.
173. S Sugimoto, T Fujii, T Morimiya, O Johdo… - Bioscience …, 2007 - academic.oup.com.
174. H Li, Z Hu, J Yuan, H Fan, W Chen… - … Journal Devoted to …, 2007 - Wiley Online Library.
175. Q Sun, F Chen, F Geng, Y Luo, S Gong, Z Jiang - Food Chemistry, 2018 - Elsevier
176. MO Benmrad, E Moujehed, MB Elhoul… - International journal of …, 2016 - Elsevier.
177. A Mageswari, P Subramanian, S Chandrasekaran… - Food chemistry, 2017 - Elsevier.
178. A Salihi, A Asoodeh, M Aliabadian - International journal of biological …, 2017 - Elsevier.
179. WAA Wahab, SA Ahmed - International journal of biological …, 2018 - Elsevier.
180. TM Pasin, E dos Anjos Moreira, RC de Lucas… - Folia microbiologica, 2020 - Springer.
181. J Mamo, P Getachew, M Samuel Kuria… - Journal of Food …, 2020 - hindawi.com.
182. RO García-Rico, C Gil-Durán, JF Rojas-Aedo, I Vaca… - Fungal biology, 2017 - Elsevier.
183. VD Jakovljević, MM Vrvić - Saudi journal of biological sciences, 2018 - Elsevier.
184. X Ao, X Yu, D Wu, C Li, T Zhang, S Liu… - AMB …, 2018 - amb-express.springeropen.com.
185. F Matkawala, S Nighojkar, A Kumar… - Biocatalysis and …, 2019 - Elsevier.
186. SV More, S Chavan, AA Prabhune - Journal of Natural Fibers, 2018 - Taylor & Francis.
187. OS da Silva, RL de Oliveira, CM Souza-Motta… - Advances in Enzyme …, 2016 - scirp.org.
188. N Aissaoui, JM Chobert, T Haertlé… - Applied biochemistry …, 2017 - Springer.

189. Q Sun, F Chen, F Geng, Y Luo, S Gong, Z Jiang - Food ChemistrMO Benmrad, S Mechri… - BMC …, 2019 - bmcbiotechnol.biomedcentral.comy, 2018 - Elsevier.
190. MO Benmrad, S Mechri… - BMC …, 2019 - bmcbiotechnol.biomedcentral.com.
191. F Nadeem, T Mehmood, M Naveed, S Shamas… - Waste and Biomass …, 2020 - Springer.
192. AC López, AE Alvarenga, PD Zapata, MF Luna… - Mycology, 2019 - Taylor & Francis.
193. F Matkawala, S Nighojkar, A Kumar… - Biocatalysis and …, 2019 - Elsevier.