

Tyrosinase: Sources, Structure and Applications

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Abstract

Tyrosinase is the natural enzymes that can be obtained from the multiple sources like bacteria, fungi, plants and mammals and can only purified to a very low degree. Different microbial strains were reported for efficient tyrosinases production like *Streptomyces glaucescens*, *Agaricus bisporus* and *Neurospora crassa*. This enzymes is mainly involved in two step process i.e. hydroxylation of monophenols and oxidation of O-diphnols for production of many pigments (black or brown pigments). Tyrosinase is useful in different industries such as food, biomedical and pharmaceutical. Apart from that they can be applied for bioremediation. Waste water or contaminated soil containing phenolic compounds can be detoxified through their action. Melanin pigment formed under the activity of tyrosinases is good protection for mammals against UV radiations as well

Keywords: Tyrosinases, Melanin, Bioremediation, Polyphenols

Introduction:

Tyrosinases a group of binuclear copper enzymes and their closely related compounds like catechol oxidases (known collectively as polyphenol oxidases) found mainly in different groups of bacteria, fungi, plants and animals that use phenolic compounds as substrates and produce compounds like melanin and many other polyphenolic products which are biologically very important (Claus & Decker, 2006; Halaouli et al., 2006; Marusek et al., 2006). Tyrosinase (EC 1.14.18.1) have dual functionality that causes monophenolase activity (hydroxylation of monophenols to o-diphenols) and diphenolase activity (oxidation of diphenols to o-quinones) (Fairhead & Thony-Meyer, 2012). This enzyme is very important for alive organisms to do different functions, like production of melanin for defensive mechanism against UV radiations (Claus & Decker, 2006; Halaouli et al., 2006). For plants it is important in the production of phenolic polymers like tannins, lignin, flavonoids (Marusek et al., 2006) and for the regulation of redox potential during plant cell respiration and healing of wounds in plants (Mayer, 2006).

Tyrosinase ability to react with phenols makes it useful for biotechnological, biosensor and biocatalysis applications (Fairhead & Thony-Meyer, 2012; Jus et al., 2008; Jus et al., 2009). It can be further applied for detoxification of water and soil contaminated with phenolic compounds (Martorell et al., 2012), in

biosynthesis of L-DOPA (L-3,4-dihydroxyphenylalanine), as a drug highly recommended for Parkinson's disease patients (Seetharam & Saville, 2002), and also as food additives due to their cross-linking properties during food processing (Lantto et al., 2007; Selinheimo et al., 2007). Tailoring polymers, like grafting of silk proteins onto chitosan as a result of tyrosinase reaction is also reported (Anghileri et al., 2007; Freddi et al., 2006). Tyrosinase in immobilized form can act as electrochemical biosensors for verity of phenolic compounds (Gu et al., 2009).

Streptomyces glaucescens is a source of best characterized tyrosinase along with the fungal species like *Agaricus bisporus* and *Neurospora crassa*. Tyrosinase from fungal and vertebrate sources initiates the first step in melanin formation from tyrosine. Plants have verity of phenolic substrates so these are oxidized by tyrosinase as observed in browning pathway when plant tissues are injured. *Agaricus bisporus* enzyme extract is highly homologous to enzyme extract of mammals so this make it as a suitable model for study on melanogenesis (Chang, 2009).

Structure of Tyrosinase:

Due to multiple sources of tyrosinase its structural properties are diverse in nature along with their distribution in tissues and cells, so no common protein is observed across all species (Mayer, 2006; Jaenicke & Decker, 2003). The difference is observed in primary

structure, size, in post modification sites like active site and in glycosylation mechanism. Common thing in all tyrosinases is their binuclear type III copper centre containing two copper atoms each connected with six histidine molecules in their active site. These copper atoms are linked with atmospheric oxygen that catalysis the two different reactions (1) ortho-hydroxylation of monophenols and (2) oxidation of o-diphenols to o-quinones. Crystal structure contain each copper coordinated with 3 histidine like in CuA and CuB as shown in the figure 1 (a) and (b).

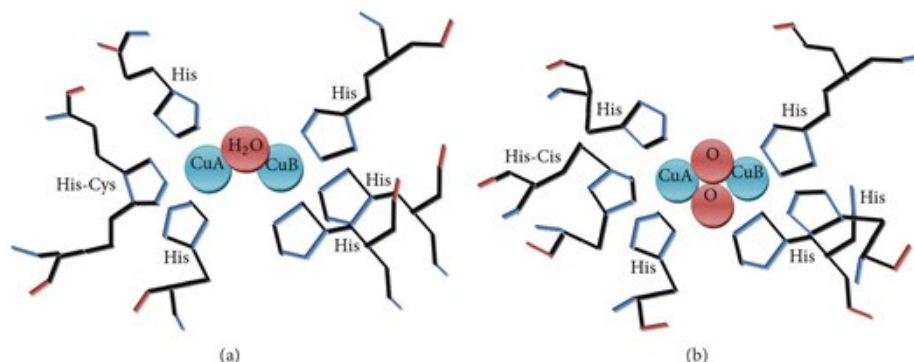


Figure 1: Structure of Tyrosinase

Human tyrosinases are glycoproteins which are membrane bounded and their monomers have more than one isoforms. Similarly tyrosinases from bacteria like *Streptomyces* species have non-modified monomers of MW 30KDa (Wu et al., 2010).

Tyrosinase Sources

Tyrosinase can be produced and extracted through number of organisms such as bacteria, fungi, plants and mammals (Table 1). Tyrosinases can be purified from these sources and studied for specific functioning.

Table 1: Sources of Tyrosinase

Sources	Species	References
Bacteria	<i>Rhizobium</i> ,	Liu et al.,2005;
	<i>Symbiobacterium thermo-</i> <i>philum</i> ,	Claus & Decker, 2006;
	<i>Pseudomonas maltophilia</i> ,	McMahon et al., 2007.
	<i>Sinorhizobium meliloti</i> ,	
	<i>Marinomonas mediterranea</i> ,	
	<i>Thermomicrobium roseum</i> ,	
	<i>Bacillus thuringiensis</i> ,	Matobaet al., 2006.
	<i>Pseudomonas putida</i>	
	<i>Streptomyces castaneoglo-</i> <i>bisporus</i> ,	
	<i>Ralstoniasolana cearum</i> ,	
<i>Verrucomicrobium spino-</i> <i>sum</i>		

Fungi	<i>Agaricus bisporus</i>	Strothkampet al., 1976.
	<i>Neurospora crassa</i>	Lerch K. 1983.
	<i>Amanita muscaria</i>	Mueller et al., 1996.
	<i>Lentinula edodes</i>	Kanda et al., 1996.
	<i>Aspergillus oryzae</i>	Nakamura et al., 2000.
	<i>Portabella mushrooms</i>	Halaouliet al., 2005.
	<i>Pycnoporussanguineus</i>	Halaouliet al., 2005.
Plants	Monastrell grape	Janovitz-Klappet al., 1989.
	Apple	Janovitz-Klappet al., 1989.
	Sunflower seed	Janovitz-Klappet al., 1989.
	Solanum melongena	Raymond et al., 1993.
	<i>Portulaca grandiflora</i>	Lee et al., 1997. Rani et al., 2007

Purification methods for Tyrosinases:

Natural enzymes are difficult to purify so as tyrosinases are also show low degree purification as these are natural enzymes. The most common methods used for purification of tyrosinases are by using ammonium sulfate, calcium salt or acetone precipitation (Mueller et al., 1996). By varying ammonium sulfate concentration the purification can be optimized as in some studies concentration varies from 35% to 70% (Kamahldin et al., 2004). For tyrosinases purification different columns like DEAE-cellulose (Fan and Flurkey, 2004) or size exclusion gel can also be performed (Wichers et al., 1996).

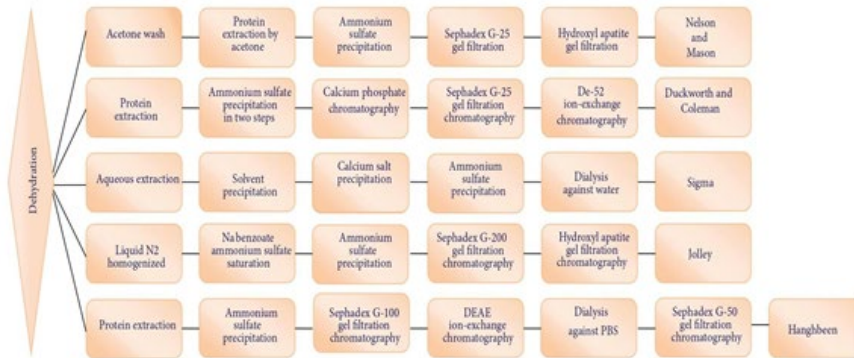


Figure 2: Methods for the purification of tyrosinase. Adopted from (Zaidi et al., 2014).

Applications in Different Industries:

Medical/Clinical Applications:

Tyrosinase is involved in the biosynthesis of melanin in the melanosomes causing pigmentation of skin, hair and eyes in mammals providing the protection against UV (Ando et al., 2007). The enzyme plays a crucial part in immune response (primary) and healing of wound in plants, various invertebrates as well as sponges. It is significant for spore forming, protecting tissues and survival after some lesion or injury in fungi. It has a vital part in protection of bacteria. The enzyme has important medical applications including melanin synthesis for therapeutic purposes, L-DOPA production, a drug utilized to treat the Parkinson's disease, manufacturing antibiotic lincomycin and treating various neurological diseases (Valipour& Burhan, 2016). Mushroom tyrosinase has clinical application to treat vitiligo (Seo et al., 2003).

Food Industry

This enzyme produce hydroxyl tyrosol that has application of food additive. This is employed in the food manufacturing industries, for instance to make theaflavins, a collection of compounds in black tea possessing anticancer and other properties (Valipour& Burhan, 2016). Biopolymers are being developed by the food industries that possess particular properties. They have functions

al., 2004). The properties of meat like capability of gel formation, textural and binding properties are vital to manufacture various meat products. The gelation of muscle proteins induced by the heat is serious in the processing of meat as it determines the texture of final product. So cross linking enzymes are exploited to tailor these gelation properties. Enzymes like transglutaminase, laccase and tyrosinase have recently been used to test for pork and chicken proteins (Selinheimo, 2008).

Phenol decontamination using Tyrosinase

Various industries like paper, chemical, textile, mining, coal and petroleum produce wastewaters that consist of the phenols and its derivatives. Tyrosinase is capable of oxidizing the phenols into insoluble substances that can be eliminated by precipitating or filtering them (Faria et al., 2007). Phenolic compounds present in aqueous solutions can be eradicated by adsorbing them onto the granular activated carbon or cloth (Brasquet et al., 1999). As tyrosine is detoxifying agent of xenobiotics having phenol structure, so among them, chlorophenols are specific contaminants present in wastewater (Marino et al., 2011). The industries such as leather, textile, pharmaceutical and paper, generate different dyes mostly azo dyes, which are a dangerous to environment. Under certain conditions, they are decolorized by bacteria and then degraded by the tyrosinase (Saratale et al., 2011). Mechanism

Fields	Applications	References
Food industry	In cereal processing, to improve the baking in order to make better the volume and crumb structure of breads.	Facio, 2011
Food industry	In dairy processing, to cross link various dairy proteins	Selinheimo, 2008
Food industry	In meat processing, for improvement of the gelation.	Selinheimo, 2008
Medical fields	As prodrug, in immunoassays and antibody microarrays, to produce L-DOPA and to treat neurological problems.	Selinheimo, 2008; Valipour& Burhan, 2016; Zaidi et al., 2014
Textile industry	To modify the wool fibres and production of different dyes.	Selinheimo, 2008; Valipour& Burhan, 2016
Cosmetic industry	As a self tanning agent.	Selinheimo, 2008; Valipour& Burhan, 2016
Environmental significance	As biosensors to detect the toxic phenolic compounds.	Selinheimo, 2008; Singh N. & Singh J., 2002

as emulsifiers and to manufacture less fat and less calorie foods. Natural polymers can be cross linked to produce new polymers using mushroom tyrosinase (Faria et al., 2007). They form cross links on the basis of accessibility and abundance of target protein. Modifications in the properties are very important for use in various fields like food processing (Heck et al., 2012). The enzyme can be used for grafting of specific compounds to biopolymers and yielding novel bioproducts. Tyrosinase provides an easy method in the conversion of byproducts of food processing to environmentally favorable items with valuable functional characteristics (Aberg et

al., 2004). The properties of meat like capability of gel formation, textural and binding properties are vital to manufacture various meat products. The gelation of muscle proteins induced by the heat is serious in the processing of meat as it determines the texture of final product. So cross linking enzymes are exploited to tailor these gelation properties. Enzymes like transglutaminase, laccase and tyrosinase have recently been used to test for pork and chicken proteins (Selinheimo, 2008).

Conclusion:

As there is a great demand for different enzymes in the industries, tyrosinase is one of significant commercial enzymes. Microbial tyrosinases are highly promising enzymes for the pharmaceutical and food bioprocessing technologies. However, to use these microbial tyrosinases to fulfill their industrial potential, further research is needed to be carried out.

Conflict of interest:

No conflict of Interest

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