1. What is the significance of this research topic?

Ancient Egyptians (7000 BC) used enzymes in the production of bread, yogurt, and cheese. Our own body produces enzymes to facilitate digestion. Enzymes are specialized proteins acting as catalysts to speed up biochemical reactions or specificity of metabolic reactions. They show up in a wide range of applications including production of beverages, infant foods, fish meal, cheese and dairy product, sweeteners, chocolate syrups, bakery products, fruit juice, soft drinks, vegetable oil, candy, in short, they are omnipresent in the food industry. first the production of enzymes has been from selected strains, derived from a small number of microorganisms primarily B. subtilis, B.licheniformis, A.niger and A.orizae. New type of strains has been added, such as E. coli K-12, F.venenatum, and P.fluorescens.

As the food processing industry became more complex, the demand for efficient production of enzymes with well-charactered characteristics increased. In response, improved recombinant DNA techniques and developments in biotechnology, such as protein engineering and directed evolution, revolutionize the commercialization of enzymes. And today most enzymes are recombinant enzymes. In 2021, the industrial enzyme market has been valued at over USD 6Millions.

The microorganisms, used for the recombinant strains, are recognized as nonpathogenic, but research is still on going to study whether they are nontoxigenic. It has been established that A.niger, A.orizae, and F.venenatum, may produce low levels of toxic secondary metabolites. In addition, several host microorganisms produce different extracellular enzymes which can degrade produced enzymes, with undesirable reactions in food. The toxicologic potential risks presented by the host strains are:

* ***Bacterial host strains:***
* Bacillus subtilis and similar bacteria: the wild-type (WT) of Bacillus species can sporulate or produce extracellular proteases which can degrade the enzyme protein.
* Escherichia coli K-12 and P.fluorescens can accumulate heterologous inclusion bodies which are eliminated during the purification process.
* ***Fungal host strains:***
* certain strains of A.oryzae can produce low-levels of mycotoxins with low-to-moderate toxicity. Strain A1560 has shown to produce low levels of various acids (3-β- nitroproprionic acid, koji acid, and cyclopiazonic acid) under inducing conditions.
* Some A.niger strains produce several mycotoxins (ochratoxin) and secondary metabolites under specific fermentation conditions (nigragillin, nigerazine B, malformins, naphto-γ-pyrones, and oxalic acid).
* Strain A3/5 from Fusarium venenatum can produce mycotoxins (trichothecenes, culmorins, and fusarins, and enniatin B).
* Trichoderma reesei is used in baking and alcohol production. A. strain of T.reesei produced two metabolites, one identified as trichothecene mycotoxin.

Advances in molecular biology, such as expression vectors or cassettes, have allowed to create more efficient and safer enzymes from production strains with the development of DNA insertion techniques which do not affect secondary metabolite pathways.

2. Who is working in this area?

<http://fhalab.caltech.edu/>

<https://enzymeresearch.com/>

https://www.businesswire.com/news/home/20190719005244/en/Top-5-Vendors-in-the-Global-Molecular-Biology-Enzymes-Kits-and-Reagents-Market-2019-2023-Technavio

3. What methods are used to study the concepts described in the paper?

4. Does the review article lead to new questions or hypotheses in this technical area (by the authors, by other researchers)?

5. What are some practical applications of the research discussed in the article?

6. How does this topic relate to other areas of cell biology, bioengineering, or medicine?