Microbial Bioconversion of Poultry Waste: Value added Products

Shivani Ojha¹, Sandip T. Gaikwad²*, Tejas Suthar³ and Abhishek Gavane⁴
¹,²,³,⁴MIT College of Food Technology, MIT ADT University, Pune, Maharashtra 412201
*Corresponding Author E-mail: gaikwad1204@gmail.com
Received: 5.01.2020 | Revised: 2.02.2020 | Accepted: 6.02.2020

ABSTRACT
The significant development of poultry sector has brought about an expanded pace of waste delivered from generations from both commercial and conventional/traditional sectors. The poultry meat handling has brought about immense amounts of strong waste, for example, quills, offal, visceral organs, blood, litter and dead winged animals. In this way, a fascinating methodology has been created for the use of these squanders utilizing the technology of microbial bioconversion. These compounds can be utilized to change over poultry wastes into helpful feed and composts. The poultry result hydrolysates show potential for being utilized as a utilitarian fixing as a result of age of bioactive substances, which are significant particles that may apply physiological impacts. Consequently, an outline on helpful microbial proteins for the bioconversion of poultry squander, for example, lipases, proteases, consolidated catalyst arrangements and keratinases for the bioconversion of "quills" has been proposed. A point by point depiction on cleansing, properties of keratinases and its generation is being reviewed.

Keywords: Microbial bioconversion, Quills/feathers, Keratinase enzyme, By-products.

INTRODUCTION
The poultry ventures in India are the rapid developing sectors of this era. Poultry meat and eggs are among the creature source nourishments most generally eaten at worldwide level, across extraordinarily differing societies, customs and religions. Poultry meat and eggs add to human sustenance by giving top notch protein and low degrees of fat, with an alluring unsaturated fat profile (Sims & Wolf, 1994, Kim et al., 2001). It will be unmistakably legitimized by observing the development pace of yield area at 1.5-2% once every year, though, for eggs and boilers it's at 8-10% once per year (Han et al., 2000). India positions fifth in egg delivering countries (Magbanua et al., 2001) and eighteenth in boiler’s production (Shih, 1993). Poultry division in India has experienced a change in outlook and change from simple backyard rearing to a significant business part in only a brief span (Ramzan et al., 2011).

Private segments and government support have led to the development of poultry in India (Agrahari & Wadhwa, 2010, Simpson, 1991).

The more up to date methods have expedited a more noteworthy impact this part. Systems, for example, hereditary building, hybridisation, invigorated feeds, better types of gear, veterinary help are the main considerations answerable for the development. India is among the not many countries that has brought the SPF (Specific Pathogen Free) in egg generation (Atuanya & Aigbirior, 2002). The critical zones for poultry ventures lies within the southern zones of the country. States like Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala are significantly contributing in this area. Poultry industry alone contributes around 26,000 Crore to the country’s economy (El Boushy & Van der Poel, 2013, Arshad et al., 2018, Topal et al., 2018).

In coming years, the pace of production and utilization of poultry will increase because of evolving ways of life, changing eating patterns, moving to urban lifestyle, inclining towards solid and adjusted eating routine. Poultry utilization is about 62% in 10 significant urban areas and the rest originates from rural areas of the nation (Mushtaq et al., 2019).

As per ICRA examination, India remains overwhelmingly a live fledgling sector with near 90% of poultry deals being done at conventional stores given buyer inclination for newly cut bird. Along these lines’ poultry preparing, is still at a beginning stage with under 10% income share (Cavalaglio et al., 2018; Dornelas et al., 2017). However, it keeps on enrolling twofold digit development driven by great financial factors. Huge integrators keep on putting resources into creating framework.

**Types of Poultry Waste**
The quick development of poultry part brings about immense measure of waste that should be managed. Primary poultry squander incorporates feathers, litter, bones, blood, offal that contains different sorts of drug residues and certain levels of microflora (Kopeć et al., 2018; Shah et al., 2019).
Poultry butchering waste comprises 34.2% dry matter. It thus contains 51.8% unrefined protein, 41.0% fat, and 6.3% ash content. Current techniques utilized for conversion of poultry squander into useful by-products involves techniques such as use of microbial enzymes for bioconversion, anaerobic treatment for methane gas formation, bio fuel production, thermal decomposition, burning or incineration, vermicomposting, and recycling poultry waste into value added products (Bhati & Mallick, 2016).

**Table 1: Poultry waste and protein concentration**

<table>
<thead>
<tr>
<th>POULTRY WASTE</th>
<th>PROTEIN CONCENTRATION (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feathers and meal</td>
<td>80-90%</td>
</tr>
<tr>
<td>Blood and meal</td>
<td>65-80%</td>
</tr>
<tr>
<td>Bones</td>
<td>20-25%</td>
</tr>
<tr>
<td>Visceral organs</td>
<td>10-15%</td>
</tr>
<tr>
<td>Offal</td>
<td>10-15%</td>
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- **Feather**
  Poultry sectors produce a great deal of waste such as feathers which are considered as waste and should be superintended appropriately. Poultry quills contains keratin protein and along these lines they could be serve as a good nitrogen compost. Composition of feather is as follow:
  - Keratin protein-91%
  - Lipid-1%
  - Water-8%

**Keratin Protein:**
  The major portion of feathers is composed of keratin (90%) which is additionally a key auxiliary component in different organs. Keratin has a fibrous structure and exists broadly in ecosystem. It is 3rd unmanageable basic protein after cellulose and chitin present in great amount in nature. Keratin protein is insoluble in any type of solvent whether it is water or any other organic solvent so it becomes a tough task to degrade it using common proteolytic enzymes (Qian et al., 2018).

**Keratin can be divided into:**
  - Soft Keratin- with cysteine level under 10% present mostly in skin epidermis.
  - Hard Keratin- with cysteine level 10–14% present widely in hooves, nails, paws of birds and animal and hair.
In spite of the fact that the idea of keratin-rich squanders, for example, feathers are impervious to debasement by basic proteases, keratins are not aggregated in nature, recommending that they are degraded by microorganisms. Studies have indicated that numerous microorganisms can debase such squanders by discharging keratinolytic and proteolytic compounds such as keratinases (Adeoye et al., 2017).

Legitimate treatment of feather may be an ecological agreeable strong waste administration device and a decent wellspring of N-rich natural compost. Feather constitutes about 5-10% of the total body weight of birds. Such a huge quantity of feather has been making a big waste issue everywhere throughout the world. Transfer techniques, for example, burning (cause air contamination). Meal from feather is manufactured in various subcontinents as the administration system of poultry feather squander chemical treatments or thermal treatment. Feather meals are promptly accessible at low cost and is considered as rich source of nitrogen (up to 15%). Regardless of whether it is new or dried, it acts as profitable bio-fertilizer and utilized as compost and in land filling. Feathers contain good amount of keratin proteins and amino acids, thus can be changed over into important N-rich natural compost. Feather meal production takes place by applying high pressure and high temperature conditions (Aniza et al., 2016; Mariyammal et al., 2018). Feathers can have multiple usage such as;

- Feather meal
- Fancy items
- Insulating material
- Quilt stuffing
- Fertilizers
- Sports
- Compost

Hatchery waste

Hatchery waste includes all types of waste including shells of eggs, infertile eggs, unhatched eggs, dead as well as winnowed chicks. It constitutes about 5-7% of the absolute waste. Hatchery waste can be utilized to prepare by products meals. It additionally contains a decent measure of calcium content in it which can be used to plan calcium rich nourishments for calcium lacking individuals (Gurav et al., 2016).

**Blood**

Blood is also a waste and is drained of after slaughtering of birds. It constitutes about 3-3.7% of the live body weight of poultry birds, it contains good amount haem proteins and iron (Vats et al., 2019). It can be utilized to manufacture various substances which can be edible items as well as non-edible products (Baba et al., 2018).

Edible/food grade products involves;

- Blood meals
- Blood sausages
- Blood pudding
- Blood curd
- Blood cakes
- Blood biscuits and breads

Non edible products involve;
- Binding agents
- Fertilizers
- Feed stuffs
- Emulsifier
- Stabilizer
- Colour additives

**Poultry Litter**

Litter is poultry waste product that consists of mainly urine, faeces etc. It can cause environmental issues such as water, land and air contaminations. It may contain several microflorae that may cause severe illness if consumed by humans or animals. Birds additionally aggregate different levels of drugs residue, heavy metals and artificial compounds that are incorporated in their feed for wholesome and pharmaceutical purposes (Gündüz et al., 2019). It is a significant organic manure added to soil that provides plants with various supplements, such as, N, P and K. Litter deposits edit the soil profile by improving water-holding limit and improve soil aeration, moisture content, water infiltration rate and drainage system. In any case, one of the primary dangers identified with this technique is the disproportion of N and P levels in the fertilizer (Atuanya & Aigbirior, 2002). These two supplements vary according to different varieties of crops grown.
Poultry manure can also be used to prepare methane gas as a source of energy.

Offal

The internal instinctive organs and guts of the butchered poultry feathered creatures are referred as offal. They include organs such as lungs, liver, stomach, intestine, brain, heart, pancreas, blood, testicles, kidney etc. Treated offal is generally high in protein and can be blended in with different ingredients to create a reasonable creature feed and pet nourishments/pet food (Gündüz et al., 2019). It is also consumed in various nations as a part of their delicacy and considered as nutritious. It contains good amount of several nutrients and is also high in calories. Gizzard, head, offal, blood etc. all are a part of poultry waste that need to be properly treated and re-utilized to minimise the load of waste on our environment.

I. Microbial Enzymes

Enzymes are biological catalyst that are liable for different bio-synthetic responses and other metabolic exercises inside the body. The essential wellspring of enzymes are microorganisms. Microorganisms duplicate quickly in an extremely brief span and can be genetically engineered according to the alluring compound. Moreover, the microbial compounds have been given more consideration because of their dynamic and stable nature than chemicals from plants and animals (Babich et al., 2018). A few tests and studies are being led on detaching new types of microscopic organisms such as bacteria, yeasts, fungi and their procurement from harsh conditions to give better assortment and better yield.

Microbial enzymes can be of different types such as Thermophilic (works at higher temperatures), Acidophilic (works at lower/acidic pH conditions), Alkalophilic (works at alkaline pH conditions). Breakthrough in enzymes obtained from microbes, opens the door for improvement of low vitality devouring advances that can be utilized for the bio transformation of poultry waste into useful finished products. Enzymatic procedures might be helpful to reuse waste rich in protein released by poultry industry, along these lines securing nature by decreasing wastage (Atuanya & Aigbirior, 2002). The significant catalysts for bio transformation of poultry squander are normally proteases and keratinases with the ability to process proteins into simpler substrates.

![Fig. 3: The process of bioconversion via microbes](image)

**Fig. 3: The process of bioconversion via microbes**

**Enzymes with industrial importance:-**
- **Protease**- Also known as peptidase, breaks down proteins into simpler peptides or amino acids.
- **Keratinase**- A type of proteolytic enzymes that decomposes keratin present in hair, feathers, nails, collagens etc.
- **Amylase**- Enzyme responsible for breakdown of starch into sugars. It is used for various purposes in industries such as saccharification of starch.
- **Xylanase**- It is responsible for catalytic breakdown of hemicellulose. It converts the polysaccharide into xylose.
- **Ligninase**- Enzyme responsible for degradation of lignin.
- **Cellulase**- Several microbes such as fungi, bacteria produce this enzyme for the breakdown of cellulose.
- **Lipase**- It is enzyme responsible for hydrolysis of triglycerides/lipids/fats into its simpler forms of fatty acids and glycerol.
- **Pectinase**- The action of breakdown of pectin by de-esterification is done by pectinase enzyme.
I Biochemical conversion of Feathers by microbial enzyme- Keratinase

Keratinase is alluding to a type of proteases which have keratinolytic properties. As keratinases can terminate insoluble and unmanageable keratins obtained from keratin-rich squanders, for example, hair, feathers and fleece, they have incredible capability of modern applications (Simpson, 1991). Keratinase can be utilized in a few fields including manures, cowhide enterprises, biomedical fields, cleansers, beautifying agents and animal feed. Keratinases displayed movement under temperatures running from 28-90°C or considerably higher. The catalysts could likewise continue its movement at pH range of 5 to 13. Concentrates likewise uncovered that the proteins from bacteria, yeast and fungi display higher ideal temperature, which offers ascend to high proficiency in keratin breakdown. For the cloning of Keratinase enzyme's gene, the technique utilized is recombinant DNA technology (Rajesh et al., 2019).

The reusing of feathers is a subject of interest as a result of its potential as a reasonable and elective protein feed. Hydrothermal debasement of quills changes over this material in a progressively digestible feather feast however leads to misfortune losses of basic amino acids. Subsequently, biotechnological approaches for utilizing microorganisms and their keratinolytic chemicals to redesign dietary benefits of feathers as supplements for feed without any loss of essential amino acids.

Microorganisms such as Bacillus licheniformis, Bacillus pumilus, Microsporum fulvum, Paecilomyces marquandii, Chryseobacterium spp. are utilized for obtaining keratinase enzyme. Feather wastes obtained from poultry sectors are biologically converted with the assistance of keratinase enzyme obtained from microbes (Han et al., 2000; Yurdakul, 2016). These feathers are then hydrolysed by keratinolytic compounds present in the catalyst to obtain raw form of hydrolysates that can be later utilized as improved feeds with better nutritional characteristics and as soil manures. These hydrolysates again can be utilized to fractionate bioactive peptide divisions for introducing cell reinforcements and obtaining antioxidants.

Keratinase enzyme can be produced using two major techniques that are using shake flask method and industrial level fermentation. After its production, the next major step is its purification. For the purification of keratinase enzyme several techniques like (NH₄)₂SO₄ precipitation, dialysis, propanone/acetone precipitation, gel filtration, ultrafiltration and ion exchange methods are employed (Desai et al., 1994).

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<thead>
<tr>
<th>TECHNIQUE</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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<tbody>
<tr>
<td>Precipitation with salt</td>
<td>Simple</td>
<td>May cause enzyme denaturation</td>
</tr>
<tr>
<td></td>
<td>Low cost</td>
<td>Dialysis is required</td>
</tr>
<tr>
<td></td>
<td>Less labour</td>
<td>Low resolution</td>
</tr>
<tr>
<td>Ultrafiltration technique</td>
<td>Simple technique</td>
<td>Costly membranes</td>
</tr>
<tr>
<td></td>
<td>Minimize denaturation</td>
<td>Low resolution technique</td>
</tr>
<tr>
<td></td>
<td>Easy to scale up</td>
<td>Membrane fouling</td>
</tr>
<tr>
<td>Gel filtration technique</td>
<td>High resolution technique</td>
<td>Slow process</td>
</tr>
<tr>
<td></td>
<td>Desalination</td>
<td>Costly process</td>
</tr>
<tr>
<td>Ion exchange chromatography</td>
<td>Good protein binding capacity</td>
<td>Costly process</td>
</tr>
<tr>
<td></td>
<td>Easy to scale up</td>
<td>Less output as compared with non-chromatography techniques</td>
</tr>
<tr>
<td></td>
<td>High resolution technique</td>
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CONCLUSION

Waste generated from poultry industry is one of the significant poisons if not appropriately treated and disposed of. Feathers can be dealt artificially or naturally with organisms to improve their nutritive estimation which can be utilized as feed, fertilizer and other useful products. They can likewise be naturally changed over into feed supplements, biofuel, and biodegradable plastic and natural compost. The manure prepared from feathers are utilized as soil conditioner or compost. Methane gas can be delivered from poultry litter and changed into power utility. Through and through, squanders from poultry can be viably used if appropriately treated to decrease the harmful impacts and a scope of significant value-added products can be delivered.

REFERENCES


