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Review Article

Microbial Bioconversion of Poultry Waste: Value added Products

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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).

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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.

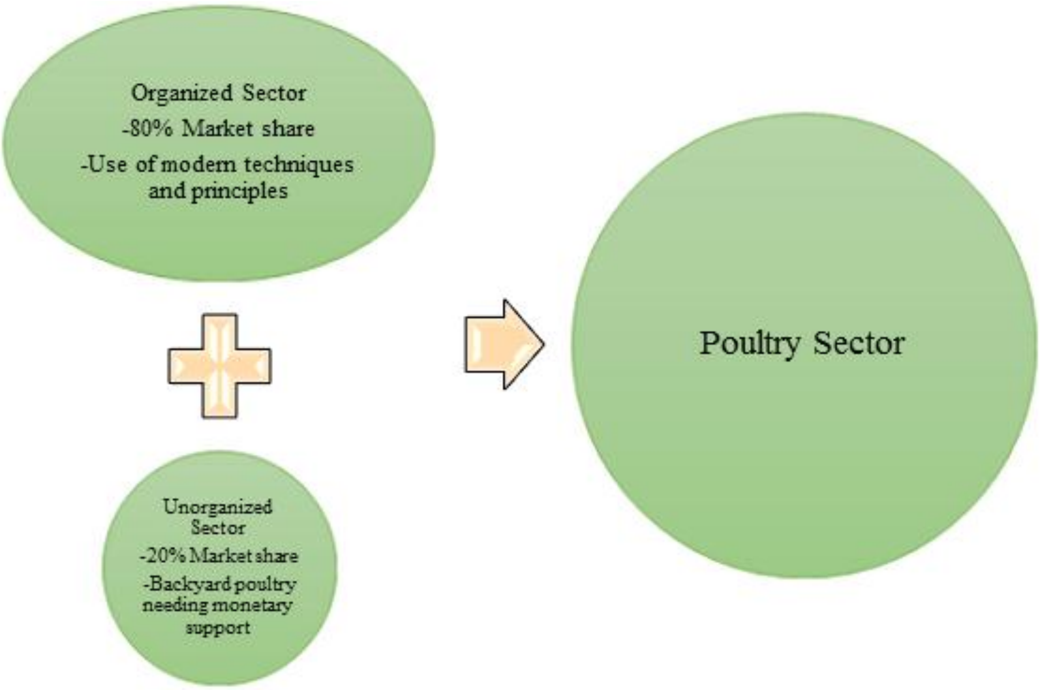

Fig. 1: Poultry Sector

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).

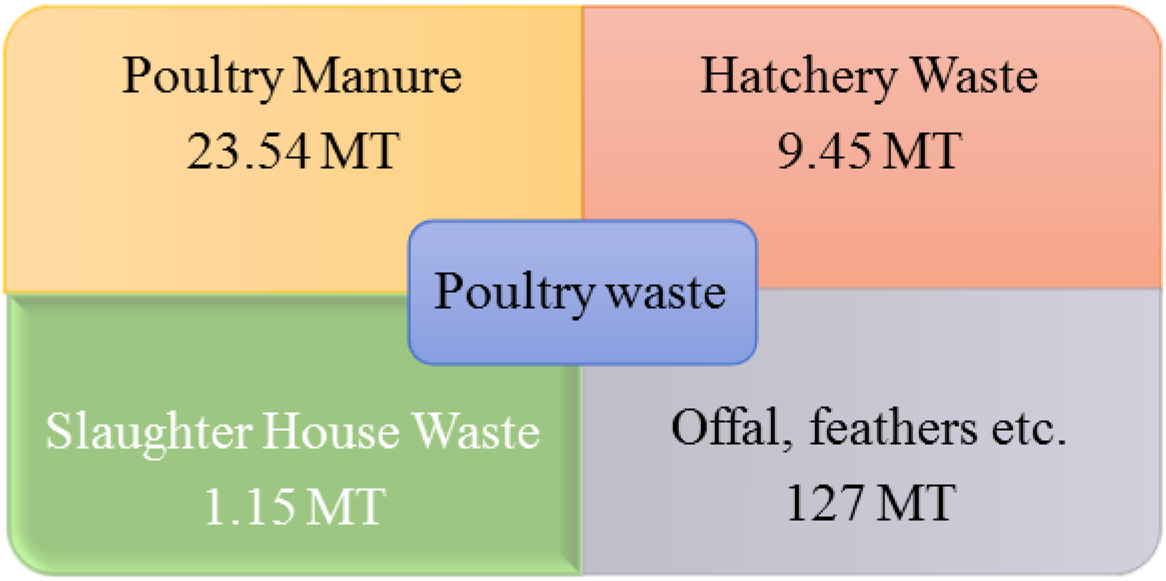

Fig. 2: Poultry waste

Poultry butcher waste comprises of 34.2% dry matter. It thus contains of 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

POULTRY WASTE	PROTEIN CONCENTRATION (%)
Feathers and meal	80-90%
Blood and meal	65-80%
Bones	20-25%
Visceral organs	10-15%
Offal	10-15%

- **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.

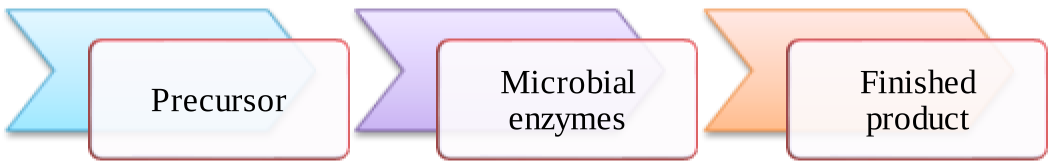

Fig. 3: The process of bioconversion via microbes

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 $(NH_4)_2SO_4$ precipitation, dialysis, propanone/acetone precipitation, gel filtration, ultrafiltration and ion exchange methods are employed (Desai et al., 1994).

Table 2: Advantages and disadvantages of techniques

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

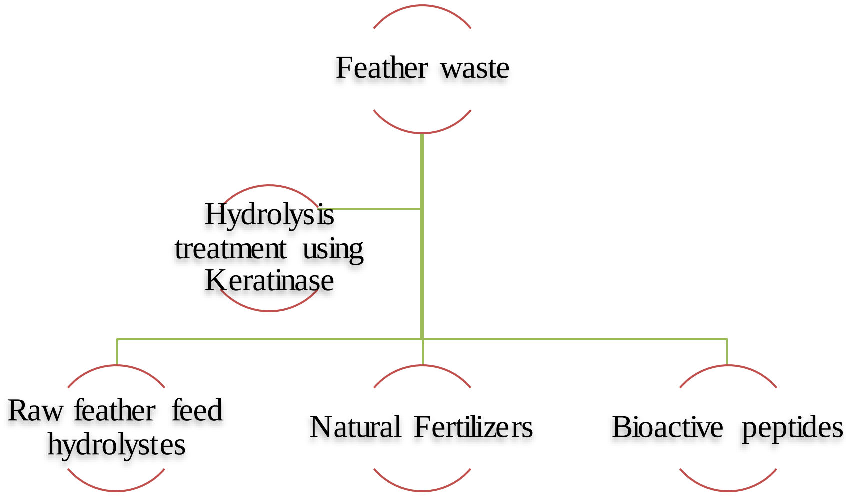

Fig. 4: flowchart of conversion feather waste into useful products

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

Adeoye, P. A., Man, H. C., Soom, M. A., Thamer, A. M., & Oluwakunmi, A. C. (2017). Contaminants Leaching from Fresh Poultry Waste: A Lysimeter Study on Sandy Soils under Tropical Conditions. *Environment and Pollution*, *6*(1), 38-51.

Agrahari, S., & Wadhwa, N. (2010). Degradation of chicken feather a poultry waste product by keratinolytic bacteria isolated from dumping site at Ghazipur poultry processing plant. *Int J Poult Sci*, *9*(5), 482-489.

Antonov, A., Ivanov, G., & Pastukhova, N. (2019, June). The Poultry Waste Management System. In *IOP Conference Series: Earth and Environmental Science* (Vol. 272, No. 2, p. 022050). IOP Publishing.

Aniza, N., Hassan, S., & Inayat, M. (2016). Thermogravimetric kinetic analysis of Malaysian poultry processing waste material under inert and oxidative atmospheres. *J. Mech. Eng. Sci*, *10*(2), 1943-1955.

Arshad, M., Bano, I., Khan, N., Shahzad, M. I., Younus, M., Abbas, M., & Iqbal, M. (2018). Electricity generation from biogas of poultry waste: An assessment of potential and feasibility in Pakistan. *Renewable and Sustainable Energy Reviews*, *81*, 1241-1246.

Atuanya, E. I., & Aigbirior, M. (2002). Mesophilic biomethanation and treatment of poultry waste-water using pilot scale UASB reactor. *Environmental monitoring and assessment*, *77*(2), 139-147.

Awasthi, M. K., Pandey, A. K., Bundela, P. S., Wong, J. W., Li, R., & Zhang, Z. (2016). Co-composting of gelatin industry sludge combined with organic fraction of municipal solid waste and poultry waste employing zeolite mixed with enriched nitrifying bacterial consortium. *Bioresource technology*, *213*, 181-189.

Baba, I. A., Banday, M. T., Khan, H. M., Sheikh, I. U., & Adil, S. (2018). Seed germination/phytotoxicity of end product fermentation of poultry farm waste.

Babich, O., Sukhih, S., Prosekov, A., Ulrikh, E., & Lukin, A. (2018). Selection of Modes of Poultry Waste Conversion into Biofertilizer. *Journal of Pharmaceutical Sciences and Research*, *10*(7), 1768-1771.

Bhati, R., & Mallick, N. (2016). Carbon dioxide and poultry waste utilization for production of polyhydroxyalkanoate biopolymers by Nostoc muscorum Agardh: a sustainable approach. *Journal of applied phycology*, *28*(1), 161-168.

Cavalaglio, G., Coccia, V., Cotana, F., Gelosia, M., Nicolini, A., & Petrozzi, A. (2018). Energy from poultry waste: An Aspen Plus-based approach to the thermo-chemical processes. *Waste Management*, *73*, 496-503.

Desai, M., Patel, V., & Madamwar, D. (1994). Effect of temperature and retention time on biomethanation of cheese whey-poultry waste-cattle dung. *Environmental Pollution*, *83*(3), 311-315.

Dornelas, K. C., Schneider, R. M., & Do Amaral, A. G. (2017). Biogas from poultry waste—production and energy potential. *Environmental monitoring and assessment*, *189*(8), 407.

El Boushy, A. H., & Van der Poel, A. F. (2013). *Handbook of poultry feed from waste: processing and use*. Springer Science & Business Media.

Gündüz, S., Aslanova, F., & Abdullah, K. S. (2019). Poultry Waste Management Techniques in Urban Agriculture and its Implications: A Case Study of Tripoli, Libya. *Ekoloji Dergisi*, (107).

Gurav, R. G., Mirajkar, D. B., Savardekar, A. V., & Pisal, S. M. (2016). Microbial degradation of poultry feather biomass by Klebsiella sp. BTSUK isolated from poultry waste disposal site. *Res. J. Life Sci. Bioinform. Pharm. Chem. Sci*, *1*, 279.

Han, F. X., Kingery, W. L., Selim, H. M., & Gerard, P. D. (2000). Accumulation of heavy metals in a long-term poultry waste-amended soil. *Soil Science*, *165*(3), 260-268.

Kim, J. M., Lim, W. J., & Suh, H. J. (2001). Feather-degrading Bacillus species from poultry waste. *Process Biochemistry*, *37*(3), 287-291.

Kopeć, M., Gondek, K., Mierzwa-Hersztek, M., & Antonkiewicz, J. (2018). Factors influencing chemical quality of composted poultry waste. *Saudi journal of biological sciences*, *25*(8), 1678-1686.

Magbanua Jr, B. S., Adams, T. T., & Johnston, P. (2001). Anaerobic codigestion of hog and poultry waste. *Bioresource technology*, *76*(2), 165-168.

Mariyammal, P., Ezhilarasu, A., Karthy, E. S., & Menaga, D. (2018). Purification and characterization of novel extracellular keratinase enzyme from poultry feather waste. *Int J Curr Res Life Sci*, *7*, 1018-1024.

Mushtaq, M., Iqbal, M. K., Khalid, A., & Khan, R. A. (2019). Humification of poultry waste and rice husk using additives and its application. *International Journal of Recycling of Organic Waste in Agriculture*, *8*(1), 15-22.

Qian, X., Lee, S., Soto, A. M., & Chen, G. (2018). Regression model to predict the higher heating value of poultry waste from proximate analysis. *Resources*, *7*(3), 39.

Ramzan, N., Ashraf, A., Naveed, S., & Malik, A. (2011). Simulation of hybrid biomass gasification using Aspen plus: A comparative performance analysis for food, municipal solid and poultry waste. *Biomass and Bioenergy*, *35*(9), 3962-3969.

Rajesh, S., Premkumar, R., & Neethipathi, J. (2019). Relative Effectiveness of Methane (Biogas) Production from Dry Grass Soaked With Vegetable Waste, Poultry Waste and Cow Dung. *Oriental Journal of Chemistry*, *35*(2), 732-737.

Sims, J. T., & Wolf, D. C. (1994). Poultry waste management: Agricultural and environmental issues. In *Advances in agronomy* (Vol. 52, pp. 1-83). Academic Press.

Shah, F. A., Rashid, N., Mahmood, Q., & Ali, A. (2019). Effect of Pretreatment and Substrate Ratios in Biorefinery Employing Co-digestion of Plant Biomass and Poultry Waste. *Frontiers in Energy Research*, *6*, 143.

Shih, J. C. (1993). Recent development in poultry waste dizgestion and feather utilization—a review. *Poultry science*, *72*(9), 1617-1620.

Simpson, T. W. (1991). Agronomic use of poultry industry waste. *Poultry Science*, *70*(5), 1126-1131.

Topal, H., Taner, T., Altınsoy, Y., & Amirabedin, E. (2018). Application of trigeneration with direct co-combustion of poultry waste and coal a case study in the poultry industry from Turkey.

Vats, N., Khan, A. A., & Ahmad, K. (2019). Anaerobic co-digestion of thermal pre-treated sugarcane bagasse using poultry waste. *Journal of Environmental Chemical Engineering*, *7*(5), 103323.

Yurdakul, S. (2016). Determination of co-combustion properties and thermal kinetics of poultry litter/coal blends using thermogravimetry. *Renewable Energy*, *89*, 215-223.