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Role of Fungi in Biomethanation Process

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Abstract

Huge amounts of fibre-rich organic waste material from the public green and private gardens have to be treated environmentally friendly; however, this fibre-rich biomass has low biogas yields. This review study assessed the presence of several fungi like Neocallimastigales, Aspergillusetc in full-scale biogas plants as well as in laboratory reactors and elucidated the importance of fungi for the biogas process.

Keywords: -*Neocallimastigales, Aspergillus, fungi, biogas*

INTRODUCTION

Anaerobic fungi particularly belonging to the phylum Neocallimastigomycota, are the most basal lineage of the kingdom Fungi. These fungi are principally known from the digestive tracts of the larger mammalian herbivores, where they play an inevitable role as primary colonisers of ingested forage. Recent researches indicate their appearance in herbivorous reptiles like the green iguana and termites also.

Anaerobic fungi are characterized by the several distinctive traits which stem from their obligatory anaerobic physiology; mitochondria, cytochromes and the other biochemical features of the oxidative phosphorylation pathway are absent. Energy generation occurs in the hydrogenosomes where ATP is formed by the malate decarboxylation to form acetate, CO2, and H2 (Bougrier et al., 2007).

The Neocallimastigales are fungi that do not typically require molecular oxygen for any of their physiological processes, and for which the presence of oxygen is toxic.

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This trait raises the questions how anaerobic fungi defend themselves against the toxic effects of oxygen, for instance when colonizing the freshly ingested forage or during dispersal between host animals. Respective in sights are presented in the following sections ―life cycle‖. Additionally, their genomes are peculiar having the highest AT-content hitherto found (often exceeding 91 % in non-coding regions) and with a substantial expansion of important hydrolytic and cellulolytic gene families (Climent et al., 2007).

Anaerobic Fungi and Their Interactions with the Methanogens and Bacteria Close allied of anaerobic fungi with methanogens is well known, with inter-species hydrogen transfer paving to both methane production and also more efficient re-generation of oxidized nucleotides (NAD+, NADP+). Syntrophicco-cultivation markedly aggrandizes fungal growth rate, with increased rates of cellulolys is and xylanolysis, consequently copiousing dry matter reduction(Nah et al.,2000).However the anaerobic fungus—methanogen interaction is more ramified than simple cross-feeding.

INTERACTION OF MICROBES

Hydrogen transfer also influences the fungal catabolic pathways and specific enzyme profiles, shifting fungal product formation away from the more oxidized end products (lactate, ethanol) towards production of more decreased products (acetate, formate) (Tanaka et al.,2002). Acetate, and in the rumen especially formate, are the preferred growth substrates for the methanogens.

This interaction is so pivotal, that some species of the anaerobic fungi cannot be isolated as axenic cultures, but only in combination with the permanent archaeal symbiont. Syntrophic interactions between the acetogenic bacteria and methanogens are well known to occur in the biogas biocoenos is. Since anaerobic fungi show the improved growth in the presence of methanogens, the idea of augmenting the biogas reactors with this microbial groups seems a logical step(Fig:1).

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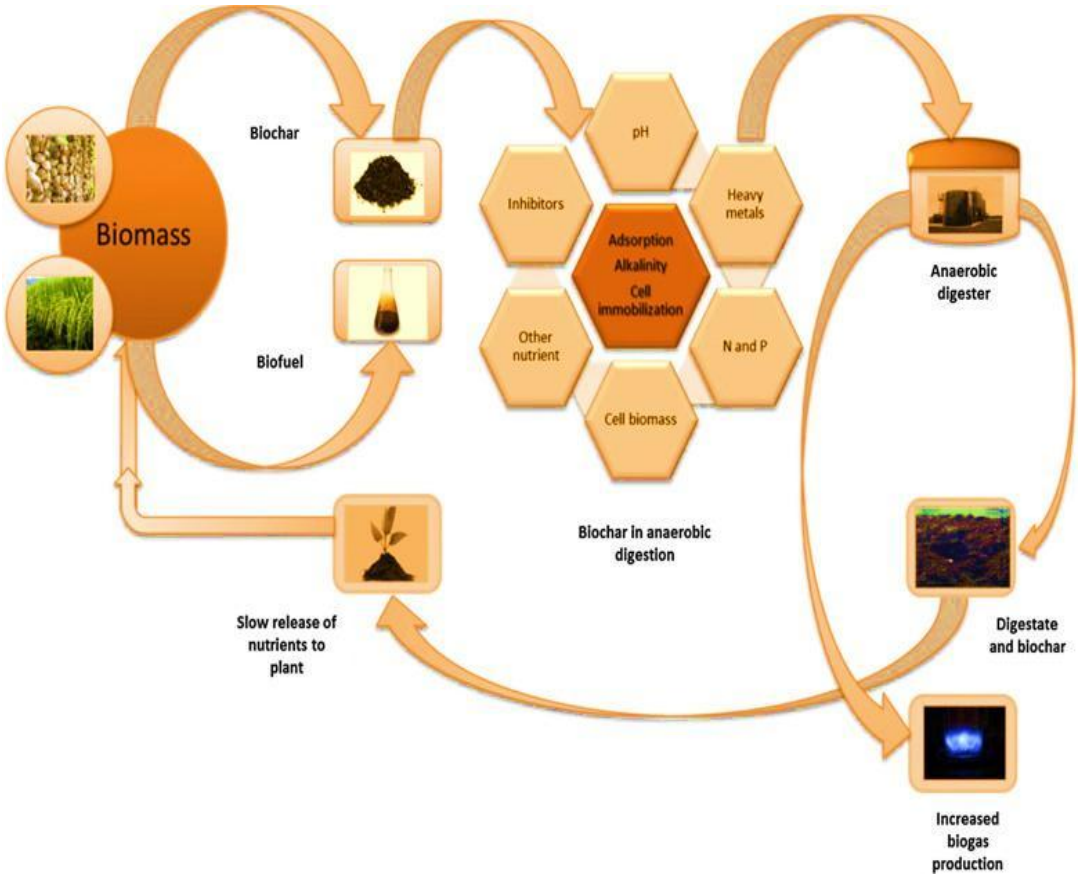


Fig:-1 Biogas production

Interactions of anaerobic fungi with bacteria can be of antagonistic and symbiotic nature as shown by some of researchers, who tested the degradation efficiency in the different culture combinations of three anaerobic fungi and two cellulolytic bacterial strains. In common both groups are competing for the same Anaerobic Fungi and Their Potential for Biogas Production ecological niche, but the breaking up of plant tissue through fungal rhizoids may also copious the overall efficiency of cellulolytic bacteria (Procházka et al., 2012). This improved degradation was also confirmed especially when testing the contribution of different microbial groups (fungi, bacteria, protozoa) on orchard grass decomposition. Presence of the protozoa was, however attributed with lower degradation efficiency and inhibition of both, bacteria and fungi. Most of these studies are fundamentally based on in vitro co-cultures, that may not completely reflect conditions of whole rumen or biogas reactor consortia and still more research is needed in this field.

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ANAEROBIC FUNGI AND THEIR POTENTIAL FOR BIOGASPRODUCTION

Under the oxygen-free conditions organic matter is decomposed by a complex of microbes which are so far divided into three functional groups: hydrolyzing and fermenting bacteria, obligate hydrogen-producing acetogenic bacteria, and the methanogenic archaea. Only little information is known regarding the role and the potential of anaerobic fungi for biogas production (Goel et al., 2003). Great potential lies in the biogas production from lignocellulosic wastes but, slow and inefficient degradation processes, the formation of the toxic intermediates and the necessity for long incubation times are only a few examples of the problems encountered. A promising strategy is the use of microbes, which are able to successfully perform such complicated degradation phenomena in their natural environment. Herbivores as the biogas reactors evolved the need for fungal symbionts for this purpose and over millions of decades natural selection has created a much highly specialized and niche specific community of anaerobic fungi (Mingardon et al., 2007).

ROLE OF FUNGI IN BIOGAS REACTORS

The average abundance of 2.04 (±1.05) × 108 fungal cells per mL reactor content (BP1) is comparable to the relative presence of the methanogenic archaea found in the same reactor. A significantly larger size of fungal cells suggests the high substrate requirement to maintain the metabolic activity of the fungal cells. It must be highlighted that the same relative copious of fungi as that of the methanogens must have consequences for the anaerobic degradation process (Teunissen et al., 2011). Moreover, the eukaryotic community dominated by fungi did not change, and the fungi remained present over the time period of 1.2year. Also certain demonstrated that a laboratory scale biogas reactor is a suitable habitat for fungi, and the authors were able to isolate the different viable fungal strains (Neis et al., 2000).Several fungi attached to the fibrous plant material. After motile flagellated zoospores from the fluid become attached to digestible materials, vegetative stages produce germ tubes that elongate very sporadically and build a network of rhizoids orhyphae in the plant tissues. Fungi from the anaerobic environments (e.g. Piromyces, Neocallimastix, Orpinomyces, Anaeromyces) are possessing fibrolytic

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activity and are able to copious the digestibility of fibrous feeds as was documented for cattle, as well as wild-living the availed substrates. It is necessary to test how strongly the fungal presence depends on the regular and repeated inoculation by animal manure. As facultative an aerobic fungi are widely distributed in the environment, biogasreactors fed by plant material may offer preferable the living conditions, even without the ruminant manure (c.f. BP1).The metabolic activity of fungi in the anaerobic process can be analysed by volatile fatty acid (VFA) concentration.

In the fungal isolates incubated on filter paper or wheat straw, the VFA concentration increased significantly (Bellissimi et al., 2009). The highest generation of acetate and formate, together with hydrogen, by the analysis, strains of Neocallimastix and Piromyces. Furthermore, anaerobic fungi are building syntrophic interactions with the archaea where the latter utilizes the fungi generated hydrogen for methanogenesis, thus keeping the hydrogen partial pressure low - a prerequisite for a stable biogas process. Markedly, the larger fungal cells had the similar share (based on cell numbers) within the reactor community as the methanogenic archaea, all closely embedded in EPS matrix.

LIFE CYCLE

Anaerobic fungi reproduce through the asexual production of the flagellated zoospores from sporangia, with no sexual reproductive life stage that identified to date. Zoospores may be posteriorly monoflagellate orpolyflagellate, with the subsequently developed the thallus being either monocentric (single reproductive body i.e. one sporangium from the single zoospore) or polycentric (many sporangia from a single zoospore). In the rumen, zoospores are released from the anaerobic fungal sporangia in response to ingestion of food, with the timing of peak zoospore density being reached within 30–65 min . Ruminal zoospore differentiation and the subsequent maturation are thought to occur through the induction of sporangia by haem and other rakishedporphyrins, which are released from ingested plant material (Madhavan et al.,2009) .Based on the influence hydrolytic enzymes the degration of substrate is fast (Divya et al.,2018). Biogas plant in a pilot scale is also constructed to assess the biomethanation process (Sreeremya(a), 2016).Methane gas in a pilot scale can be assessed by balloon method (Sreeremya(b), 2016)

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The locomotion of their leased Neocallimastix frontalis zoospores is provided by beating of up to 8–18 flagella which form a locomotory organelle; the activity. Motile zoospores locate plant material for the colonisationvia chemotactic responses to soluble sugars and/or phenolic acids. Flagellated zoospores of the Piromyces communis and N. frontalis show chemotaxisin vivo towards the stomata and lateral spikes on ingested plant material, with certain soluble sugars leaking from these and typically other areas of damaged tissues creating a gradient towards which zoospores are preferentially attracted (Van Maris et al., 2007). The high sensitivity of the anaerobic fungal zoospores to soluble sugars means that freshly ingested food is very quickly colonised, prior to or at the same time as the other rumen microorganisms. As soluble carbohydrates are generally depleted 2–4 h after feeding in sheep, rapid colonisation of plant material by anaerobic fungi is crucial in the competitive environment of rumen (Appels et al., 2008).

CONCLUSION

Neocallimastix, Piromyces are the major anaerobic fungi involved in the biogas production. A simulated enzymatic action is produced in the fungal system to breakdown the complex macromolecules of carbohyrdrates to simple sugars. This paper discusses the efficiency of fungi in biogas reactor

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