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Review Article

Solid Substrate Fermentation (Ssf): An Advancement in Feed Technology

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Abstract

With increasing livestock population and consequently the rising demand of animal feed and fodder results in more research in the field of animal nutrition. The advancement in the field of biotechnology led to increased attention on the utilization of solid-state fermented feed (SSF). Solid-state fermented feed has been a significant strategy to alleviate the contradiction between supply and demand of animal feed resources, ensures food hygiene safety, promoting energy conservation, and emission reduction. SSF has positive effects on growth performance, GIT ecology and immune system. During the making of SSF, a variety of organic acids, vitamins, enzymes, peptides and other unknown growth factors are produced, which could affect the performance of animals; therefore, hinders the application and standardized production of SSF.

Introduction

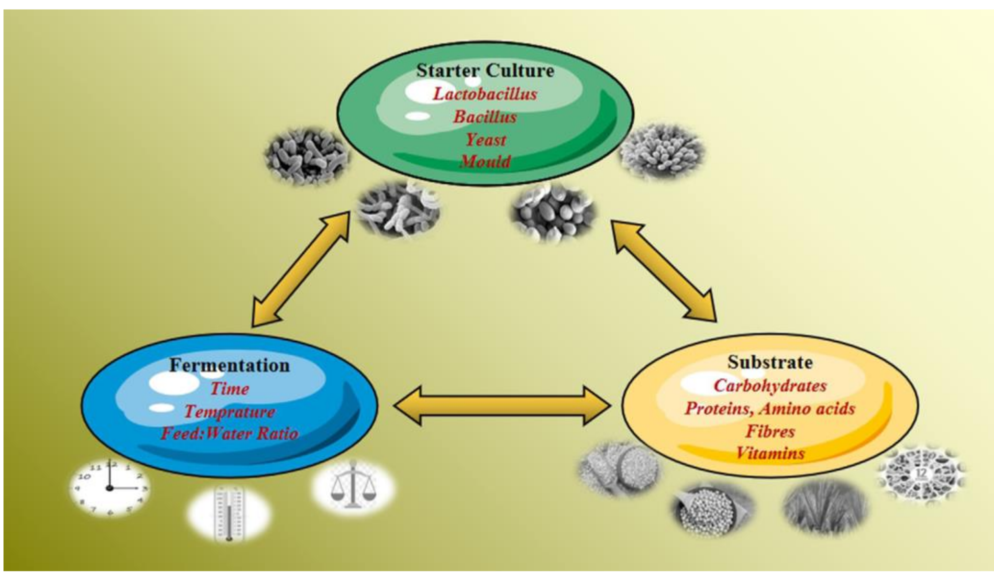
In food processing and preservation sector, fermentation technique has been used past thousands of years across the world. In livestock sector also; this technique has recently gained increasing interest as a tool for adjusting nutritive value of feed and thus the output of livestock products. Solid-state fermented feed (SSF) could be defined in several ways i.e., a raw feed ingredient or commercial feed in which macromolecular substances and anti-nutritional factors (ANF) are converted into more adept and non-toxic nutrients by metabolic activities of micro-organisms.

Solid-state fermented feed (SSF) can be referred to the feed substrate fermentation by using natural or artificially added microorganisms (as inoculum) under artificially controlled conditions such as water content is generally kept below 70%; so as to change the nutritional characteristics, palatability, digestibility, and thus safety of feed. Additionally, SSF can be regarded as the potential strategy for replacing the antibiotics in livestock feed. The nutritional properties of fermented feed i.e., SSF mainly depends on the substrates, fermentation starter (i.e. bacterial culture which is used to start fermentation), and fermentation conditions (mainly temperature and incubation time) used.

Several studies have confirmed that; this SSF fermentation could be an approach to improve the nutritional value of feed ingredients before being offered to animals, but the quality of feed produced by different manufacturing techniques and effects of these techniques on animal performance have not been consistent. Due to this inconsistency in terms of animal performance, industry professionals are encouraged to explore SSF. Therefore, in recent years, researchers have carried out a large number of experiments and studies by in vivo and in vitro to explore applications of SSF. However, a perfect set of SSF production and evaluation systems is currently unavailable because of the instability of SSF.

Effect of Manufacturing Technique on SSF –

The end-products of SSF are affected by interactions among starter cultures, incubation parameters, and substrate characteristics. But the effect of SSF on animals; produced through different technologies are different. Therefore, to ensure correct management of SSF production to capture its potential, a thorough knowledge of the manufacturing processes of different fermentation attributes are required.



(Source – Nibaet al., African Journal of biotechnology; 2009**)**

1. Starter cultures and substrate characteristics:

The most important factors for successful manufacturing of SSFare the choices of substrates and starter culture. But when the same substrate is allowed to ferment by different starter cultures, the end-products are also found to be different. Widely used starter culture for SSF are

*Lactobacillu*s spp., yeast, bacillus, and moulds and the most commonly used substrates are wheat straw, wheat bran, apple pomace, sugarcane bagasse, rice straw, citrus peel, corn cob powder, sorghum straw, bread waste.

The production of SSF also produces substances like amylase, protease, lipase, cellulase, pectinase and glucanase, which degrades macromolecular substances into smaller compounds; that are more conducive to animal absorption. Effective utilization of fiber by microorganisms is a primary advantage of SSF.Also lactic acid, short-chain fatty acid (SCFA) and other metabolites improve palatability of feed, and plays an important role in promoting intestinal health. Microorganisms/starter culture can decompose dietary fiber and produce a variety of monosaccharides which are more easily used by intestinal flora. In addition, the monosaccharides can also nourish the growth of microorganisms, acting as prebiotics and probiotics. Microbes used in SSF can degrade potentially hazardous raw materials and can transform them into less harmful metabolites and thus improves storage qualities of the ingredient.

2. Incubation parameters

The attributes of SSF are closely related to temperature, moisture content, and incubation time which leads to diverse quality of feed. Since appropriate temperature guarantees proper growth and metabolism of microorganisms; because it shortens the stable time of fermentation and improve fermentation products. From the enzymatic kinetics views, increasing system temperature accelerates speed of reaction and growth and metabolism of microorganisms.

Also, rapid growth of microorganisms generates excess heat. Poor heat transfer efficiency of solid-state fermentation feed leads to a sharp rise in temperature of substrates and if excess heat cannot be dissipated within time, growth and metabolism of microorganisms is checked.

Moisture content of substrates is also a crucial factor affecting the qualities of final end products. Low moisture content of SSF reduces diffusion of nutrients and metabolites and thus affects activity of enzymes, resulting in limited growth of microorganisms. While, high moisture content reduces; porosity of substrates, reduces oxygen and heat transfer, and increases risk of mycotoxin contamination. Increased moisture content, also decreases dry matter recovery of SSF. The moisture content of fermentation substrates should be adjusted according to properties of substrates, microbial characteristics (anaerobic, aerobic or facultative anaerobic), temperature, and time.

The effect of incubation time on quality of SSF is also significant. Because in early stages of incubation, the substrate contains enough nutrients for vigorous growth of microorganisms. If fermentation is terminated prematurely, fermentation would be incomplete and concentration of the end product would be too low. While, if fermentation time is too long, nutrients would be consumed in large quantities, and bacteria numbers could decline and autophagy would occur.

Beneficial Effect of SFF On Animal Health –

SSF has a great impact on gastrointestinal ecology, including changes in microflora and metabolic behavior, leading avital role in metabolism to host. Thus, it is reasonable that feeding SSF could be an effective strategy to improve GI ecology and to reduce the infection vulnerabilities of enteric diseases for animals.

SSF hasa sour fragrance and also has the potential to stimulate appetite, and logically might improve animal production performance. The degradation of soluble NSP during fermentation improves nutritive value and digestibility of feed components and thus can improve the performance of monogastric animals.

Feeding of SSF decreases mortality rates and has positive impact on immune responses of animals. In *Lactobacillus* mediated immune responses, SSF also stimulates cellular-mediated immune responses (CMI). SSF feeding also increases the content of *Lactobacillus* in the intestine. In addition, *Lactobacillus* could also promote B-cells proliferation in small intestinal lymphoid tissue, enhance mucosal immune responses, and can induce plasmocytes to produce a large concentration of IgA, thereby enhances immune function of animals.

The development of probiotics and their metabolic products in SSF can stimulate lymphocytes in intestinal mucosa and can also promote production of interleukins (IL), tumor necrosis factor (TNF) and interferons (INF).

Conclusion

SSF plays avital role in today's ecological animal husbandry’s has positive effects on growth performance, gastrointestinal ecology and immune system. However, the innovative research and industrialization level of SSF still need to be improved, and many problems need to be solved. In order to ensure the sustainable and healthy development of SSF, strict screening and identification of starter culture are essential. In the future, the R& D of SSF should focus on the screening of characteristic strains with strong antinutritional factor degradation ability, colonization ability Andrich metabolites, the evaluation of biological potency for digestion and absorption of raw materials, improvement of body health and improvement of animal product quality, and the dynamic monitoring of fermentation process and product quality.

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