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A Review on Potential of Glutamate Producing Lactic Acid Bacteria of West Sumatera's Fermented Food Origin, as Feed Additive for Broiler Chicken

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ABSTRACT

Increasing broiler populations must be supported by cheap and high quality feed. Improving the quality of feed can be done by adding feed additives. Glutamate is a non-essential amino acid that can be used as a feed additive in the form of flavoring agents in broiler feed which functions as a neurotransmitter of taste, basic structure of proteins, and in metabolism of the body. Lactic Acid Bacteria (LAB) are one of the microbes that are considered faster and safe in producing glutamate. Fermented foods of West Sumatera, Indonesia origin serve as sources of LAB include dadih (fermented milk), asam durian (fermented durian), ikan budu (fermented fish) and tapai (fermented rice and cassava). The West Sumatra's fermented foods are potential sources of glutamate. Supplementation of glutamate in broiler diet can increase body weight, protein digestibility, reduce faecal ammonia and improve carcass quality (improve umami taste, and reduce bruises and abdominal fat).

Key words: Carcass quality, Feed additive, Fermented food, Glutamate, Lactic acid bacteria, Performance

INTRODUCTION

Broiler is a meat-producing animal that has enough potential to meet people's needs for animal protein. This is because broiler meat is relatively inexpensive and easily obtained compared to other animal proteins. High broiler populations must be supported by high quality feed to improve the performance and quality of broiler carcasses. One important component of feed needed to increase growth and feed efficiency is feed additive. According to Slyamova et al. (2016), feed additives has function in improvement of immune system against disease attacks and effects of stress, increase appetite, stimulate growth, and increase the production of meat and eggs. Feed additives can be flavoring agents, antibiotics, enzymes, antioxidants, hormones, probiotics and anticoccidials (Lesson and Summers, 2001).

One of the feed additives that can be used in animal feed is glutamate. Glutamate is a feed additive that serves as flavoring agent which helps to increase feed consumption. According to Fujimura et al. (2001), glutamate functions as a neurotransmitter for taste, where glutamate is serves as umami, flavors or savory. Besides functioning as a glutamate flavoring agent, it functions as a protein building block, a substrate in the synthesis of protein, precursor of glutamine and helps the body's metabolism (Young and Ajami, 2000).

Giving glutamate to broilers has been carried out by several researchers. According to Berres et al. (2010), administering glutamate to broilers decreases abdominal fat, improves meat examination by reducing red bruises on carcasses and increasing meat protein content. The administration of 0.75% glutamate in feed increases muscle free glutamate and improves the taste of meat (Fujimura et al., 2001; Imanari et al., 2008). Furthermore, administration of glutamate improves broiler performance, reduce the feed conversion ratio, affect the length of intestinal villi, reduce raw ration protein and reduce faecal ammonia (Zulkifli et al., 2016; Ribeiro et al., 2015; Bezerra et al., 2016).

The sources of glutamate are animals, plants and microbes. Microbes are mostly used to produce glutamates probably because it is easier, faster, safer and relatively inexpensive compared to other sources. Glutamate production can be done by fermentation or by chemical processes. At present, most glutamates are produced by fermentation because it is superior to chemical processes. The fermentation process produces L-glutamate while the chemical process produces racemic glutamate (D- and L-glutamic acid) (Sono, 2009). The difference of L-glutamate and D-glutamate is their uses in the body. According to Wijayasekara and Wansapala (2017), L-glutamate is the form glutamate is used in the body.

Lactic Acid Bacteria (LAB) are examples of microbes that produce glutamate. According to Lucke (2000), LAB is one of the gram-positive bacterium that produces glutamate which is considered safe and environmentally friendly. A number of LAB isolated from different sources have been reported to produce glutamate. These include LAB from tapaipulut (Ishak et al., 2017), *Lactobacillus plantarum* MNZ from fermented food (Zareian et al., 2012), *Bacillus spp* from vegetable protein (Lawal et al., 2011) and *Lactobacillus* from skim milk (Zalan et al., 2010).

West Sumatera is rich in the production of fermented foods which are sources of LAB. Fermented foods in West Sumatera that are widely consumed contain dadih (fermented milk), asam durian (fermented durian), ikan budu (fermented fish) and tapai (fermented rice and cassava) (Mustopa and Fatimah, 2014). Purwandhani et al. (2018) isolated LAB from dadih of West Sumatera origin. Yusra (2014) reported of *Bacillus spp* from ikan budu in Pariaman. Furthermore, Chuah et al. (2017) found six LAB strains in asam durian (*Fructobacillus durionis*, *Lactobacillus plantarum*, *Lactobacillus fructivorans*, *Leuconostoc dextranicum*, *Lactobacillus collinoides and Lactobacillus paracasei*) and Sujaya et al. (2001) *Weissella spp* in tapai. There is high diversity of fermented foods in West Sumatera, therefore, it is necessary to explore their nature and potentials as sources of LABs capable of producing glutamate, which can serve as feed additive for broilers.

Food Fermentation from West Sumatra

Fermentation was carried out in the past based on non-scientific studies and much was not known about the role of microbes in changing food characteristics. It was based on traditional techniques of storing and handling food ingredients which turns out to produce new food products that are different from the original ones. The goal of initial food fermentation was to preserve seasonal foods that were easily damaged. During fermentation, the digestibility and nutritional quality of foods are improved. There is the addition of vitamins, and essential amino acids and fatty acids during fermentation (Steinkraus, 2002).

Indonesia has many fermented foods scattered throughout the region. Some fermented foods in Indonesia include: Brem (fermented rice) from Madiun and Wonogiri, danke (fermented buffalo milk) from Sulawesi, lemea (fermented bamboo) from Bengkulu, oncom (fermented tofu waste) from West Java, pakasam and wadi (fermented fish) from various regions of Indonesia, tempe (fermented soybeans) from various regions of Indonesia, gatot and growol (fermented dried yam) from Yogyakarta, Tempoyak (fermented durian) from various regions of Indonesia and urutan (pig fermentation) from Bali (Nuraida, 2015). Even though, the same fermented foods may be produced in different regions, the manufacturing process are slightly different. West Sumatra also has a lot of fermented foods, among them are dadih, asam durian, ikan budu and tapai.

Dadih

Dadih is a fermented food from milk which is a potential functional food and a source of probiotic. Dadih processing is still done traditionally without any standard processing procedure. Curds are made from buffalo milk poured into a bamboo tube to ferment naturally for 24 to 48 hours at room temperature. The natural fermentation process in making curds involves various types of microbes found on the surface of the inner bamboo tube, the surface of the cover leaves and from buffalo milk used. According to Hasim et al. (2017), dadih produced in West Sumatra are made from buffalo milk by relying on natural microbes as the inoculum. The bamboo is usually covered with taro leaves, banana leaves, plastic, or left without a cover, depending on the region (Maskiyah and Broto, 2011).

Isolation and use of LAB in dadih have been reported by several researchers. In a study by Surono (2003), LAB in curds were dominated by *Lactococcus* bacteria consisting of *Lactococcus lactis*, *Leuconostoc mesenteroides*, *Lactococcus brevis*, Lactococcus *casei*, *Lactoscoccus plantarum*, and *Enterococcus faecium*. Pato et al. (2005) found the following LAB, *Lactobacillus casei* subsp *casei*, *Leuconostoc paramesenteroides*, *Enterococcus faecalis* subspecies *liquefaciens,* and *Lactococcus lactis* subsp *lactis* in dadih.

Asam durian

Asam durian is a fermented product made from durian. Fermented foods are found in several regions (West Sumatra, Jambi and Riau) of Sumatera, Indonesia. The process of making asam durian and the name given to it differ among each region. In Jambi of Indonesia, durian fermentation is called tempoyak while in West Sumatera and Riau it is known as asam durian. Fermentation of durian is done by the Jambi community by adding salt (Anggraini and Widawati, 2015). LAB found in salt-containing asam durian includes *Lactobacillus species*, *Lactobacillus plantarum*, *Pediococcus acidilactici* and *Weissella paramesenteroides* (Yuliana and Dizon, 2011).

Asam durian found in West Sumatera Indonesia has differences from other regions. The manufacturing process is spontaneous fermentation, by natural microorganisms found in nature without adding salt during incubation. Six types of bacteria have been identified in asam durian. They are: *Lactobacillus plantarum, Pediococcus acidilactici, Leuconostoc mesentroides, Staphylococcus saprophyticus, Lactobacillus curvatus,* and *Micrococcus variance* (Hasanudin, 2010).

Ikan budu

Ikan budu is a product made from fermented fish and mainly from coastal areas of Pasaman Regency and Padang Pariaman in West Sumatera, Indonesia. In Indonesia, it is found only in West Sumatra. This fermented food product is made from large sea fish and has white meat. Example of fishes used for making budu are mackerel (*Scomberomorus guttatus*) and chamfer (*Chorinemus lyson* L). Budu fish has a distinctive aroma, not rotten, non-rancid and soft-textured. Yusra et al. (2014) found that *Bacillus* and *Micrococcus* species were involved in ikan budu fermentation.

Malaysia also produce budu but the fermentation process and type of fish used is different from that of West Sumatra. Budu from Malaysia appear as thick brown, and it is prepared from salted raw anchovy (*Stolephorus spp*.) and stored in a large concrete tank at 30-40^{o}C for 6-12 months (Sim et al., 2015). Sim et al. (2015) identified *Pediococcus* (9.4%), *Candida* (8.0%), *Micrococcus* species (28.7%), *Staphylococcus* (26.7%), *Lactobacillus* (6.7%), *Saccharomyces* (4.0%), and *Lactococcus* (2.7%) from Malaysian budu. Fujimura et al. (2012) also isolated LABs from Malaysian budu.

Tapai

Tapai is one of Indonesia's traditional foods produced from the fermentation of carbohydrate foods such as cassava and sticky rice. Tapai fermentation process takes place because of the activities of several types of microorganisms such as bacteria, yeast and fungi. Tapai is produced by fermenting cassava with yeast, LAB, and amylolytic bacteria (Sujana, 2001). Different from other places, glutinous tapai from Indonesia, especially from West Sumatra, uses black glutinous rice stored in containers coated with banana leaves, while in other areas guava leaves (*Syzygium*) or rubber (*Hevea brasiliensis*) are used. Suhartatik et al. (2014) isolated LAB such as *L. mesenteroides*, *L. pentosus*, *L. brevis*, and *L. plantarum,* from Tapai. Also, Maslami et al. (2017) isolated *Lactobacillus sp* from tapai of West Sumatera origin. In Malaysia, different ingredients and fermentation processes are used in tapai preparation.

Tapai from Sabah, Malaysia is an alcoholic drink but not food (Campbell-Platt, 2000). In Sabah, the basic ingredients for making tapai are rice, cassava, pineapple and corn which are fermented using cultural starter from Sasak (Chiang et al., 2006). Tapai is also produced at Peninsula, Malaysia. The processing method employed in Peninsula, Malaysia is similar to how tapai is prepared in Singapore and Brunei, that is, they all carry out fermentation in banana leaves (Campbell-Platt, 2000). LAB found in tapai of Sabah origin include *L. brevis, L. plantarum, P. pentosaceus, L. lactis* and *L.s paracasei* (Chiang et al., 2006). *L. casei* is also involved in the fermentation process of tapai of Malaysia origin (Adnan and Tan, 2007).

LAB Producing Glutamate

Research on glutamate producing microbes has been carried out by several researchers. Glutamate producing microbes isolated from various sources can be seen in table 1.

Effects of glutamate on performance and quality of broiler carcasses

Glutamate plays an essential role in the metabolism and increases feed consumption. The purposes and dosages for the administration glutamate in broiler is presented in table 2.

Table 1. Glutamate producing lactic acid bacteria and their source of isolation

Researcher	Source	Bacteria	Production
Tarek and Mustafa (2009)	Egyptian infants	*Lactobacillus paracasei*	68.78 mg/l.
Zareian et al. (2012)	Fermented soybean	*Lactobacillus plantarum*	489 Mmol/ L
	Fermented durian		20 Mmol/ L
	Fermented tapioca		59 Mmol/ L
	Fermented rice		65 Mmol/ L
	Fermented shrimp		11 Mmol/ L
	Fermented fish		106 Mmol/ L
Fudou et al. (2002)	Soils and vegetable	*Corynebacterium.*	-
Lawal et al. (2011)	Vegetable protein	*Bacillus subtilis*	8.4 mg/ml
		Bacillus pumilus	8.2 mg/ml
		Bacillus licheniformis	6. 4 mg/ml
		Bacillus polymyxa	6.2 mg/ml

Table 2. Purpose and dosage of glutamate administration

Researcher	Purpose	Glutamate dose
Stilborn and Moran (2010)	Increase performance and anticoccidial	1.75 %
Zulkifli et al. (2016)	Growth and physiological anti-stress on broiler chicks	1%
Joshua et al. (2015)	Anti-stress due to heat stress in the tropics	Stater (0.50% - 1 %) Finisher (0.50% - 1 %)
Ribeiro et al. (2015)	Improve performance and immune system	0.4 %
Shakeri et al., (2014)	Anti-stress on broiler chicks which are affected by heat stress	0.50 %
Berres et al. (2010)	Improve feed efficiency	Age 1-7 days (0.13% and 0.26%) Age 8-21 days (1.46%, 1.66% and 3.13%) Age 22-35 days (1.24%, 1.40% and 3.50%) Age 36-42 days (1.04%, 1.18% and 3.22%)
Khadiga et al. (2009)	Increase performance	1%
Bezzera et al. (2015)	Efficient use of feed protein	Age 1-7 days (crude protein 20.29% and glutamate 3.41) Age 8-21 days (crude protein 18.99 and glutamate (3.32) Age 22-35 (crude protein 16.24 and glutamate 2.64 Age 36-45 (crude protein 17.04 and glutamate 2.96)

Improve performance

Glutamate is known as a conditional or non-essential amino acid. Glutamate binds with other amino acids to form protein structures (Berres et al., 2010). Weight gain in 21 day broilers given an additional 1% of glutamate supplements was significantly higher (11%) than those fed without 1% glutamate addition (Bartell and Batal, 2007). The positive effect of glutamate on broiler chickens have been reported by other researchers. According to Bazzera et al. (2014), broilers fed on glutamate containing feed (1.66% up to 3.13%) performed better than those fed without glutamate supplemented feed during heat stress. Feeding broilers on glutamate increases broiler body weight and the deposition of connective tissues at growth phase (Zhang et al., 2008). According to Zulkifli et al. (2016) administration of 1% glutamate in rations can increase body weight, reduce feed consumption, improve feed conversion, and reduce death. Administration of 2% glutamic acid reduces crude protein of ration and can improve performance and reduce faecal ammonia (Ribeiro et al., 2015; Bezerra et al., 2016).

Glutamate is essential for the maintenance of intestinal mucosa and seen as an efficient source of a non-specific nitrogen source. This is because its energy source is for rotating the mucosa, through ATP which results from the citric acid cycle (Berres et al., 2010). The synthesis of nitric oxide in some tissues (e.g. brain tissue) are regulated by glutamate (Li et al., 2007). Glutamate also act as precursor for glutathione. Glutathione is an important compound responsible for elimination of oxidants and immune system modulation (Li et al., 2007). According to Silva et al. (2001), adding L-glutamate (5, 10 and 15%) to broiler feed takes care of protein deficiencies in rations with efficiencies greater than 10%.

Carcass quality

Glutamate is a vital amino acid responsible for flavor enhancement and as feed additive (Fujimura et al., 2001). In its free form or unbound to other amino acids in protein, glutamate has a flavor enhancing effect (Yamaguchi and Ninomiya, 2000). This free glutamate functions effectively as a flavor generator and plays a role in improving delicacy. Free glutamate also known as an important taste component of meat and contributes to meat tastes (umami, brothy taste and delicious). The chicks of poultry contains more free glutamate than pork and beef (Kato and Nishimura, 1987). Pork also contain more free glutamate than beef (Kato and Nishimura 1987). The hydrolysis of protein by the supplementation of heat during cooking causes glutamate to release protein molecule that can causes umami taste (Khropychheva et al., 2009). However, when protein molecules bind with glutamate, umami taste is not released and make the protein source tasteless (Khropychheva et al., 2009).

Glutamate supplementation has a significant effect on broiler carcass quality. Low glutamate content in broiler meat will result in less glutamate being stored in muscle fibers. Glutamate level can become low because it is widely used for metabolism and as an energy source by intestinal cells. When free glutamate is present in broiler meat its umami taste reduces (Tang et al., 2009). Glutamate content in broiler meat can be increased by adding glutamate to broiler feeds.

Glutamate can also improve the quality of broiler carcasses. According to Ajinomoto (2007) and Bezerra et al. (2015) glutamate can increase meat protein, reduce meat fat, reduce meat bruises and improve meat flavor. Meat protein is increased because glutamate is a precursor of several amino acids (Berres et al., 2010). In addition, a decrease in meat fat is caused by foods that contain good source of amino acids and less energy for fat accumulation. Moran and Stilborn (1996) reported that, there was a decrease in bruises and thigh deformation and an increase in connective tissue deposition at growth phase of broilers fed by glutamate supplemented feed.

CONCLUSION

Glutamate can improve carcass traits, performance and quality of meat. One of the microbes that can produce glutamate is LAB. A potential and unexplored LAB source, that produce the glutamate found in fermented foods in West Sumatera, Indonesia.

DECLARATIONS

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Competing interest

The authors declare that they have no competing interests.

Author’s contribution

All the authors have made contribution to the study.

Consent to publish

All the authors gave their informed consent prior to their inclusion in the study.

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