Production of GABA (gamma amino butyric acid) by Lactic Acid Bacteria

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Abstract

Gamma-amino butyric acid (GABA) is a kind of pharmacological and biological component and its application is wide and useful in Korea specially, becoming aging society in the near feature. GABA is request special dose for the purposed biological effect but the production of concentrated GABA is very difficult due to low concentration of glutamic acid existed in the fermentation broth. To increase GABA concentrate using fermentation technology, high content of glutamic acid is required. For this reason, various strains which have the glutamic acid decarboxylase (GAD) and can convert glutamic acid to GABA, were isolated from various fermented foods. Most of GABA producing strains are lactic acid bacteria isolated from kimchi, especially added monosodium glutamate (MSG) as a taste enhancer. Optimizing the formulation of culture media and the culture condition, GABA conversion yield and amounts were increased. Finally GABA concentration of fermentation broth in batch or fed batch fermentation reached 660 mM or 1000 mM, respectively. Furthermore formulation of culture media for GABA production developed commercially. Many studies about GABA-rich product have been continued, so GABA-rich kimchi, cheese, yogurt, black raspberry juice and tomato juices has been also developed. In Korea many biological effects of GABA are evaluated recently and GABA will be expected to be used in multipurpose.

Key words: lactic acid bacteria, fermentation, GABA, kimchi, high concentration

Introduction

Meat consumption per capita is increasing depending on the increase of the national income. According to the Korea Rural Economic Institute, annual meat consumption per capita in 2011 was 40.4 kg (average consumption per capita was 110.6 g/day) and it has increased to 4.2% (1.6 kg) compared with that of 2010, 38.7 kg. Compared with 32 kg consumption in 2005, consumption amount is increased about 26.2% (KREI, Agricultural and livestock industry products statistics, 2011). The increase of meat consumption is changing to factory-style and corporate-style in domestic livestock industry. The factory-style livestock industry means adapting livestock’s ecology to the industrial scale. So, it affects the increase of scale of livestock husbandry and density. In early 2000s, the numbers of livestock increased to three times for the chicken and five times for the pig compared with the early 1980s. Consequently, poultry farmers raising more than 30,000 chickens increased to 48.9% in 2007, whereas 0.2% in 1990, and ones raising less than 5,000 chickens decreased to 3.4% from 97.2%. This overcrowding and unnatural breeding environment gives livestock causing a lot of stress and creates a vicious cycle of weakening immune system and antibiotic overdose (Moon, 1998; Song et al., 1998).

On the other hand, the European Union banned the antimicrobial growth-promoter for formula feed since 2006 responding to the worldwide needs of safety and high-quality livestock products. Korea also banned the use of antimicrobial growth-promoter from July 2012 (Ministry for Food, Agriculture, Forestry and Fisheries. Announcement No. 2010-3; The Agriculture, Fisheries and Livestock’s News. 2011). The development of various natural feed additives that can be replaced by it is completed or in progress (Kim, 2010; Lim et al., 2011).

In accordance with increasing domestic consumers’ tendency to prefer eco-friendly livestock products, consumers’ interest on food safety is also increasing and the development of feed additives to promote livestock’s function as a way of producing eco-friendly livestock products (Lee et al., 2008; Lee, 2009). The researches and developments for functional feed additives are indispensable for both consumers and producers for the future of the livestock...
The stress arising from the overcrowding of the factory-style livestock industry as well as the sanitary problems causes infectious diseases or diarrhea by reducing livestock’s immunity and finally reduces productivity and coefficient of reproduction. It is possible to rely on the facilities in order to minimize various stresses that occur when livestock breeding, but it has the cost problem. Therefore, developing a substance being able to reduce stress and using it for livestock breeding can respond effectively to the factory-style livestock industry. Besides, various environmental and nutritional stresses arising from the modern livestock industry necessarily lead to the reduced livestock growth and feed availability and result in economic losses of farmers, so the study of anti-stress functional feed additives is essential (Jung et al., 2010; Magoto et al., 2004).

γ-Aminobutyric acid (GABA) is the non-protein amino acid that is widely distributed in nature, and generated irreversibly through the α-decarboxylation of L-glutamic acid in a reaction catalyzed by glutamate decarboxylase (GAD). GAD and GABA have been found from bacteria to higher organisms widely. GABA is well known as inhibitory neurotransmitter. The concentration of glutamate as excitatory neurotransmitter and GABA is controlled by GAD (Ueno, 2000).

GABA promotes the metabolism of brain cells by increasing the oxygen supply and activating cerebral blood flow and inhibits the secretion of the vasopressin (antidiuretic hormone) by acting on the vasomotor center of medulla oblongata. Furthermore, GABA regulates growth hormone secretion, drops the blood pressure by expanding the blood vessels, and has the diuretic, anti-depressive, anti-oxidant effects, effective pain relief, as well as a medicine for the stroke treatment, especially (Hao and Schmit, 1993; Kono and Himeno, 2000; Leventhal et al., 2003; Shelp et al., 1999). In recent years, its sleep-inducing effect was proved by the animal experiment which establishes the production of serotonin and melatonin which act as sleep inducer, is facilitated significantly in the GABA-containing milk feeding group (Kim et al., 2010). The interest of GABA as a functional food ingredients has been heightened due to the recent proof of various biological functions of GABA and it is reported that GABA-reinforced soy, tea, red yeast rice and chlorella drop the blood pressure in the experiment in Spontaneously Hypertensive Rats (Abe et al., 1995; Bae, 2008; Hayakawa et al., 2004; Nakamura et al., 2000; Tsuji et al., 1992).

GABA is available in many fruits and vegetables but the concentration is low in nature of which rang is from 0.03 to 2.00 μmol/g-wet weights (Fougère et al., 1991; Rhodes et al., 1986), which is known to be difficult to have biological activity. However, it is reported tea contains sufficient amount of GABA to hypertensive patient, showing the effect in lowering blood pressure without any side effects. It means various functional foods can be developed in case of available concentration of GABA added.

Various researches to increase GABA contents are in progress, and the method of increasing the amount of GABA in green tea under anaerobic conditions is one of the examples (Chang et al., 1992; Sawai et al., 2001; Tsu-shida and Murai, 1987; Wang et al., 2006). GABA production is stimulated through the action of decarboxylase in embryos by water immersing (Saikusa et al., 1994), increasing GABA content using high-pressure and germination of brown rice (Miwako et al., 1999), producing GABA containing yogurt (Park and Oh, 2007). Most of these methods produce GABA from glutamic acid by promoting the reaction of decarboxylase existing in the natural products. Therefore, the amount of GABA is proportional to the amount of glutamic acid existing in the various materials and addition of glutamic acid should be necessary in order to obtain a high concentration of GABA.

The study for the production of high concentrations of GABA using microorganisms is progressing in order to overcome these limitations. Recently, it is reported that lactic acid bacteria isolated from variety of fermented foods such as kimchi and salted seafood produces GABA using glutamic acid as a substrate. PharmaFood company (Japan) produced GABA by conversion of monosodium glutamate using lactic acid bacteria isolated from kimchi and sells as a functional food ingredient and it has reported to produce 6.3 mM GABA by inoculating Lactobacillus brevis IFO 12005 isolated from kimchi to Soju jigemi made from rice (Ueno et al., 1997; Yokoyama et al., 2002), 302 mM of GABA by adding pyridoxal phosphate as a coenzyme of GAD by Lb. paracasei NFRI 7415 isolated from Japanese traditional fermented food funasushi (Komatsuzaki et al., 2005). Recently, Yang et al. (2008) has reported to produce 78 mM of GABA using Streptococcus salivarius in China, and domestic researchers are developing the isolation of strains producing GABA and have reported to produce 19 mM, 251 mM of GABA respectively by isolation of GABA-producing strains such as Lb. brevis OPK 3, Lb. buchneri from traditional fermented foods such as kimchi (Cho et al., 2007; Park and Oh, 2006).