同時利用納豆菌及寡孢根黴菌發酵黃豆

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摘 要

日本的納豆（natto）是以枯草芽孢桿菌納豆變種（Bacillus subtilis var. natto，簡稱Bacillus natto或納豆菌）接種於無脫皮的熟黃豆發酵製成的黏稠物。印尼的天貝（tempeh）是以小孢根黴菌寡孢變種（Rhizopus microsporos var. oligosporus，簡稱Rhizopus oligosporus或天貝菌）接種於脫皮的熟黃豆發酵所製成的糕餅狀食物。兩者均具有相同但又獨特的保健效果。雖然兩菌種的生長速率不同，但若能使兩菌株平衡生長（balanced growth）於無脫皮的熟黃豆中，當能成功製成兼具兩種特色的保健發酵食品。因此，本研究以熟黃豆為原料，以不同方式製備的納豆菌和天貝菌同時接種於黃豆基質上進行固態發酵(solid-state fermentation)，探討兩種菌可以同時平衡生長的條件，並以納豆菌數、天貝菌絲量(以葡萄糖胺glucosamine含量為基準)、氨氮含量及黃豆上方之頂空（headspace）氧氣含量的變化做為評估產品品質是否有改善及兩菌株是否能同時平衡生長的標準。 在單獨納豆菌的發酵下，不管緊密覆蓋在發酵盤上之錫箔紙有無戳洞及接種液如何被製備，納豆菌數皆可達109 CFU/g，而且生長愈好，生成的氨氮量愈多；有戳洞組別的氨氮可達0.46%，是無戳洞組別的三倍。基於頂空氧氣含量、黃豆中菌數及葡萄糖胺含量的測量值，可以知道何時菌種開始積極生長。例如，不管有無戳洞，在單菌發酵中，納豆菌均在第4小時才開始積極生長，天貝菌則在第6至8小時才開始。而且，納豆菌比天貝菌生長快速。 在單獨天貝菌的發酵下，以不同方式製備的天貝菌在黃豆發酵上會有不同的生長速率及遲滯時間，且最終的葡萄糖胺含量介於9.53至10.63 mg/g之間，幾乎無氨氮產生。無接種的熟黃豆在此時段中也不產生氨氮，因此，混合菌發酵黃豆中氨氮的產生主要來自納豆菌。 在黃豆蒸煮30分鐘及發酵溫度37°C的操作下，混合菌發酵可達最佳的效果，且產生平衡的生長；納豆菌數超過109 CFU/g、葡萄糖胺含量達12 mg/g以上、氨氮含量為0.38 %。 在以不同方式單獨製備納豆菌和天貝菌然後同時接種之發酵中，以馬鈴薯葡萄糖培養液(potato dextrose broth)培養之天貝菌液及以市售納豆菌粉同時接種於黃豆中的發酵為最佳，兩菌可平衡生長；經24小時戳洞發酵後，納豆菌數可達109 CFU/g、葡萄糖胺含量12 mg/g以上、氨氮含量較低（0.29%），並在不戳洞下於9小時內耗盡頂空氧氣。 若用同樣培養基同時培養混合菌，再予接種於黃豆上，則以酵母精麥芽液(yeast malt broth)同時培養納豆菌及天貝菌的發酵最好，兩菌也可平衡生長；經24小時戳洞發酵後，最後納豆菌數可達109 CFU/g、葡萄糖胺含量12 mg/g以上、氨氮含量最低（0.13%），但在不戳洞下則於12小時內耗盡頂空氧氣。因此，混合菌發酵可以降低氨氮及促進天貝菌的生長。另外，錫箔紙有無戳洞顯著影響混合菌的生長及氨氮含量；有戳洞的發酵可以促進納豆菌及天貝菌的生長，但會有較多的氨氮產生。

關鍵詞 : 混合菌發酵 ; 納豆菌 ; 天貝菌 ; 納豆 ; 天貝 ; 平衡生長

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