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研究科及び専攻	連合農学研究科 生物資源科学
学位論文題目	Studies on the characterizations of functionalities in the rice miso products supplementary with beans and buckwheat at different fermentation periods（異なる熟成期間における豆類及び蕎麦を添加した米味噌製品の機能性に関する研究）
学位審査委員	主査 帯広畜産大学教授 小嶋 道之 副査 村山 哲也(山形 教授),姜 興起(帯広 教授),塚本 知玄(岩手 教授)

論 文 の 内 容 の 要 旨

In recent years, prevention of lifestyle-related diseases such as obesity, diabetes mellitus is noted, the development of new rice miso products for beneficial and healthy has been expected. As a processed soybean fermented product, rice miso is a traditional Japanese seasoning food which not only prolongs the consumption period, but also has good sensory characteristics. Therefore, we fermented rice miso products by supplementary with black soybean, kidney bean, red bean and buckwheat to improve the potential functionality, and aim to clarify the nutritional components, antioxidant activity and enzyme inhibitory activity of improved rice miso products with different fermentation period.

Black soybean, kidney bean, adzuki bean, and buckwheat were respectively mixed with soybean, and fermented by rice koji malt (*Aspergillus oryzae*) to prepare rice miso products. Rice miso supplementary with black soybean (RM-BS), rice miso supplementary with kidney bean (RM-KB), rice miso supplementary with adzuki bean (RM-AB), rice miso supplementary with buckwheat (RM-BW) and rice miso (RM; as a control) were fermented for 3 months, 6 months, 24 months and 36 months, and a part of the fermented products was cooled at -20°C freezer for chemical analysis. Subsequently, the peptide, reducing sugar, melanoidin, and polyphenol content were quantified and DPPH radical scavenging activity, ABTS radical scavenging activity, lipase inhibitory activity and α -glucosidase inhibitory activity of rice miso products with different fermentation period were evaluated. We investigated the influence of these functional components in fermented rice miso products on the antioxidant activity, the effect on the anti-obesity action, and the effect on the inhibition of glucose metabolism.

The results showed that the melanoidin and polyphenol content was increased since the fermentation period of rice miso products were processed, and the ratio between the melanoidin and polyphenol content was increased from about 3 folds to 7 folds. Moreover, since the protein and carbohydrate are decomposed by rice koji malt (*Aspergillus oryzae*), peptide and reducing sugar content were increased up, and then for the melanoidin is synthesized, peptide and reducing sugar content were sharply decreased. In addition, the peptide, reducing sugar, melanoidin, and polyphenol content contained in rice miso products supplementary with black soybeans, kidney bean, adzuki bean, and buckwheat were significantly higher than that of rice miso (control) ($p < 0.05$).

DPPH radical scavenging activity and ABTS radical scavenging activity contained in the rice miso product were also increased with the prolongation of the fermentation period, and the RM-BS, RM-KB, RM-AB, and RM-BW were significantly higher than those of rice miso (RM) ($p < 0.05$). Furthermore, the melanoidin content and the polyphenol content have a high positive correlation between DPPH radical scavenging activity and ABTS radical scavenging activity, respectively, and since the melanoidin content was about 7 folds higher than the polyphenol content, it was recognized that the substances contributed to antioxidant activity in rice miso products were mainly melanoidin.

The lipase inhibitory activity and α -glucosidase inhibitory activity of rice miso products were also increased with the prolongation of the fermentation period. however, and the maximum value of RM-BS was detected at fermented after 36 months, and the highest value of RM-KB, RM-AB, RM-BW, and RM were detected at fermented after 24 months. Moreover, the lipase inhibitory activity and α -glucosidase inhibitory activity of RM-BS, RM-KB, RM-AB, and RM-BW were significantly higher than that of RM ($p < 0.05$). There was also a correlation between melanoidin content, polyphenol content and lipase inhibitory activity the correlation coefficient was 0.7405 and 0.7754 at 0.2g DW miso and a correlation between melanoidin content, polyphenol content and α -glucosidase inhibitory activity with the correlation coefficient 0.6206 and 0.6314 at 0.2g DW miso, respectively.

From the above results, we suggest that adding high-performance raw materials, such as black soybean, kidney bean, adzuki bean, and buckwheat into traditional rice miso could increase useful components and improve the functionality, which may exert health beneficiary, in particular, potential applications for high antioxidant activity, and suppression of diabetes and body weight increase.

論文審査の結果の要旨

米味噌には抗酸化活性のあることがすでに知られているが、本研究は、黒大豆、金時豆、小豆及び蕎麦を添加して製造した米味噌を長期発酵熟成すると、コントロールの米味噌よりも有意に抗酸化活性が高くなることを明らかにした論文である。

黒大豆、金時豆、小豆と蕎麦を添加した米味噌の熟成期間の延長に伴い、DPPH ラジカル消去

活性と ABTS ラジカル消去活性は徐々に増加し、コントロールの米味噌のそれらよりも有意に高いこと ($p < 0.05$) を明らかにした。メラノイジン含量は DPPH ラジカル消去活性、ABTS ラジカル消去活性との間に高い正の相関が認められた。また、ポリフェノール含量と DPPH ラジカル消去活性、ABTS ラジカル消去活性との間にもそれぞれ高い正の相関が認められた。メラノイジン含量はポリフェノール含量よりも約 7 倍高く、メラノイジンとポリフェノールの重量当たりの抗酸化活性の効果はほぼ同じであることから、米味噌の抗酸化活性に寄与する物質は含量の多いメラノイジンであると考えられる。メラノイジン含量とポリフェノール含量の比率は、熟成初期に比べ約 3 倍から 7 倍まで増加した。黒大豆、金時豆、小豆と蕎麦を添加した米味噌に含まれるメラノイジンとポリフェノールの含量は発酵熟成期間の増加に伴い上昇し、コントロールの米味噌のそれらよりも有意に高い値を示した ($p < 0.05$)。

また、黒大豆、金時豆、小豆、蕎麦を添加した米味噌のリパーゼ阻害活性と α -グルコシダーゼ阻害活性が、コントロールの米味噌に比べ有意に高いことも明らかにした ($p < 0.05$)。熟成期間の延長に伴い、5 種類の米味噌のリパーゼ阻害活性と α -グルコシダーゼ阻害活性は増加し、金時豆、小豆、蕎麦添加米味噌及びコントロール米味噌では 24 ヶ月熟成味噌、黒大豆添加米味噌では 36 ヶ月熟成味噌であった。リパーゼ阻害活性とメラノイジン含量及びポリフェノール含量との間にそれぞれ正の相関関係のあること、 α -グルコシダーゼ阻害活性とメラノイジン含量及びポリフェノール含量との間にもそれぞれ正の相関関係のあることを明らかにした。

以上の結果より、黒大豆、金時豆、小豆、蕎麦を添加した米味噌の機能性成分含量はコントロールの米味噌に比べて多く、生体内の抗酸化作用や消化酵素の阻害活性の向上が期待され、体内脂肪の蓄積や血糖値上昇の抑制に寄与することが期待される。

以上により、本審査委員会は、「岩手大学大学院連合農学研究科博士学位論文審査基準」に則り審査した結果、本論文を博士(農学)の学位論文として十分価値のあるものと認めた。

学位論文の基礎となる学術論文

1. Jiang CY, Ci ZH, Kojima M. (2018). Antioxidant Activity, α -Glucosidase and Lipase Inhibitory Activity in Rice Miso with Kidney Bean. *Journal of Food and Nutrition Research*. 6(8):504-508.
2. Jiang CY, Ci ZH, Kojima M. (2019). Antioxidant Activity and Lipase Inhibitory Activity in Rice Miso Supplementary with Black Soybean, Buckwheat and Adzuki Bean. *American Journal of Food Science and Technology*. 7(1):7-12.
3. Jiang CY, Ci ZH, Kojima M. (2019). α -Glucosidase Inhibitory Activity in Rice Miso Supplementary with Black Soybean. *American Journal of Food Science and Technology*. 7(1):27-30.