# Effect of Continuous Dewaxed Brown Rice Ingestion on the Cognitive Function of Elderly Individuals

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***Summary*** Dewaxed brown rice (DBR), which is prepared by removing only the outermost wax layer of brown rice using a new rice milling technique, has improved water absorbency, digestibility, and taste compared to regular brown rice. DBR has a nutritional value close to that of brown rice, including a rich amount of lipopolysaccharides that are known to improve cognitive function in mice. This study thus aimed to verify the influence of continuous DBR ingestion on cognitive function among elderly individuals. The present study employed a crossover comparison design using the Revised Hasegawa Dementia Scale to assess cognitive function. Our findings confirmed that long-term DBR ingestion contributed to the prevention and reduction of overall cognitive decline, especially among elderly individuals with low cognitive function. Thus, DBR has the potential to be a useful staple food that maintains brain homeostasis among elderly individuals.
***Key Words*** dewaxed brown rice, cognitive function, lipopolysaccharide, elderly

A recently developed type of brown rice called dewaxed brown rice (DBR), wherein only the outermost wax bran layer have removed using a new rice milling technique (*1*). Furthermore, DBR can be cooked as easily as polished white rice (WR) and can be added to any diet in the form of porridge or rice meal.

We have previously demonstrated that lipopolysaccharide (LPS) in DBR can activate macrophages primarily through the Toll-like receptor 4 pathway and, to a lesser extent, the Toll-like receptor 2 pathway (*2*). LPS are the primary component of the outer membrane of gram-negative bacteria (e.g., *Acetobacter aceti*, *Zymomonas mobilis*, and *Xantomonas campestris*), which are symbionts of edible plants, such as cereals, vegetables, rice, wheat, and soybean. Reports have shown that LPS extracted from plants activate macrophages (or immune cells), while oral LPS ingestion produces various physiologically active effects (*3–5*).

Experiments using senescence-accelerated mouse-prone 8 (SAM-P8) mice have revealed that oral LPS administration activates brain microglia, enhances the phagocytosis of amyloid $\beta$, a cause of Alzheimer's disease, and markedly decreases memory impairment (*6, 7*). Thus, continuous ingestion of LPS-containing DBR

as a staple food may be useful in slowing or even preventing the deterioration of cognitive function. However, the effects of DBR on the cognitive function of elderly individuals remain unclear. Hence, this study aimed to investigate the effects of continuous DBR ingestion as a staple food on cognitive function among elderly individuals.

## Materials and Methods

*Study Design.* A crossover comparison trial was conducted on 31 elderly residents of special nursing homes who were divided into two groups. Both groups ingested WR and DBR for 6 mo (three meals a day). Cognitive function was assessed before and 6 mo after the start of the trial using the Revised Hasegawa Dementia Scale (HDS-R) (*8*) (Fig. 1). This study protocol complied with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the Ethics Committee of Nagoya Keizai University, Aichi, Japan (Receipt No. 2016-1).

*Dietary Intervention.* Koshihikari WR from Aichi Prefecture was used, while Koshihikari raw material from Niigata Prefecture was used to produce DBR, which was process by Toyo Rice Corp. (Saitama, Japan). The nutritional value of WR was calculated using the Standard Tables of Food Composition in Japan—2017

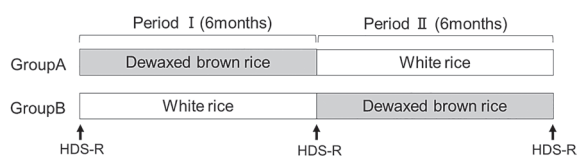E-mail: uenobe.maya@u-nagano.ac.jp

Fig. 1. Study design. A controlled crossover trial was conducted on 31 elderly individuals in special nursing homes who were divided into two groups and ingested either dewaxed brown rice (DBR) or white rice (WR) three times a day for 6 mo, followed by the ingestion of the other test food for the next 6 mo. Cognitive function was assessed prior to and 6 mo after each test meal intake using the Revised Hasegawa dementia scale.

Table 1. Revised Hasegawa Dementia Scale.

| Questions | Score |
|---|---|
| 1. Age (self-orientation) | 1 |
| 2. Date (date orientation) | 4 |
| 3. Place (place orientation) | 2 |
| 4. Repeating of three words (working memory) | 3 |
| 5. Serial subtractions of 7 s (calculation) | 2 |
| 6. Digits backward (working memory) | 2 |
| 7. Recalling of three words (short-term memory) | 6 |
| 8. Recalling five objects (visual memory) | 5 |
| 9. Word fluency (fluency) | 5 |
| Total score | 30 |

Table 2. Nutritive values of WR and DBR diets.

| Nutrients | WR | DBR |
|---|---|---|
| Calorie (kcal) | 4 | 4 |
| Protein (g) | 0.6 | 0.5 |
| Fat (g) | 0.1 | 0.2 |
| Carbohydrate (g) | 9.4 | 6.5 |
| Dietary fiber (g) | 0.1 | 0.4 |
| LPS (ng) | 0.04 | 0.81 |

WR, white rice; DBR, dewaxed brown rice; LPS, lipopolysaccharide. Component values are indicated per 1 g dry weight.

Table 3. Participant characteristics.

| Variable | Group A | Group B | $p$ |
|---|---|---|---|
| Number (men/women) | 18 (4/14) | 13 (3/10) | |
| Age (y) | 84.3±0.3 | 83.8±9.1 | 0.768 |
| Body weight (kg) | 44.5±10.0 | 47.3±8.9 | 0.428 |
| BMI (kg/m$^2$) | 19.0±5.5 | 18.8±7.0 | 0.922 |
| HDS-R | 7.1±10.0 | 8.0±6.9 | 0.785 |

BMI, body mass index; HDS-R, Revised Hasegawa Dementia Scale. Data are presented as mean and standard deviation, while $p$ values were obtained using Student's $t$-test.

Table 4. Difference in total HDS-R score between each group.

| | Difference in total score of HDS-R | | $p$ |
|---|---|---|---|
| | White rice | Dewaxed brown rice | |
| Group A | 1.6±0.7 | 1.1±0.9 | 0.683 |
| Group B | −1.0±0.8 | 1.3±0.9 | 0.063 |
| Group A+B | 0.5±0.6 | 1.2±0.6 | 0.441 |

HDS-R, Revised Hasegawa Dementia Scale. Data are presented as mean and standard error, while $p$ values were obtained using the paired $t$-test. Group A, $n=18$; Group B, $n=13$; Group A+B, $n=31$.

(Seventh Revised Edition), the nutritional value of DBR was measured by the Japan Food Industry Association, and LPS content was measured by Macrophi Inc. (Kagawa, Japan).

*Cognitive Function.* The HDS-R (*8*), which was administered prior to and 6 mo after each test meal intake, was used to assess cognitive function. HDS-R is a test developed to screen for age-associated dementia (*8*) and comprises nine simple items that measure orientation, memory, attention/calculation, and fluency of words, with a maximum total score of 30 points (Table 1).

*Statistical Analysis.* Data were analyzed using SPSS version 24.0 (IBM Corporation, Tokyo, Japan) for Windows. Values for participants' characteristics are presented as means and standard deviations, while HDS-R scores are presented as means and standard errors. The present study categorized subjects into low and high cognitive function groups, the former including subjects with a total HDS-R score of 1 or more and less than 10. Paired $t$-tests were used to assess the statistical significance of HDS-R scores and differences between paired changes in both groups. A $p$ value of <0.05 in all tests was considered statistically significant.

### Results

*Diet Parameters.* Total calorie consumption was the same for DBR and WR. Protein contents were 0.5 and 0.6 g and fat contents were 0.2 and 0.1 g for DBR and WR, respectively. Carbohydrate contents were 6.5 and 9.4 g and dietary fiber contents were 0.4 and 0.1 g for DBR and WR, respectively. LPS contents in the DBR and WR diets were 0.81 and 0.04 ng, respectively (Table 2).

*Participants' Characteristics.* Table 3 summarizes the participants' characteristics, among whom 18 were in group A and 13 were in group B. No significant differences in the characteristics of the two cohorts had been observed.

*Cognitive Function Assessment Using the HDS-R.* Table 4 shows the difference in total HDS-R score between each group. Group B had a score difference of −1.0±0.8 after WR ingestion and 1.3±0.9 after DBR ingestion. However, no significant difference in total score was observed between WR and DBR in Groups A, B, and A+B. Table

Table 5. Difference in total HDS-R score among the low cognitive function group.

| | Difference in total HDS-R score | p |
|---|---|---|
| White rice | −0.5±0.5 | |
| Dewaxed brown rice | 2.8±0.7 | 0.001 |

HDS-R, Revised Hasegawa Dementia Scale. Data are presented as mean and standard error, while the p value was obtained using the paired t-test. The low cognitive function group (n=13) included subjects with a total HDS-R score of 1 or more and less than 10.

5 shows the difference in total HDS-R scores among the low cognitive function group (total HDS-R score of 1 or more and less than 10). Accordingly, the score difference was −0.5±0.5 after WR ingestion and 2.8±0.7 after DBR ingestion. In this group, however, DBR ingestion resulted in a significant higher total HDS-R score compared to WR ingestion (paired t-test, p=0.001).

## Discussion

This study investigated the effect of long-term regular dietary intake of DBR on the cognitive function of elderly individuals. To the best of our knowledge, this has been the first human intervention study to utilize DBR, a substance which has generally been considered difficult to ingest, especially for elderly individuals with deteriorated chewing or swallowing capabilities. However, throughout the study period, none of the subjects dropped out of the program, indicating that DBR was regularly ingested in our study cohort. In addition, our findings revealed that long-term DBR ingestion contributed to the prevention and reduction of overall cognitive decline, especially among elderly individuals with low cognitive function. We hypothesized that LPS, the nutrient-rich functional component of DBR, can be useful for maintaining brain homeostasis. However, the effects of LPS in DBR and other food components on human microglia and brain function, as well as their mechanisms of action, remain unknown. Moreover, the nutritional components of rice have been known to from area-by-area even in the same brand. In the future, analyzing the nutritional components of rice and using rice harvested in the same area to produce WR and DBR. Visual assessment of the amount of WR or DBR consumed daily by the individuals had also been conducted (data not shown). Accordingly, the relationship between the results provided herein and the amount of rice consumed by the individuals should also be analyzed. Considering that medical history, drug intake history, and genetic background had not been screened herein, care should be taken in the interpretation of the results. Furthermore, we need to consider the fact that DBR contains other bioactive compounds, such as polyphenols, vitamins, and dietary fiber. Nonetheless, we believe that

LPS is a major functional component of DBR and speculate that the interaction between LPS and other functional components contributed toward improving cognitive function—a topic that our future investigations will cover. Future studies that seek to investigate the association between BR intake and cognitive function should objectively evaluate the effects of long-term DBR intake.

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