Effects of Dietary Protein of Korean Foxtail Millet on Plasma Adiponectin, HDL-Cholesterol, and Insulin Levels in Genetically Type 2 Diabetic Mice

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We examined the effects of intake of Korean foxtail millet protein (FMP) on plasma levels of lipid, glucose, insulin, and adiponectin in genetically type 2 diabetic KK-A<sup>y</sup> mice. When mice were fed a normal FMP diet or a high-fat-high-sucrose diet containing FMP for 3 weeks, in both experiments plasma concentrations of high-density lipoprotein cholesterol (HDL-cholesterol) and adiponectin increased remarkably in comparison with a casein diet group, whereas concentrations of insulin decreased greatly and that of plasma glucose was comparable to that in the casein diet group. Considering the role of adiponectin, insulin, and HDL-cholesterol in diabetes, atherosclerosis, and obesity, it appears likely that FMP may improve insulin sensitivity and cholesterol metabolism through an increase in adiponectin concentration. Therefore, FMP would serve as another beneficial food component in obesity-related diseases such as type 2 diabetes and cardiovascular diseases.

Key words: foxtail millet; type 2 diabetes; adiponectin

An increase in the prevalence of obesity-related type 2 diabetes has been reported worldwide.1,2 Obesity causes abnormal lipid and glucose metabolism, and subsequently leads to an increased risk of chronic diseases such as cardiovascular disease and type 2 diabetes.3 Obesity-related type 2 diabetes is characterized by defects in both insulin action and insulin secretion, which should lead to alteration of lipid and glucose metabolism.4 These metabolic syndromes are usually attributed to insulin resistance, hyperinsulinemia, hypertension, and dyslipidemia. Diabetic atherosclerosis is also accompanied by the development of insulin resistance, which is known markedly to increase the risk of type 2 diabetes and may be the basis of a complicated metabolic disorder related to impaired glucose metabolism and dyslipidemia. Moreover, serum lipid abnormalities in type 2 diabetes are characterized by decreased HDL cholesterol and hypertriglyceridemia.3,4

It is well known that accumulation of abdominal visceral adipose tissue caused by overnutrition and physical inactivity may lead to the development of metabolic syndromes. Further, it has recently been recognized that adipose tissue is not simply an energy storage tissue, but also expresses genes of a variety of adipocytokines and secretes tumor necrosis factor-α, interleukin-6, resistin, leptin, and adiponectin.5,6 In particular, adiponectin has been widely noticed because it has anti-atherogenic and anti-insulin resistance properties.5,6 Plasma concentrations of adiponectin decrease with the development of obesity and type 2 diabetes.7,8 Therefore, to ameliorate the abnormalities of lipid and glucose metabolism by a specific food component would be useful for preventing or retarding the progression of obesity and type 2 diabetes.9–11 Several studies have shown that animal and vegetable proteins influence lipid metabolism in humans and experimental animals.11–13 In particular, soybean protein, as compared with animal proteins, was effective in improving hypercholesterolemia14 and reducing body weight.15,16

The millets, including sorghum, proso, and Japanese millet are a valuable source of human food in Africa and Asia. Approximately one hundred million tons of millet has been reported to be produced worldwide.17 Recently, consumption of millet has increased because people consider millet to be a healthy food and a replacement cereal for those allergic to certain grains. We reported that protein of proso millet (Panicum miliaceum L.) is effective for improving lipid metabolism.18,19 Specifi-
cally, it has been shown that the feeding of protein of proso millet elevated plasma levels of high-density lipoprotein (HDL) cholesterol concentrations in rats and mice. In addition, it has been reported that this protein has a preventive effect on liver injury.\textsuperscript{20}

Foxtail millet (\textit{Setaria italica} Beauv.) is used as a human food in Korea, and 1,851 tons were produced in 2001.\textsuperscript{21} This millet has higher fiber and lipid content when compared to other millets,\textsuperscript{22} but no study on the health benefits of Korean foxtail millet has been reported.

In this study, we examined the effects of dietary protein of Korean foxtail millet on plasma concentrations of lipid, glucose, insulin, and adiponectin in genetically type 2 diabetic KK-A\textsuperscript{y} mice. The objective of the first experiment was to determine the influence of intake of foxtail millet protein (FMP) under normal dietary conditions. In the second experiment, we examined the effects on the blood parameters mentioned above under serious diabetic conditions in KK-A\textsuperscript{y} mice fed a high-fat diet containing high sucrose. KK-A\textsuperscript{y} mice have been used as an animal model for obesity and type 2 diabetes, which exhibits severe obesity, hyperinsulinemia, and insulin resistance.\textsuperscript{23,24}

This is the first report on the health benefits of Korean foxtail millet. The results indicate that the dietary protein of foxtail millet has beneficial effects on plasma concentrations of HDL-cholesterol, adiponectin, and insulin.

Materials and Methods

\textbf{Materials.} The foxtail millet used in this study was of the green glutinous type, harvested and obtained from a farmer in Yeosu, Korea in 2002. Protein concentrate of foxtail millet was prepared according to the method of a farmer in Yeosu, Korea in 2002. Protein concentrate of the green glutinous type, harvested and obtained from a farmer in Yeosu, Korea in 2002 (Lactase SR-40 and Enzylon GA-4, Rakuto Kasei, Ltd., Ohtsu, Shiga, Japan) was used to digest the starch at 60°C for 24 h (pH 7.0). Then, after removal of the soluble fraction, the resultant material was freeze-dried and defatted with n-hexane. The composition of the protein concentrate was as follows (g/100 g): moisture, 10.8; protein, 52.4; lipid, 5.1; total dietary fiber, 15.4.

The amino acid composition of protein concentrates, determined by an amino acid analyzer, (JLC-500/V, JEOL, Tokyo, Japan) is shown in Table 1. As compared to that of casein,\textsuperscript{25} alanine, cystine, and leucine content in the protein concentrate of millet were much higher.

\textbf{Animals and diet.} Two separate experiments in which animals were given a normal diet or a high-fat diet containing high sucrose were performed as follows: In experiment 1, the effects of dietary FMP on plasma concentrations of glucose, insulin, adiponectin, and lipid were examined using genetically type 2 diabetic KK-A\textsuperscript{y} mice fed a normal diet. Male KK-A\textsuperscript{y} mice aged 8 weeks were obtained from Clea Japan (Tokyo, Japan). The mice were kept in an air-conditioned room at 22 ± 1°C with a 12-h light-dark cycle (6:00 to 18:00), and given free access to food and water. The animals were fed a diet containing 20% casein\textsuperscript{26} for 7 d. Then they were divided into two groups of 6 animals each and fed the experimental diets (Table 2) containing casein (casein diet group) or FMP (FMP diet group) as a protein source for 3 weeks. The animals in the FMP diet group were pair-fed the diet, in contrast with the casein diet group. The FMP diet was supplemented with 1.5% L-lysine monohydrochloride to simulate the amino acid composition of casein.\textsuperscript{25} The animals were thereafter fasted for 8 h and blood was collected from the abdominal vena cava.

\begin{table}[h]
\centering
\caption{Amino Acid Compositions of Casein and Protein Concentrate of Foxtail Millet (mg/g N)}
\begin{tabular}{l|l|l}
\hline
& Casein\textsuperscript{1} & FMP\textsuperscript{2} \\
\hline
Asp & 460 & 418 \\
Thr & 270 & 208 \\
Ser & 340 & 248 \\
Glu & 1400 & 1415 \\
Pro & 750 & 638 \\
Gly & 120 & 150 \\
Ala & 200 & 638 \\
Val & 440 & 296 \\
Cys & 32 & 70 \\
Met & 200 & 295 \\
Ile & 360 & 243 \\
Leu & 620 & 793 \\
Tyr & 370 & 230 \\
Phe & 340 & 358 \\
Lys & 530 & 48 \\
His & 200 & 124 \\
Arg & 240 & 167 \\
\hline
\end{tabular}
\end{table}

Values show means for 4 measurements.
\textsuperscript{1}Standard tables of food composition in Japan, 5th ed. (2001).\textsuperscript{25}
\textsuperscript{2}FMP, Foxtail millet protein (for details, see “Materials and Methods”).

\begin{table}[h]
\centering
\caption{Composition of Experimental Diets (%)}
\begin{tabular}{l|l|l|l|l}
\hline
Dietary protein & Normal diet (Exp. 1) & & High-fat diet containing & \\
& Casein & FMP\textsuperscript{3} & & high sucrose (Exp. 2) \\
& & & & Casein & FMP\textsuperscript{3} \\
\hline
Casein\textsuperscript{1} & 23.6 & — & 27.4 & — \\
FMP\textsuperscript{3} & — & 38.3 & — & 45.0 \\
Salt mixture\textsuperscript{2} & 3.5 & 3.5 & 4.1 & 4.1 \\
Vitamin mixture\textsuperscript{2} & 1.0 & 1.0 & 1.2 & 1.2 \\
Corn oil\textsuperscript{3} & 7.0 & 5.0 & 7.0 & 4.7 \\
Lard & — & — & 20.8 & 20.8 \\
Choline bitartrate\textsuperscript{4} & 0.2 & 0.2 & 0.2 & 0.2 \\
Cellulose\textsuperscript{4} & 5.9 & — & 6.9 & — \\
\(\alpha\)-Cornstarch & 48.5 & 40.5 & 9.8 & — \\
Sucrose & 10.0 & 10.0 & 22.3 & 22.3 \\
L-Cystine\textsuperscript{3} & 0.3 & — & 0.4 & — \\
L-Lysine+HCl\textsuperscript{3} & — & 1.5 & — & 1.7 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{1}Oriental Yeast Co., Tokyo, Japan.
\textsuperscript{2}AIN-93 composition.
\textsuperscript{3}Ajinomoto Co., Tokyo, Japan.
\textsuperscript{4}Wako Pure Chemical Industries Ltd., Osaka, Japan.
\textsuperscript{5}FMP, Foxtail millet protein (for details, see “Materials and Methods”).
cava under anesthesia with diethyl ether. Blood was quickly centrifuged at 3,550 × g for 15 min at 4°C to obtain plasma. The liver and epididymal adipose tissue were also excised. These samples were quickly frozen in liquid nitrogen and stored at −80°C until analyzed. In experiment 2, the effects of FMP intake on plasma concentrations of glucose, insulin, adiponectin, and lipid were studied with male KK-A' mice at 8 weeks of age given a high-fat diet containing high sucrose. They were fed a 20% casein diet for 7 d and thereafter were divided into two groups of 6 animals each, which were fed the high fat high sucrose FMP or the high fat high sucrose casein diets respectively (Table 2) for 3 weeks. The animals in the FMP diet group were pair-fed the diet, in contrast with the casein diet group. They were thereafter subjected to the same procedure as that of experiment 1. The animal experiments were done according to the conditions established by the Animal Care and Use Committee of Iwate University.

**Analysis.** Plasma concentrations of total cholesterol, HDL-cholesterol, triglyceride, and glucose were measured enzymatically with commercial kits (Total cholesterol E-Test Wako, HDL-cholesterol E-Test Wako, Triglyceride E-Test Wako, and Glucose CH-Test Wako, Wako Pure Chemical Industries, Osaka, Japan). The plasma insulin concentration was measured by the ELISA method (Levis mouse insulin kit, Shibayagi, Gunma, Japan). We also measured plasma adiponectin concentrations using the mouse/rat adiponectin ELISA kit (Otsuka Pharmaceutical, Tokyo, Japan). Liver lipids were extracted by the method of Folch et al.,\(^\text{77}\) and the cholesterol and triglyceride concentrations were measured with the above kits.

**Statistical analysis.** An analysis of variance was done on the experimental data, and the differences between means were considered to be significant at \(p < 0.05\) by Student’s t test. These analyses were done by InStat ver. 3.0 (GraphPad Software, San Diego, CA, U.S.A.).

**Results**

**Experiment 1**

Table 3 shows the effects of dietary FMP on food intake, body weight gain, liver and epididymal adipose tissue weight, plasma concentrations of lipids and glucose, and liver lipid values when KK-A' mice were fed two different normal diets for 3 weeks. No significant differences in body weight gain, weight of epididymal adipose tissue, or plasma triglyceride concentration were observed between the two dietary groups, but liver weight in the FMP diet group was higher than in the casein diet group. The total plasma cholesterol concentration in the FMP diet group was significantly higher than in the casein diet group, but the elevation of total cholesterol resulted from a large increase in HDL-cholesterol concentration (Fig. 1). This value of HDL-cholesterol concentration in the FMP diet group was more than twice that in the casein diet group.

<table>
<thead>
<tr>
<th>Dietary group</th>
<th>Casein</th>
<th>FMP(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food intake (g/20 d)</td>
<td>149 ± 6</td>
<td>149 ± 5</td>
</tr>
<tr>
<td>Body-wt. gain (g/20 d)</td>
<td>1.72 ± 0.7</td>
<td>2.4 ± 0.6</td>
</tr>
<tr>
<td>Plasma lipids (mg/dl)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>102 ± 5</td>
<td>138 ± 10*</td>
</tr>
<tr>
<td>(LDL+VLDL)-cholesterol</td>
<td>71.6 ± 9.6</td>
<td>65.6 ± 7.2</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>124 ± 28</td>
<td>125 ± 14</td>
</tr>
<tr>
<td>Plasma glucose (mg/dl)</td>
<td>322 ± 21</td>
<td>323 ± 21</td>
</tr>
<tr>
<td>Adipose tissue wt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epididymal (g/100 g body wt.)</td>
<td>3.8 ± 0.2</td>
<td>3.8 ± 0.1</td>
</tr>
<tr>
<td>Liver wt. (g/100 g body wt.)</td>
<td>4.8 ± 0.1</td>
<td>5.4 ± 0.2*</td>
</tr>
<tr>
<td>Liver lipids (mg/g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>3.9 ± 0.1</td>
<td>2.7 ± 0.3*</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>25.6 ± 3.8</td>
<td>38.6 ± 4.5*</td>
</tr>
</tbody>
</table>

Values are means ± SEM of 6 mice.

\(^*\)Significantly different from the casein diet (\(p < 0.05\)).  
\(^1\)FMP, Foxtail millet protein (for details, see “Materials and Methods”).

![Fig. 1. Effects of Dietary Proteins on Plasma Levels of HDL-Cholesterol (A), Insulin (B), and Adiponectin (C) in KK-A' Mice Fed Normal Diets (Experiment 1).](image-url)

Values are means ± SEM of 6 mice. *Significantly different from the casein diet (\(p < 0.05\)). FMP, Foxtail millet protein (for details, see “Materials and Methods”).
without an elevation of LDL+VLDL-cholesterol concentration (Fig. 1). Plasma insulin concentration in mice given the FMP diet decreased 57% in comparison with animals fed the casein diet (Fig. 1), although there was no difference in concentration of plasma glucose. In contrast to the concentrations of insulin and glucose, the plasma adiponectin concentration in the FMP diet group was approximately 64% greater than in the casein diet group (Fig. 1). In liver, the cholesterol concentration decreased significantly in mice that received the FMP diet compared with those ingesting the casein diet, whereas triglyceride values were higher in the FMP diet group.

**Experiment 2**

Table 4 shows the effects of dietary FMP on food intake, body weight gain, liver and epididymal adipose tissue weight, plasma concentrations of lipids and glucose, and liver lipid values when KK-A\(^y\) mice were given a high-fat diet containing high sucrose for 3 weeks. No significant differences in body weight gain or liver weight were observed between the two dietary groups, while the weight of epididymal adipose tissue in the FMP diet group was significantly lower than in the casein diet group. The plasma triglyceride concentration in the FMP diet group was significantly higher than in the casein diet group.

Similarly to experiment 1, the plasma concentration of HDL-cholesterol in the FMP diet group was remarkably higher than in the casein diet group without a significant elevation of LDL+VLDL-cholesterol (Fig. 2). There was no difference in concentrations of plasma glucose, but the plasma insulin concentration in mice given the FMP diet decreased markedly compared with that in animals fed the casein diet (Fig. 2). In contrast to insulin concentrations, the plasma adiponectin concentration in the FMP diet group increased almost two-fold over that of the casein diet group (Fig. 2). Thus FMP had a similar effect on HDL-cholesterol, adiponectin, and insulin levels in mice fed the normal diet to that in those animals ingesting a high-fat diet. In the liver, cholesterol concentrations decreased significantly when mice received the FMP diet compared with those receiving the casein diet, but there was no difference in concentrations of liver triglyceride between groups.

### Discussion

Type 2 diabetes is one of the most common chronic diseases, together with obesity. It has been strongly emphasized that not only medical therapy but also improvements in lifestyle are effective in preventing these diseases. It would be highly desirable to be able to regulate these diseases by consumption of specific food components. We examined the preventive functions of Korean foxtail millet against the development of atherosclerosis and type 2 diabetes using genetically type 2 diabetic KK-A\(^y\) mice.

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**Table 4.** Effects of Dietary Protein on Food Intake, Body Weight Gain, Liver and Adipose Tissue Weights, Plasma and Liver Lipids, and Plasma Glucose Concentrations in KK-A\(^y\) Mice Fed a High-Fat Diet Containing High Sucrose (Experiment 2)

<table>
<thead>
<tr>
<th>Dietary group</th>
<th>Casein</th>
<th>FMP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food intake (g/20 d)</td>
<td>129 ± 3</td>
<td>129 ± 1</td>
</tr>
<tr>
<td>Body wt. gain (g/20 d)</td>
<td>3.4 ± 0.6</td>
<td>4.7 ± 0.6</td>
</tr>
<tr>
<td>Plasma lipids (mg/dl)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>113 ± 7.4</td>
<td>163 ± 11.2*</td>
</tr>
<tr>
<td>(LDL+VLDL)-cholesterol</td>
<td>55.6 ± 8</td>
<td>71.6 ± 7.2</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>40.4 ± 4.3</td>
<td>63.7 ± 4.2*</td>
</tr>
<tr>
<td>Plasma glucose (mg/dl)</td>
<td>547 ± 30</td>
<td>588 ± 31</td>
</tr>
<tr>
<td>Adipose tissue wt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epididymal (g/100 g body wt.)</td>
<td>3.6 ± 0.1</td>
<td>3.3 ± 0.1*</td>
</tr>
<tr>
<td>Liver wt. (g/100 g body wt.)</td>
<td>6.2 ± 0.4</td>
<td>6.8 ± 0.4</td>
</tr>
<tr>
<td>Liver lipids (mg/g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>4.4 ± 0.5</td>
<td>3.2 ± 0.2*</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>92.6 ± 10</td>
<td>112.1 ± 6.5</td>
</tr>
</tbody>
</table>

 Values are means ± SEM of 6 mice.

*Significantly different from the casein diet (p < 0.05).

FMP, Foxtail millet protein (for details, see “Materials and Methods”).

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**Fig. 2.** Effects of Dietary Proteins on Plasma Levels of HDL-Cholesterol (A), Insulin (B), and Adiponectin (C) in KK-A\(^y\) Mice Fed a High-Fat Diet Containing High Sucrose (Experiment 2).

Values are means ± SEM of 6 mice. *Significantly different from the casein diet (p < 0.05). FMP, Foxtail millet protein (for details, see “Materials and Methods”).
With regard to the effect of dietary protein intake on plasma adiponectin, insulin, and HDL-cholesterol levels, Nagasawa et al.\textsuperscript{28} reported that the plasma adiponectin concentration and gene expression of adipose adiponectin were elevated, although plasma glucose and insulin concentrations were not modulated in Wistar rats fed soy protein. They also observed that plasma glucose concentrations decreased, although adiponectin concentrations did not change under conditions of restricted food intake after feeding a high-fat diet to KK-A\textsuperscript{Y} mice given soy protein.\textsuperscript{29} On the other hand, Lavigne et al.\textsuperscript{10} indicated that dietary cod and soy proteins lowered plasma glucose and insulin concentrations, and that these dietary proteins improved glucose clearance and insulin sensitivity as compared with casein. Dietary cod protein also improved undesirable modulations, including insulin signaling and GLUT 4 translocation or insulin resistance in obese rats fed a high-fat diet.\textsuperscript{30} Similarly, Ascencio et al.\textsuperscript{31} recently observed that insulin concentrations clearly decreased in two feeding experiments on soy protein of 10 d and 150 d in the rat. However, in both experiments 1 and 2 in the present study, dietary FMP increased remarkably the plasma concentrations of HDL-cholesterol and adiponectin, whereas the concentration of insulin decreased greatly and that of plasma glucose was comparable to that in the casein diet group.

Tschritter et al.\textsuperscript{32} reported that there is a strong positive correlation between plasma adiponectin and HDL-cholesterol concentrations in nondiabetic individuals. Moreover, the serum adiponectin concentration was shown to be associated positively with levels of HDL-cholesterol and apolipoprotein-A or LDL particle size, and negatively related to levels of triglyceride and apolipoprotein-B in young healthy men.\textsuperscript{33} Zietz et al.\textsuperscript{34} assumed that adiponectin represents an independent cardiovascular risk factor predicting serum HDL-cholesterol concentration in type 2 diabetes. Thus our results using KK-A\textsuperscript{Y} mice are in agreement with these findings. Recently we observed that dietary Japanese millet protein, compared with casein, significantly elevated plasma HDL-cholesterol and adiponectin concentrations in genetic type 2 diabetic GK rats fed a normal diet for 3 weeks (unpublished data). These observations are consistent with our present results. Consequently, it is likely that adiponectin has a protective action similar to HDL-cholesterol for atherosclerosis.\textsuperscript{5,32}

Interestingly, it has been reported recently that resistin levels in adipose tissues correlated with serum adiponectin concentrations positively. Therefore, resistin concentration should also be examined together with that of adiponectin.\textsuperscript{35} From detailed studies using monkeys, Hotta et al.\textsuperscript{36} highlighted the importance of the suggestion that a decrease in plasma adiponectin concentration may be associated with the progression of insulin resistance. Further, Tschritter et al.\textsuperscript{32} observed that plasma adiponectin concentration was more closely related to increases in insulin sensitivity than to changes in body weight or plasma glucose concentration, suggesting that hyperinsulinemia and insulin resistance are major determinants of the hyperadiponectinemia in obesity and type 2 diabetes. On the other hand, it has also been established that the plasma adiponectin concentration is negatively correlated with the fasting plasma insulin level in type 2 diabetic individuals.\textsuperscript{7} Yu et al.\textsuperscript{30} also reported that treatment with thiazolidinediones (TZDs), an insulin-sensitizing agent, increased adiponectin concentrations accompanied by an elevation in HDL-cholesterol concentration and a decrease in fasting insulin concentration in normal, obese, and type 2 diabetic individuals. At the same time they also confirmed these results in normal rats treated with TZDs. Yu et al.\textsuperscript{36} claimed that adiponectin might play a physiological role in enhancing insulin sensitivity. These observations on type 2 diabetic individuals and animals treated with TZDs appear to be consistent with our present results. Therefore, plasma adiponectin levels can serve as a marker of degree of insulin sensitivity.\textsuperscript{5,6,36}

But, the mechanism by which FMP acts on increases in HDL-cholesterol and adiponectin levels and reduction of insulin is still unclear and the effective component is under study. It is known that differences in the amino acid compositions of dietary proteins can mediate lipid metabolism and insulin secretion.\textsuperscript{37} For example, although leucine enhances glucose and insulin homeostasis by stabilizing fasting and postprandial levels of blood glucose,\textsuperscript{38} the leucine content of FMP is comparable to that of casein. Hence it is unlikely that the responses of insulin dynamic and HDL-cholesterol metabolism can be attributed to the difference in amino acids alone.

In conclusion, taking into account the role of adiponectin, insulin, and HDL-cholesterol in diabetes, atherosclerosis, and obesity, it appears likely that FMP improves insulin sensitivity and cholesterol metabolism through an increase in adiponectin concentration. Therefore, FMP can serve as another beneficial food component in obesity-related diseases such as type 2 diabetes and cardiovascular diseases.

Acknowledgments

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21) Korea National Crop Experiment Station, Millet Production. KNCES (1999).


