ABSTRACT: Using a panel of chemical, biochemical, and cell assays, we determined inhibitory effects of extracts of the pigmented black rice brans on in vitro allergic reactions. Ethanol-water (70% v/v) extracts from 5 pigmented brans were found to be more effective than an extract from a nonpigmented rice cultivar in suppressing the release of histamine and β-hexosaminidase from basophilic RBL-2H3 cells stimulated with both IgEophore A23187 and immunoglobulin E (IgE)-antigen complexes. Suppression was also obtained with A23187-stimulated rat peritoneal mast cells. The extent of inhibition of these 2 markers of the immune response was accompanied by an influx of calcium ions. The inhibition of the immune process by the pigmented brans was confirmed by the observed modulation of the proinflammatory cytokine gene expressions and cytokine release, as indicated by the reduction in tumor necrosis factor (TNF-α), interleukin (IL)-1β, IL-4, and IL-6 mRNA expressions determined with the reverse transcription-polymerase chain reaction (RT-PCR). Reduction of TNF-α, IL-1β, and IL-6 protein release from both the cultured cell line and peritoneal cells was further confirmed by enzyme-linked immunoadsorbent assays. Rice bran from the LK1-3-6-12-1-1 cultivar was the most effective inhibitor in all assays. This particular rice variety merits further evaluation as part of a human diet to ascertain its potential to protect against allergic diseases such as hay fever and asthma.

Keywords: allergy, antiallergic black rice bran, basophilic cells, cytokines, histamine, mast cells, β-hexosaminidase

Introduction

An allergic reaction takes place when the immune system of an animal or human responds (reacts) to the exposure of a variety of substances (cosmetics, molds, peanut proteins, soy proteins, pollen, spores) called allergens (Alberts and others 1994; Brandon and Friedman 2002). These allergens induce the release of histamine from basophilic and mast cells, mediators of inflammatory responses. Histamine is largely responsible for the clinical manifestations of several allergic reactions, including asthma and hay fever. The mediation process is accomplished by release of the granules containing preformed allergenic substances and enzymes. Histamine and β-hexosaminidase are considered to be markers of mast cell degranulation (Matsubara and others 2004b). Inhibition of antigen-induced release of histamine and β-hexosaminidase by food and medicinal and herbal plant ingredients appears to be a requirement for an antiallergic response. In this sense, blockade of cellular Ca2+ influx is thought to be important, because FceRI-mediated mast cell degranulation results from granule-to-plasma or granule-to-granule membrane fusion in response to elevated cytosolic Ca2+ levels (Castle and others 2002). Other manifestations of antiallergicity include the inhibition or suppression of antigen-induced release of proinflammatory cytokines that are also involved in mediating and signaling of the immune response at the genetic level.

These include the tumor necrosis factor (TNF-α) and several interleukins (IL). Intracellular Ca2+ ions are also involved in the active expression of TNF-α and IL-genes.

In previous studies (Nam and others 2005a, 2005b, 2006), we showed that 70% ethanol-water extracts of several newly developed pigmented rice cultivars exhibited antioxidative, antimutagenic, and anticarcinogenic effects in chemical and cell assays. The main objective of the present study was to compare the potential of bran extracts from 1 nonpigmented and 5 pigmented rice cultivars to inhibit release of histamine and of β-hexosaminidase in in vitro allergic reactions mediated by stimulated basophilic leukemia and rat peritoneal mast cells, widely used in studies of antiallergic effects. The results demonstrate that pigmented rice brans may prevent allergic and antiinflammatory responses of the immune system.

Materials and Methods

Materials
p-Nitrophenyl-N-acetyl-β-glucosaminide, OPT, ionophore A23187, guanidium thiocyanate, and other chemicals were purchased from Sigma Chemical Co. (St. Louis, Mo., U.S.A.). Fluoro-AM was purchased from Calbiochem (San Diego, Calif., U.S.A.). All reagents were of analytical grade and were used without further purification. RPMI 1640 medium, Hank’s balanced salt solution, fetal bovine serum (FBS), and other cell culture reagents were obtained from Hyclone Laboratories (Logan, Utah, U.S.A.). Anti-DNP IgE and DNP-BSA were also purchased from Sigma Chemical Co. Cytokine assay kits for enzyme-linked immunoadsorbent (ELISA) were obtained from Biorosource U.S.A. (Camarillo, Calif., U.S.A.). AMV reverse transcriptase, Taq DNA polymerase, and dNTP mix were products of Takara Bio Inc. (Kyoto, Japan). All PCR primers were custom-synthesized and purified by Bioneer Co. (Daejon, Korea).
RBL-2H3 cells, rat basophilic leukemia cell line from Japan Health Science Resource Bank (Osaka, Japan), were maintained in RPMI 1640 medium with 10% FBS at 37 °C in an atmosphere consisting of 5% CO₂-contained humidified air. The cells were detached with a trysin-EDTA solution. The cells were then washed and resuspended in the medium or in an appropriate buffer for subsequent experiments.

**Rice bran extracts**

Five pigmented black rice cultivars (Jamalalocal-1, DZ78, Elwhee, LK1A-2-12-1-1, and LK1-3-6-12-1-1) and 1 nonpigmented cooking rice (Chuchung) was harvested at the experimental rice field of the College of Agriculture and Life Science, Seoul Natl. Univ. (Suwon, Korea). The rice seeds were dehulled, degermed, polished in a laboratory mill, and then passed though 60-mesh sieve, resulting in a unified fraction of rice bran. The pigments and other compounds in the bran were extracted by shaking overnight at room temperature with 19 times the sample weight of 70:30 ethanol/water (v/v). The mixture was then filtered and the filtrate was then passed through Whatman No. 1 filter paper. The solvent was then removed from the extract by rotary evaporation at room temperature.

**Preparation of rat peritoneal mast cells**

Male Sprague-Dawley rats aged 7 wk were purchased from Orient Inc. (Seoul, Korea). Animals were individually housed in stainless steel cages in a room maintained at 20 to 22 °C and 50 ± 10% relative humidity with 12-h light and dark alternate cycles. The rats were fed a commercial chow diet and sterile water ad libitum.

Isolation and purification of rat peritoneal mast cells was performed according to the method of Lu and others (2004) with slight modification. The rats were first anesthetized with chloroform. This was followed by gavageing of the peritoneal cavity with 30 mL of Tyroid B buffer (137 mM NaCl, 2.7 mM KCl, 12 mM NaHCO₃, 0.3 mM NaHPO₄, 3 mM glucose, 0.1% gelatin, pH 7.2). Repeated washings were performed and centrifuged at 200 g for 10 min at 4 °C. The exudated cell pellet was then resuspended in 1 mL of Tyroid A buffer (10 mM HEPES, 130 mM NaCl, 5 mM KCl, 1.4 mM CaCl₂, 1 mM MgCl₂, 5.6 mM glucose, 0.1% BSA, pH 7.2) and layered onto 2 mL of Histopaque (Sigma Chemical Co.). The cell suspension was then centrifuged at 400 g for 15 min at 4 °C. Recovered cells in the pellet were resuspended in the Tyroid A buffer. Cell number and viability were determined by trypan blue staining.

**Histamine and β-hexosaminidase secretion assays**

The histamine secretion assay was performed according to the method of Kawasaki and others (1994) with some modification. RBL-2H3 or mast cells were suspended in Tyroid A buffer to adjust to a cell density of 1 × 10⁶ cells/mL. For stimulation of cells with A23187, the cells were seeded into a 24-well plate to mix with various amounts of rice extracts for 15 min at 37 °C. For stimulation of cells with DNP-BSA, the same number of cells was preloaded at 37 °C overnight with 1 µg of anti-DNP IgE, and the cell suspension was then mixed with various amounts of rice extracts and incubated for 15 min at 37 °C. For priming cell functions, following treatment with rice extracts, ionophore A23187 or DNP-BSA were added to the cell suspension to a final concentration of 10 µM or 10 µg/mL, respectively. Incubation was continued for another 20 min. The cell suspension was then centrifuged at 300 × g for 10 min to recover the supernatant, which contained the released histamine. The histamine level was measured by a fluorometric assay described by Shore and others (1959). In this assay, to 1 mL of recovered supernatant, 0.2 mL of 1N NaOH, and 0.1 mL of 1% OPT were added and the sample incubated at room temperature for 5 min. The reaction was terminated by addition of 0.2 mL of 1N HCl. The fluorescence intensity was then measured with a spectrophuorometer (RF-550, Shimadzu Co., Kyoto, Japan) at an excitation wavelength of 360 nm and an emission wavelength of 450 nm.

To evaluate the level of cell degranulation, β-hexosaminidase, a component of the basophilic secretory granule, was determined by the method of Jeong and others (2002b) with some modification. RBL-2H3 or mast cells were suspended in Tyroid A buffer to adjust to a cell density to 1 × 10⁶ cells/mL and then divided into a 96-well plate. Preloading of the rice extract and cell-priming with each stimulant were performed with the same procedure as described above for histamine. Recovered supernatant containing released β-hexosaminidase (50 µL) was added the same volume of 1 mM p-nitrophenyl-N-acetyl-β-glucosaminid solution (pH 5.2). The sample was then incubated at room temperature for 1 h with continuous shaking. The reaction was terminated by addition of 0.2 mL of 1 M sodium carbonate buffer (pH 10.2). The plate was read at 405 nm with a microplate reader (Model-550, Bio-Rad, Hercules, Calif., U.S.A.).

**Determination of intracellular Ca²⁺ levels**

The intracellular Ca²⁺ responses were assessed using Fluo-3-AM with the aid of confocal microscope according to the method of Matsubara and others (2004b) with minor modification. RBL-2H3 or mast cells were cultivated at a density of 1 × 10⁴ cells/mL on a dish used exclusively for confocal microscopic cell imaging. The cells were suspended in Ca²⁺ buffer (137 mM NaCl, 2.7 mM KCl, 1.8 mM CaCl₂, 1 mM MgCl₂, 1 mg/mL glucose, 1 mg/mL BSA, 20 mM HEPES, pH 7.4). They were then loaded with Fluo-3-AM to a final concentration of 10 µM and incubated at 37 °C for 30 min. After washing with the same buffer to remove excess dye, the rice extracts appropriately diluted with Ca²⁺ buffer, were added to the cells and incubated for additional 15 min. Washing 3 times with the same buffer terminated sample treatment. The cells were immediately placed onto the confocal scanning laser microscope (LSM510, Carl Zeiss Inc., Thornwood, N.Y., U.S.A.) and stimulated with 10 µM ionophore A23187 for 1 min or 20 µg/mL DNP-BSA for 4 min. The change in fluorescence of Fluo-3-AM was monitored at an excitation wavelength of 488 nm and emission wavelength of 540 nm. Integrated software was used to capture images of the cells at 2 s intervals over the time course of 300 s after treatment with stimulants.

**Reverse transcription-polymerase chain reaction (RT-PCR) analysis of cells**

Total RNA was prepared from 1 × 10⁷ cells/mL of RBL-2H3 cells or rat peritoneal mast cells by the acid phenol guanidium thiocyanate-chloroform extraction procedure of Chomczynski and Sacchi (1987). First, single stranded cDNA synthesis from 1 µg of the total RNA was performed using an AMV reverse transcriptase and oligo dT18 as primer. DNA amplification was primed in a reaction mixture containing 20 µM each of the primer sets representing the target genes as well as 400 µM of a dNTP mix and 2.5 U of Taq DNA polymerase. PCR was conducted using a thermocycler (PTC-200, MJ Research Inc., Reno, Nev., U.S.A.) with 1 cycle of 5 min at 94 °C, followed by 30 cycles of 30 s at 94 °C, 45 s at 58 °C, and 45 s at 72 °C, and then 1 cycle of 5 min at 72 °C. All PCR products were subjected to 1.5% agarose gel electrophoresis. The intensity of separated bands under DNA was quantitated by a gel documentation system (LAS-1000CH, Fuji Film Co., Tokyo, Japan) with integrated analyst software.
ELISA of cytokines

After stimulating 1 x 10^6 RBL-2H3 or rat peritoneal mast cells, supernatants containing the cultures were recovered and stored at −20°C until use. The cytokines released into supernatant (TNF-α, IL-1β, and IL-6) were measured with a cytokine assay kit according to the manufacturer’s instructions. Briefly, the recovered supernatants and standard solution were transferred to the 96-well pre-coated with appropriate monoclonal antibody raised against each of the target cytokines, and then incubated at room temperature for 1 h. After thorough washing with wash buffer included in the kit, biotin-conjugated secondary antibody was added to 96-well. Incubation at room temperature was continued for 1 h. After removal of the added secondary antibody by washing, peroxidase-conjugated avidin was in turn added to the wells. The wells were then incubated at room temperature for 30 min. After final washing of the reaction solution, substrate for enzymatic reaction was added and the sample incubated for another 30 min in the dark. The reaction was terminated by addition of stop solution, followed by the measurement of the absorbance at 420 nm in a microplate reader (Model-550, Bio-Rad).

Statistical analysis

Statistical analysis was accomplished with SAS software package (SAS Inst. Inc., Cary, N.C., U.S.A.). Significant differences between means were determined by ANOVA procedure test, and a P value of < 0.05 was considered to be statistically significant. The results are expressed as the mean ± SD from triplicate test data.

Results and Discussion

Inhibition of histamine and β-hexosaminidase release from rat basophilic leukemia cells

Table 1 shows the inhibition by rice bran extracts of release of histamine and β-hexosaminidase from A23187-stimulated RBL-2H3 cells. Mean values for the amount of released histamine (ng/mL) ranged as follows: negative control, 14.6; ionophore A23187-stimulated control, 74.1; nonpigmented Chuchung rice, 67.1; pigmented LK1-A-2-12-1-1 rice, 57.2; pigmented Jumlalocal-1 rice, 49.0; pigmented DZ78 rice, 42.9; pigmented Elwee rice, 39.7, and pigmented LK1-3-6-12-1-1 rice, 36.4. Because each observed value is inversely proportional to the antiallergic effect, these results show that nonpigmented rice has no effect. By contrast, the antihistamine effect of the pigmented cultivars was significant. The LK1-3-6-12-1-1 cultivar showed the highest potential to suppress histamine release.

Data of Table 1 also demonstrate similar trends for β-hexosaminidase, with the % inhibition for the pigmented varieties ranging from 100 for the stimulated control to 25.9 for LK1-3-6-12-1-1 cultivar, and 12.4 for Elwee rice. Substances in these 2 pigmented varieties appear to be highly effective in suppressing release of the enzyme from the RBL-2H3 cells.

Table 2 shows similar trends for the inhibition of histamine and β-hexosaminidase by the rice extracts from RBL-2H3 cells stimulated via FcεRI with anti-DNP IgE-DNP-BSA complexes. The results obtained in these experiments reinforce the conclusion that the extracts from the Elwee and LK1-3-6-12-1-1 pigmented rice are highly effective in preventing release of both histamine and β-hexosaminidase from stimulated cell lines. They show that these pigmented rice extracts were highly potent in blocking FcεRI-mediated mast cell degranulation.

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Inhibition of histamine and $\beta$-hexosaminidase release from rat peritoneal mast cells

Table 3 shows the results from a related study on the inhibition of histamine and $\beta$-hexosaminidase release by rice bran extracts from A23187-stimulated rat peritoneal mast cells. The following 3 cultivars appear most effective in suppressing the release of histamine: Elwee, LK1 A-2-12-1-1, and LK1-3-6-12-1-1. The other cultivars exhibited only minor changes as compared to that of the stimulated

Table 4—Cell viability changes in RBL-2H3 basophilic leukemia cells (RBL-2H3) and by the MTT assay at peritoneal mast cells (RPMC) following treatment with 3 levels of pigmented rice bran extracts.

<table>
<thead>
<tr>
<th>Rice cultivar</th>
<th>Control</th>
<th>1 µg/mL</th>
<th>10 µg/mL</th>
<th>100 µg/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 µg/mL</td>
<td>10 µg/mL</td>
<td>100 µg/mL</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>99.9 ± 4.71a</td>
<td>99.9 ± 4.71a</td>
<td>99.9 ± 4.71a</td>
<td></td>
</tr>
<tr>
<td>Chuchung</td>
<td>99.5 ± 4.76a</td>
<td>100.1 ± 1.51a</td>
<td>97.5 ± 4.51a</td>
<td></td>
</tr>
<tr>
<td>Jumilocal-1</td>
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<td>102.3 ± 5.08a</td>
<td>108.6 ± 1.97a</td>
<td></td>
</tr>
<tr>
<td>DZ78</td>
<td>103.3 ± 3.47a</td>
<td>104.4 ± 6.67a</td>
<td>75.0 ± 1.44a</td>
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</tr>
<tr>
<td>Elwee</td>
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<td>101.2 ± 1.65a</td>
<td>71.3 ± 1.24a</td>
<td></td>
</tr>
<tr>
<td>LK1A-2-12-1-1</td>
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<td>102.4 ± 0.59a</td>
<td>101.9 ± 0.55a</td>
<td></td>
</tr>
<tr>
<td>LK1-3-6-12-1-1</td>
<td>102.7 ± 3.37a</td>
<td>105.0 ± 1.94a</td>
<td>82.3 ± 3.07a</td>
<td></td>
</tr>
</tbody>
</table>

*Values in each column with the same superscript letters are not significantly different at $P < 0.05$. 

Figure 1—Fluorescence assay of effects of pigmented rice extracts on the cellular $\text{Ca}^{2+}$ responses using Fluo-3AM with a confocal microscopic fluorometric imaging in A23187-stimulated (A); anti-DNP IgE-stimulated RBL-2H3 basophilic cells (B); and A23187-stimulated rat peritoneal mast cells (C).
control. Elwee and LK1-3-6-12-1-1 cultivars exhibited the highest suppressing activity, while the other cultivars were less effective.

**Cell viabilities of leukemia and mast cells**

Table 4 shows the results of exposing the basophilic leukemia RBL-2H3 cells to 3 concentrations over a 100-fold range of rice bran extracts on the viabilities of the cells determined by the MTT assay. Viability was not affected by concentrations of 1.0 or 10 µg/mL. At 100 µg/mL, viabilities decreased by 20% to 30% on exposure to the Elwee, LK1 A-2-12-1-1, and LK1-3-6-12-1-1 extracts.

Results from an analogous study, also summarized in Table 4, show that 3 concentrations of the rice bran extracts did not affect viabilities of the rat peritoneal mast cells. The results from both cultured cell line and peritoneal cells suggest that the rice bran extracts are not cytotoxic in these cells at concentrations < 100 µg/mL.

**Effect on intracellular Ca^{2+} ions in mast cells**

Because elevation of intracellular Ca^{2+} ion levels occurs during mast cell degranulation and Ca^{2+} ions are also involved in the activation of TNF-α and IL-gene expressions, we wanted to find out whether pigmented rice extracts also suppress Ca^{2+} ions influx. Figure 1 shows the effects of pigmented rice bran extracts and controls on intracellular calcium ion levels in the basophilic RBL-2H3 and rat peritoneal mast cells determined by fluorescence spectroscopy. The plots show that Ca^{2+} influx levels induced by preloading the pigmented rice extracts were generally lower than that by the normal brown rice extract, and that the extracts from the pigmented cultivars LK1A-2-12-1-1 and LK1-3-6-12-1-1 induced the highest decreases in intracellular calcium ion levels, even showing in some case somewhat lower calcium ion levels than those of the unstimulated control cells preloaded with only vehicle. These data confirm the antiallergic potential of these rice cultivars determined by the other assays.

**Inhibition of release of cytokines**

Inhibition of production of proinflammatory cytokines is another manifestation of an antiallergic effect at the cellular level. Figure 2A and 2B show results of exposure of the basophilic cells on the inhibition of release of 3 cytokines: IL-1β, TNF-α, and IL-6. Extracts from the LK1 A-2-12-1-1 and LK1-3-6-12-1-1 cultivars induced significant inhibitions in the release of IL-1β. The best results for the inhibition of the TNF-α were obtained with extracts from Elwee and LK1-3-6-12-1-1 cultivars, and for IL-6, with the DZ78 and LK1-3-6-12-1-1 cultivars.

Results from an analogous study with stimulated rat peritoneal mast cell are depicted in Figure 2C. The proinflammatory cytokine releases were induced to the same extent in response to the chemical or biological stimulants in both *in vitro* cultured cells and *ex vivo* exuded cells. These results support the validity of the assay system used in the present study. Measurements with the rice extracts show that compared to the other rice cultivars, the extract from LK1-3-6-12-1-1 was most effective in reducing the allergic
manifestations through modulation of pro-inflammatory cytokine releases.

Parallel studies shown in Figure 3 on inhibition of gene expressions of the cytokines obtained with RT-PCR, using the previously reported primer set from the proinflammatory genes (Jeong and others 2002a; Matsubara and others 2003a; Ye and others 2006), agree with the above-mentioned trends on the inhibition of cytokines by the rice bran extracts. Evidently, the biosynthesis of the proinflammatory cytokines is mainly modulated at the transcription level.

Biologically active rice compounds

Rice (Oryza sativa L.) is a basic food for a large part of the world’s population (Friedman 1996). In addition to good quality protein, fiber content, and vitamin content, pigmented rice varieties have the potential to promote human health because they contain antioxidative compounds, some of which may be responsible for the observed antiallergic effects. These compounds include anthocyanins (glycosides) – cyanidin-3-O-β-D-glucoside and peonidin-3-O-β-glucoside (Ryu and others 1998; Ichikawa and others 2001; Hu and others 2003); anthocyanidins (aglycones) – cyanidin and malvidin (Hyun and Chung 2004); polymeric proanthocyanidins (Oki and others 2002); the phenolic compounds anisole, 4-hydroxycinnamic acid (p-coumaric), 4, 7-dihydroxyvanillic acid, protocatechuic acid methyl ester, syringaldehyde, and vanillin (Asamarai and others 1996; Lee and others 2003; Miyazawa and others 2003; Goffman and Bergman 2004); the phenolic compounds ferulic and sinapinic acids and the sucrose esters 6′-O-(E)-feruoylsucrose and 6′-O-(E)-sinapoylsucrose (Tian and others 2004); the ferulic acid ester γ-oryzanol (Parrado and others 2003); and the alkaloid 4-carboxymethoxy-6-hydroxy-2-quinolone (Chung and Woo 2001). The total anthocyanin content of black rice (3276 µg/g) was highest among several colored cereal grains evaluated, approximately 35 times higher than that of red rice (Abdel-Aal and others 2006). These observations suggest that pigmented rice varieties contain high levels of potential health promoting antioxidative substances, as confirmed by the following observations.

Previous studies have shown that (1) the cyanidin 3-O-β-D-glucoside isolated from purple black rice contributed to the antioxidative activity of the rice extract through scavenging of superoxide anions (Ichikawa and others 2001); (2) a quinolone alkaloid isolated from the aleurone layer contributed to the antioxidative activity of anthocyanin-pigmented rice (Chung and Woo 2001); (3) the anthocyanins cyanidin and malvidin isolated from a dark rice variety inhibited the growth of leukemia cells (Hyun and Chung 2004); (4) the pigmented fraction from black rice seeds suppressed both reactive oxygen species and nitric oxide in an in vitro model system (Hu and others 2003); (5) dietary black rice and rice extracts reduced the progression of dietary cholesterol-induced atherosclerotic plaque development and cholesterol plasma levels in rabbits (Ling and others 2001); and (6) feeding pigs black rice bran lowered total plasma cholesterol levels without affecting pork quality (Kil and others 2006).
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Figure 2 shows that for every indicator of the allergic response evaluated in this study, stimulated cells exhibited a more than 2-fold greater activity than did the unstimulated cells. In addition, of the 5 pigmented black rice extracts evaluated, the cultivar LK1-3-6-12-1 showed the highest potency in inhibiting cytokine production. Previously, we reported that this cultivar also exhibited high antioxidative activity (Nam and others 2005b, 2006). These observations suggest that antioxidative activities of black rice brans may govern antiallergic potencies, in analogy to reported effects of curcumin (Suzuki and others 2005). The nature of the compounds in these brans that may be responsible for both activities merit further study.

Antiallergic food ingredients

The results of the present study complement reported anti-allergenic properties of other plant food ingredients. These include (1) a hot water extract from hops (Humulus lupulus L.) containing kaempferol and quercetin glycosides (Segawa and others 2006); (2) a buckwheat grain (Fagopyrum esculentum) containing kaempherol and quercetin glycosides (Segawa and others 2006); (3) naringenin chalcone from a tomato (Solanum lycopersicum L.) cv. Heungjin (Kondo and others 2006); (5) arabinoxylans from a soy sauce shoyu polysaccharide (SPS) (Kobayashi and others 2006); (2) a buckwheat grain (Fagopyrum esculentum) containing kaempherol and quercetin glycosides (Segawa and others 2006); (10) grape seed procyanidins (Choi and Koops 2005); (11) polyphenol-enriched apple extracts (Tokura and others 2005); (1) an extract from purple black rice (Oryza sativa L.) cv. Heungjin mediates cytotoxicity against human monocytic leukemia cells by arrest of G0/G1 phase and induction of apoptosis (Jariwalla 2001; Pourpak and others 2005). Moreover, transgenic rice is emerging as an important new therapeutic tool for both allergy and autoimmunity (Ma and Jevnikar 2005). It would be of interest to find out whether anthocyanin levels of different dark rice cultivars correlate with anti-allergic effects.

Conclusions

Collectively, the results of the present study suggest that extracts from the pigmented rice cultivar LK1-3-6-12-1-1 had the highest inhibitory activities in all the cellular/molecular tests designed to define an anti-allergic potency of a food ingredient. Rice and corn have been suggested as the best substitute for wheat in children with wheat allergy (Jariwalla 2001; Pourpak and others 2005). Moreover, transgenic rice is emerging as an important new therapeutic tool for both allergy and autoimmunity (Ma and Jevnikar 2005).

Because pigmented rice bran extracts also exhibited in vitro anti-carcinogenic activities (Nam and others 2005a), they merit further evaluation as part of a human diet to determine whether they can prevent or protect against inflammatory and allergic manifestations associated with various human diseases such as hay fever and asthma as well as cancer.

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References


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