Effect of Palm Oil on Oxidative Stress-Induced Hypertension in Sprague-Dawley Rats

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Background: Oxidative stress, associated with increased plasma isoprostane (ISO) and reductions in plasma glutathione (GSH), has been shown to cause severe hypertension in normal rats. Palm oil (PO), with an unsaturated-to-saturated fatty acid ratio close to one and rich in antioxidant vitamins, has been investigated for its beneficial effects on arterial thrombosis and atherosclerosis. In this study, the effect of PO on oxidative stress induced by inhibition of GSH synthesis (using buthionine sulfoximine [BSO]) was examined.

Methods: Sprague-Dawley rats were separated into two groups and received either natural vitamin-rich PO (Carotino, 5 g/kg daily) or water by gavage. After 4 weeks, they were further divided between receiving either BSO (30 mmol/L/day in the drinking water) or drug-free water for an additional week. Mean arterial pressure (MAP), heart rate (HR), and body weight (BW) were measured before and weekly during the experiment. The levels of plasma ISO, nitric oxide (NO), prostacyclin (PGI₂), and thromboxane A₂ (TXA₂) were determined by enzyme immunoassay, and plasma, heart, and kidney GSH by high-performance liquid chromatography.

Results: The PO reduced the age-dependent increase in MAP, and the pressor response to BSO, without changing the HR or BW compared to the BSO and control groups. It also elevated PGI₂, NO, and aortic cGMP, but decreased TXA₂ and aortic cAMP. In addition, the BSO-induced increase in ISO and TXA₂, and the reduction in kidney GSH were attenuated by PO. However, the PO effect on NO, PGI₂, cGMP, and TXA₂ was partly counteracted by BSO.


Key Words: Oxidative stress, glutathione, vitamin-rich palm oil, endothelial function.

Oxidative stress has been shown to have a role in various cardiovascular diseases, including hypertension, and ischemic heart disease. Increased production of reactive oxygen species (ROS) like superoxide anion (O₂⁻) and hydrogen peroxide has been associated with cellular injury due to increased lipid peroxidation, DNA damage, and protein modification or altered gene expression.

The pathogenesis of hypertension due to increased ROS has been attributed to endothelial dysfunction caused by inactivation of nitric oxide (NO), generation of vasoconstrictive isoprostanes from arachidonic acid peroxidation, and a direct vasopressor or diminished vasodilator activity. On the other hand, levels of free radical scavengers, such as vitamin E, glutathione (GSH), and superoxide dismutase have been reported to be depressed in hypertensive patients and experimental animals.

Buthionine sulfoximine (BSO), a selective inhibitor of γ-glutamylcysteine synthetase (an enzyme in the GSH biosynthetic pathway) has been used as an effective biologic tool for inhibition of GSH synthesis and induction of oxidative stress. Glutathione is the most abundant non-protein intracellular thiol with multiple roles as an antioxidant agent. It functions as a scavenger of ROS, NO, and peroxynitrite. Hypertension induced by oxidative stress has been demonstrated in normal rats, after GSH depletion.

Palm oil (PO), obtained from the fruit of the tropical...
plant *Elaeis guineensis*, is the second major edible oil used worldwide, contributing approximately 23% of the consumption rate.\(^\text{14}\) It has an unsaturated-to-saturated fatty acid ratio close to one and is rich in vitamins A and E. Having a relatively higher proportion of saturates and antioxidant vitamins than most other major oils, PO is extremely stable,\(^\text{15}\) and is suitable for cooking, frying, and as a shortening in a variety of food products. In addition to its antioxidant potential, previous studies have demonstrated beneficial effects of PO on arterial thrombosis\(^\text{16,17}\) and blood pressure (BP).\(^\text{18}\) Also treatment with PO for 4 weeks in Sprague-Dawley rats has been shown to increase aortic prostacyclin (PGI\(_2\)) and reduce thromboxane A\(_2\) (TXA\(_2\)).\(^\text{19}\) Natural vitamin-rich PO is a commercially available edible oil, recently introduced on the market, produced using a Palm Oil Research Institute of Malaysia (PORIM)-patented refining short-path distillation to retain most of the qualities of fresh PO.\(^\text{20}\)

The main objective of this study was to evaluate the cardiovascular effects of natural vitamin-rich PO on oxidative stress induced by GSH depletion. Also to assess its effect on endothelium-derived factors and associated signal transduction pathways, specifically the changes in aortic tissue cyclic adenosine 5'-monophosphate (cAMP) and cyclic guanosine 5'-monophosphate (cGMP).

**Methods**

**Experimental Design**

Male Sprague-Dawley rats (Harlan Sprague-Dawley, Indianapolis, IN), 4 to 5 weeks old, were used in these experiments. Upon arrival, rats were grouped five per cage in the animal facility that has 12-h light/dark cycles with the temperature controlled at 21° to 23°C. Rodent Lab. Chow (Purina Mills Inc., Richmond, IN) and water were made available ad libitum. After 1 week of acclimatization, the animals were individually housed and separated into two groups receiving either regular tap water or PO (5 g/kg per day) by gavage (\(n = 12\) per group). During this time, the indirect mean arterial pressure (MAP), heart rate (HR), and body weight (BW) were measured every 2 weeks.

After 4 weeks the animals were further divided and treated for 1 more week as follows: 1) regular tap water (1 mL by gavage in addition to drinking water); 2) BSO (Sigma Chemical Co., St. Louis, MO), 30 mmol/L/day or \(0.55\) g/kg per day in the drinking water, based on previous studies in the rat;\(^\text{13}\) 3) PO; and 4) PO with BSO (\(n = 6\) each). The PO used in these experiments, Carotino, was a kind gift from PORIM. The composition of this oil as specified by the manufacturer is: saturated fat, 50%; monounsaturated fat, 39%; polyunsaturated fat, 11%; carotene (pro-vitamin A), 500 ppm; and vitamin E, 800 ppm.

**Animal Surgery**

After the final MAP and HR measurements were taken, each animal was anesthetized using intramuscular 70 mg/kg ketamine and 10 mg/kg xylazine and the carotid and jugular veins were cannulated using PE50 tubing containing heparin (20 IU/mL) in 0.9% NaCl. The cannulae were externalized in the posterior cervical region and occluded with a metal plug, and flushed with heparinized saline every 12 h. The animals were then put in individual cages and allowed to recover from surgery. After 24 h, blood (2 mL) was collected by free-flow from the carotid artery and replaced by an equal volume of saline. Under anesthesia (ketamine/xylazine mixture), blood (5 mL) was collected by cardiac puncture and the heart, kidneys, and aortic arch were removed.

**Indirect BP Measurement in Conscious Rats**

Tail-cuff plethysmography (Rat Tail Blood Pressure Monitor and Universal Oscillograph, Harvard Apparatus Inc., Holliston, MA) was used to measure indirect MAP. Heart rate was measured from the arterial pulse wave at the same time. Measurements of basal MAP and HR as well as readings every 2 weeks were taken throughout the experiment.

**Collection and Storage of Blood Samples**

Blood samples, for plasma NO, TXA\(_2\), and PGI\(_2\) measurements, were collected by free-flow through the polyethylene cannula in the carotid artery into heparinized and indomethacin (100 mmol/L)-rinsed (for prostaglandin samples) tubes, and the volume of blood withdrawn from rats was replaced with saline.

To assess plasma GSH and isoprostane (ISO) concentrations, blood samples (5 mL) were withdrawn by cardiac puncture from all animals (under intravenous ketamine/xylazine) before sacrifice. Both samples were centrifuged at 3000 g for 25 min at 4°C. For ISO assay, butylated hydroxytoluene was added to 1.0 mL of plasma to give a final concentration of 0.005% (v/v). All the supernatants were collected, frozen in aliquots, and stored at −80°C until assayed.

For GSH assay, 1.0 mL of 10% metaphosphoric acid was added to 1.0 mL of plasma, the mixture was vortexed, incubated for 5 min at room temperature, and then centrifuged at 3000 g for 3 min. The supernatant was collected, frozen, and stored at −20°C until analysis.

**Tissue Harvesting for In Vitro Studies**

Immediately after cardiac puncture, the heart and the kidneys were harvested from all the animals and frozen in liquid nitrogen and stored at −80°C. The aortic arch was put into buffered saline solution (with indomethacin) and kept on dry ice before cAMP and cGMP incubations; after which the tissues were frozen in liquid nitrogen and stored at −80°C.
**Total Plasma, Heart, and Kidney GSH Assays**

Heart and kidney tissues were mixed 1:1.5 (w/v) with cold phosphate-buffered saline (PBS), and homogenized for ~3 min, at 1-min on and 1-min off intervals. The mixture was then centrifuged at 3500 g for 30 min. The supernatant was collected and frozen at ~80°C until assayed. An aliquot was taken for protein determination by the BioRad method.23

The GSH levels were determined according to a procedure described by Vester and Rasmussen,22 and modified in our laboratory.23 Briefly, a mixture of 50 μL of plasma or homogenate, 25 μL of internal standard, and 25 μL of PBS (pH 7.4) was incubated with 10 μL of 100 g/L tris (2-carboxyethyl) phosphate for 30 min at room temperature to reduce and release protein-bound thiols, after which 90 μL of 100 g/L trichloroacetic acid containing 1 mmol/L of EDTA was added for deproteinization. After the sample was centrifuged for 10 min at 13,000 g, 50 μL of the supernatant was added to an autosampler vial containing 10 μL of 1.55 mol/L NaOH, 125 mol/L borate buffer containing 4 mmol/L EDTA at pH 9.5, and 550 μL of 1 g/L of ammonium 7-fluoro-2, 1,3-benzoxadiazole-4-sulfonate in the borate buffer. The sample was then incubated for 60 min at 60°C. Further analysis was done by high-performance liquid chromatography using a 150 × 4.6 mm Phenomenex Luna column (Torrance, CA), and a scanning fluorescence detector set at 385 nm excitation and 515 nm emission.

**Total Plasma ISO (Free and Esterified) Assay**

Plasma ISO was measured according to the procedure provided with the manufacturer’s kit (Cayman Chemical Corp., Ann Arbor, MI). The samples (1.0 mL) were allowed to thaw to room temperature. Absolute ethanol was then added, followed by thorough mixing and centrifugation to remove the precipitated proteins. The supernatant was added into an equal volume of 15% KOH and incubated for 1 h at 40°C. After incubation the samples were diluted 10-fold with ultra-pure water and the pH adjusted to 7.0 to 7.5 with HCl. The samples were loaded on Sep-Pak columns (Cayman Chemical Corp.). The column was washed with 0.1 mol/L PBS (pH 7.4) and ultra-pure water. The ISO was eluted from the column with a solution of 95%/5% absolute ethanol/ultra-pure water, which was then dried off by vacuum centrifugation. After reconstitution into 0.5 mL of assay buffer, measurements were made by enzyme immunoassay, and the data expressed as picograms per milliliter.

**Plasma NO Measurement**

A microplate assay kit (Cayman Chemical Corp.) was used to measure plasma NO levels (as nitrate + nitrite), as previously described.24 Nitrates in each sample were converted to nitrites by 3 h of incubation with nitrate reductase, followed by the addition of the Greiss reagent, which converts nitrite into a deep purple azo compound, which allows spectrophotometric measurement of the absorbance at 540 nm. The concentration of NO (in micromoles per liter) for each sample was calculated as total nitrite (nitrate + nitrite) from a nitrate standard curve.

**Determination of Plasma PGI2 (as 6-keto-PGF1α), and TXA2 (as TXB2) Levels**

The plasma was diluted with 2 ml of ethanol, after which 6-keto-PGF1α, and TXB2 were extracted through a Sep-Pak C-18 column (Cayman Chemical Corp.). Briefly, the column was activated by rinsing with methanol followed by deionized water. The sample was added and allowed to pass through the column, after which it was rinsed with deionized water followed by high-performance liquid chromatography grade hexane (Sigma Chemical Co.). The prostaglandins were eluted with ethyl acetate containing 1% methanol (v/v). The ethyl acetate was then evaporated to dryness under a stream of dry nitrogen. After purification, plasma levels (in picograms per milliliter) of PGI2 and TXA2 were determined using enzyme immunoassay kits (Cayman Chemical Corp.) as described by the manufacturer.

**Measurement of Aortic cGMP and cAMP**

Aortic tissue pieces (7 mm in length) were incubated in 4-(2-hydroxyethyl)-1-piperazine-ethanesulphonic acid (HEPES)-buffered Ringer’s solution (composition in millimoles per liter: NaCl, 130; KCl, 5.5; CaCl2, 2; MgSO4, 1.8; NaHPO4, 1; glucose, 5.5; HEPES, 10 at pH 7.4) containing 100 μmol/L indomethacin (a nonselective cyclooxygenase inhibitor) and 100 μmol/L zaprinast (a cGMP phosphodiesterase inhibitor) at 37°C. After 20 min in the absence or presence of test compounds, the tissue was frozen in liquid nitrogen and stored at −80°C. After deproteinization, cGMP was determined by enzyme immunoassay (Cayman Chemical Corp.) and expressed as femtomoles of cGMP per milligram of protein. For cAMP, the protocol was identical to that of cGMP, except that 100 μmol/L of isobutylmethylxanthine replaced 100 μmol/L of zaprinast in the cAMP enzyme immunoassay kit (Cayman Chemical Corp.).

**Statistical Analysis**

Values are reported as mean ± standard error (SE), where n refers to the number of rats used. Statistical significance (P < .05) was evaluated using either Student t test, or for multiple groups, analysis of variance (ANOVA) followed by the Tukey-Kramer multiple comparison test.

**Results**

**MAP and HR**

The basal MAP in the rats treated with PO was 82 ± 2 mm Hg compared to 79 ± 2 mm Hg at the end of the experiment. However, the MAP in the control rats increased...
from 86 ± 1 mm Hg to 108 ± 2 mm Hg. Administration of BSO for 1 week elevated MAP to 143 ± 3 mm Hg in the control group compared to 99 ± 1 mm Hg in the PO group (P < .05). Therefore, supplementation with PO for 4 weeks reduced the age-dependent increase in MAP and the BSO-induced pressor response (108 ± 2 mm Hg vs 79 ± 2 mm Hg and 143 ± 3 mm Hg vs 99 ± 1 mm Hg, respectively; P < .05) (Fig. 1A). The increase in BP in response to BSO was 34 ± 4 mm Hg (32% increase) in the absence of PO and 20 ± 2 mm Hg (24% increase) in its presence. Therefore, PO significantly attenuated the BSO-induced pressor response (P < .05). The different forms of treatment did not significantly alter the HR (Fig. 1B).

**Body Weight**

The body weights in all groups showed a stepwise increase with time; however, there was no significant difference between the groups (Table 1).

**Plasma and Tissue GSH**

Treatment with BSO caused a significant reduction in GSH levels compared to the control group: in the plasma (6.4 ± 0.5 μmol/L vs 17.5 ± 2.6 μmol/L) (Fig. 2A), the heart (11 ± 1 μmol/L/mg heart protein vs 66.4 ± 3 μmol/L/mg heart protein) (Fig. 2B), and the kidney (4.5 ± 0.3 μmol/L/mg kidney protein vs 9.4 ± 1 μmol/L/mg kidney protein) (P < .05) (Fig. 2C). Pretreatment with PO suppressed the BSO-induced reduction of GSH levels in the kidney (6.7 ± 0.2 μmol/L/mg kidney protein in the BSO and PO-treated vs 4.6 ± 0.3 μmol/L/mg kidney protein in the BSO group; P < .05) (Fig. 2C). The PO did not significantly alter GSH levels or modify the BSO effect in the heart or plasma.

**Plasma Levels of ISO and TXA₂**

Plasma levels of ISO were significantly reduced by treatment with PO (42.8 ± 7.6 pg/mL vs 81.5 ± 14 pg/mL in the control group, P < .05, Fig. 3A). It also reduced plasma TXA₂ levels (17.9 ± 3 pg/mL vs 54.6 ± 10 pg/mL in the control group, P < .05, as shown in Fig. 3B). The PO also attenuated the BSO-induced increases in both plasma ISO and TXA₂ (50.4 ± 2.3 pg/mL vs 167.5 ± 8.6 pg/mL, and 64.8 ± 11 pg/mL vs 137.4 ± 34 pg/mL, P < .05), respectively as shown in Fig 3.

**Plasma PGI₂ and NO Levels**

Plasma PGI₂ levels were significantly increased by PO (329 ± 17 pg/mL vs control, P < .05), and reduced by BSO (91 ± 17 pg/mL vs 234 ± 28 pg/mL in the control group, P < .001) (Fig. 4A). The PO significantly increased NO levels (57 ± 2 μmol/L compared to the control, P < .001), whereas BSO did not have a significant effect (16 ± 2 μmol/L vs 22 ± 3 μmol/L in the control group; Fig. 4B). When administered with PO, the BSO effect on plasma PGI₂ remained largely intact, and the effect of PO was attenuated. The PGI₂ levels were 132 ± 13 pg/mL in the PO + BSO group vs 91 ± 17 pg/mL in the BSO and 329 ± 17 pg/mL in the PO groups (P < .001) (Fig. 4A). The PO attenuated the BSO effect on NO (34 ± 9 μmol/L vs 16 ± 2 μmol/L), although its maximum effect was reduced in

**Table 1.** Effect of palm oil and buthionine sulfoximine (BSO) on body weight in Sprague-Dawley rats

<table>
<thead>
<tr>
<th></th>
<th>Basal (g)</th>
<th>2 Weeks (g)</th>
<th>4 Weeks (g)</th>
<th>5 Weeks (g)</th>
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<tbody>
<tr>
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<td>157 ± 2</td>
<td>249 ± 3</td>
<td>312 ± 6</td>
<td>339 ± 6</td>
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<tr>
<td>Palm oil</td>
<td>159 ± 2</td>
<td>242 ± 3</td>
<td>296 ± 9</td>
<td>324 ± 9</td>
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<tr>
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<td>—</td>
<td>320 ± 6</td>
<td>329 ± 7</td>
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<tr>
<td>Palm Oil + BSO</td>
<td>—</td>
<td>—</td>
<td>308 ± 5</td>
<td>323 ± 7</td>
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+ Data represent mean ± standard error for n = 12 for basal and 2-week values and n = 6 for 4- and 5-week values.

FIG. 1. Effect of palm oil (PO) and buthionine sulfoximine (BSO) on (A) mean arterial pressure and (B) heart rate in Sprague-Dawley rats. Data are represented as mean ± SEM for six animals per group; however, during the first 4 weeks, n = 12 for PO and control groups. Significant difference (P < .05) is denoted as asterisk (*) for all comparisons to the control, (X) for PO versus BSO, (X) for PO + BSO versus BSO, and (closed diamond) for PO + BSO versus PO.

FIG. 2. Suppression of oxidative stress-induced hypertension by PO. Data represent mean ± SEM for six animals per group. Basal (g) 2 Weeks (g) 4 Weeks (g) 5 Weeks (g) for PO versus BSO, (P < .05) is denoted as asterisk (*) for all comparisons to the control, (X) for PO versus BSO, (X) for PO + BSO versus BSO, and (closed diamond) for PO + BSO versus PO.
the presence of BSO (57 ± 2 μmol/L vs 34 ± 9 μmol/L, respectively; \( P < .05 \)) (Fig. 4B).

**Aortic cAMP and cGMP Levels**

Administration of PO was associated with a reduction in aortic cAMP (1.27 ± 0.24 pmol/mg protein vs 79.7 ± 8 pmol/mg protein in the control group; \( P < .01 \)). When BSO was administered with PO, cAMP levels were further decreased to 0.89 ± 0.08 pmol/mg protein (\( P < .01 \)) (Fig. 5A). Buthionine sulfoximine alone significantly decreased cAMP levels (21 ± 4 pmol/mg protein vs 79.7 ± 8 pmol/mg protein in the control group; \( P < .05 \)). However, cGMP levels were profoundly elevated by PO (15,852 ± 2000 fmol/mg protein vs 91.6 ± 17 fmol/mg protein in the control group; \( P < .01 \)). Buthionine sulfoximine also showed a tendency to reduce cGMP levels (42.9 ± 6.3 fmol/mg protein vs 91.6 ± 16.7 fmol/mg protein in the control group). When BSO was given to PO-pretreated animals, the BSO effect was attenuated and cGMP levels were increased from 42.9 ± 6 fmol/mg protein to 164.5 ± 40 fmol/mg protein (\( P < .05 \)). On the other hand, PO + BSO reduced the PO effect (164.5 ± 40 fmol/mg protein vs 15,852 ± 2000 fmol/mg protein; \( P < .01 \)), as shown in Fig. 5B.

**Discussion**

Buthionine sulfoximine-induced reduction in plasma GSH has been associated with a significant elevation of MAP without a significant change in HR or BW.\(^{13}\) In the present study, pretreatment with PO suppressed both the age-

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**FIG. 2.** Effect of PO and BSO on (A) plasma, (B) heart, and (C) kidney levels of glutathione (GSH) in Sprague-Dawley rats. Data are represented as mean ± SEM for six animals per group. Significant difference (\( P < .05 \)) is denoted as asterisk (*) for all comparisons to the control, (+) for PO versus BSO, (ψ) for PO + BSO versus BSO, and (closed diamond) for PO + BSO versus PO. Other abbreviations as in Fig. 1.

**FIG. 3.** Effect of PO and BSO on (A) plasma isoprostane and (B) thromboxane (TXB\(_2\)) levels in Sprague-Dawley rats. Data are represented as mean ± SEM for six animals per group. Significant difference (\( P < .05 \)) is denoted as asterisk (*) for all comparisons to the control, (+) for PO versus BSO, (ψ) for PO + BSO versus BSO, and (closed diamond) for PO + BSO versus PO. Other abbreviations as in Figs. 1 and 2.
dependent and the BSO-induced increases in BP. This finding correlates with previous work in which concomitant antioxidant therapy with both vitamin E and vitamin C was shown to ameliorate BSO-induced hypertension in normal rats and supports the notion that oxidative stress may be involved in the pathogenesis of hypertension.

Administration of BSO for 1 week caused a significant reduction in GSH levels in plasma, heart, and kidney. When administered with PO, the BSO-induced reduction of GSH levels was changed in the kidney, but not the heart or plasma. This pattern of change is consistent with previous studies that demonstrated the GSH-reducing effect of BSO and its interorgan translocation, turnover, and metabolism. There is a relatively rapid turnover of GSH in the kidney compared to the other tissues, where GSH is resistant to transpeptidation.

The GSH depletion observed in this study indicates a significant level of oxidative stress associated with elevated plasma levels of the vasoconstrictor compounds (ISO and TXA2), and reductions in endothelium-derived vasodilators (NO and PGI2).

The PO reduced TXA2 and ISO and elevated PGI2, NO, and aortic cGMP, but not cAMP. Supporting evidence for the antioxidant potential of PO was shown by its ability to reduce the BSO-induced ISO elevation and suppress the BSO effect on kidney GSH. Plasma levels of ISO are considered to be a sensitive and reliable measure of in vivo oxidative stress. Vitamin E, in particular, has been demonstrated to suppress ISO generation in vivo and reduce atherosclerosis in apolipoprotein-deficient mice.

Furthermore, PO increased plasma levels of NO. It has been suggested that natural antioxidants may preserve the biological activity of endothelium-derived nitric oxide, either by decreasing oxidative stress or directly stimulating NO synthesis. The attenuation of the PO-elevating effect on NO observed in the BSO-treated animals is related to its inactivation by ROS. During oxidative stress NO and O2- react to form peroxynitrite (ONOO-), a potent cytotoxic oxidant.

Plasma TXA2 was also reduced by PO. Likewise, Palmvitee, a PO fraction rich in tocotrienols, has been shown to decrease thromboxane synthesis in humans. In previous studies in rats it was shown that treatment with PO reduced TXA2 and facilitated the utilization of ara-
chidonate for prostacyclin synthesis, hence decreasing the thromboxane-to-prostacyclin ratio. The unsaturated fatty acid fraction of PO may be responsible for the increased production of PGI$_2$. The counteraction of the PO effect on PGI$_2$ and TXA$_2$ by BSO reflects the direct effect of ROS on prostanoid biosynthesis.

Consistent with our findings, PO profoundly elevated aortic cGMP, which is a biologically active NO signaling mediator. Nitric oxide diffuses out of endothelial cells, where it is synthesized, and stimulates guanylate cyclase in vascular smooth muscle cells, causing vascular relaxation. Vitamin E, in particular, has been shown to increase production of cGMP and prevent the development of nitrate tolerance in patients with ischemic heart disease. In the presence of BSO, however, the PO-elevating effect on cGMP was reduced, probably because of the interaction between ROS and NO. With regard to cAMP, earlier studies to assess the effect of dietary PO in rats demonstrated a significant reduction in the release of its substrates, adenosine 5'-triphosphate and adenosine 5'-diphosphate, that correlated with the lower degree of platelet aggregation. This effect was attributed to oleic acid and the tocopherols and tocotrienols present in PO.

Our findings, therefore, suggest that PO reduces BSO-induced oxidative stress and attenuates hypertension by mechanisms involving changes in endothelium-derived factors. This study may have implications for the use of antioxidant-rich dietary components as adjunct to antihypertensive therapy.

References