

**Supplementary Fig. S1.** Effect of GOS on (A) ACE and (B) Shannon indexes in OVA-sensitized mice. Data are presented as the mean  $\pm$  standard error of the mean. \* $p < 0.05$  vs. OVA-C. NOR: control group, OVA-C: oral administration of saline to OVA-sensitized mice group, PC: oral administration of promethazine hydrochloride (1 mg/kg) to OVA-sensitized mice group, GL: oral administration of GOS (100 mg/kg) to OVA-sensitized mice group, GH; oral administration of GOS (200 mg/kg) to OVA-sensitized mice group. ns: not statistically significant among all groups.

**Supplementary Fig. S2.** Effect of GOS on the relative abundance of the cecal microbiota at (A) phyla, (B) Deferribacteres phyla, and genus (C: lactic acid bacteria, D: *Bifidobacteria*, E: *Lactobacillus*, F: *Lactococcus*) levels in OVA-sensitive mice. The relative abundance of lactic acid bacteria is the sum of the relative abundances of *Bifidobacteria*, *Lactobacillus*, and *Lactococcus*. Data are presented as the mean±standard error of the mean. \*\*p < 0.01, \*\*\*p < 0.001 vs OVA-C. NOR: control group, OVA-C: oral administration of saline to OVA-sensitized mice group, PC: oral administration of promethazine hydrochloride (1 mg/kg) to OVA-sensitized mice group, GL: oral administration of GOS (100 mg/kg) to OVA-sensitized mice group, GH; oral administration of GOS (200 mg/kg) to OVA-sensitized mice group. ns: not statistically significant among all groups.

**Supplementary Fig. S3.** Effect of GOS on skin-water holding capacity, TEWL, erythema value, and melanin value in OVA-sensitized mice. Data are shown as mean  $\pm$  standard error of the mean. \* $p < 0.05$ , \*\* $p < 0.05$ , \*\*\* $p < 0.001$  vs OVA-C. NOR: control group, OVA-C: oral administration of saline to OVA-sensitized mice group, PC: oral administration of promethazine hydrochloride (1 mg/kg) to OVA-sensitized mice group, GL: oral administration of GOS (100 mg/kg) to OVA-sensitized mice group, GH: oral administration of GOS (200 mg/kg) to OVA-sensitized mice group, TEWL: transepidermal water loss, ns: not statistically significant among all groups.