**Supplementary File 1**

**Study population**

From seven cycles of NHANES datasets, 70,190 participants were initially included. We excluded participants if they: (1) participants without complete information to calculate the US fatty liver index and cardiometabolic risk factors to diagnose MASLD (n = 49,944); (2) participants without a complete assessment of urinary phthalate metabolites (n = 13,636); (3) age <20 (n = 1,283) or with incomplete covariates: body mass index (BMI) (n = 13) and education level (n = 4); (4) participants without two complete 24-h recall interviews and an assessment of 15 antioxidant agents (n = 852); (5) participants with hepatic steatosis but consumed alcohol over ≥140/210 g/week (females/males), hepatitis B, or hepatitis C (n = 330); (6) participants without information on drinking status (n = 127); or (7) participants with an unreliable record of daily energy intake (<600 kcal/day or >5000 kcal/day, n = 40). Finally, 3,961 participants were included.

**Definition of MASLD**

Based on hepatic steatosis, MASLD was further diagnosed with the presence of more than one cardiometabolic risk factor. Due to its excellent performance in the U.S. population, the US fatty liver index was adopted, with a value over 30 indicating hepatic steatosis. The formula is as follows: **The US fatty liver index** = (e−0.8073 × Non−Hispanic Black + 0.3458 × Mexican American + 0.0093 × Age+0.6151 × loge(Gamma glutamyltransferase) + 0.0249 × Waist Circumference + 1.1792 × loge(Insulin) + 0.8242 × loge(Glucose) − 14.7812)/(1+e−0.8073 × Non−Hispanic Black + 0.3458 × Mexican American + 0.0093 × Age + 0.6151 × loge(Gamma glutamyltransferase) + 0.0249 × waist circumference + 1.1792 × loge(Insulin) + 0.8242 × loge(Glucose) - 14.7812)\*100.
According to the latest Delphi consensus statement, the cardiometabolic risk factors associated with MASLD were as follows:

(1) BMI ≥25 kg/m2 or waist circumference over 94/80 cm (male/female); (2) Fasting serum glucose level ≥5.6 mmol/L (100 mg/dL), hemoglobin A1c level ≥5.7% (39 mmol/mol), type 2 diabetes, or treatment for type 2 diabetes; (3) Blood pressure ≥130/85 mmHg or specific antihypertensive drug treatment; (4) Plasma triglyceride level ≥1.70 mmol/L (150 mg/dL) or lipid-lowering treatment; (5) Plasma high-density lipoprotein cholesterol ≤1.0 mmol/L (40 mg/dL, males) and ≤1.3 mmol/L (50 mg/dL, females), or lipid-lowering treatment. 1

**Detailed information about urinary phthalate metabolites**

Urine specimens were collected and stored under appropriate frozen conditions (–20°C to –40°C) until they were shipped to the National Center for Environmental Health for testing. Urine samples were processed using enzymatic deconjugation of the glucuronidated phthalate monoesters and then analyzed by online solid-phase extraction coupled with reversed-phase high-performance liquid chromatography–isotope dilution–tandem mass spectrometry. The low limit of detection (LLOD) for each phthalate metabolite was provided by NHANES, and LLOD/√2 replaced values below LLOD. Detailed information about the phthalate analytical methods is available on the NHANES website (http://www.cdc.gov/nchs/nhanes.htm).

The full names and types of phthalate metabolites are as follows: mono-(2-ethylhexyl) phthalate (MEHP), mono-(2-ethyl-5-hydroxylhexyl) phthalate (MEHHP), mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP), and mono-(2-ethyl-5-carboxypentyl) phthalate (MECPP) are metabolites of Di-(2-ethyl-hexyl) phthalate (DEHP); mono-isobutyl phthalate (MiBP) is a metabolite of di-isobutyl phthalate (DiBP); mono-isononyl phthalate (MiNP) and mono-(carboxyoctyl) phthalate (MCOP) are metabolites of Di-iso-decyl phthalate(DiDP); mono-ethyl phthalate (MEP) is the metabolite of diethyl phthalate (DEP); mono-n-butyl phthalate (MnBP) is the metabolite of dibutyl phthalate (DBP); monobenzyl phthalate (MBzP) is the metabolite of butylbenzyl phthalate (BBzP); and mono-(3-carboxypropyl) phthalate (MCPP) is a non-specific metabolite of several phthalates, including mono-n-butyl phthalate (MnBP), dibutyl phthalate (DBP), mono-n-octyl phthalate (MnOP), and di-n-octyl phthalate (DnOP).

**Detailed information about covariates**

Covariates included age (divided by quantiles: <34, 34–50, 50–64, >64), sex (male or female), race (Mexican American, Non-Hispanic White, Non-Hispanic Black, and others), BMI (<25kg/m2, 25-30kg/m2, >30kg/m2), hypertension, diabetes, education level (less than high school, high school graduate, college or above), smoking status (never, former, and current smokers), drinking status (drinker, non-drinker), poverty-income ratio (<1.3, 1.3–3.5, >3.5, missing), urinary creatinine (mg/dL), total energy intake (kcal/day), dietary supplement usage (any dietary supplements and medications during the past month), healthy eating index-2020 (HEI-2020), and composite dietary antioxidant index (CDAI).

Hypertension was diagnosed by blood pressure ≥ 140/90 mmHg, the use of antihypertensive medications, or a doctor's diagnosis. Diabetes was defined as self-reported or hospital-diagnosed type 2 diabetes, fasting plasma glucose level ≥126 mg/dL, or glycated hemoglobin A1c over 6.5%. Smoking status was defined as never smokers (<100 cigarettes in a lifetime), former smokers (>100 cigarettes in a lifetime but not smoking now), or current smokers (>100 cigarettes in a lifetime and smoking now). Leisure time physical activity, including sports, fitness, and recreational activities, was classified as insufficient (<150 m/week) or sufficient (≥150 m/week using the ‘Global Physical Activity Questionnaire’). Participants were categorized as non-drinkers if they had fewer than 12 alcoholic drinks in the past year or in their lifetime, while those who consumed more than 12 alcoholic drinks in the past year or in their lifetime were considered drinkers. HEI-2020 is a scoring system composed of 13 food components, evaluating overall diet quality. CDAI, which reflects an estimate of an individual's overall antioxidant exposure, is a combined index calculated using dietary antioxidants, including manganese, selenium, zinc, and vitamins A, C, and E. HEI-2020 and CDAI were calculated as previously reported. 2, 3

**Antioxidant agent assessment**

Intakes of antioxidants were assessed by two 24-h dietary recall interviews. The first interview was conducted by trained interviewers in the Mobile Examination Center, and the second was collected three to 10 days later by telephone. The 24-h dietary recall interviews recorded the types and amounts of foods and beverages consumed during the 24-h period before the interview, and food energy and 64 nutrients/food components were calculated using USDA's Food and Nutrient Database for Dietary Studies. The included antioxidants were as follows: vitamin A (mcg/day), thiamin (vitamin B1) (mg/day), riboflavin (vitamin B2) (mg/day), vitamin B6 (mg/day), vitamin C (mg/day), alpha-carotene (mcg/day), beta-carotene (mcg/day), beta-cryptoxanthin (mcg/day), lutein + zeaxanthin (mcg/day), retinol (mcg/day), lycopene (mcg/day), food folate (mcg/day), selenium (mg/day), iron (mg/day), and zinc (mg/day).

**Weighted quantile sum (WQS) regression**

WQS regression was performed to explore the effects of a phthalates mixture on MASLD, using the 'gWQS' package in R. This method tests the combined effect of chemicals, where their weights are constrained to sum to 1. We tested both the positive and negative effects of the phthalates mixture and selected the significant direction. The WQS index is calculated by the weighted sum of chemical concentrations and is then included in the regression model. Bar plots were used to display the sorted weights of the phthalates.

**References**

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