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Natural sea salt consumption confers protection against hypertension and kidney damage in Dahl salt-sensitive rats

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ABSTRACT

In spite of the fact that sea salts have become more common, the health advantages of eating them instead of refined salt are not well-known. Natural sea salt (SS) and refined salt (RS) were compared in a well-established animal model of hypertension for their ability to induce hypertension. Diets enriched with varied quantities of salt were provided to five groups of Dahl salt-sensitive rats. For each of the four groups, there were 10 people in the control (CON) group, four people in the RS4 group (n = 4), and four people in the SS4 group (n = 4). Systolic (SBP) and diastolic (DBP) blood pressure were considerably lower in the SS4 and SS8 groups than in the RS4 and RS8 groups after 15 weeks in the study. The SBP and DBP of the RS8 rats were significantly greater than those of the other groups. RS4, SS8, and RS8 hearts were abnormally measured by echocardiography before to sacrifice, but CON and SS4 hearts were normal. Serum renin and aldosterone levels were comparable across groups, however individuals in the high salt group had lower levels than those in the CON group. While the glomerulosclerosis index was elevated in the RS4 and RS8 rats, kidney morphology in the SS4 and SS8 rats was comparable to that of the CON kidneys. In the salt-sensitive Dahl rat, our research shows that natural sea salt causes less hypertension than refined salt.

Introduction

Chronically elevated blood pressure is the most common symptom of cardiovascular disease, and hypertension is the most common cause of this condition. Many cardiovascular and other diseases, including coronary heart disease, stroke, congestive heart failure, peripheral vascular disease and renal insufficiency, have been linked to uncontrolled hypertension [1]. Because high blood pressure is linked to cardiovascular disease and arterial vascular alterations, dietary salt consumption must be regulated to avoid high blood pressure. Sodium, one of the most important electrolytes, is crucial in maintaining a healthy blood pressure.. As a result, sodium homeostasis is necessary for a wide range of cell activities, including excitability, excitability–contraction coupling, energy metabolism, pH control, and heart development and growth [2]. Because most persons with high blood pressure are very sensitive to salt, excessive sodium consumption from dietary sources may be a severe risk factor for the condition. Obesity, diabetes, a lack of physical activity, and chronic alcohol use all have a significant influence in the development of cardiovascular disease [3]. Ambard & Beaujard [4] in 1904, Blackwood [5], Morris [6], and Dahl et al. [7] have all stressed the importance of salt intake in hypertension for many years. This study proved conclusively that a person's salt consumption is linked to their blood pressure. Cutler et al. [8] found that a low-sodium diet reduced

both systolic and diastolic blood pressure (SBP and DBP) for at least one to 12 months (DBP).

It has also been shown that people who eat a low-sodium diet for an extended period of time are more sensitive to the salty taste, which helps them to stick with it. As a result, there is substantial evidence that a low-sodium diet may help prevent and treat hypertension. For hypertension management, the source of salt consumption may be as essential as the quantity of salt consumed. Refined (table) salt, sea salt, floral salt, and processed salt are the most prevalent salt sources for consumers [11]. Sea salt has a lower sodium level than refined salt, but it still includes traces of natural minerals including MgSO4, CaSO4, CaCl2, and KCl. It's becoming more common knowledge that sea salt is good for you; nevertheless, there's no evidence that it has a direct influence on blood pressure management [12]. The goal of this research was to see whether ingesting sea salt may have a positive impact on blood pressure

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and its associated physiological markers. For 15 weeks, male Dahl salt-sensitive (DSS) rats were fed diets containing either sea salt or refined salt, which resulted in a significant reduction in blood pressure.

Methods and materials

Animals

Japan SLC, Inc. confiscated four-week-old male Dahl salt-sensitive rats (Shizuoka, Japan). After an adaptation period of nine weeks, the rats were given the experimental food for 15 weeks and kept at a temperature of 21 1°C with a humidity of 50–60% and a 12-hour light/dark cycle. There were five groups: control diet (CON), 4 percent sea salt diet (SSS4), 4 percent refined salt diet (RS4), 8 percent sea salt diet (SS8), and 8 percent refined salt (RS8), which were all randomly allocated to the rats. During the 15-week experiment, participants had unlimited access to food and drink. Following a 12-hour fast and zolazepam (25 mg/kg BW + xylazine (10 mg/kg BW) anaesthesia, the rats were killed. The Seoul National University Institutional Animal Care and Use Committees (SNU 120316–2), where the rats were kept, authorised all of the animal research.

Preparation of a diet

Teklad Global 18% Protein Rodent Food (Harlan Teklad, WI) was employed as the control diet in this study. Rat chow had 58% carbohydrate, 18% fat, and 24% protein in its energy content. Jeonnam Sinan sea salt and Hanju refined salt came from Korea's Hanju area. The Korea Food Research Institute's facilities were used to turn the powdered chow into feed. Both salts were weighed up and poured into the rat food. CODEX STAN 150–1985 and ICP-AES (Activa, HORIBA Jobin-Yvon, Longjumeau, France) were used to determine the general composition and mineral content of the salts. Using a weight basis, we found that sea salt had 85.7 percent NaCl, while refined salt contained 99.9% NaCl. There were also traces of iron, manganese, and zinc in the sea salt, in addition to the sodium chloride (NaCl) concentration. No trace quantities of any other mineral could be found in refined salt.

Measuring one's weight and the amount of food one consumes

Each participant's weight was recorded on a weekly basis at the same time. The amount of feed that remained in the cages after 24 hours was used to estimate intake twice a week. Feed input was divided by body weight growth to arrive at the feed efficiency ratio (FER).

Blood pressure may be measured.

In weeks 1, 2, 3, 10, 12, 13, 14, and 15, blood pressure was taken by the tail cuff technique using the LE 5002 Storage Pressure Meter (Panlab, Barcelona, Spain). Before the tail cuff was applied, the rats were held at 32–34°C in a temperature-controlled heat chamber (Heater Scanner LE 5650/6, Panlab, SI Barcelona, Spain). The findings were based on the lowest reading among five attempts at taking the patient's blood pressure.

Echocardiography

At the conclusion of the research, six rats from each group were randomly chosen for echocardiographic assessment. Rats had been fasted for 12 hours and anaesthetized with zolazepam and xylazine prior to the use of an M-mode echocardiography system (Sonoace 9900, Madison, WI). The following were the measurements: It is important to know the thickness of the interventricular septum at the end of diastole, as well as the LVDd (left ventricular end-diastolic dimension), IVSs (interventricular septal thickness at the end of systole) and the LVPWd (left ventricle posterior wall in diastole) and LVPWs (left ventricle posterior wall in diastole) (left ventricular mass, g).

Measurements of blood and urine A blood sample was taken from the abdomen and centrifuged at 3,000 rpm for 15 minutes to get plasma samples. Before being analysed, all samples were kept at –20°C. Radioimmunoassay was used to assess the activities of aldosterone and renin [13]. An ADVIA 2400 analyser (Siemens, Inc. Munich, Germany) was used to test the electrolytes (Na+, K+, Cl, Mg2+, Ca2+) and an osmolality vapour pressure osmometer 5600 was used to assess osmolality (Wescor, Inc. Logan, UT, USA). The creatinine-corrected urinary electrolytes and aldosterone were analysed.

Analysis of the tissues

When the 15-week experiment was over, organs such as the testicles and testicles were dissected and weighed to determine their weight. Using an automatic embedder, the organs were preserved with

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a 10 percent neutral buffered malin solution before being embedded in paraffin. The tissue morphology was examined by staining the paraffin blocks with haematoxylin and eosin (H&E) after they had been sliced to a thickness of 3 um using a microtome. Gly merulosclerosis index was computed using the usual Masson's trichrome staining technique for kidney sections [12].

The study of statistics

SPSS 20.0 for Windows was used for statistical analysis (SPSS Inc. Chicago, USA). Both ANOVA and the t-test were employed to identify significant differences between the groups. The Duncan's multiple range test was used to determine the variations in group means. At p 0.05, statistical significance was taken into account.

Results

A person's weight, the amount of food they consume, and the amount of salt they consume

FER, weight, and feed intake are all shown in Table 1 for your perusal. Except for the RS8 group, the starting weight of the SS8 group was significantly greater (p 0.05) than that of the other groups. It was shown that the RS8 group had the lowest average ultimate weight (p 0.001) of all the groups studied. The CON, SS4, and RS4 groups all gained the same amount of weight, however the RS8 group gained the least (3.68 0.85 g) followed by the SS8 group (4.65 0.69 g). There was a significant difference in the amount of food consumed by each group, with the CON group consuming the least (20.44 g) and the SS8 group consuming the most (26.31 g). Even though the rats' food intakes differed, the rats' salt intakes were almost identical (Table 1). This was because the SS groups consumed more food, despite the fact that the RS diet had more salt than the SS diet. There are certain theories as to why rats preferred SS diets to the RS diets, such as the fact that the rats devoured more of their food. This also eliminates salt intake as a potential contributor to the observed variations in parameters between the RS4 and SS4 groups and the RS8 and SS8 groups.

High blood pressure

Figure 1 depicts the results of the 15-week research period's SBP measurements. The SBPs of those who consumed salt grew progressively, but the SBP of those in the CON group remained rather stable over time. Starting at roughly 125 mmHg, the SBPs of the experimental groups were identical and proceeded to increase gradually 1–2 weeks later. For the RS8 group, the SBP was considerably greater than that of the SS4 (136.80 10.41 mmHg), SS8 (155.30–9.35) and RS4 (156.17–13.32 mmHg) groups (p 0.001) at the end of the 10-week period. At

Table 1. Body weight, feed intake, FER and mineral intakes of rats fed high-salt diets for 15 weeks.

Parameters	CON	RS4	SS4	RS8	SS8
Initial weight (g)	366.80 ± 4.29^{a}	369.76 ± 4.34^{a}	369.33 ± 3.58^{a}	374.16 ± 2.35^{ab}	384.16 ± 4.69^{b}
Final weight (g)	458.60 ± 5.54^{b}	461.1 ± 6.42^{b}	455.25 ± 5.30^{b}	427.85 ± 2.92^{a}	453.93 ± 4.11^{b}
Weight gain (g)	6.12 ± 0.16^{c}	6.09 ± 0.23^{c}	5.73 ± 0.21^{c}	3.58 ± 0.25^{a}	4.65 ± 0.20^{b}
Feed intake (g/day)	20.44 ± 0.23^{a}	22.49 ± 0.27^{b}	23.02 ± 0.14^{b}	23.07 ± 0.09^{b}	26.31 ± 0.65^{c}
Feed efficiency ratio (%)	0.29 ± 0.01^{c}	0.27 ± 0.02^{b}	0.24 ± 0.01^{b}	0.13 ± 0.02^{a}	0.16 ± 0.01^{a}
Sodium intake (g)	0.04 ± 0.00^{a}	0.35 ± 0.00^{c}	0.32 ± 0.00^{b}	0.72 ± 0.00^{d}	0.73 ± 0.02^{d}
Potassium intake (g)	0.122 ± 0.001^{a}	0.130 ± 0.001^{b}	0.133 ± 0.000^{b}	0.127 ± 0.000^{ab}	0.146 ± 0.003^{c}
Magnesium intake (g)	0.041 ± 0.000^{a}	0.043 ± 0.000^{b}	0.044 ± 0.000^{b}	0.042 ± 0.000^{ab}	0.049 ± 0.001^{c}

Values are presented as mean±SEM. Values with different superscripts within each row are significantly difference at $p < 0.05$ by Duncan's multiple range test.

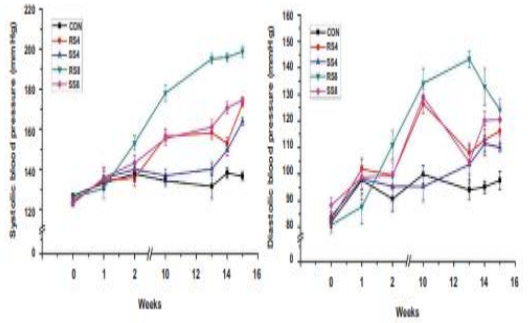

Figure 1 shows the results of the 15-week study's SBP and DBP readings. Statistical significance is shown by an asterisk in the data, which are provided as the mean SEM; the asterisk indicates that a point is substantially different from week 0.

The RS8 group's SBP (198.67 8.76 mmHg) peaked in week 15 and had grown by 72.92 10.09 mmHg over the starting SBP (p 0.001), the most significant increase. When it comes to blood pressure (SBP), the groups in the study had SBPs of 176.45, 176.52, and 163.67 millimetres of mercury (mmHg), respectively. SS8, RS4, and SS4 groups had an increase in SBP of 51.53 mmHg, 48.67 mmHg, and 40.59 mmHg, respectively, throughout the 15-week period. A significant difference in SBP increase between the SS and RS groups was seen for both the 4 percent and 8

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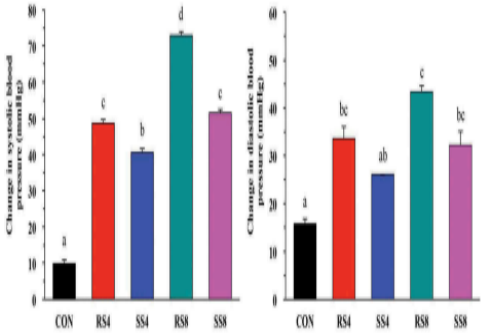
percent groups. Diastolic blood pressure (DBP) was 85 mmHg on average across all groups, and it began to rise after the first week. After week 10, the DBP levels of the SS8, RS4, and SS4 groups remained at the same level as they had been at week 10. A total of 43.33 21.18 mmHg was added to the RS8 group's DBP over the course of the 15 weeks, making it the highest among the groups. The remainder of the rise in DBP was as follows: In the RS4, SS8 (32.27–20.69), SS4 (26.44–5.53), and CON (15.70–19.06 mmHg) groups, the average systolic blood pressure was 33.58–14.92 mmHg. Even while the SS groups' DBP decrease across the 15-week study period was smaller than the RS groups' (Figure 2) for the 4% and 8% diet groups, the differences were not statistically significant (p>0.05).

Echocardiography

After 15 weeks of feeding, an echocardiogram was done, and the results are reported in Table 2 in M-mode echocardiogram form. SS8 (0.25 0.03 cm) and RS8 IVSd (interventricular septal thickness)



From week zero to week 15, rats on high salt diets had a significant increase in their blood pressure. For the sake of simplicity, all data are provided as mean standard error of measurement. Duncan's multiple range test shows a significant difference between the labelled means without a common letter of P 0.05.

Table 2. Echocardiography of rats fed high-salt diets for 15 weeks.

	CON(n = 6)	RS4(n = 6)	SS4(n = 6)	RS8(n = 6)	SS8(n = 6)
IVSd (cm)	0.20 ± 0.01^{a}	0.23 ± 0.02^{bc}	0.22 ± 0.01^{ab}	0.25 ± 0.02^{c}	0.25 ± 0.03^{c}
IVSs (cm)	0.33 ± 0.01^{a}	0.39 ± 0.02^{b}	0.34 ± 0.01^{a}	0.38 ± 0.02^{b}	0.40 ± 0.05^{b}
LVDWd (cm)	0.19 ± 0.01^{a}	0.21 ± 0.03^{ab}	0.19 ± 0.01^{a}	0.22 ± 0.03^{b}	0.23 ± 0.03^{b}
LVPWs (cm)	0.31 ± 0.01^{a}	0.36 ± 0.04^{abc}	0.32 ± 0.03^{ab}	0.37 ± 0.03^{c}	0.37 ± 0.06^{bc}
LV Mass (g)	1.43 ± 0.06^{a}	1.68 ± 0.10^{b}	1.54 ± 0.08^{a}	1.71 ± 0.10^{b}	1.77 ± 0.11^{b}

Values are presented as mean±SEM. Values with different superscripts within each row are significantly difference at $p < 0.05$ by Duncan's multiple range test.

IVSd, interventricular septal thickness at end-diastole; **LVDd**, left ventricular end-diastolic dimension; **IVSs**, interventricular septal thickness at end-systole; **LVDs**, left ventricular dimension in diastole; **LVPWd**, left ventricle posterior wall in diastole; **LVPWs**, left ventricle posterior wall in systole; **LV mass**, left ventricular mass.

It was found that the thickness of (0.25 0.02 cm) was considerably greater than that of both the CON and SS4 groups (p 0.01 cm) When it comes to SS4 group IVSd, it wasn't different from the CON group (0.22 0.01 cm), but it was much thicker than that of the CON group (p=0.001). The interventricular septal thickness at the conclusion of systole showed a similar pattern (IVSs). In contrast to the CON and SS8 groups, the IVSs of RS4 (0.39 0.02 cm) and RS8 (0.38 0.03 cm) as well as SS8 (0.40 0.05 cm) were substantially thicker than those of the other two groups (p 0.001). The CON and SS8 groups had IVSs that were significantly thinner than those of the other two groups. LVPWd and LVPWs of RS4, SS8, and RS8 groups were found to be hypertro phied compared to those of CON and SS4 groups (p 0.05). (RS4; 1.68 0.10 mL, SS8; 1.77 0.11 M), and CON (1.43/0.06) were significantly greater than those of the three high-salt diet groups (RS4; 1.68; SS8; 1.77; RS8; 1.71) (p = 0.001). However, the LV mass of the SS4 group was not different from the CON group (1.54 0.08 mL). Stroke volume, Ejection Fraction and Fractional Shortening were all found to be comparable across the two groups.

Table 3 displays the sacrificed organ weights. Compared to the other experimental groups, the heart weight of the CON group was substantially lower at 1.65 0.12 g (SS4; 1.85 0.23 g, R4; 1.98 0.17, S8; 1.90; 0.14, RS4; 1.91; 0.11 g). All of the high salt diet groups had kidney weights that were significantly lower than those for all of the CON groups (SS4; 3.21 0.16 g, RS4; 3.36 0.1 g, SS8; 3.46; 0.14, RS8; 3.60; 3.60) (p = 0.001), but the CON group had kidney weights that were not significantly different from those of the high salt diet groups. All of the groups had the same size liver, spleen, and epididymal weight.

The kidney's cellular structure.

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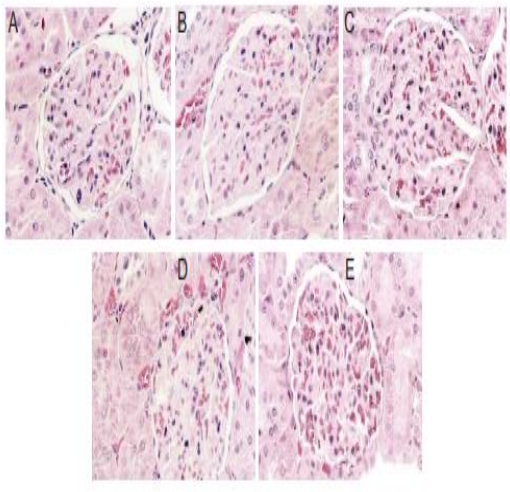
Kidney sections were stained with haematoxylin and eosin to look for any structural irregularities that may have been produced by excessive salt intake and salt type. In contrast to the CON group (A), rats from the RS4 (B) and RS8 (C) groups developed minor focal segmental glomerulosclerosis (FSG) in their kidneys, as illustrated in Figure 3.

Table 3. Organ weight of rats fed high-salt diets for 15 weeks.

	CON	RS4	SS4	RS8	SS8
Heart	1.65 ± 0.04^{a}	1.98 ± 0.05^{b}	1.85 ± 0.07^{ab}	1.91 ± 0.03^{b}	1.90 ± 0.04^{b}
Kidney	2.88 ± 0.06^{c}	3.36 ± 0.03^{bc}	3.21 ± 0.05^{b}	3.60 ± 0.07^{a}	3.46 ± 0.04^{ab}
Liver	14.54 ± 0.66	14.98 ± 0.65	14.41 ± 0.65	14.70 ± 0.78	14.39 ± 0.57
Spleen	0.85 ± 0.04	0.86 ± 0.03	0.82 ± 0.03	0.89 ± 0.03	0.83 ± 0.04
Testicle	4.16 ± 0.08	4.08 ± 0.14	4.17 ± 0.05	4.03 ± 0.05	4.25 ± 0.08

Values are presented as mean ± SEM. Values with different superscripts within each row are significantly difference at $p < 0.05$ by Duncan's multiple range test.



(H & E stain, 400x magnification) Figure 3: Kidney histopathology after a high-salt diet. (a) There are no pathological findings. (b) Tufts in the glomeruli are richer in RS4, the hyaline matrix. These droplets (arrows) are eosinophilic homogenous hyaline droplets in the cytoplasm of convoluted epithelium at the proximal end. Homogeneous hyaline droplets packed with proximal convoluted epithelial cytoplasm (arrows) are shown in (c) RS8. In glomerular tufts, there is an increase in the pale eosinophilic hyaline matrix. For (d) SS4 and (e) SS8, the cytoplasm of proximal convoluted epithelial cells only contains a few eosinophilic homogenous hyaline droplets (arrows). The glomerular tufts show no signs of pathology.

In these cases, glomeruli have been sclerosised in some but not all of the cases. Only a small part of the capillary tufts were impacted in the glomeruli that were affected. To further demonstrate that the renal tubular epithelial cells of the renal tubules were abnormal in the RS4 and RS8 rats, many hyaline droplets were seen in the kidney cytoplasm. Renal disease associated with protein loss in urine was indicated by the presence of proteinous components in the lumen of tubular cells (proteinuria). There was minimal structural damage to the kidneys of rats in both groups, and the tubules and glomeruli in the SS4 (D) and the SS8 (E) groups seemed to be mostly unaffected (Figure 3). Using the kidney sections stained with Masson's trichrome, we generated the glomerulosclerosis index scores for each salt group (Figure 4) in order to more precisely measure the amount of renal damage (Figure 4, bottom). Glomerulosclerosis scores in SS groups were lower than in RS groups, as predicted (p 0.05); nevertheless, this was not statistically significant. It was shown that RS8 rats had the highest glomerulosclerosis score among the RS groups. This suggests that sea salt is much less damaging to the kidneys when consumed in large quantities than normal salt.

Chemotherapy

Table 4 displays the findings of blood chemistry. There were significant differences in the plasma renin concentrations in CON and high salt diet groups (p-values less than 0.001). Aldosterone concentrations in the CON group were greater than those in the high salt diet groups, following the same pattern as renin levels. The high salt diet groups did not vary significantly in terms of renin or aldosterone, on the other hand. Despite differences in salt intake, the serum electrolytes of all the groups were remarkably similar. In the high salt diet groups, both potassium and calcium concentrations were greater than those in the control group. Blood

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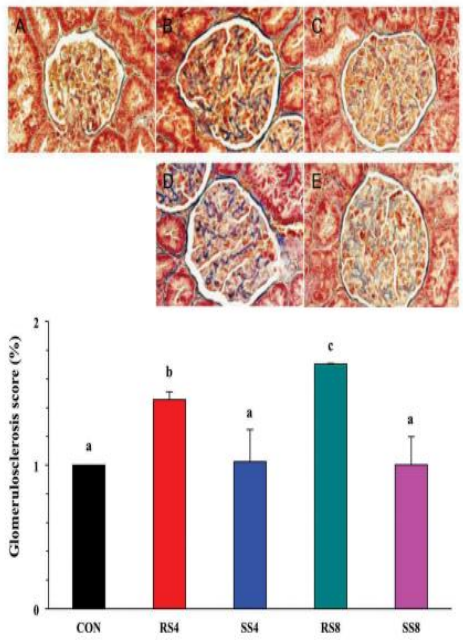

Figure 4 depicts the glomerular capsule and tufts stained by Masson's trichrome staining as a result of a high-salt diet on kidney histology. (a): CON, no fibrosis was found. mild fibrosis in the RS4 subgroup (arrows). severe fibrosis (RS8) (arrows). Both SS4 and SS8 have very little fibrosis (arrows). For Dahl salt-sensitive rats given the three diets for 15 weeks, the graph on the bottom displays a quantitative depiction of renal damage. Each rat's kidney damage was calculated based on its glomerulosclerosis index. As previously mentioned, data is provided as mean standard error of measurement (SEM). Means with no common letter are statistically significant at a P 0.05 level of significance

Table 4. Biochemical indices of rats fed high-salt diets for 15 weeks.

	CON	RS4	SS4	RS8	SS8
Plasma					
Renin (mg/dL)	4.11 ± 1.13^{b}	0.87 ± 0.15^{a}	0.86 ± 0.33^{a}	1.94 ± 0.45^{a}	1.30 ± 0.26^{a}
Aldosterone (pg/mL)	76.78 ± 31.52	21.74 ± 8.83^{a}	16.15 ± 4.71^{a}	24.58 ± 3.17^{a}	16.33 ± 3.89^{a}
Serum					
Na (mEq/L)	146.29 ± 0.94^{a}	148.33 ± 0.62^{a}	149.33 ± 0.61^{b}	149.92 ± 0.83^{b}	148.64 ± 0.70^{b}
Cl (mEq/L)	101.14 ± 0.51^{abc}	101.75 ± 0.37^{bc}	102.50 ± 0.56^{c}	100.83 ± 0.51^{ab}	100.00 ± 0.60^{a}
K (mEq/L)	5.97 ± 0.19^{a}	6.75 ± 0.22^{b}	6.73 ± 0.23^{b}	6.61 ± 0.25^{ab}	6.47 ± 0.24^{ab}
Ca (mg/dL)	9.76 ± 0.11^{a}	10.33 ± 0.13^{b}	10.25 ± 0.10^{b}	10.23 ± 0.12^{b}	10.44 ± 0.12^{b}
Mg (mg/dL)	2.41 ± 0.10^{ab}	2.29 ± 0.03^{a}	2.44 ± 0.07^{ab}	2.35 ± 0.06^{ab}	2.53 ± 0.06^{b}
Osmolality (mOsm/kg)	308.43 ± 5.65^{ab}	306.33 ± 5.85^{a}	307.83 ± 3.66^{a}	313.27 ± 4.63^{bc}	315.25 ± 7.42^{c}
Urine					
Aldosterone (pg/mL)	51.17 ± 4.75^{a}	49.47 ± 2.36^{a}	57.34 ± 3.01^{a}	77.21 ± 3.91^{b}	61.94 ± 6.58^{a}
Na (mEq/L)	45.20 ± 6.41^{a}	191.33 ± 19.59^{c}	123.83 ± 13.78^{b}	258.18 ± 22.40^{d}	196.55 ± 22.55^{c}
Cl (mEq/L)	66.80 ± 12.56^{a}	202.17 ± 19.84^{c}	129.17 ± 13.79^{b}	276.73 ± 23.28^{d}	232.36 ± 30.27^{cd}
K (mEq/L)	78.47 ± 12.95^{b}	49.51 ± 4.32^{a}	57.83 ± 8.65^{ab}	43.33 ± 8.68^{a}	44.37 ± 5.21^{a}
Ca (mg/dL)	9.78 ± 1.56^{a}	25.77 ± 2.80^{c}	17.23 ± 1.68^{b}	20.17 ± 2.48^{bc}	22.03 ± 2.18^{bc}
Mg (mg/dL)	22.16 ± 4.44^{a}	32.42 ± 4.37^{ab}	32.77 ± 4.74^{ab}	25.91 ± 5.71^{ab}	38.27 ± 3.84^{b}
Creatinine (mg/dL)	101.38 ± 21.06^{ab}	97.81 ± 15.19^{ab}	144.49 ± 21.22^{b}	49.57 ± 9.94^{a}	109.54 ± 20.04^{b}
Osmolality (mOsm/kg)	931.50 ± 156.09	1022.67 ± 83.37	1140.17 ± 123.55	925.00 ± 130.61	1085.00 ± 111.24

Values are presented as mean ± SEM. Values with different superscripts within each row are significantly difference at $p < 0.05$ by Duncan's multiple range test.

The osmolality was comparable between the CON and the 4 percent salt groups, whereas the 8 percent salt groups had a higher average. In general, the analytes in urine were substantially more variable than the ones in serum, as was the case in our study. The concentration of aldosterone in urine was substantially greater in the RS8 group than in any of the other groups (p 0.001). No surprise that urine sodium concentrations of CON group were considerably lower than those of high salt diet groups (SS4, RS4, SS8 and RS8), with the RS8 group being the highest (p = 0.001). The CON group had the lowest urinary sodium concentrations, with the RS8 group having the highest. High salt diet groups had urine chloride levels between 129 to 277 mEq/L in comparison to the CON group's 66.8 mEq/L. High salt diet groups had greater calcium and magnesium concentrations than the CON group, although potassium concentrations were higher in the CON group.

Discussion

For the prevention of hypertension, good lifestyle choices and medical therapy must be maintained on a long-term basis. Diet treatment (DASH), weight loss, salt intake reduction, regular exercise, and moderate alcohol use are all recommended by the report of the Joint National Committee 7 [14] for lifestyle adjustment. Sodium consumption over the recommended daily limit of 2.0 grammes (74.1% of adult fatalities worldwide) was shown to be the cause of 1.65 million cardiovascular disease deaths in persons in 66 countries in 2010 [15]. However, while the causes of salt-induced hypertension in DSS rats have been disputed by several researchers, one

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suggestion is that when Na+/Ca+ exchanger concentrations rise, cellular calcium concentrations rise as well. Blood pressure rises when calcium levels rise, which causes the contraction of vascular smooth muscle and cardiac muscle. DSS rats do not develop hypertensive without chloride loading, but the anion accompanying sodium plays an important role in determining the amount of the blood pressure elevation [17].

It was our primary goal to compare the hypertensive effects of DSS rats fed either 4 percent or 8 percent of either 4 percent or 8 percent sea salt or refined salt chow during a 15-week period. Hypertension research relies on the exact monitoring and recording of blood pressure variations in study animals. A preferable approach for measuring blood pressure is to use an implanted radiotelemetry device rather than a standard tail-cuff, but many organisations are unable to afford the requisite equipment and training to use it, making it impracticable [18,19]. Tail-cuffing was a suitable approach for our investigation, and the employees who did it were well-trained. Even when fed an 8 percent salt diet, Dahl salt-resistant rats' blood pressure remains normal [20], but when DSS rats are fed the same amount of salt, both their SBP and DBP rise [21]. SBP and DBP are both shown to be higher in those who were exposed to

Salty food diets Between week 0 and week 15, the SBP of all groups rose by 7%, 33%, 39%, 42%, and 58% for CON, SS4, RS4, SS8, and RS8 correspondingly. In terms of DBP, we saw a similar pattern. While salt consumption is identical, the RS4 and SS4 and RS8 and SS8 blood pressure variances are constant. Sea salt has about half as much sodium as refined salt, as seen in Table 1, yet despite this, the RS and SS rats in this study had identical intakes of sodium chloride (NaCl).

It is thus impossible to explain the observed variations in the parameters between the RS and the SS rats to differences in salt consumption. Sea salt seems to have unique qualities that make it more resistant to hypertension than refined salt, according to all of these studies. It's unclear how the anti-hypertensive effects of a sea salt diet are achieved. Other than sodium, one thing to consider is the sea salt's mineral composition. With regard to NaCl content by weight, the sea salt we utilised had an average of 85,7% whereas the refined salt had an average of 99,9%. Sea salt also includes calcium (1.5 mg/g), potassium (2.9 mg/g), magnesium (3.9 mg/g), and a trace amount of iron, manganese, and zinc in addition to sodium. It is recognised that dietary potassium may alter blood pres sure, and that it can play a role in reducing blood pressure in hypertensive individuals. Studies have shown that even with high salt consumption, human individuals who consume high quantities of potassium are less likely to develop hypertension. Additionally, increased potassium consumption reduces blood pressure rises generated by excessive salt intake in rats [23]. For those with hypertension, potassium excretion is not only inversely linked with systolic blood pressure, but it is also associated with a decreased risk of mortality and cardiovascular events [24, 25]. The relaxation of arterial vessels caused by calcium consumption has been linked to a reduction in blood pressure [26]. SBP was shown to be reduced in an older Turkish population with relatively high calcium consumption [27]. Magnesium is another essential nutrient for blood pressure control. Magnesium shortage causes a rise in blood pressure, however the more severe the magnesium deficit, the greater the increase in blood pressure [28]. The natural calcium channel blocker effect of taking 500–1000 mg/day of magnesium, on the other hand, has been shown to lower blood pressure and improve endothelial dysfunction via boosting nitric oxide. A subgroup of rats from each group was subjected to echocardiography to see whether long-term elevated blood pressure affected their cardiac function.

As a diagnostic tool, echocardiography plays an important role in evaluating diastolic function and the estimate of pulmonary hypertension pressures [30], as well as the assessment of right ventricular size and function [31]. To keep the left ventricular wall taut under the strain of high blood pressure, the ventricular wall thickens in hypertensive individuals [32]. RS4, SS8, and RS8 groups were found to have substantially greater levels of IVSs, IVSd, LLVDd, and LV mass than the CON group, suggesting abnormalities in the left ventricular function in these groups. Even though they consumed the same amount of salt as the RS4 rats, the SS4 rats did not develop these problems. These echocardiography studies show that high salt diets cause hypertrophy of the heart, and that sea salt consumption reduces this load relative to refined salt intake. When it comes to organ weights, all the high salt diet groups were heavier than the control group. Because of the body's equilibrium being disrupted by increased salt consumption, larger organ weight is the result. Results from this study are consistent with the

findings of Aoi and colleagues, who found that a high salt diet led to an increase in DSS rats' heart and kidney weight. A typical side effect of chronic high blood pressure is kidney injury [34], as seen by the high levels of glomerulosclerosis found in the rat kidneys of the RS4 and RS8 strains (Figure 4). It is important to note that the renin-aldosterone system (RAS) plays an important role in regulating sodium and potassium balance, extracellular volume, and blood pressure.

A greater plasma aldosterone concentration was found in the RS4 group than in the SS4 group in our investigation. RS8 subjects had a considerably greater urinary aldosterone excretion than SS8 subjects. The RAS homeostasis may be disrupted by diets rich in refined salt, which may lead to an increase in blood pressure. To sum up, our data show that sodium consumption and type have a direct impact on blood pressure. Blood pressure rose as a result of a larger salt intake. Although the effects of salt concentration could not be ruled out, sea salt consumption resulted in lower blood pressure and less hypertension than refined salt.

reduced heart and renal damage. Because sea salt is rich in minerals that are anti-hypertensive, it is believed that this mineral richness is responsible for the sea salt's therapeutic effects. In addition, it is conceivable that the sea salt contains unidentified components that might protect against hypertension. The mechanism by which sea salt lowers blood pressure has to be studied further. As a result of our results, it's critical to find out if human use of sea salt has the same impact on blood pressure.

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