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Original article

# Culinary herbs and spices for low-salt dietary management: Taste sensitivity and preference among the elderly

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ABSTRACT

*Background:* Low-salt dietary management is a strategy for maintaining the health of the elderly. However, the elderly face the challenge of reducing salt consumption because of taste changes associated with aging.
*Objective:* This study aimed to evaluate the effectiveness of using herbs and spices for low-salt dietary management and its effect on taste sensitivity and preferences among the elderly.
*Methods:* The study involved 54 nursing home residents with a mean age of 71 ± 8.2 years. Taste preference data were collected from self-reported questionnaires, whereas salty taste sensitivity was measured using the sodium chloride detection threshold (DT) using a forced-choice method with three different concentrations (0.1709, 0.3418, and 0.6837 M). Culinary preference was evaluated using three different formulas: F1 (regular salt), F2 (50% sodium reduction), and F3 (50% sodium reduction with herbs and spices addition). The assessed items included three side dishes (braised chicken, marinated tempeh, and spiced tofu) and three snacks (tofu schotel, vegetable omelet, and mushroom shumai), and the assessment was conducted using a single-blind method.
*Results:* The majority of the subjects liked the salty taste (75.9%) and had good taste sensitivity (81.5%), especially women (16.2% higher). Subjects preferred 50% reduced salt with herbs and spices, similar to standard, but least liked the salt-only reduction formula. Statistical analyses showed that there was an association between culinary preferences in F1 and F2 and salty taste preference ($p < 0.05$), especially among women, but not salty taste sensitivity ($p > 0.05$). Increased levels of certain minerals were also found in all dishes.
*Conclusion:* The study findings suggest that using herbs and spices is an effective method for low-salt dietary management in the elderly population and that taste preference plays a more important role in food selection than taste sensitivity.

## 1. Introduction

The global elderly population is on a significant rise, with the most substantial increments in the Asian and Latin American populations [1]. The World Health Organization also emphasizes that this growth surpasses that of the general population, both numerically and proportionally [2]. The expanding of the elderly population not only correlated with economic challenges and increased burden of financial security and housing, and healthcare costs [3–5], but also led to an escalation in frailty and dependency, particularly in the very old population [5,6]. Consequently, despite the extension of life expectancy, the number of years spent in good health may decline, so effective nutritional strategies are needed.

Nutrition has a considerable impact on the well-being and quality of life of the elderly, with a nutrient-dense and healthy diet promoting health and reducing the risk of chronic diseases [7]. However, several studies have revealed that nursing home residents often fall short of dietary guidelines and recommendations, particularly in terms of energy and protein intake [8,9]. Another study across nursing homes also reported that residents are exposed to insufficient energy, protein, omega-3 fatty acids, and fiber [10], but nearly double of salt reccomendation [11]. Notably, high salt intake is a major dietary risk factor contributing to 3 million deaths and 70 million disability-adjusted life years worldwide [12]. Therefore, it is necessary to implement a comprehensive plan

*Abbreviations:* SBP, systolic blood pressure; DBP, diastolic blood pressure; DT, detection threshold; AI, visual analog scale; MATS, microwave-assisted thermal sterilization; OB, obesity; OISE, odor-induced saltiness enhancement; OW, overweight; RCT, randomized controlled trial.

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to reduce sodium consumption.

A low-salt diet can significantly improve health, with studies showing a 7% reduction in stroke and heart attack [13], a reduced systolic blood pressure (SBP) by 4.8 mmHg, and a sodium-creatinine ratio of 36% [14]. Several studies have also found that a low-salt diet can lower blood pressure and consistently reduce the need for antihypertensive medications [15–17]. Strategies to reduce sodium intake include salt removal, salt replacement (e.g., calcium chloride, potassium chloride, magnesium chloride), and physical and taste modifications (e.g., herbs and spices, monosodium glutamate, and amino acids/peptides) [18–20]. Among these strategies, the use of herbs and spices as taste enhancers is emerging as a straightforward approach to improve taste and acceptability [19,21,22]. The use of herbs, spices, or their combinations provides novel flavors, aromas, and sensory experiences that effectively offset reduced salt consumption. Several studies have suggested that incorporating herbs and spices can boost appetite and reduce salt usage by up to 50% in ready-to-eat chicken pasta [23] and legume-based mezze [24], without reducing taste intensity and hedonic satisfaction. In addition to enhancing taste, herbs and spices have been explored as potential methods to address age-related changes in taste sensitivity. The aging process affects taste acuity at around 60 years old [25]. Approximately 60% of the elderly aged 65–80 years and 80% of those aged over 80 years experience this decline, leading to discrepancies in taste perception [15,26], and encourages the addition of more salt to their diet [27,28]. Consequently, elderly may develop nuanced preferences, such as choosing salty foods to satisfy their sensory needs.

Overall, declining salt taste sensitivity in the elderly can influence their food preferences, although these preferences vary among individuals. The use of spices and seasonings offers a valuable alternative to maintain desired salt preferences without compromising health. Therefore, this study was conducted to investigate the effectiveness of herbs and spices in low-salt dietary management, as well as their impact on taste sensitivity and food preferences in elderly individuals.

## 2. Material and methods

### 2.1. Study design

This observational and cross-sectional design was conducted from October to the end of the year 2022. It involved elderly individuals residing in the UPTD Griya Werdha Nursing Home located in Surabaya, Indonesia. The study's design consisted of three stages. In the first stage, interviews were conducted to identify the characteristics of the subjects and assess their preference for salty taste using a questionnaire. In the second stage, salty taste sensitivity was analyzed by measuring the salty taste detection threshold (DT) using the rapid detection threshold method adapted for the elderly. This approach allowed researchers to determine the minimum salt concentration that each subject could perceive, thereby providing valuable information on individual salt sensitivity. The third stage was the evaluation of culinary preferences for three different formulations. Each subject was instructed to taste the three formulations, consisting of three salty side dishes and three salty snacks, followed by selecting the one they preferred the most.

### 2.2. Subject characteristics

#### 2.2.1. Screening of subjects

In this study, 64 elderly individuals residing in the UPTD Griya Werdha Surabaya Nursing Home were screened. Sample size was determined using the formula proposed by Lemeshow et al., a well-established method for determining sample sizes in health-related studies [29]. The prevalence of hypertension among the elderly used in this calculation was 34.1% [30], with a desired precision level of 5%. Subjects were recruited using purposive sampling and were required to meet specific inclusion criteria. The inclusion criteria were age of $\geq$60 years; good health condition and not bedridden; and no dementia, taste, gastrointestinal or otorhinolaryngological disorders (such as influenza), food allergies, and acute infectious diseases. Additionally, the subjects were required to communicate actively and cooperate. Based on these criteria, 54 elderly individuals (age $>$ 60 years) were selected for the study, consisting of 13 males and 41 females.

#### 2.2.2. Anthropometric measurement

Height was assessed using a SECA 213 GEA portable stadiometer (SECA GmbH & Co. KG, Hamburg, Germany) with a precision of 0.1 cm, and subjects were instructed to stand upright without footwear. Body weight was determined by Bioelectrical Impedance Analysis (BIA) using the Karada Scan HBF-375 (OMRON Healthcare Co., Kyoto, Japan), with a precision of 0.1 kg., BMI is calculated by dividing body weight in kilograms by the square of the height in meters, which was categorized as underweight ($<$18.5 kg/m$^2$), normal (18.5–25 kg/m$^2$), and overweight ($>$25 kg/m$^2$) [31]. Before anthropometric assessments, the physical capabilities of the elderly individuals were observed. It was ensured that the elderly subjects involved in these measurements were able to stand unassisted and hold the BIA device.

#### 2.2.3. Blood pressure measurement

Blood pressure was measured using an OMRON HEM-7201 digital sphygmomanometer (OMRON Healthcare Co., Kyoto, Japan). Two measurements were performed at an interval of 2 min. If the difference between the first and second measurements was over 10 mmHg, a third measurement was performed. According to the Joint National Committee-8 (JNC 8) guidelines, based on blood pressure, the elderly population can be classified as normal if systolic blood pressure (SBP) is $<$120 mmHg and diastolic blood pressure (DBP) is $<$80 mmHg; pre-hypertensive if SBP ranges from 120 to 139 mmHg or DBP ranges from 80 to 89 mmHg; and hypertensive if SBP is $>$140 mmHg or DBP is $>$90 mmHg [32].

#### 2.2.4. Salty taste preferences

This study used self-reported measures to assess the subject's preferences for salty taste. During interviews, subjects were asked about their preference for salty food using the question, "Do you like salty taste?" and were given the option to answer "yes" or "no." In addition, subjects were asked to indicate their degree of preference for salty taste by selecting either "like salty taste" or "not like salty taste" in response to the question, "How much do you like salty taste?". To ensure the reliability of data, we regularly checked subject responses throughout the study duration. These checks were conducted to validate the consistency of their answers over time.

### 2.3. Salty taste sensitivity measurement

Salty taste sensitivity was evaluated using a DT measurement method based on the procedure proposed by Neumann, Schauren, and Adani [33], which effectively minimizes the impact of sensory fatigue, particularly among the elderly. The subjects were instructed to abstain from brushing their teeth and eating for at least 1 h before the study. The study was conducted between 9:00 a.m. and 11:00 a.m., and each subject was paired with one researcher. Table salt (NaCl) obtained from Daesang Agung Indonesia Co., Gresik, Indonesia, was the compound used in this study. To prepare the solution, NaCl was dissolved in distilled water from the convenience store, at concentrations of 0.1709, 0.3418, and 0.6837 M and then placed in a disposable cup of 10 mililiters.

Sensitivity testing was performed using the forced-choice method, wherein the subjects were presented with three sets of samples, with each set comprising one sample containing the salt solution and two blank samples containing distilled water. Each sample was coded with a random three-digit number and presented in a nonsequential manner. The solutions were applied to the anterior part of the tongue using a cotton bud from the lowest to highest concentration. Subjects were given 15 s to identify each set of samples. Each sample set were tested twice to prevent guessing the answer. In between the tests, the mouth was rinsed with distilled water at 10-s intervals to reduce flavor buildup. The answer sheet was marked as (+) for correct answers and (0) for incorrect ones. Taste sensitivity was categorized based on the total number of correct answers (+) provided by the subjects. Specifically, subjects were considered to have 'good taste sensitivity' if they achieved three (all) correct answers. Conversely, individuals with one or two correct answers were classified as having a less sensitive taste. Distilled water was used to ensure absence of contaminants and minerals, to prevent alteration of the original taste of the sample.

### 2.4. Culinary herbs and spices formulation

#### 2.4.1. Recipe development

In this study, an experienced nutritionist was involved throughout the procedure (from recipe development to sensory evaluation). This research focused on herbs and spices-based culinary formulations, specifically selected based on the dishes commonly consumed by the local community and featured in the daily menus of nursing homes. The methodology employed for formulating these dishes adhered to the traditional Indonesian culinary framework, encompassing both side dishes and snacks. Each dish underwent three formulation variations, all of which prioritized the addition of salt without the use of additional flavoring agents. Each dish was created according to a predetermined standard recipe.

In this study, the nutritional content of the dishes was analyzed using the NutriSurvey 2007 software (EBISpro, Willstaett, Germany). The database provided through the indo.fta source was used to analyze the nutritional content of the food ingredients. If nutritional values were not available in the database, references from two Indonesian food composition databases, namely Daftar Komposisi Bahan Makanan (DKBM) 2017 and the Tabel Komposisi Pangan Indonesia (TKPI) 2017, available on the website www.panganku.org, were used [34]. All ingredients and spices were obtained from local markets in Surabaya, Indonesia, and weighed using digital scales with an accuracy of 0.1, as calibrated by the laboratory staff from the Department of Nutrition at Universitas Airlangga, Indonesia.

The side dishes prepared in this formulation included three main variations: braised chicken, marinated tempeh, and spiced tofu. The recipe for braised chicken was made from chicken (breast) with a flavorful mixture of garlic (solid blubs), shallots (red, fresh), galangal (plump, tight skin), candlenut (yellowish), turmeric (bright, fresh), lemongrass (ivory white), bay leaves (dark, fresh), coriander (ground), salt (0.5 g), and sugar (1.25 g). The preparation of tempeh bacem involved boiling tempeh (firm) with the addition of shallots (red, fresh), garlic (solid blubs), candlenuts (yellowish), nutmeg (ground), bay leaves (dark color, fresh), coriander (ground), galangal (plump, tight skin), salt (1 g), and brown sugar (4 g). Spiced tofu was prepared from fried tofu (drained, firm) sauteed with shallots (red, fresh), garlic (solid blubs), red chili (red, shiny), cayenne pepper (red, fresh), galangal (plump, tight skin), candlenut (yellowish), bay leaves (dark, fresh), sugar (5 g), and salt (1 g). Notably, all side dish preparations were executed in a single batch, in order to ensure a consistent and uniform flavor profile for all subjects.

This study included a variety of easily accepted snacks, such as tofu schotel, vegetable omelet, and mushroom shumai. To prepare tofu schotel, tofu (drain, firm) and vegetables (potatoes, carrots, oyster mushrooms) were mixed with eggs, non-dairy creamer (a commercial product from Lautan Natural Krimerindo Co., Indonesia), skimmed milk, and palm oil (Salim Ivomas Pratama Tbk, Indonesia). The herbs and spices used included onion (firm, dry), garlic (flavorful, solid blubs), pepper (ground), salt (1 g), and sugar (0.5 g). The batter was then baked at 180 °C for 20 min. The ingredients for vegetable omelet included egg (clean, not cracked), vegetables (spinach and carrots), noodles (dry), spring onions (fresh), shallots (red), garlic (solid blubs), pepper (ground), sugar (1 g), and salt (0.75 g). The omelet was roasted for 40 min at 175 °C. Meanwhile, mushroom shumai were made by steaming tofu skin (commercial product from Bintang Jaya, Indonesia) filled with chicken (breast), ear mushrooms, carrots, eggs, flour, celery, garlic (flavorful, solid blubs), shallots (red, fresh), salt (0.75 g), and sugar (1 g).

After the formulation phase, the prepared dishes were subjected to an organoleptic evaluation conducted by five limited panelists, comprising lecturers and nutrition laboratory assistants from Airlangga University. The primary focus of the evaluation was to assess the taste acceptance of the dishes. A standard recipe was established based on organoleptic evaluation (F1), which was characterized by a distinct salty taste, typically obtained from various salty and sweet recipes found in online sources and cookbooks. F2 was prepared by reducing the amount of salt and sugar (50% of the F1 content) in the same composition, thereby ensuring that the dish did not taste salty or sweet. Furthermore, F3 was prepared by reducing the amount of salt (same as F2), with all herbs and spices doubled. In simple terms, the developed formula is described as follows:

F1: Culinary food with regular salt.

F2: Culinary food with sugar and salt reduction.

F3: Culinary food with sugar and salt reduction and herb and spice additions.

Three variations were prepared using the same primary ingredients, but with different amounts of salt and species. Once the standard formula (F1) was established, F2 and F3 were prepared and evaluated by panelists. The amount of each ingredient in the approved formulas is detailed in Table 1.

This culinary menu ensures the management of a low-salt diet, that has been proven to be related to blood pressure control in the elderly population [14,35,36]. In this series of studies, the primary ingredients used in snacks were a combination of vegetables, such as potatoes, carrots, and oyster mushrooms in tofu schotel dishes. Additionally, the omelet menu included a combination of spinach and carrots, whereas the mushroom shumai contained a mixture of wood ear mushrooms and carrots. This approach aims not only to minimize salt intake but also to design formulations that enhance the levels of potassium, calcium, and magnesium. These three minerals are known to play a supportive role in blood pressure regulation. Furthermore, we employed the braising method for all of our side dishes and the steaming technique for snacks with a soft texture, which are ideal for elderly consumption. The braising method ensures that the food remains tender and retains its flavor and tenderness as the spices and herbs are infused, while minimizing the waste of ingredients [37]. Furthermore, the steaming method for snacks not only makes the food healthier and lower in fat because it eliminates the need for added oil, but also produces soft, smooth, and moist food that is more suitable for consumption by the elderly. These qualities can enhance taste acceptance, particularly for salty tastes sensory quality. In terms of nutrition, various cooking methods can affect the phytochemical contents of foods. However, it was discovered that the water-cooking method was more effective at preserving antioxidants [38]. Additionally, steaming and microwaving were found to retain more phytochemicals and antioxidants than the other cooking techniques in another study [39]. Information regarding the nutritional composition of each formula is presented in Table 2.

#### 2.4.2. Evaluation of tested sample

A preference test was conducted in the morning (09.00–11.00 a.m.), at the dining room of the nursing home in a single-blinded procedure. The room was kept sterile to ensure an optimal research environment. Each subject enrolled was guided by an assigned researcher to receive clear instructions regarding the assessment procedure. Prior to the testing session, the subjects were instructed to consume a drink as a preparatory step. Each 10 g sample was placed on a plastic material called oriented polypropylene laminated plastic and labeled with a random code. The testing process began with the evaluation of the side dishes and then continued with the snack samples. The order of

**Table 1**
The formula recipes and quantity of ingredients.

| Menu | Ingredients | Composition (g/ formula recipe) | | |
|---|---|---|---|---|
| | | F1 | F2 | F3 |
| Side dish | | | | |
| Braised chicken | Chicken breast | 45 | 45 | 45 |
| | Garlic | 3 | 3 | 6 |
| | Shallot | 2 | 2 | 4 |
| | Galangal | 3 | 3 | 6 |
| | Candlenut | 2 | 2 | 4 |
| | Turmeric | 1 | 1 | 2 |
| | Lemongrass | 1 | 1 | 2 |
| | Bay leaf | 1 | 1 | 2 |
| | Coriander | 0.1 | 0.1 | 0.2 |
| | Sugar | 2.5 | 1.25 | 1.25 |
| | Salt | 1 | 0.5 | 0.5 |
| Marinated tempeh | Tempeh | 80 | 80 | 80 |
| | Shallot | 10 | 10 | 20 |
| | Garlic | 5 | 5 | 10 |
| | Candlenut | 2 | 2 | 4 |
| | Nutmeg | 2 | 2 | 4 |
| | Galangal | 1 | 1 | 2 |
| | Bayleaf | 0.1 | 0.1 | 0.2 |
| | Coriander | 0.25 | 0.25 | 0.5 |
| | Brown sugar | 8 | 4 | 4 |
| | Salt | 2 | 1 | 1 |
| Spiced tofu | Tofu | 80 | 80 | 80 |
| | Shallot | 9 | 9 | 18 |
| | Garlic | 6 | 6 | 12 |
| | Red chili | 10 | 10 | 20 |
| | Cayenne pepper | 1 | 1 | 1 |
| | Galangal | 3 | 3 | 6 |
| | Nutmeg | 1 | 1 | 2 |
| | Bayleaf | 3 | 3 | 6 |
| | Sugar | 10 | 5 | 5 |
| | Salt | 2 | 1 | 1 |
| Snacks | | | | |
| Tofu schotel | Tofu | 60 | 60 | 60 |
| | Potato | 60 | 60 | 60 |
| | Carrot | 20 | 20 | 20 |
| | Oyster mushroom | 10 | 10 | 10 |
| | Egg | 15 | 15 | 15 |
| | Non-dairy creamer | 6 | 6 | 6 |
| | Skimmed milk | 4 | 4 | 4 |
| | Palm oil | 3 | 3 | 3 |
| | Spring onion | 5 | 5 | 5 |
| | Onion | 3 | 3 | 3 |
| | Garlic | 5 | 5 | 10 |
| | Pepper | 0.25 | 0.25 | 0.4 |
| | Sugar | 1 | 0.5 | 0.5 |
| | Salt | 2 | 1 | 1 |
| Vegetable omelet | Egg | 50 | 50 | 50 |
| | Spinach | 15 | 15 | 15 |
| | Carrot | 10 | 10 | 10 |
| | Noodle | 10 | 10 | 10 |
| | Spring onion | 3 | 3 | 3 |
| | Shallot | 4 | 4 | 8 |
| | Garlic | 4 | 4 | 8 |
| | Pepper | 0.25 | 0.25 | 0.25 |
| | Sugar | 2 | 1 | 1 |
| | Salt | 1.5 | 0.75 | 0.75 |
| Mushroom shumai | Tofu skin | 3 | 3 | 3 |
| | Ear mushroom | 20 | 20 | 20 |
| | Chicken breast | 15 | 15 | 15 |
| | Carrot | 20 | 20 | 20 |
| | Egg | 8 | 8 | 8 |
| | All-purpose flour | 15 | 15 | 15 |
| | Tapioca flour | 5 | 5 | 5 |
| | Celery | 1 | 1 | 1 |
| | Shallot | 5 | 5 | 10 |
| | Garlic | 8 | 8 | 16 |
| | Sugar | 2 | 1 | 1 |
| | Salt | 1.5 | 0.75 | 0.75 |

presentation between samples was randomized, with each subject testing the samples from right to left, in order to prevent any bias in judgment. Each subject was allocated approximately 1 min to analyze each sample and determine the most preferred formula. At the end of the test, any formula that received a positive preference from the subjects was assigned a score of 1.

### 2.5. *Statistical analysis*

All statistical calculations were conducted using Statistical Package for Social Science version 25 (IBM Corp., New York, USA). Categorical data are summarized as counts and percentages. For continuous data, means and standard deviations were employed as measures of central tendency and dispersion, respectively. A univariate analysis was performed to delineate the frequency distribution of self-reported salty taste preference, salty taste sensitivity test, and the most preferred formula. Culinary preference data were obtained by recounting the six types of dishes mentioned previously. Each subject counted the number of times they selected their preferred formula at one table, resulting in six tables with values of 0–6. These data were analyzed with salty taste sensitivity and preference, both of which were tables with two groups of data (dichotomous). The chi-squared test was performed for the analysis. The significance level of the analysis was a $p$-value of $<0.05$.

## 3. Results

### 3.1. *Subject characteristics*

The subjects had a mean age of 71 ± 8.2 years; 75.9% were women, which was aligns with the demographic distribution at Griya Wreda Surabaya. The mean of BMI all subjects were 21.6 ± 4.57 kg/m$^2$ and 61.1% subjects had normal BMI. However, underweight was still relatively high (22.2%). Furthermore, the study investigated the blood pressure levels among the subjects. Regarding SBP, 15 subjects (27.8%) exhibited hypertension, while 5 subjects (9.3%) were pre-hypertensive. In the DBP analysis, three subjects (5.6%) were classified as hypertensive and one subject (1.9%) as pre-hypertensive. These findings highlight the prevalence of hypertension among the subjects, as more than a quarter of the subjects (27.8%) were found to have hypertension, although 72.7% were normal (mean 127.03 ± 17.96/73.03 ± 9.06 mmHg). The demographic characteristics of the subjects are shown in Table 3.

### 3.2. *Salty taste sensitivity and preferences*

Moving beyond health indicators, the study indicated that 80% of the subjects had good taste sensitivity, with a higher proportion of women than of men (85.4% vs. 69.2%). Meanwhile, for salty taste preference, a notable three-quarters of the subjects showed a liking for salty taste, and the distribution was found to be equal among men and women (76.9% vs. 75.6%). The detailed results for salty taste sensitivity and preference are presented in Table 4.

### 3.3. *Culinary herbs preferences*

In addition to taste-related investigations, this study encompassed culinary dish formulations involving three side dishes and three snacks. The results presented in Table 5 show that the subjects preferred the standard recipe (F1), such as marinated tempeh (55.6%), tofu shotel (48.1%), vegetable omelet (44.4%), and spiced tofu (33.3%). This was closely followed by F3 (e.g., braised chicken, spiced tofu, and shumai mushroom), with the least preference observed for F2. These results underscore that incorporating herbs and spices to low-salt dishes are preferred over sugar and salt-reduced formula. Additionally, this study explored the relationship between the preference of each formula, and salty taste sensitivity and preference. A significant association was

**Table 2**
Nutritional composition of the formulation dishes.

| Menus | Nutritional composition per 100 g | | | | | | |
|---|---|---|---|---|---|---|---|
| | Energy (kcal) | Sodium (mg) | Potassium (mg) | Calcium (mg) | Magnesium (mg) | Fiber (mg) | Sucrose (mg) |
| Side Dish | | | | | | | |
| Braised chicken | | | | | | | |
| F1 | 164.5 | 438.3 | 291.7 | 78.9 | 29.1 | 1.8 | 2.5 |
| F2 | 159.6 | 244.7 | 291.5 | 78.7 | 29.1 | 1.8 | 1.3 |
| F3 | 188.1 | 359.5 | 501.5 | 151.7 | 49.0 | 3.8 | 2.1 |
| Marinated tempeh | | | | | | | |
| F1 | 213.3 | 793.6 | 463.9 | 148.0 | 69.9 | 3.0 | 6.9 |
| F2 | 198.2 | 404.8 | 449.9 | 144.1 | 68.8 | 3.0 | 3.6 |
| F3 | 222.0 | 416.1 | 592.3 | 209.7 | 80.7 | 5.2 | 4.1 |
| Spiced tofu | | | | | | | |
| F1 | 135.6 | 802.4 | 364.7 | 165.0 | 104.9 | 3.2 | 10.0 |
| F2 | 116.2 | 415.1 | 364.5 | 164.5 | 104.9 | 3.2 | 5.1 |
| F3 | 162.4 | 727.1 | 612.1 | 243.7 | 125.8 | 5.0 | 8.8 |
| Snacks | | | | | | | |
| Tofu schotel | | | | | | | |
| F1 | 184.5 | 835.1 | 510.4 | 138.5 | 89.4 | 2.9 | 1.5 |
| F2 | 182.5 | 447.8 | 510.3 | 138.0 | 89.4 | 2.9 | 1.0 |
| F3 | 188.5 | 448.5 | 536.7 | 141.9 | 91.0 | 3.2 | 1.2 |
| Vegetable omelet | | | | | | | |
| F1 | 135.4 | 652.6 | 213.0 | 67.7 | 21.8 | 1.1 | 2.2 |
| F2 | 131.6 | 362.1 | 213.0 | 67.3 | 21.8 | 1.1 | 1.3 |
| F3 | 140.4 | 363.7 | 243.8 | 73.4 | 24.9 | 1.3 | 1.4 |
| Mushroom shumai | | | | | | | |
| F1 | 169.7 | 618.6 | 228.5 | 39.9 | 27.6 | 1.5 | 2.3 |
| F2 | 165.9 | 328.1 | 228.5 | 39.5 | 27.6 | 1.5 | 1.4 |
| F3 | 175.4 | 328.8 | 264.9 | 44.3 | 29.9 | 1.7 | 1.6 |

**Table 3**
Characteristics of subjects.

| Variable | Category mean/ n (%) |
|---|---|
| Age (years) | 71 ± 8.2 |
| Sex | |
| Men | 13 (24.1) |
| Women | 41 (75.9) |
| Body mass index (kg/m$^2$) | 21.6 ± 4.57 |
| Underweight | 12 (22.2) |
| Normal | 33 (61.1) |
| Overweight | 9 (16.7) |
| Systolic blood pressure (mmHg) | 127.03 ± 17.96 |
| Normal | 34 (63.0) |
| Pre-hypertension | 5 (9.3) |
| Hypertension | 15 (27.8) |
| Diastolic blood pressure (mmHg) | 73.03 ± 9.06 |
| Normal | 50 (92.6) |
| Pre-hypertension | 1 (1.9) |
| Hypertension | 3 (5.6) |
| Hypertension status | |
| Normal | 39 (72.2) |
| Hypertension | 15 (27.8) |

**Table 4**
Distribution of salty taste sensitivity and salty taste preference among subjects.

| Variable | Total ($n$ = 54) | Men ($n$ = 13) | Women ($n$ = 41) |
|---|---|---|---|
| | n (%) | n (%) | n (%) |
| Salty taste sensitivity | | | |
| Less sensitive | 10 (18.5) | 4 (30.8) | 6 (14.6) |
| Good sensitive | 44 (81.5) | 9 (69.2) | 35 (85.4) |
| Salty taste preference | | | |
| Like salty taste | 41 (75.9) | 10 (76.9) | 31 (75.6) |
| Not like salty taste | 13 (24.1) | 3 (23.1) | 10 (24.4) |

**Table 5**
Culinary preference and the association with salty taste sensitivity and preference.

| Menus | Culinary preference n (%) | | | Significancy value (p) | |
|---|---|---|---|---|---|
| | F1[#] | F2 | F3 | Salty taste sensitivity | Salty taste preference |
| Side dish | | | | | |
| Braised chicken | 18 (33.3) | 17 (31.5) | 19 (35.2) | 0.918 | 0.025 |
| Marinated tempeh | 30 (55.6) | 9 (16.7) | 15 (27.8) | 0.423 | 0.000* |
| Spiced tofu | 18 (33.3) | 17 (31.5) | 19 (35.2) | 0.490 | 0.957 |
| Snacks | | | | | |
| Tofu schotel | 26 (48.1) | 9 (16.7) | 19 (35.2) | 0.677 | 0.010* |
| Vegetable omelet | 24 (44.4) | 11 (20.4) | 19 (35.2) | 0.036* | 0.172 |
| Mushroom shumai | 12 (22.2) | 20 (37.0) | 22 (40.7) | 0.258 | 0.108 |

* significant, p < 0.05, chi-square test.
# F1 preferred was associated with less salt sensitivity and more salty preference.

observed between vegetable omelet and salty taste sensitivity ($p$ = 0.036). Similarly, a significant association was discovered between marinated tempeh ($p$ = 0.000) and tofu schotel ($p$ = 0.010) with salty taste preference.

Based on Table 6, it was concluded that a significant association between culinary preferences and sensitivity to salty taste exists among both, males and females (p > 0.05). Nonetheless, the results differed regarding the salty taste preference. In this study, there was a significant association between culinary preferences and salty taste preference in F1 ($p$ = 0.004) and F2 ($p$ = 0.001), especially in the female group (p = 0.001 and $p$ = 0.005, respectively). This finding strongly implies that subjects are inclined to select food options, either salty or less salty, from

**Table 6**
The sex association with culinary preference of dishes, salty taste sensitivity, and preference.

| Variables | | Culinary preference significancy value (p) | | |
|---|---|---|---|---|
| | | F1 | F2 | F3 |
| Salty taste sensitivity | | | | |
| Total (54) | Less sensitive (10)<br>Good sensitive (44) | 0.285 | 0.740 | 0.129 |
| Men (13) | Less sensitive (4)<br>Good sensitive (9) | 0.790 | 0.790 | 0.460 |
| Women (41) | Less sensitive (6)<br>Good sensitive (35) | 0.593 | 0.539 | 0.131 |
| Salty taste preference | | | | |
| Total (54) | Like salty taste (41)<br>Not like salty taste (13) | 0.004* | 0.001* | 0.410 |
| Men (13) | Like salty taste (10)<br>Not like salty taste (3) | 0.534 | 0.118 | 0.241 |
| Women (41) | Like salty taste (31)<br>Not like salty taste (10) | 0.001* | 0.005* | 0.270 |

* significant, $p < 0.05$, chi-square test.

their taste preference.

## 4. Discussion

### 4.1. Salty taste sensitivity among elderly nursing home residents

Diminished salty taste sensitivity among elderly poses challenges in dietary management. While, some studies suggest that the ability to discern sweet tastes remains relatively stable, salty taste experiences the most significant decline compared with other tastes [25,40]. This study observed that over three-quarters of subjects exhibited good sensitivity to sodium chloride (NaCl) concentrations ranging from 0.1709 to 0.6837 M (0.1–0.4 g/L), similar to another study conducted in Brazil [33], but notably lower in the separate study (21 mM) [21]. Essentially, disparities in taste sensitivity can be attributed to various factors, including methodologies, stimulus concentrations, and external conditions such as health issues, drug use, oral hygiene, and subject traits such as sex and age [41]. Taste and smell decline markedly with age, greatly impacting safety, food intake, and quality of life [42].

Epidemiological studies across various age groups have indicated that women perceive stronger taste intensities than men [43,44] and consistent with these findings. Additionally, women have a 1.7-point greater ability to detect salty tastes than men [45] with a density of fungiform papillae, which are most abundant around the tip of the tongue and more prevalent in women [46,47]. Moreover, smoking habits, which are more intense in men, can lower taste sensitivity or increase the risk of dysgeusia [48]. Nicotine exposure decreases the density of fungiform papillae, alters their morphology and vascularization, decreases saliva quality, and reduces saliva flow rate, which plays a crucial role in salty taste detection. However, smoking might be not a risk factor of taste problems in the elderly in this study, since the elderly in nursing homes were prohibit to smoke. Although some nurses reported some elderly men were smoking secretly. In addition, since taste loss can be exacerbated by factors commonly linked with aging, such as polypharmacy and chronic diseases [28], it's essential to acknowledge about medications but not recorded in this study. Basically, elderly residents take medication only as prescribed by nursing home doctors to treat their specific illnesses, such as amlodipine for hypertensive residents.

### 4.2. Salty taste preferences among elderly nursing home residents

Alterations in sensory perception and its impact on food preferences have been observed in the elderly. A cross-sectional study conducted on the elderly in urban coastal areas of Indonesia, a vulnerable group due to high exposure to salty food, showed high salt intake among the elderly [49]. Surprisingly, 68.6% of the subjects avoided salty foods, despite three-quarters expressing a preference for salty tastes [50]. This suggests that taste preference is not solely controlled by diminished taste sensitivity but also by the interaction of various other factors, such as self-awareness. This study further revealed that most subjects, regardless of sex, preferred salty tastes and aligned with French cohort study that found an age-related increase in liking for salty tastes among both sexes [51]. This phenomenon is often associated with salt usage as a cultural rather than a sensory attribute [52,53]. Hence, it is necessary to evaluate saltiness perception using food trials to accurately understand genuine taste preferences.

### 4.3. Low-salt dietary intervention with herbs and spices

Culinary herbs and spices have emerged as valuable agents for the pursuit of effective low-salt dietary management strategies. These natural flavor enhancers have the potential to mitigate the adverse effects of sodium reduction on taste perception and overall meal satisfaction in the elderly. By strategically incorporating herbs and spices into dishes, the sensory experience can be enhanced and the reduced sodium content can be compensated for [21,23,24,54]. Our evaluation found that subjects prefer regular sweet and salty tastes commonly found in commercial products over the low-salt formula (containing half of the standard recipe). A Croatian study found that a 30% salt reduction (0.15–0.35 *w/*w) in tomato soup, mashed potato, and baked chicken, did not impact the preference of the elderly [21], and emphasized the gradual adjustment of sodium reduction through a dual-test methodology spanning over two visits. However, our research employed a single-test approach. Nevertheless, their study demonstrated that the addition of herbs and spices effectively elevated the perception of saltiness to a level equivalent to that of a standard recipe. Our findings are consistent with theirs, as the subjects also enjoyed the addition of herbs and spices in proportions similar to the standard dishes. Therefore, it can be said that about 50% salt reduction from common dishes can be effectively compensated by the addition of herbs and spices. In essence, the addition of herbs and spices resulted in a heightened saltiness intensity without compromising sensory satisfaction compared to that of only reducing salt.

Positive responses to the addition of herbs and spices for modifying low-salt dietary management have also been reported in other studies. A randomized crossover trial found that incorporating herbs and spices into low-salt legume-based mezze dishes (0.4%w/w, with a standard of 0.8%*w*/w) led to higher overall linking and appetite ratings (measured using a visual analog scale/ VAS) compared to the low-salt version [24]. Another study employing herbs and a Microwave-Assisted Thermal Sterilization (MATS) system on chicken pasta revealed that using herbs enabled a 50% salt reduction while maintaining the same saltiness perception [23]. Notably, when herbs were added to dishes with full and 75% salt usage, the dish was considered to be overly salty. The study also highlighted that a 25% reduction in salt intake significantly heightened saltiness perception (measured through odor-induced saltiness enhancement/ OISE). This finding suggests that the effect of herb addition on saltiness perception was more pronounced at lower salt concentrations.

### 4.4. Association of culinary preferences with salty taste sensitivity and preferences

This study found a significant association between detection threshold and vegetable omelet but not with other dishes. In line with these results, a cluster randomized controlled trial (RCT) conducted in Denmark also found that salt-reduced bread was not associated with a detection threshold or recognition threshold, with or without dietary counseling [55]. The acceptance of taste is influenced by four attributes:

quality, intensity, temporal pattern, and spatiality [56]. In the context of salty taste perception, the intensity of acceptance is affected by the sodium concentration and the entire process from the moment the food enters the mouth to swallowing [57]. Chewing ability also plays a role in the optimal release of taste; food textures such as softness, elasticity, and suppleness can affect taste perception in the elderly, with or without oral problems [58]. For this reason, soft, smooth, and moist dishes [59], such as vegetable omelets are more suitable for and easily accepted by the elderly compared to other sample dishes.

This study did not find any association between culinary preferences and detection threshold; however, a significant association was found between culinary preferences and salty taste preferences, specifically among women. These results are consistent with those of another study that analyzed the effect of gradual lowering of salt content in bread over 16 weeks [55]. Long-term interventions have been found to be important in the identification of individual preferences, and gradual salt reduction has been deemed more effective in maintaining food acceptability in some studies [60,61]. This study highlights that gradual salt reduction throughout several studies was considered more effective than an abrupt reduction due to better food acceptability throughout the process.

### *4.5. Health benefits of herbs and spices in low-salt dietary management*

Herbs and spices not only add distinctive flavors but also provide substantial health benefits. Numerous studies suggest that consuming certain herbs and spices can positively impact an individual's health, particularly in those with high blood pressure [62–66]. For example, ginger has been shown to reduce proprotein convertase subtilisin/kexin type 9 levels by modulating lipid levels [63]. Turmeric has been shown to inhibit endothelial dysfunction, smooth muscle proliferation, and decrease the rate of atherosclerosis [64,65], whereas cardamom may increase fibrinolytic activity [62]. According to this study, incorporating herbs and spices into foods results in an increase in the content of specific minerals, such as potassium (5–72%), calcium (2–92%), and magnesium (2–68%), compared to standard recipes. The fiber content also significantly increased, especially in braised chicken dishes (up to 111%). Incorporating herbs and spices into recipes apparently will increase food energy consumption little and not significantly. Despite being very low in calories, adding twice as many herbs and spices as in F3 can increase the energy content of food compared to using low salt although it did not show any effect on the dish's preference, as previously reported [24]. Herbs and spices not only serve as effective sources of energy but also possess anti-obesity properties through their ability to decrease lipid absorption, inhibit pre-adipocyte differentiation and proliferation, and enhance lipolysis [67]. Notably, the administration of specific herbs and spices at doses ranging from 1 to 3 g for 4 to 16 weeks has been found to significantly diminish obesity-related indicators, including body weight, BMI, and waist circumference [68]. This observation highlights the potential of herbs and spices as viable anti-obesity agents for the elderly population. The addition of herbs and spices also resulted in a slight increase in sodium content, but it was still lower than that of the standard formula. Previous research has shown that replacing 0.5 g of salt with herbs and spices in macaroni and cheese (American cheese) can reduce the sodium content by 56% while maintaining flavor [69]. This suggests that herbs and spices can be appealing alternatives for increasing food energy and moderating sodium intake without compromising taste.

Nonetheless, there are challenges to address concerning the integration of herbs and spices into low-sodium diet management, particularly in terms of cost [70]. However, it is crucial to acknowledge that these additions do not act as the main ingredient; therefore, the increase in cost is acceptable. Thus, the use of herbs and spices in cooking not only enhances food flavor but also positively contributes to mineral and fiber intake, which are crucial in low-salt dietary management.

### *4.6. Strength and limitation*

The strength of this study is that it integrated food formulations commonly used in nursing homes and ensured the acceptability of the menu in terms of taste and culture. The use of a variety of diets also provided more diverse inputs regarding taste perception, including factors such as texture. However, this study had some limitations. First, the exclusion of the influence of smoking habits and certain medications on the results may affect the validity of the findings. Our subjects were elderly, with the majority of them in the middle age category, and received regular care from the institution. Therefore, we categorized them as healthy individuals, that is, patients who were not on bed rest and not ill. Second, the limited range of salt concentrations used may not have provided robust results for salt taste sensitivity. Therefore, it is recommended that research should consider using a wider range of salt concentrations that cover a broader spectrum and that the culinary preference test be conducted only once and without repetition, preventing the analysis of result progression. Future research should consider using methods that can test gradual salt reduction over a longer period to obtain more comprehensive results.

## 5. Conclusions

This study explored the impact of taste sensitivity and preferences on food choices among the elderly. While taste responses may be altered in older individuals, taste preferences still play a significant role in determining whether food is consumed. This study suggests that using herbs and spices to reduce salt consumption can be an effective solution to reduce taste perception among the elderly. Integrating herbs and spices into meals can reduce salt usage by up to 50% while still being well accepted by the elderly. Adding herbs and spices can also increase certain minerals and fiber in food, thereby maintaining blood pressure. This finding is particularly relevant in nursing homes and other healthcare settings where it is important to create healthy menus that do not compromise the taste of food. However, further research is needed to understand individual variations, such as oral health and medication use, to provide more specific and effective recommendations for managing low-salt diets among the elderly.

## Ethical statement

This study was conducted with required approval. The study protocol adhered to the ethical standard of the Helsinki Declaration and ethical approval for the involvement of human subjects in this study was granted by the Ethics Committee of the Faculty of Public Health, Universitas Airlangga, with approval number 78/EA/KEPK/ 2022, on May 11, 2022. Permission to conduct the study in the study area was obtained from the Surabaya Social Service Agency in Indonesia. Prior to participation, written informed consent was obtained from the head of the nursing home and from each subject. Only those who provided consent proceeded with the study procedure.

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## CRediT authorship contribution statement

**Farapti Farapti:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – review & editing, Supervision. **Afifah Nurma Sari:** Methodology, Investigation, Resources, Data curation, Writing – original draft. **Annis Catur Adi:** Supervision. **Hazreen B. Abdul Majid:** Supervision.

## Declaration of competing interest

None.

## Data availability

Data supporting the findings of this study are included in the manuscript. Personal data are not publicly accessible due to ethical considerations, but they can be obtained from the corresponding author upon request.

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## References

[1] United Nations Department of Economic and Social Affairs, Population Division, World Population Prospects 2022: Summary of Results United Nation, Newyork, 2022.
[2] World Health Organization, Ageing and Health, 2022 [Online], https://www.who.int/news-room/fact-sheets/detail/ageing-and-health, 2022 (accessed 18 August 2023).
[3] M. Cristea, G.G. Noja, P. Stefea, A.L. Sala, The impact of population aging and public health support on EU labor markets, Int. J. Environ. Res. Public Health 17 (2020) 1–27, https://doi.org/10.3390/ijerph17041439.
[4] Z. Ismail, W.I.W. Ahmad, S.H. Hamjah, I.K. Astina, The impact of population ageing: a review, Iran. J. Public Health 50 (2021) 2451–2460, https://doi.org/10.18502/ijph.v50i12.7927.
[5] M.Y. Wang, H.C. Sung, J.Y. Liu, Population aging and its impact on human wellbeing in China, Front. Public Health 10 (2022) 883566, https://doi.org/10.3389/fpubh.2022.883566.
[6] G. Onder, I. Carpenter, H. Finne-Soveri, J. Gindin, D. Frijters, J.C. Henrard, T. Nikolaus, E. Topinkova, M. Tosato, R. Liperoti, F. Landi, R. Bernabei, SHELTER project, assessment of nursing home residents in Europe: the services and health for elderly in long TERm care (SHELTER) study, BMC Health Serv. Res. 12 (2012) 5, https://doi.org/10.1186/1472-6963-12-5.
[7] L. Rodríguez-Mañas, R. Murray, C. Glencorse, S. Sulo, Good nutrition across the lifespan is foundational for healthy aging and sustainable development, Front. Nutr. 9 (2023) 1113060, https://doi.org/10.3389/fnut.2022.1113060.
[8] J. Bauer, G. Biolo, T. Cederholm, M. Cesari, A.J. Cruz-Jentoft, J.E. Morley, S. Phillips, C. Sieber, P. Stehle, D. Teta, R. Visvanathan, E. Volpi, Y. Boirie, Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the prot-age study group, J. Am. Med. Dir. Assoc. 14 (2013) 542–559, https://doi.org/10.1016/j.jamda.2013.05.021.
[9] J. Borkent, M. Manders, A. Nijhof, L. Wijker, E. Feskens, E. Naumann, M. de Van der Schueren, Too low protein and energy intake in nursing home residents, Nutrition 110 (2023) 112005, https://doi.org/10.1016/j.nut.2023.112005.
[10] I. Keser, S. Cvijetić, A. Ilić, I. Colić Barić, D. Boschiero, J.Z. Ilich, Assessment of body composition and dietary intake in nursing-home residents: could lessons learned from the COVID-19 pandemic be used to prevent future casualties in older individuals? Nutrients 13 (2021) https://doi.org/10.3390/nu13051510.
[11] G.A. Aytekin Sahin, Z. Caferoglu, The food service quality and its effects on nutritional status in nursing home residents, Clin. Nutr. ESPEN 47 (2022) 233–239, https://doi.org/10.1016/j.clnesp.2021.12.004.
[12] GBD, Risk factors collaborators, global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019, Lancet 396 (2020) (2019) 1223–1249, https://doi.org/10.1016/S0140-6736(20)30752-2.
[13] World Health Organization, Reducing Salt Improves Health, WHO EMRO, 2021 [Online], https://www.emro.who.int/noncommunicable-diseases/highlights/reducing-salt-improves-health.html (Accessed 23-Aug-2023).
[14] S.P. Juraschek, C.L. Millar, A. Foley, M. Shtivelman, A. Cohen, V. McNally, R. Crevatis, S.M. Post, K.J. Mukamal, L.A. Lipsitz, J.L. Cluett, R.B. Davis, S. Sahni, The effects of a low sodium meal plan on blood pressure in older adults: the sotrue randomized feasibility trial, Nutrients 13 (2021) 1–13, https://doi.org/10.3390/nu13030964.
[15] L.J. Appel, M.A. Espeland, L. Easter, A.C. Wilson, S. Folmar, C.R. Lacy, Effects of reduced sodium intake on hypertension control in older individuals: results from the trial of nonpharmacologic interventions in the elderly (TONE), Arch. Intern. Med. 161 (2001) 685–693, https://doi.org/10.1001/archinte.161.5.685.
[16] F.M. Sacks, L.P. Svetkey, W.M. Vollmer, L.J. Appel, G.A. Bray, D. Harsha, E. Obarzanek, P.R. Conlin, E.R. Miller, D.G. Simons-Morton, N. Karanja, Effects on blood pressure of reduced dietary sodium and the dietary approaches to stop hypertension (DASH) diet: editor's comments, Curr. Hypertens. Rep. 3 (2001) 373–375, https://doi.org/10.1007/s11906-001-0052-4.
[17] H. Qi, Z. Liu, H. Cao, W.P. Sun, W.J. Peng, B. Liu, S.J. Dong, Y.T. Xiang, L. Zhang, Comparative efficacy of antihypertensive agents in salt-sensitive hypertensive patients: a network meta-analysis, Am. J. Hypertens. 31 (2018) 835–846, https://doi.org/10.1093/ajh/hpy027.
[18] S. Nurmilah, Y. Cahyana, G.L. Utama, A. Aït-Kaddour, Strategies to reduce salt content and its effect on food characteristics and acceptance: a review, Foods 11 (2022) 1–25, https://doi.org/10.3390/foods11193120.
[19] P.R. Trumbo, K.M. Kirkpatrick, J. Roberts, P. Smith, P. Zecca, Perspective: challenges and strategies to reduce the sodium content of foods by the food service industry, Adv. Nutr. 14 (2023) 592–598, https://doi.org/10.1016/j.advnut.2023.04.013.
[20] A. Dunteman, Y. Yang, E. McKenzie, Y. Lee, S.Y. Lee, Sodium reduction technologies applied to bread products and their impact on sensory properties: a review, Int. J. Food Sci. Technol. 56 (2021) 4396–4407, https://doi.org/10.1111/ijfs.15231.
[21] H. Tomić-Obrdalj, I. Keser, J. Ranilović, M. Palfi, D. Gajari, T. Cvetković, The use of herbs and spices in sodium-reduced meals enhances saltiness and is highly accepted by the elderly, Food Qual. Prefer. 105 (2023) 104789, https://doi.org/10.1016/j.foodqual.2022.104789.
[22] S.K. Ghawi, I. Rowland, L. Methven, Enhancing consumer liking of low salt tomato soup over repeated exposure by herb and spice seasonings, Appetite 81 (2014) 20–29, https://doi.org/10.1016/j.appet.2014.05.029.
[23] S.M. Barnett, S.S. Sablani, J. Tang, C.F. Ross, Utilizing herbs and microwave-assisted thermal sterilization to enhance saltiness perception in a chicken pasta meal, J. Food Sci. 84 (2019) 2313–2324, https://doi.org/10.1111/1750-3841.14736.
[24] A. Dougkas, M. Vannereux, A. Giboreau, The impact of herbs and spices on increasing the appreciation and intake of low-salt legume-based meals, Nutrients 11 (2019) 1–20, https://doi.org/10.3390/nu11122901.
[25] S. Jeon, Y. Kim, S. Min, M. Song, S. Son, S. Lee, Taste sensitivity of elderly people is associated with quality of life and inadequate dietary intake, Nutrients 13 (2021) 1–14, https://doi.org/10.3390/nu13051693.
[26] S. Aliasgharzadeh, J.S. Tabrizi, L. Nikniaz, M. Ebrahimi-Mameghani, N.L. Yagin, Effect of salt reduction interventions in lowering blood pressure: a comprehensive systematic review and meta-analysis of controlled clinical trials, PLoS One 17 (2022) 1–36, https://doi.org/10.1371/journal.pone.0277929.
[27] A. Imoscopi, E.M. Inelmen, G. Sergi, F. Miotto, E. Manzato, Taste loss in the elderly: epidemiology, causes and consequences, Aging Clin. Exp. Res. 24 (2012) 570–579, https://doi.org/10.3275/8520.
[28] G. Sergi, G. Bano, S. Pizzato, N. Veronese, E. Manzato, Taste loss in the elderly: possible implications for dietary habits, Crit. Rev. Food Sci. Nutr. 57 (2017) 3684–3689, https://doi.org/10.1080/10408398.2016.1160208.
[29] S. Lemeshow, D.W. Hosmer, J. Klar, S.K. Lwanga, Adequacy of Sample Size in Health Studies, John Wiley & Sons Ltd, Chichester, 1990.
[30] E. Astutik, F. Farapti, T.D. Tama, S.I. Puspikawati, Differences risk factors for hypertension among elderly woman in rural and urban Indonesia, Yale J. Biol. Med. 94 (2021) 407–415.
[31] S.H. Lee, D.H. Kim, J.H. Park, S. Kim, M. Choi, H. Kim, D.E. Seul, S.G. Park, J. H. Jung, K. Han, Y.G. Park, Association between body mass index and mortality in the Korean elderly: a nationwide cohort study, PLoS One 13 (2018) e0207508, https://doi.org/10.1371/journal.pone.0207508.
[32] K. Bell, J. Twiggs, B.R. Olin, Hypertension: The Silent Killer: Updated JNC-8 Guideline Recommendations, 2015.
[33] L. Neumann, B.C. Schauren, F.S. Adami, Taste sensitivity of adults and elderly persons, Rev. Bras. Geriatr. Gerontol. 19 (2016) 797–808, https://doi.org/10.1590/1809-98232016019.150218.
[34] Indonesian Ministry of Health, Data Komposisi Pangan Indonesia. https://www.panganku.org/id-ID/beranda, 2017 (accessed 16 August 2023).
[35] M. Asri, A.M. Irwan, E.L. Sjattar, Y. Hardianto, Effectiveness of a low-salt diet in rural hypertensive patients: a systematic review, Clin. Epidemiol. Glob. Health 15 (2022) 101024, https://doi.org/10.1016/j.cegh.2022.101024.
[36] T. Filippini, M. Malavolti, P.K. Whelton, A. Naska, N. Orsini, M. Vinceti, Blood pressure effects of sodium reduction: dose-response meta-analysis of experimental studies, Circulation 143 (2021) 1542–1567, https://doi.org/10.1161/CIRCULATIONAHA.120.050371.
[37] J.F. Kerry, Effects of novel thermal processing technologies on the sensory quality of meat and meat products, in: Processed Meats: Improving Safety, Nutrition and Quality, Nutrition and Quality, 2011, pp. 617–665, https://doi.org/10.1533/9780857092946.3.617.
[38] V.I.F. Ogliano, N.I.P. Ellegrini, Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables, J. Agric. Food Chem. 56 (2008) 139–147, https://doi.org/10.1021/jf072304b.
[39] H. Fang, X. Yin, J. He, S. Xin, H. Zhang, X. Ye, Food chemistry: X cooking methods affected the phytochemicals and antioxidant activities of potato from different varieties, Food Chem. X 14 (2022) 1–7, https://doi.org/10.1016/j.fochx.2022.100339.
[40] L.M. Donini, C. Savina, C. Cannella, Eating habits and appetite control in the elderly: the anorexia of aging, Int. Psychogeriatr. 15 (2003) 73–87, https://doi.org/10.1017/S1041610203008779.
[41] A.N. Sari, F. Farapti, N.Md. Nor, Salt taste threshold as a detection of salt intake in hypertensive individuals, J. Berk Epidemiol. 10 (2022) 227–236, https://doi.org/10.20473/jbe.v10i32022.227.
[42] R.L. Doty, V. Kamath, The influences of age on olfaction: a review, Front. Psychol. 5 (20) (2014) 1–21, https://doi.org/10.3389/fpsyg.2014.00020.
[43] M. Yoshinaka, K. Ikebe, M. Uota, T. Ogawa, T. Okada, C. Inomata, H. Takeshita, Y. Mihara, Y. Gondo, Y. Masui, K. Kamide, Y. Arai, R. Takahashi, Y. Maeda, Age

and sex differences in the taste sensitivity of young adult, young-old and old-old Japanese, Geriatr Gerontol Int 16 (2016) 1281–1288, https://doi.org/10.1111/ggi.12638.
[44] R. Barragán, O. Coltell, O. Portolés, E.M. Asensio, J.V. Sorlí, C. Ortega-Azorín, J. I. González, C. Sáiz, R. Fernández-Carrión, J.M. Ordovas, D. Corella, Bitter, sweet, salty, sour and umami taste perception decreases with age: sex-specific analysis, modulation by genetic variants and taste-preference associations in 18 to 80 year-old subjects, Nutrients 10 (2018) 1–23, https://doi.org/10.3390/nu10101539.
[45] N.N. Veček, L. Mucalo, R. Dragun, T. Miličević, A. Pribisalić, I. Patarčić, C. Hayward, O. Polašek, I. Kolčić, The association between salt taste perception, Mediterranean diet and metabolic syndrome: a cross-sectional study, Nutrients 12 (2020), https://doi.org/10.3390/nu12041164.
[46] M.E. Fischer, K.J. Cruickshanks, C.R. Schubert, A. Pinto, R. Klein, N. Pankratz, J. S. Pankow, G.H. Huang, Factors related to fungiform papillae density: the beaver dam offspring study, Chem. Senses 38 (2013) 669–677, https://doi.org/10.1093/chemse/bjt033.
[47] A.M. Khan, S. Ali, R.V. Jameela, M. Muhamood, M.F. Haqh, Impact of Fungiform Papillae Count on Taste Perception and Different Methods of Taste Assessment and Their Clinical Applications 19, 2019, pp. 184–191.
[48] L. Berube, V.B. Duffy, J.E. Hayes, H.J. Hoffman, S. Rawal, Associations between chronic cigarette smoking and taste function: results from the 2013–2014 national health and nutrition examination survey, Physiol. Behav. 240 (2021) 113554, https://doi.org/10.1016/j.physbeh.2021.113554.
[49] F. Farapti, S.R. Nadhiroh, S. Sayogo, N. Mardiana, Urinary and dietary sodium to potassium ratio as a useful marker for estimating blood pressure among older women in Indonesian urban coastal areas, Mediterr. J. Nutr. Metab. 10 (2017) 113–122, https://doi.org/10.3233/MNM-17138.
[50] F. Farapti, A.D. Fatimah, E. Astutik, A.C. Hidajah, T.N. Rochmah, Awareness of salt intake among community-dwelling elderly at coastal area: the role of public health access program, J. Nutr. Metab. 2020 (2020) 8793869, https://doi.org/10.1155/2020/8793869.
[51] A. Lampuré, P. Schlich, A. Deglaire, K. Castetbon, S. Péneau, S. Hercberg, C. Méjean, Sociodemographic, psychological, and lifestyle characteristics are associated with a liking for salty and sweet tastes in French adults, J. Nutr. 145 (2015) 587–594, https://doi.org/10.3945/jn.114.201269.
[52] A.L. Deierlein, K.B. Morland, K. Scanlin, S. Wong, A. Spark, Diet quality of urban older adults age 60 to 99 years: the cardiovascular health of seniors and built environment study, J. Acad. Nutr. Diet. 114 (2014) 279–287, https://doi.org/10.1016/j.jand.2013.09.002.
[53] D. Lau, Role of food perceptions in food selection of the elderly, J. Nutr. Elder. 27 (2008) 221–246, https://doi.org/10.1080/01639360802261821.
[54] M.L. Montero, C.F. Ross, Saltiness perception in white sauce formulations as tested in older adults, Food Qual. Prefer. 98 (2022) 1–12, https://doi.org/10.1016/j.foodqual.2022.104529.
[55] N.L. Riis, K.S. Bjoernsbo, U. Toft, E. Trolle, G. Hyldig, I.E. Hartley, R. Keast, A. D. Lassen, Impact of salt reduction interventions on salt taste sensitivity and liking, a cluster randomized controlled trial, Food Qual. Prefer. 87 (2021) 104059, https://doi.org/10.1016/j.foodqual.2020.104059.
[56] J. Chandrashekar, M.A. Hoon, N.J.P. Ryba, C.S. Zuker, The receptors and cells for mammalian taste, Nature 444 (2006) 288–294, https://doi.org/10.1038/nature05401.
[57] D.G. Liem, F. Miremadi, R.S.J. Keast, Reducing sodium in foods: the effect on flavor, Nutrients 3 (2011) 694–711, https://doi.org/10.3390/nu3060694.
[58] M. Vandenberghe-Descamps, C. Sulmont-Rossé, C. Septier, G. Feron, H. Labouré, Using food comfortability to compare food's sensory characteristics expectations of elderly people with or without oral health problems, J. Texture Stud. 48 (2017) 280–287, https://doi.org/10.1111/jtxs.12250.
[59] F. Liu, J. Yin, J. Wang, X. Xu, Food for the elderly based on sensory perception: a review, Curr. Res. Food Sci. 5 (2022) 1550–1558, https://doi.org/10.1016/j.crfs.2022.09.014.
[60] N. Bobowski, A. Rendahl, Z. Vickers, Preference for salt in a food may be alterable without a low sodium diet, Food Qual. Prefer. 39 (2015) 40–45, https://doi.org/10.1016/j.foodqual.2014.06.005.
[61] C.A.M. Anderson, L.K. Cobb, E.R. Miller, M. Woodward, A. Hottenstein, A. R. Chang, M. Mongraw-Chaffin, K. White, J. Charleston, T. Tanaka, L. Thomas, L. J. Appel, Effects of a behavioral intervention that emphasizes spices and herbs on adherence to recommended sodium intake: results of the SPICE randomized clinical trial1,2, Am. J. Clin. Nutr. 102 (2015) 671–679, https://doi.org/10.3945/ajcn.114.100750.
[62] S.K. Verma, V. Jain, S.S. Katewa, Blood pressure lowering, fibrinolysis enhancing and antioxidant activities of cardamom (*Elettaria cardamomum*), Indian J. Biochem. Biophys. 46 (2009) 503–506.
[63] M.M. El-Seweidy, R. Sarhan Amin, H. Husseini Atteia, R.R. El-Zeiky, N.A. Al-Gabri, Dyslipidemia induced inflammatory status, platelet activation and endothelial dysfunction in rabbits: protective role of 10-dehydrogingerdione, Biomed. Pharmacother. 110 (2019) 456–464, https://doi.org/10.1016/j.biopha.2018.11.140.
[64] J.F. Zhao, L.C. Ching, Y.C. Huang, C.Y. Chen, A.N. Chiang, Y.R. Kou, S.K. Shyue, T. S. Lee, Molecular mechanism of curcumin on the suppression of cholesterol accumulation in macrophage foam cells and atherosclerosis, Mol. Nutr. Food Res. 56 (2012) 691–701, https://doi.org/10.1002/mnfr.201100735.
[65] S. Zhang, J. Zou, P. Li, X. Zheng, D. Feng, Curcumin protects against atherosclerosis in apolipoprotein E-knockout mice by inhibiting toll-like receptor 4 expression, J. Agric. Food Chem. 66 (2018) 449–456, https://doi.org/10.1021/acs.jafc.7b04260.
[66] K.S. Driscoll, A. Appathurai, M. Jois, J.E. Radcliffe, Effects of herbs and spices on blood pressure: a systematic literature review of randomised controlled trials, J. Hypertens. 37 (2019) 671–679, https://doi.org/10.1097/HJH.0000000000001952.
[67] M. Bahmani, Z. Eftekhari, K. Saki, E. Fazeli-Moghadam, M. Jelodari, M. Rafieian-Kopaei, Obesity phytotherapy: review of native herbs used in traditional medicine for obesity, J. Evid. Based Complement. Altern. Med. 21 (2016) 228–234, https://doi.org/10.1177/2156587215599105.
[68] C. Deekshith, M. Jois, J. Radcliffe, J. Thomas, Effects of culinary herbs and spices on obesity: a systematic literature review of clinical trials, J. Funct. Foods 81 (2021) 1–23, https://doi.org/10.1016/j.jff.2021.104449.
[69] K.S. Petersen, V.L. Fulgoni, H. Hopfer, J.E. Hayes, R. Gooding, P. Kris-Etherton, Using herbs/spices to enhance the flavor of commonly consumed foods reformulated to be lower in overconsumed dietary components is an acceptable strategy and has the potential to lower intake of saturated fat and sodium: a national health and nutrition ex, J. Acad. Nutr. Diet. (2023) 1–14, https://doi.org/10.1016/j.jand.2023.07.025. S2212-2672.
[70] F. Farapti, et al., Potassium intake is associated with nutritional quality and actual diet cost: a study at formulating a low sodium high potassium (LSHP) healthy diet, J. Nutr. Sci. 11 (2022) 1–9, https://doi.org/10.1017/jns.2021.104.