Original Research Article

Saltiness and hedonic liking rating of miso soup associated with conscious salt reduction levels: a consumer acceptance study with gradual salt reduction

ABSTRACT

Aims: This study aimed to survey whether the reduction in salt concentration of miso soup, which was covertly and gradually decreased, was perceived by consumers, and whether the miso soup with reduced salt was accepted by consumers in a company cafeteria where meals were continuously served to nearly the same people.
Methods: The salt concentration in miso soup served in the cafeteria was covertly decreased at 0.1% per week, from 1.0% to 0.7%, over a period of 4 weeks (baseline and phases 1–3). The questionnaire based on miso soup's taste was administered four times (at the end of every week). The saltiness and hedonic liking levels of the miso soup were rated using a 7-point saltiness score ("1−way too little" to "7−way too much" and "4−just about right") and a 7-point hedonic liking score ("1−dislike very much" to "7−like very much" and "4−neither like nor dislike"), respectively.
Results: The participants were divided into three groups (high-, medium-, and low-conscious groups) according to the salt reduction-consciousness level. The saltiness and hedonic liking scores significantly decreased after weeks 1 and 2, respectively, compared to the baseline. The saltiness scores significantly differed between the conscious groups in all the four surveys, being consistently higher in the high-conscious group. Contrarily, the hedonic liking scores demonstrated a different decrease pattern based on the salt reduction-consciousness levels. The hedonic liking score in the high-conscious group did not decrease significantly.
Conclusion: The saltiness and hedonic liking ratings for the miso soup decreased with decreasing salt concentration and were associated with the consumers' salt reduction-consciousness level.

Keywords: Consumer acceptance; Dietary sodium; Miso soup; Gradual salt reduction; Saltiness; Hedonic liking.

1. INTRODUCTION

Habitual high salt intake increases the risk of hypertension, stroke, and cardiovascular disease [1–5]. A recent study has quantified the impact of the consumption of major foods and nutrients on the mortality and morbidity associated with non-communicable diseases, and the results indicated that a high-salt diet was the leading dietary risk factor for mortality and disability-adjusted life-years in East Asia and the high-income Asia-Pacific region [6]. Contrarily, salt intake in the 2019 Japan National Health and Nutrition Surveys was 10.1 g/day [7], which is much higher than the World Health Organization (WHO) recommendation of less than 5 g/day [8]. Furthermore, salt intake has not decreased since the 2014 survey [7]. Therefore, salt intake reduction is considered the most important diet-associated concern in Japan.

In 2013, the WHO recommended that all member states reduce the salt intake of the population by 30% [9]. Currently, national- and community-level strategies for salt reduction have been undertaken in many countries around the world. The United Kingdom policies, which include reducing the salt content in processed foods, have resulted in a 16% reduction in salt intake over 9 years [10]. Readjusting the amount of salt in processed foods has been shown to be the most efficient strategy for salt reduction at the population level [11–13]. Contrastingly, since salt plays an important role in the taste and texture of food, reducing the amount of salt in food products may result in a decrease in the food quality and consumer acceptance [14].

Recent studies have demonstrated that the decrease of consumer acceptance of salt reduction can be minimized by gradual phase wise reduction of the salt content in food without informing the consumer [15]. A study based on the data from the INTERMAP study has demonstrated soup to be one of the main food sources of salt in the Japanese population [16]. In addition, a population-based cohort study in Japan has demonstrated that miso soup contributes 18.8% of the total dietary salt intake [17]. Our study aimed to survey whether the decrease in salt concentration of miso soup, which was covertly and gradually decreased, was perceived and further acceptable by consumers in a company cafeteria where meals were continuously served to nearly the same people.

2. MATERIAL AND METHODS

2.1 Design

This study was conducted in the company cafeteria of the Tohoku Murata Manufacturing Co. Ltd., Koriyama plant. The salt reduction strategy of this study presenting the change in salt concentration in miso soup served in the company cafeteria is shown in Fig. 1.There was no control group in this study. The salt concentration in miso soup was decreased phase wise at 0.1% per week, up to a final concentration of 0.7%, over 4 weeks (baseline and Phases 1–3). The salt concentration in miso soup normally served in the company cafeteria before the study began was 1.0%. Miso soup was served five times a week on weekdays. The fact that the salt concentration in the miso soup gradually decreased was not disclosed to the consumers. The survey on the taste of miso soup was administered a total of four times (at the end of every week) (Fig. 1), to everyone who consumed miso soup on the survey days; the survey included questionnaires containing the same contents. The questionnaire was distributed to all the visitors of the cafeteria, and only those who consumed the miso soup were asked to answer the questionnaire. The surveys were anonymously administered, and the respondents' privacy was strictly protected. The participants were informed that participation in the survey was voluntary, and that there were no disadvantages upon refusal to participate, the purpose of the survey was better meal service, and the results of the survey would be made public through various media. Since this study was anonymous and questionnaire-based, the participants were not subjected to any harm; thus, no ethical committee review was required. The study protocol was conducted according to the Declaration of Helsinki.

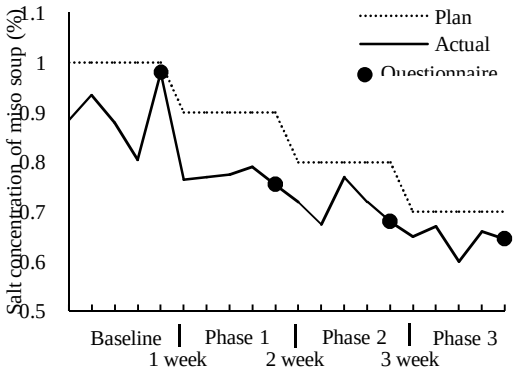

Fig. 1.Changes in salt concentration of miso soup in this study

2.2Miso Soup

Miso soup was prepared based on the usual miso soup preparation method served in the cafeteria before initiation of the study. Miso soup consisted of Japanese granulated broth (Ajinomoto Co., Inc., Tokyo), miso (Hanamaruki Foods Inc., Nagano), and certain ingredients that changed every day (tofu, seaweed, vegetables, etc.), and 60 L of miso soup was prepared each day. Japanese granulated broth and miso contained 44.0 g and 12.0 g of salt per 100 g, respectively. Japanese granulated broth was added to the miso soup at 5 g/L (0.25% salt concentration), unchanged for the study period.The ingredients added to the miso soup in this study were shown in Table 1. All the ingredients were boiled and discard the liquid before adding to the miso soup. After adding the ingredients, miso was added to the miso soup until the target salt concentration was reached, using PAL-SALT (ATAGO Co.; Ltd., Tokyo) to measure the salt concentration. The salt concentration of the miso soup was measured every 30 min while the cafeteria was open and remained constant. The miso soup was served at 150 ml per cup and about 80°C. A portion of all the miso soup served during the study period was stored at -20°C and its salt concentration was measured at 25°C using PAL-SALT in the laboratory.

Table 1.The ingredients added to the miso soup in this study

	Ingredients 1	Ingredients 2
Day 1	Japanese radish	Fried tofu
Day 2	Bean sprout	Brown seaweed
Day 3	Dried wheat gluten	Namekomushroom
Day 4	Tofu	Brown seaweed
Day 5 (Questionnaire)	Bean sprout	Fried tofu

Two different ingredients were added to the miso soup.

2.3Questionnaire

The questionnaires used in the four surveys contained the same content and were anonymous surveysto increase the response rates; therefore, follow-up data were absent. The questionnaires enquired about the age, sex, frequency of eating behavior with conscious salt reduction (always, sometimes, not), usage frequencies of the company cafeteria (rarely, < 1 time/week, 1–2 times/week, 3–4 times/week, nearly every day), and the saltiness and hedonic liking levels of miso soup on the day the questionnaire was administered. The saltiness and hedonic liking levels of the miso soup were rated using a 7-point saltiness score (“1–way too little” to “7–way too much” and “4–just about right”) and a 7-point hedonic liking score (“1–dislike very much” to “7–like very much” and “4–neither like nor dislike”), respectively. The list of questions included in the questionnaires are given in Appendix (Table S1).

2.4Statistical Analysis

The 7-point scores for saltiness and hedonic liking of miso soup are presented as means and standard deviations. Differences in the scores between the groups were assessed using a one-way analysis of variance (ANOVA) followed by Tukey's post-hoc test. Categorical variables were compared using the chi-square test. All the statistical analyses were performed using the Statistical Package for the Social Sciences Software Ver. 28.0 for Windows (IBM SPSS, Inc., Chicago, IL, USA); *P* values of < .05 were considered statistically significant.

3. RESULTS

The changes in the salt concentration of the miso soup served during the study period are shown in Fig. 1. The means of the salt concentration in each phase were 0.90%, 0.77%, 0.71%, and 0.65% at baseline, and phases 1, 2, and 3, respectively. The salt concentrations of the miso soup in the survey day in each phase were 0.98%, 0.76%, 0.68%, and 0.65% at baseline, and phases 1, 2, and 3, respectively.

3.1Questionnaire Collection Rate

The questionnaire was distributed to all the visitors of the cafeteria. Only those who consumed the miso soup were asked to answer the questionnaire; those who did not were asked to destroy the questionnaire. The questionnaire collection rate in each phase was 133.2%, 97.2%, 90.4%, and 98% at baseline, and phases, 1, 2, and 3, respectively (Table 2).

Table 2. Collection rate in the four questionnaires

	Baseline	Phase 1	Phase 2	Phase 3
Number of miso soups served	235	354	405	296
Number of questionnaires collected	313	344	366	290
Questionnaire collection rate (%)	133.2	97.2	90.4	98.0

3.2Participant Characteristics

The characteristics of the participants are shown in Table 3. At baseline, the mean age and percentage of men were 40.8 years and 81.7%, respectively, and these results did not differ significantly across the three subsequent surveys. The frequency of eating behavior with conscious salt reduction (always, sometimes, and not) was considered as the salt reduction-consciousness level (high, medium, and low, respectively). At baseline, the percentages of the high, medium, and low salt reduction-consciousness level were 11.9%, 52.3%, and 35.8%, respectively, and these results did not differ significantly across the three subsequent surveys. The percentage of participants who visited the cafeteria nearly every day was >90% in all the four surveys.

Table 3. Characteristics of the respondents in the four questionnaires

	Baseline	Phase 1	Phase 2	Phase 3	*p*
N	313	344	366	290	
Age	40.8 ± 10.2	41.5 ± 10.2	41.9 ± 10.2	41.9 ± 10.1	.51
Sex (male %)	81.7	78.1	82.7	78.5	.36
Salt reduction-consciousness level (%)					
High	11.9	13.5	12.8	15.1	.83
Medium	52.3	53.6	52.9	48.7	
Low	35.8	33.0	34.3	36.2	
Usage frequencies of the cafeteria (%)					

Rarely used	0.3	1.4	0.3	0.6	.29
< 1 time/week	1.7	0.0	0.7	1.0	
1–2 times/week	3.2	1.6	1.4	1.6	
3–4 times/week	3.2	3.8	3.8	3.5	
Nearly every day	91.6	93.2	93.8	93.3	

Data presented as % or mean ± standard deviation. The frequency of eating behavior with conscious salt reduction (always, sometimes, and not) was considered as the salt reduction-consciousness level (high, medium, and low, respectively).

3.3Changes in the Saltiness and Hedonic Liking Scores

The changes in the mean scores for the saltiness and hedonic liking of the miso soup are shown in Fig. 2. The saltiness scores significantly decreased sequentially at all phases compared to the baseline (Tukey's post-hoc test, baseline vs. phase 1, p = .04; baseline vs. phase 2, p< .001; baseline vs. phase 3, p< .001). The hedonic liking scores significantly decreased in phases 2 and 3 compared to the baseline (Tukey's post-hoc test, baseline vs. phase 2, p = .03; baseline vs. phase 3, p< .001). The changes in the proportion of saltiness and hedonic liking score are given in appendix (Fig. S1).

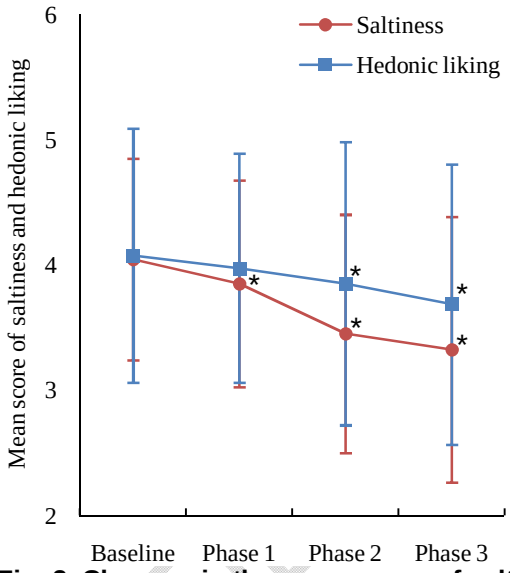

Fig. 2. Changes in the mean score of saltiness and hedonic liking.

*The saltiness and hedonic liking levels of the miso soup were rated using a 7-point saltiness score ("1−way too little" to "7−way too much" and "4−just about right") and a 7-point hedonic liking score ("1−dislike very much" to "7−like very much" and "4−neither like nor dislike"), respectively. The error bars indicate standard deviation. * Tukey's post-hoc test, p< .001, compared to the baseline.*

3.4Saltiness and Hedonic Liking Scores According to age and sex

According to age and sex, the participants were divided into three and two groups, and the changes in the saltiness and hedonic liking scores were assessed. There were no significant differences in changing the saltiness and hedonic liking scores according to age and sex (Fig. S2 and S3).

3.5Saltiness and Hedonic Liking Scores According to the Salt Reduction-consciousness Level

According to the salt reduction-consciousness level, the participants were divided into three groups (high-, medium-, and low-conscious groups) and the changes in the saltiness and

hedonic liking scores were assessed (Fig. 3). The saltiness scores significantly differed between the salt reduction-consciousness groups in all the four surveys (ANOVA, baseline, $p < .001$; phase 1, $p = .04$; phase 2, $p = .001$; phase 3, $p = .005$), being higher and lower in the high- and low-conscious groups, respectively. The saltiness scores in all the salt reduction-consciousness groups significantly decreased in phases 2 and 3 compared to the baseline (Tukey's post-hoc test, in all conscious groups in each, baseline vs. phase 2, $p < .001$; baseline vs. phase 3, $p < .001$). On the other hand, the hedonic liking scores significantly differed between the salt reduction-consciousness groups only in phase 3 (Fig. 3B, ANOVA, $p = .005$). The hedonic liking scores in the low-conscious group significantly decreased in phases 2 and 3 compared to the baseline (Tukey's post-hoc test, baseline vs. phase 2, $p = .03$; baseline vs. phase 3, $p < .001$), while the hedonic liking scores in medium-conscious group significantly decreased in phase 3 (Tukey's post-hoc test, baseline vs. phase 3, $p = .009$). Interestingly, in the high-conscious group, no significant decrease in the hedonic liking scores was observed; rather, the mean hedonic liking scores tended to remain flat during the survey period. The changes in the proportion of saltiness and hedonic liking score according to the salt reduction-consciousness level are given in Appendix (Fig. S4).

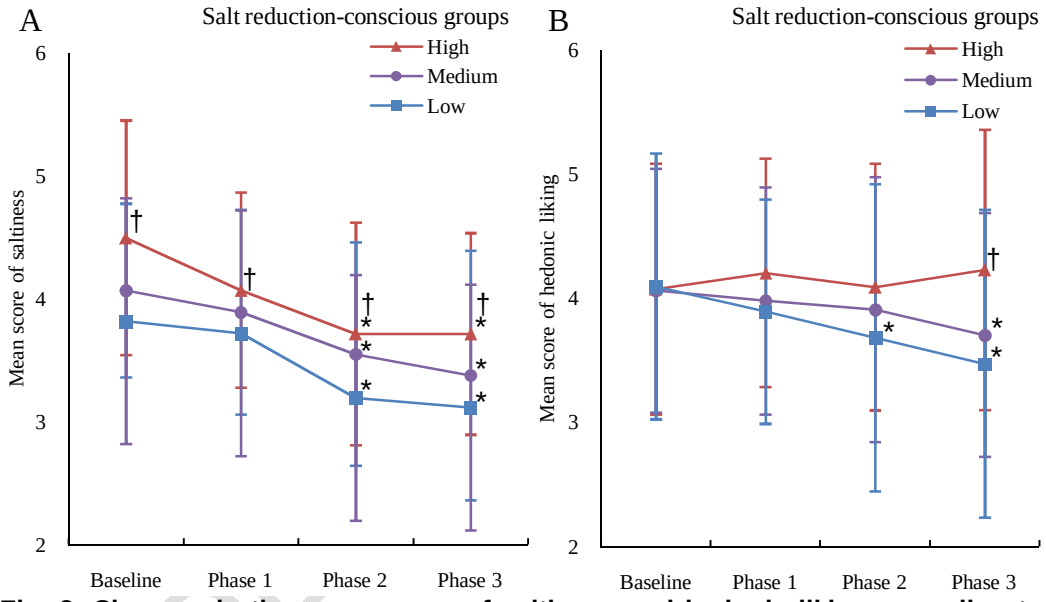

Fig. 3. Changes in the mean score of saltiness and hedonic liking according to the salt reduction-consciousness level.

*The saltiness (A) and hedonic liking (B) levels of the miso soup were rated using a 7-point saltiness score ("1−way too little" to "7−way too much" and "4−just about right") and a 7-point hedonic liking score ("1−dislike very much" to "7−like very much" and "4−neither like nor dislike"), respectively. The frequency of eating behavior with conscious salt reduction (always, sometimes, and not) was considered as the salt reduction-consciousness level (high, medium, and low, respectively). Error bars indicate standard deviation. * Tukey's post-hoc test, $p < .05$, compared to the baseline. † One-way analysis of variance, $p < .05$, between the salt reduction-consciousness groups.*

4. DISCUSSION

In the company cafeteria in this study, where more than 90% of the patrons visited the cafeteria nearly every day, the salt concentration of the miso soup was covertly and gradually decreased. The saltiness scores significantly differed among the salt reduction-consciousness groups but decreased regardless of the salt reduction-consciousness level. Therefore, the reduced salt concentration had probably been recognized by the consumer.

However, the hedonic liking scores decreased significantly after the stage 2, but demonstrated a different pattern of decrease dependent on the salt reduction-consciousness levels. The hedonic liking score in the high-conscious group did not decrease significantly.

In this study, the saltiness scores were significantly decreased in all the salt reduction-consciousness groups; the saltiness scores in the high-conscious group were consistently higher than those in the low-conscious group in all the four surveys. A randomized controlled trial evaluating bread with gradually reduced salt content demonstrated that the saltiness scores were significantly lower in the intervention group than in the control group, which did not reduce the salt content [18]. A reduction in the salt content in foods, even if gradual, may be perceived by consumers. In addition, Tanaka et al. cross-sectionally examined the relationship between miso soup liking and dietary habits in 254 female university students. The percentage of participants who had low-salt eating habits was higher in the group that reported miso soup with a salt concentration of 0.8% as thick and lower in the group that reported it as thin [19]. The intensity of saltiness of foods may be associated with the frequency of eating behavior with conscious salt reduction (i.e., the salt reduction-consciousness level).

Several intervention studies have demonstrated that hedonic liking for saltiness was influenced by the saltiness level of foods usually eaten and may be modified by repeated taste experiences. Girgis et al. examined the effect of a gradual decrease in the sodium content of bread on liking and demonstrated that a gradual weekly decrease did not decrease the liking for bread [18]. Bobowski et al. examined the effect of a reduction in the sodium content of tomato juice on liking and showed that repeated consumption of low-sodium tomato juice for 14 weeks increased the liking, whether the sodium content was reduced abruptly or gradually [20]. Methven et al. examined the effect of repeated exposure to the taste of the no additional salt added soup on liking and showed that an 8 days experience of tasting the no additional salt added soup increased liking to a level equivalent to the salted soup [21]. In this study, the hedonic liking scores in the high-conscious group did not decrease, even though the salt concentration of the miso soup gradually decreased. The participants in the high-conscious group reported “always” as the frequency of eating behavior with conscious salt reduction; thus, they may have usually experienced low-salt tastes frequently, and may have already had an increased liking for low-salt miso soup. Although the salt concentration of miso soup gradually decreased per week in this study, investigating whether the results changed if the rate of decrease was slower (e.g., per month) or if the decrease was made more abruptly would be interesting.

The targets for the levels of salt in the soups in the United Kingdom salt reduction program [22] and Australia’s Healthy Food Partnership Reformulation Program [23] are 0.50 g salt per 100 g and 280 mg sodium per 100 g (0.69% salt concentration), respectively, while miso soup commercially sold in Japan generally has a salt concentration of 1.0–1.2%. The salt concentration of miso soup in this study was decreased from 1.0 to 0.7%, which corresponds to a reduction of 0.5 g/day of daily salt intake for all consumers. Several studies suggest that achieving a salt reduction in a population, even with relatively small reductions, could be expected to affect stroke and coronary heart disease prevention and healthcare cost reduction [24,25]. Contrarily, a recent scoping review identified that one of the barriers of dietary salt reduction was profit loss owing to loss of sales, and one of the perceptions of dietary salt reduction was that low-salt food was recognized as tasteless [26]. Since saltiness is a major factor in the palatability of foods, a greater liking for foods with low saltiness levels is essential for continued salt reduction. In this study, the saltiness scores in the low-conscious group were consistently lower than those in the medium- and high-conscious groups throughout the study period, and the hedonic liking scores in the low-conscious group decreased linearly over the study period. A study examining the barriers to

and facilitators of serving salt-reduction meals in worksite cafeterias indicated the customers' desire for salt-reduction meals (customers perceive the importance of eating low-salty foods and choose them) to be the most important factor [27].

Our study had certain limitations. First, the surveys were administered anonymously and thus the data did not include follow-up data. However, large-scale follow-up studies are expensive, and moreover, recruiting participants with the low salt reduction-consciousness levels can be challenging owing to increased burden on the participants. Data on the participants with the low salt reduction-consciousness levels are essential to obtain information needed for population-based salt reduction strategies. In this study, the questionnaire collection rate was more than 90%, the percentage of participants with low salt reduction-consciousness levels was approximately 35%, and the percentage of participants who visited the cafeteria nearly every day was more than 90%. Second, the study period was short. A slower rate of gradual salt reduction (e.g., per month) would be of interest; however, it could potentially damage the cafeteria's reputation and sales. Third, the questionnaire collection rate in the baseline was over 100%, so it is possible that some people who did not consume miso soup also responded to the questionnaire. Fourth, due to cafeteria business reasons, it was not possible to standardize the ingredients for the miso soup throughout the experiment. However, by boiling all the ingredients once, we were able to minimize the influence of differences in the flavors of the ingredients.

4. CONCLUSION

In a company cafeteria, which was visited by more than 90% of the patrons nearly every day, a gradual decrease in the salt concentration of miso soup from 1.0% to 0.7% significantly decreased both the saltiness score and the hedonic liking score. The saltiness scores significantly differed among the salt reduction-consciousness level groups, being consistently higher in the high-conscious group and decreased with reduction of salt concentration regardless of the conscious level. On the other hand, the hedonic liking score showed a different pattern of decrease based on the salt reduction-consciousness level, with the high-conscious group showing a rather insignificant decrease.

ETHICAL APPROVAL

The ethical review committee in the author'sinstitution stipulated that ethical review is not required for anonymous questionnaire survey that ensured that individuals cannot be identified, that the participants' personalities are respected, and that inquiries about the survey areresponded to.Therefore, no ethical committee review was required.

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ABBREVIATIONS

WHO: World Health Organization
ANOVA: analysis of one-way variance

APPENDIX

Table S1. List of questions included in the questionnaires used in this study

Questions	Options
1. What is your gender?	Male / Female
2. What is your age?	years old
3. How often do you eat with a conscious effort to reduce salt?	Always / Sometimes / Not
4. How was the saltiness of today's miso soup? Please circle the number.	Just about right ↓ Way too little ← 1 / 2 / 3 / 4 / 5 / 6 / 7 → Way too much
5. How did you like the miso soup today? Please circle the number.	Neither like nor dislike ↓ Dislike very much ← 1 / 2 / 3 / 4 / 5 / 6 / 7 → Like very much
6. How often do you use the cafeteria for lunch?	Rarely / < 1 time/week / 1–2 times/week 3–4 times/week / Nearly every day

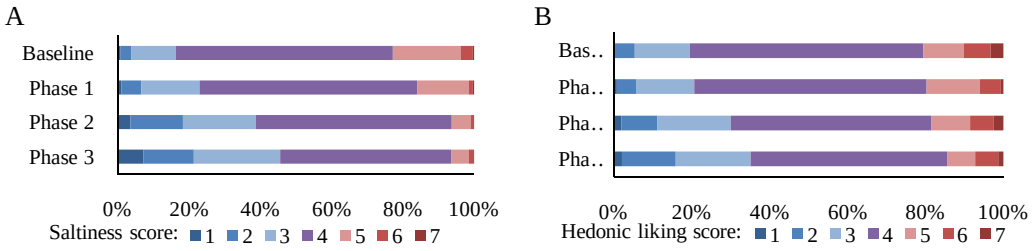

Fig. S1. Changes in the proportion of saltiness and hedonic liking score
The saltiness (A) and hedonic liking (B) levels of the miso soup were rated using a 7-point saltiness score (“1–way too little” to “7–way too much” and “4–just about right”) and a 7-point hedonic liking score (“1–dislike very much” to “7–like very much” and “4–neither like nor dislike”), respectively.

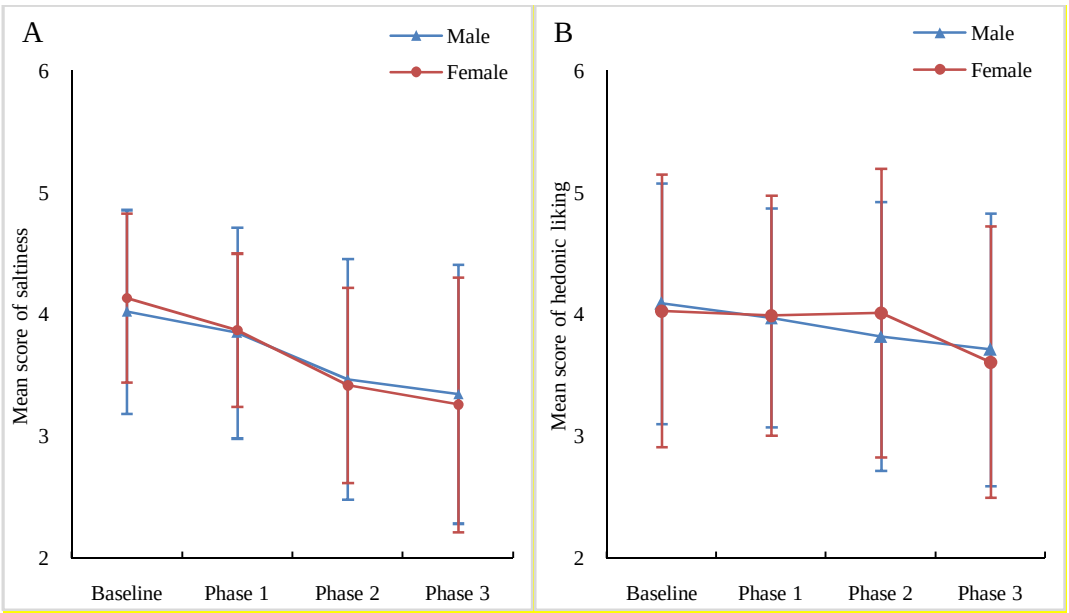

Fig. S2. Changes in the mean score of saltiness and hedonic liking according to sex

*The saltiness (A) and hedonic liking (B) levels of the miso soup were rated using a 7-point saltiness score ("1−way too little" to "7−way too much" and "4−just about right") and a 7-point hedonic liking score ("1−dislike very much" to "7−like very much" and "4−neither like nor dislike"), respectively. Error bars indicate standard deviation. * Student t test, p < .05, between the male and female.*

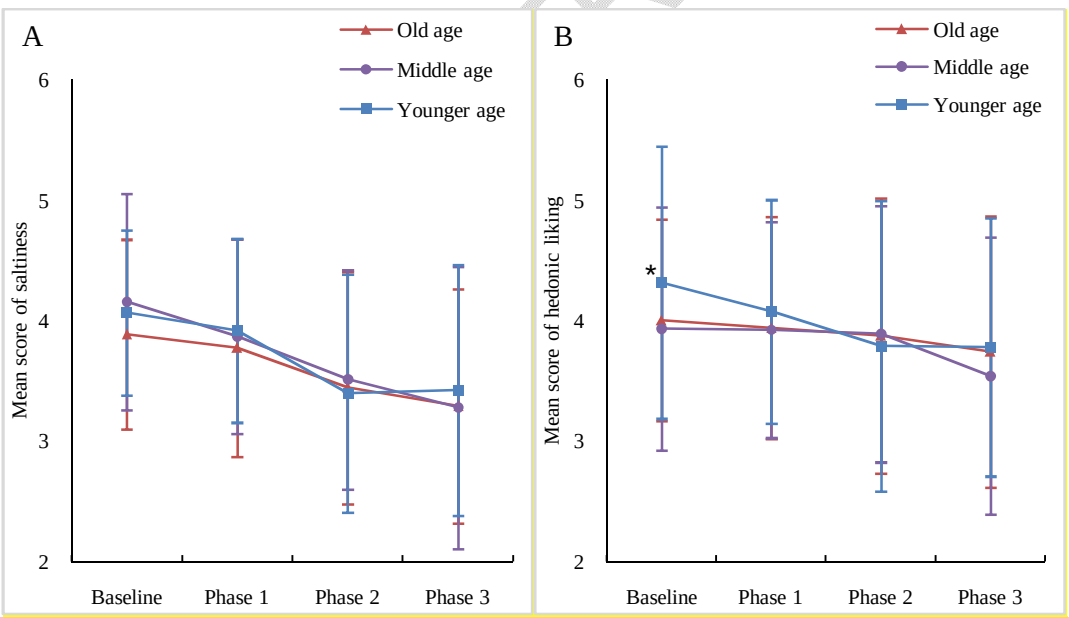

Fig. S3. Changes in the mean score of saltiness and hedonic liking according to age

*The saltiness (A) and hedonic liking (B) levels of the miso soup were rated using a 7-point saltiness score ("1−way too little" to "7−way too much" and "4−just about right") and a 7-point hedonic liking score ("1−dislike very much" to "7−like very much" and "4−neither like nor dislike"), respectively.According to age, the participants were divided into three groups (younger age, 19–35 years old; Middle age, 36–47 years old; and old age, 48–68 years old). Error bars indicate standard deviation. * One-way analysis of variance, p < .05, between the age groups.*

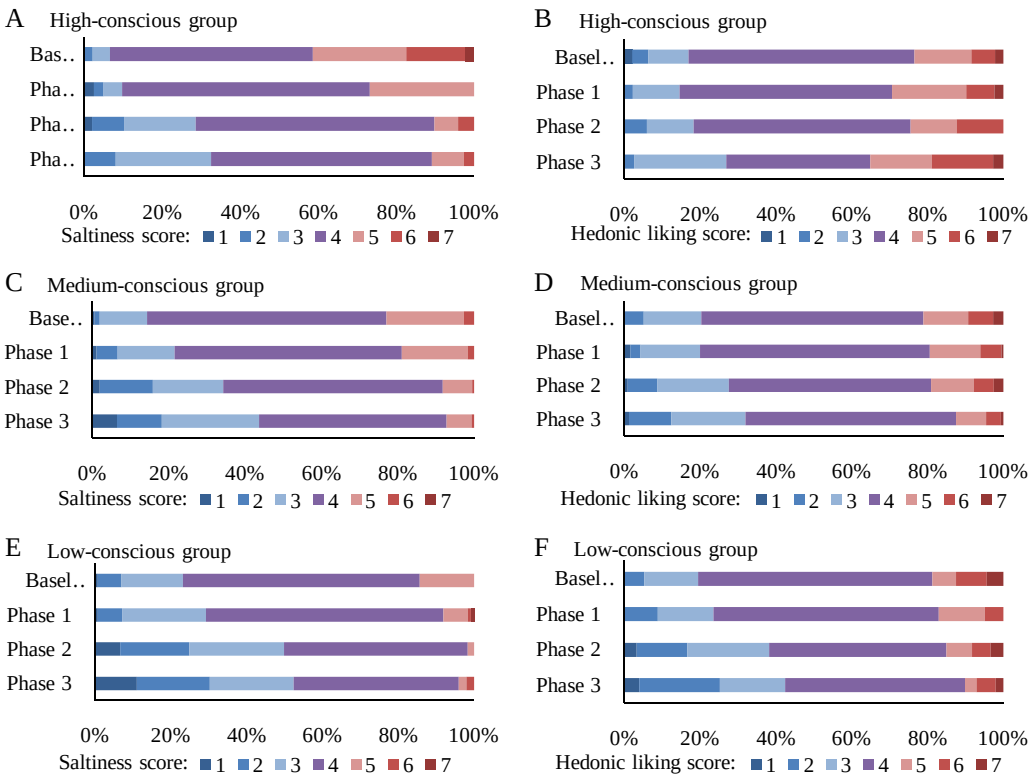

Fig. S4. Changes in the proportion of saltiness and hedonic liking score according to the salt reduction-consciousness level

The frequency of eating behavior with conscious salt reduction (always, sometimes, and not) was considered as the high- (A and B), medium- (C and D), and low- (E and F) consciousness level, respectively. The saltiness (A, C, and E) and hedonic liking (B, D, and F) levels of the miso soup were rated using a 7-point saltiness score ("1–way too little" to "7–way too much" and "4–just about right") and a 7-point hedonic liking score ("1–dislike very much" to "7–like very much" and "4–neither like nor dislike"), respectively.