

**ORIGINAL****What influences appetite more : eating approaches or cooking methods?**

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**Abstract :** In general, vegetables are abundantly consumed in a calorie-restricted diet to achieve sufficient satiety through fresh food or various cooking methods. In this study, we examined the effects of different cooking methods on appetite and specific perceptions of the food after consumption ; eating approaches were also analyzed by meal duration. A total of 153 individuals aged 20-59 years were assigned to 2 groups : raw vegetable or boiled vegetable meals, including packed meals that were served as test meals with the same energy and vegetable amount. Subjective levels of sensory properties and meal duration were assessed over time using visual analog scales, including questionnaires. Results showed that meal duration was significantly longer for raw vegetable meals than boiled vegetable meals, and there were significantly stronger correlations between meal duration and fullness. A higher degree of fullness was provided by a raw vegetable meal than a boiled vegetable meal, especially in men. However, an excess of raw vegetables led to overall insufficient satisfaction. Taken together, these findings suggest that cooking methods should be altered for different situations with an adequate amount of vegetables, and the meal duration should be recommended to be given as much attention as cooking methods. *J. Med. Invest.* 61 : 118-125, February, 2014

**Keywords :** *appetite sensation, raw vegetable, boiled vegetable, meal duration, visual analog scales*

**INTRODUCTION**

Obesity is currently one of the most rapidly increasing health problems worldwide. Lifestyle interventions with low-calorie diet and the correct eating approach are becoming the strongly recommended strategies for overweight and obese individuals (1-3).

Eating slowly is often recommended as a correct eating approach for weight control because of the

hypothesis that slower eating provides satiety before a large amount of food is consumed (4, 5). Meanwhile, vegetables that are extremely low in calories are usually consumed in abundance in a calorie-restricted diet to reach sufficient satiety through fresh plant foods or a variety of cooking methods (6, 7). Vegetable consumption is always believed to be associated with the maintenance of human health. Increased consumption of vegetable food is recommended by several organizations such as the Food and Agriculture Organization (FAO) and World Health Organization (WHO) (8).

Epidemiological evidence shows that high vegetable diets can be a good strategy for reducing the risk of chronic degenerative diseases (9). Among vegetables, the *Brassicaceae* family, such as cabbage,

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cauliflower, and potherb mustard, are rich in phytochemicals, including vitamins, carotenoids, and polyphenols (10).

Because cruciferous vegetables are the common vegetable in the human diet, some researchers have focused on the function or specific nutrients before and after technological processes are applied to these vegetables (11, 12). Some studies have indicated that a loss of vitamins occurs during the various cooking treatments compared with the fresh (raw) state (13).

Bearing this information in mind, nowadays, consumers, who are becoming more health conscious, have less time to prepare meals in their daily lives and are often confused about which cooking method and eating approach can be more convenient but still be based on fresh vegetable products. The published data are still incomplete regarding appetite variations as a function of cooking methods and eating approaches in a practical diet.

The *Brassicaceae* family, particularly potherb mustard, are vegetables cultivated in temperate zones and are frequently used, fresh or cooked, in several types of dishes in a Japanese-style meal (14). Therefore, considering the high applicability of potherb mustard and the absence of data on perceptions of food cooked using various methods, the aim of this study was to examine the effects of different cooking methods between raw- and boiled-type meals on appetite and the specific perceptions of foods after consumption; the eating approaches were also investigated in this study by meal duration. The fundamental purpose was to develop the effective low-energy meal for weight management; and how to reach sufficient fullness and satisfaction in 500 kcal meals was the point in this study. The results may improve practicality of cooking and eating approaches that involve vegetables in the low-energy meal.

## SUBJECTS AND METHODS

### *Participants*

A total of 153 individuals aged 20-59 years were selected in Tokushima, Japan, with sedentary clerical occupations and steady lifestyles, who agreed to participate in the study. Data on height and weight were self-reported according to the recorded data from their annual official medical examinations.

All participants were provided with detailed written and verbal explanations of the general purpose and procedures of the study. All procedures of the

study were approved by the Ethics Committee of the Tokushima University Hospital.

### *Study design*

During the study period, all participants were randomly assigned to 2 groups: raw vegetable or boiled vegetable meals. Participants were asked to refrain from skipping meals, drinking excessive alcohol, and to maintain exercise at a consistent level before each scheduled instruction session. Packed test lunches were provided to the 2 groups on a specified day of the week. The study was designed such that the majority of daily food and energy consumed was from the test foods, according to 2010 Dietary Reference Intakes for Japanese (15).

### *Test meals*

Two types of packed lunches were used as test meals with their composition remaining constant. Rice was the staple food, and the main entrées were mackerel simmered in miso, chopped burdock and lotus root cooked in sesame oil with potherb mustard, stewed freeze-dried tofu, and celery cabbage; a mixed salad consisting of crab sticks, soybean, tomato, lettuce, and potherb mustard was also served as an integral part of each meal. Information on the macronutrient and energy contents is provided in Table 1.

The test meals varied in the cooking method of potherb mustard (raw or boiled form). Each participant was given 0.5 L of chilled water to consume along with the meal. Additional water was supplied if requested, but extra food and other drinks were forbidden. The 2 meals were provided on the test day with the same energy and vegetable amount as follows: (i) a raw vegetable meal (Raw): energy 501 kcal, vegetable amount 206 g; (ii) a boiled vegetable meal (Boiled): energy 501 kcal, vegetable amount 206 g.

### *Comparison of assessment approaches*

The 2 types of meals that differed in the cooking method were provided to the 2 groups, and specific sensory responses were compared between them. Moreover, the correlations between meal duration and appetite (fullness and satisfaction), depending on the different cooking methods, were also examined.

### *Visual analog scales (VAS)*

Participants completed a series of 100-mm visual analog scale (VAS) rating questionnaires (16) on

**Table 1** Energy and macronutrient composition of the test meals<sup>1</sup>

Menu	Weight (g)	Energy (kcal)	ED (kcal/g)	Protein (g)	Fat (g)	Carbohydrate (g)	Vegetable (g)
Rice	150.0	252.0	1.7	3.8	0.5	55.7	0.0
Mixed salad of crab sticks and soybean	50.0	38.0	0.8	3.6	1.3	3.2	25.0
Mackerel simmered in miso	121.0	110.0	0.9	9.5	5.1	6.5	46.0
Chopped burdock and lotus root	82.7	48.0	0.6	1.5	0.6	9.5	65.0
Stewed freeze-dried tofu and celery cabbage	82.8	49.0	0.6	3.7	2.3	3.8	50.0
Tomato	20.0	4.0	0.2	0.1	0.0	0.9	20.0
Total	506.5	501.0	1.0	22.2	9.8	79.6	206.0

<sup>1</sup>Two versions of each meal were varied by the cooking method of potherb mustard (in raw or boiled form). All values were calculated on the basis of test meals.

the predicted amount of the total meal, rice, side dish, vegetables, taste, and appetite of fullness and satisfaction. For example, the predicted amount of the total was rated on the 100-mm line preceded by the question, “How do you feel right now about the total amount?” and anchored on the left by “too little” and on the right by “too much”. The anchor for the question about taste was “light taste” on the left and “rich taste” on the right. The anchor for the question about fullness was “not at all” and “very much”, which also consisted of anchors for satisfaction assessment. The ratings were completed at 0.5 h after meals.

#### Additional questionnaires

After the VAS ratings, participants were asked to complete brief questions about their meal durations from starting to end, perceptions regarding the predicted energy and price of the test meal.

#### Data analysis

Unpaired *t* tests were used to assess differences between Raw and Boiled groups on VAS ratings and questions of additional questionnaires in the whole sample and among men and women. In addition, Pearson’s correlation coefficient was used to assess bivariate correlations between meal duration and appetite of fullness and satisfaction, depending on the different cooking methods.

All statistical analyses were performed using Statistical Package for Social Science (SPSS) software (version 16.0, 2007, SPSS Inc., Chicago, IL, USA). The results were presented as mean  $\pm$  SEM, and the differences were considered significant at  $P < 0.05$ .

## RESULTS

### Participants

Participant characteristics are shown in Table 2. The 153 adults included 47 men and 106 women with an average age of  $39.7 \pm 0.8$  years, average weight of  $56.4 \pm 0.7$  kg, average height of  $162.5 \pm 0.6$  cm, and average BMI of  $21.2 \pm 0.1$  kg/m<sup>2</sup>. The Boiled group included 26 men and 52 women, whereas the Raw group included 21 men and 54 women; the groups were matched by age and BMI. There were no significant differences in age and BMI between the Boiled and Raw groups.

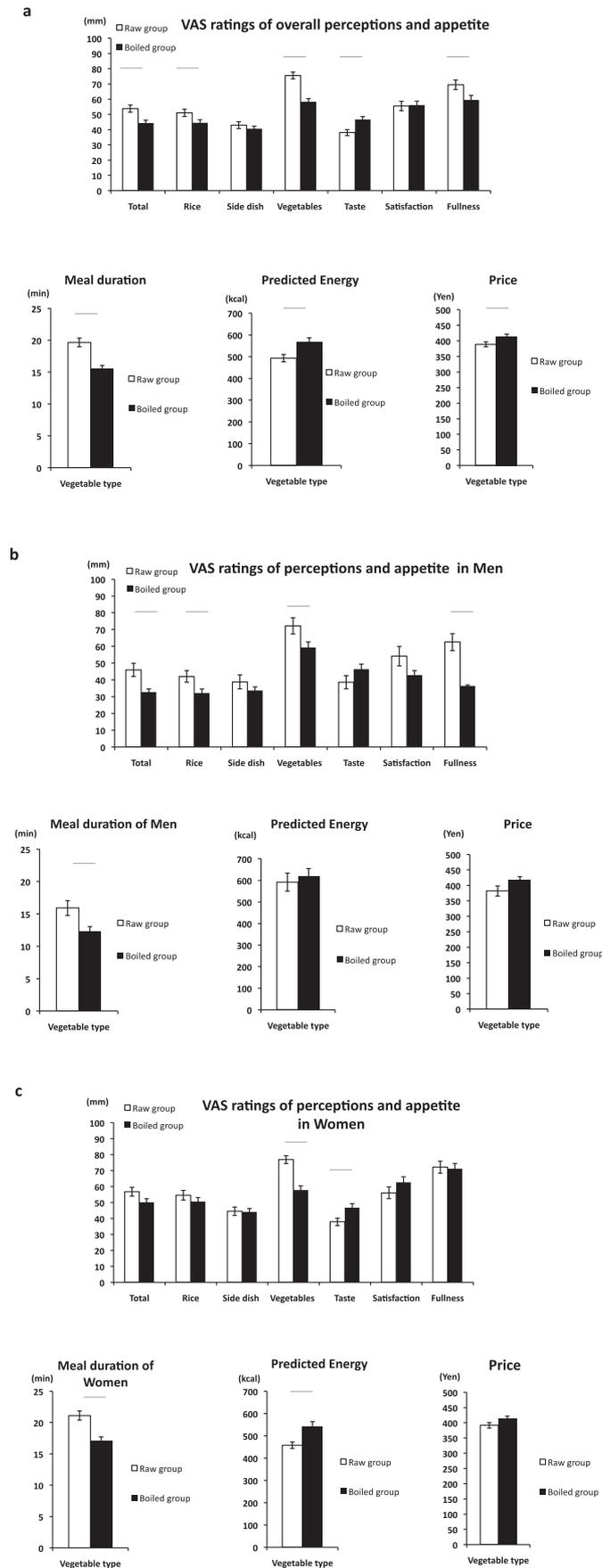
**Table 2** Characteristics of participants<sup>1</sup>

	Total (n=153)	Boiled (n=78)	Raw (n=75)
Age	$39.7 \pm 0.8$	$40.5 \pm 0.9$	$38.9 \pm 1.2$
Male/Female	47/106	26/52	21/54
Height (cm)	$162.5 \pm 0.6$	$162.9 \pm 1.0$	$162.2 \pm 0.8$
Weight (kg)	$56.4 \pm 0.7$	$57.4 \pm 1.0$	$55.3 \pm 0.9$
BMI (kg/m <sup>2</sup> )	$21.2 \pm 0.1$	$21.5 \pm 0.2$	$21.0 \pm 0.2$

<sup>1</sup>All values are expressed as mean  $\pm$  SEM. There were no significant differences in age and BMI between the boiled-vegetable group and raw-vegetable group.

### Overall comparisons (Figure 1a)

Ratings of the predicted amount of the total meal ( $P < 0.01$ ), rice ( $P < 0.05$ ), and vegetables ( $P < 0.001$ ) were significantly higher in the Raw group than the Boiled group. In contrast, ratings of the taste were significantly lower in the Raw group than in the Boiled group ( $P < 0.01$ ). Although VAS ratings of fullness were significantly higher in the Raw group than in the Boiled group ( $P < 0.01$ ), no significant differences in satisfaction were identified between



**Figure 1** Comparison of data between the Boiled and Raw groups. Differences ( $P < 0.05$ ) between groups (mean  $\pm$  SEM) were assessed using unpaired  $t$  tests. Significant differences between the 2 groups are represented by the horizontal lines. The Raw group, white bars; Boiled group, black bars. (a) Shows comparison in the whole sample; (b) shows comparison in men; (c) shows comparison in women.

the groups.

Meal duration in the Raw group was significantly longer than that in the Boiled group ( $P < 0.001$ ). Predicted energy in the Raw group was significantly lower than that in the Boiled group ( $P < 0.01$ ), and the price in the Raw group was also significantly lower than that in the Boiled group ( $P < 0.05$ ).

#### Comparison of data in men (Figure 1b)

Ratings of the predicted amount of the total meal ( $P < 0.01$ ), rice ( $P < 0.05$ ), and vegetables ( $P < 0.05$ ) were significantly higher in the Raw than in the Boiled group. Although VAS ratings of fullness were significantly higher in the Raw than the Boiled group ( $P < 0.001$ ), no significant differences in satisfaction were identified between the groups.

Meal duration in the Raw group was significantly longer than that in the Boiled group ( $P < 0.01$ ). There were no significant differences in predicted energy and price of a meal.

#### Comparison of data in women (Figure 1c)

Ratings of the predicted amount of vegetables ( $P < 0.001$ ) were significantly higher in the Raw than in

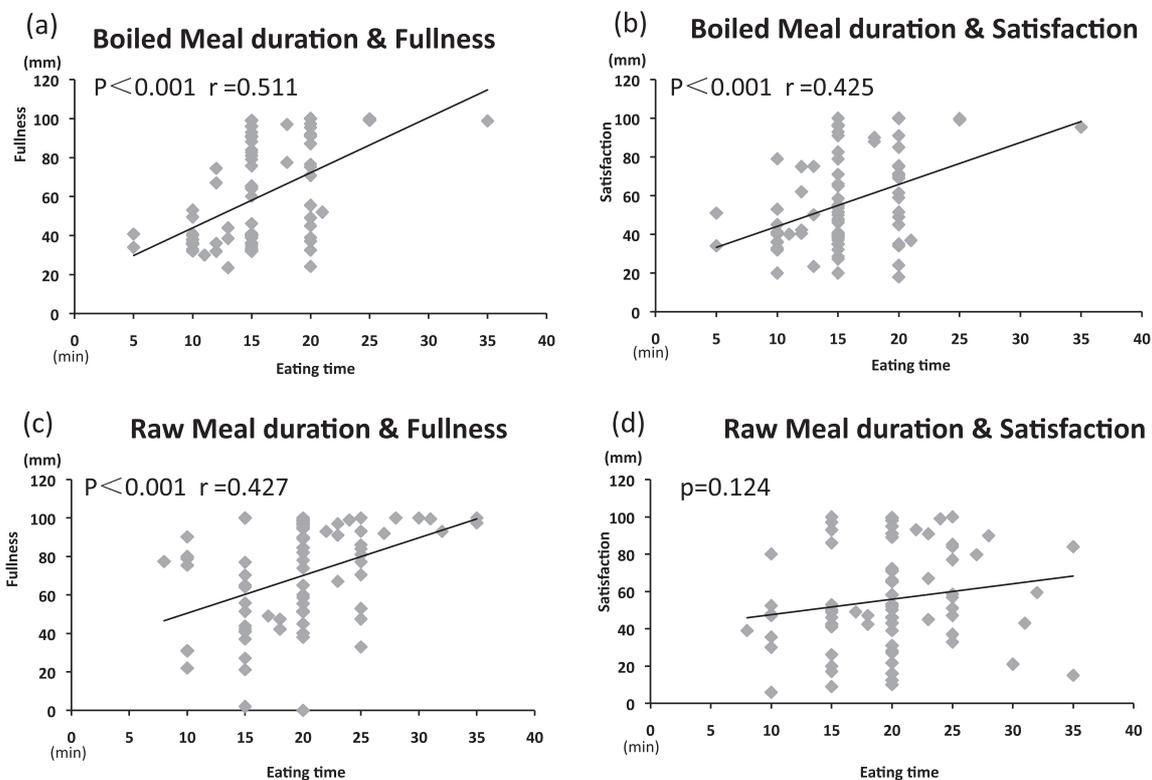
the Boiled group. In contrast, ratings of taste were significantly lower in the Raw than in the Boiled group ( $P < 0.05$ ). No significant differences in fullness and satisfaction were identified between the groups.

Meal duration in the Raw group was significantly longer than that in the Boiled group ( $P < 0.001$ ), and predicted energy of a meal in the Raw group was significantly lower than that in the Boiled group ( $P < 0.01$ ). There were no significant differences in predicted price of a meal.

#### Correlations between meal duration and appetite of fullness and satisfaction (Figure 2)

In the Boiled group, there was a significant correlation between meal duration and fullness ( $r = 0.511$ ,  $P < 0.001$ ). Moreover, there was also a significant correlation between meal duration and satisfaction ( $r = 0.425$ ,  $P < 0.001$ ).

In the Raw group, there was a significant correlation between meal duration and fullness ( $r = 0.427$ ,  $P < 0.001$ ), but there was no significant correlation between meal duration and satisfaction ( $P = 0.124$ ).



**Figure 2** Correlations between meal duration and appetite of fullness and satisfaction by the different cooking methods. Differences ( $P < 0.05$ ) were assessed using bivariate correlations with Pearson's correlation coefficient. (a) Shows correlation between Boiled meal duration and fullness ; (b) shows correlation between Boiled meal duration and satisfaction ; (c) shows correlation between Raw meal duration and fullness ; (d) shows correlation between Raw meal duration and satisfaction.

## DISCUSSION

To the best of our knowledge, this study is the first to examine the effects of different cooking methods on appetite and specific perceptions of foods from typical Japanese diets using a significant sample size and population-based prospective design. For more specific comparison, we also compared the data in the gender groups, respectively.

The results of this study demonstrate the different effects of vegetables (between raw- and boiled-type meals) on the appetite and perceptions. This study had 3 main findings : (i) a raw vegetable meal provided significantly greater fullness, particularly in men ; however, no significant differences in satisfaction were identified between the meal types ; (ii) meal duration was significantly longer with in raw vegetable meal, regardless of genders ; and (iii) overall, there were significantly stronger correlations between meal duration and fullness, regardless of meal types.

In the present study, fullness and satisfaction serve as appetite factors because of their major roles in the diet selection. In contrast to fullness, which is the feeling of satiety that persists after eating to suppress further food consumption, satisfaction causes one to stop eating. Both fullness and satisfaction influence the total energy intake, which regulates appetite (7, 17).

Vegetables, particularly those of the *Brassicaceae* family, are commonly cooked before consumption. It is known that cooking influences chemical composition of bioactive compounds in vegetables and can reduce the amount of vitamin C and other thermolabile compounds during thermal treatment and processing (18).

Although consumption of fresh unprocessed plant foods is widely advocated, positive effects have also been reported with other processing conditions, such as thermal treatment. Processing can increase the bioaccessibility of several phytochemicals and improve the nutritional quality of vegetables (19).

In case of boiling, physical properties of vegetables are greatly affected by heat treatments (20, 21). In our findings, a meal of boiled vegetables resulted in a significantly lower perception of the amount of the meal, particularly in men. One possible explanation is that cooked vegetables exhibit poor color quality in comparison with fresh ones (21).

Although fullness was significantly higher in raw vegetable meals, particularly in men, there was no significant difference in satisfaction, indicating that

an excess of raw vegetable meal may lead to insufficient satisfaction probably because of less palatable taste. In women, taste was significantly stronger in boiled vegetable meal, and no significant difference was observed in fullness. Although the differences between types of meals were not significant, a trend for satisfaction in women was higher with boiled vegetables, whereas in men, satisfaction was somewhat higher with raw vegetables as was the fullness rating. We speculated that the physiological feedback of fullness is easier to achieve in men than in women. These findings are in agreement with reports of women's greater sensitivity and more attention towards nutrition (22, 23).

In addition, meal duration was significantly longer in raw vegetable meals than in boiled vegetable meals, regardless of the gender. With respect to correlations, there were significantly stronger positive correlations between meal duration and fullness, regardless of meals. These findings suggest that compared with cooking methods, the eating approach that involves intentional changes in meal duration is a more effective approach to fullness, which is also consistent with previous reports that encourage the slower eating rate (5, 24). One of the previous studies has indicated that eating slowly favors higher fullness after the 30-min than after the 5-min meal duration of a test meal of 300 ml ice cream (675 kcal) because of the higher concentration of anorexigenic gut peptides, PYY and GLP-1 (25).

The strengths of this study are that it provides information on the effects of different cooking methods on appetite and perception of the meal and compares cooking methods with the eating approach that involves meal duration. Our results may encourage the food industry to explore specific cooking methods to help maintain the culinary and nutritional function of vegetables that we eat. Limitations of this study include the limited range of participant characteristics and the unbalanced gender ratio ; therefore, further research is required with more diverse samples. Furthermore, it is unknown what happens at other time points, past 0.5 h after consumption. Those results may differ with different vegetables, depending on cooking methods. Further research into the effects of various cooking methods on appetite or eating behavior would be worthwhile.

## CONCLUSION

Higher fullness was attained with a raw vegetable meal than a boiled vegetable meal, especially in men. In contrast, an excess of raw vegetables led to overall insufficient satisfaction, suggesting that cooking methods should be changed for different situations with an adequate amount of vegetables.

Furthermore, slower eating resulted in higher fullness after meal consumption, in contrast to the weak effect of the cooking methods on fullness. Thus, the eating approach of varying the meal duration should receive as much attention as cooking methods. More detailed studies on the nutritional and sensory properties of different foods are required to gain insight into the effect of various eating approaches and cooking methods.

## CONFLICT OF INTEREST

None of the authors have any conflicts of interest to declare.

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