Analysis of Kimchi, vegetable and fruit consumption trends among Korean adults: data from the Korea National Health and Nutrition Examination Survey (1998-2012)

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BACKGROUND/OBJECTIVES: The purpose of this study is to analyze daily kimchi, vegetable and fruit consumption by general characteristics and vegetable and fruit consumption from 1998 to 2012 by the Korean population based on the data of the KNHANES (Korea National Health and Nutrition Examination Survey).

SUBJECTS/METHODS: This study is based on the 1998-2012 KNHNES. Analysis data on 54,700 subjects aged 19 years and older were obtained from health behavior interviews and the 24-hour dietary recall method.

RESULTS: Daily kimchi consumption and portion size of kimchi decreased significantly from 1998 to 2012 (adjusted $P$ for trend < 0.0001). Meanwhile, daily consumption of both non-salted vegetable and fruit with and without kimchi did not significantly change between 1998 and 2012. Reduced consumption of kimchi, non-salted vegetable, and fruit was observed for both genders as well as daily meal episodes and cooking locations. Male and female subjects with insufficient non-salted vegetable and fruit intake were increased 1.4 times and 1.3 times, respectively, in 2012 than 1998. All subjects consumed at least 400 g/day of non-salted vegetable, fruit, and kimchi in each survey year, although they consumed insufficient amounts (< 400 g/day) of non-salted vegetable and fruit without kimchi.

CONCLUSIONS: Since Koreans generally consume high amounts of fermented vegetables, including kimchi, total vegetables and fruit. Consumption of these foods by the Korean adult population reached 400 g, which is the recommended intake of the WCRF/AICR. Based on this result, it is necessary to promote consumption of kimchi in the Korean population and research the development of low sodium kimchi in the future.

INTRODUCTION

Kimchi is a traditional Korean fermented food and basic side dish of the Korean diet. It was published in a famous health magazine that Kimchi is one of the five healthiest foods in the world [1]. Kimchi is made from various vegetables, red pepper, other spices, and fermented seafood and is rich in various vitamins, minerals, dietary fiber, and other biological components [2]. Moreover, the annual tradition Gimjang involves preparing and storing a large quantity of kimchi for the winter season [3]. Gimjang culture was registered in the Intangible Cultural Heritage of Humanity list of United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2013. This achievement can be used to draw international attention to Korean kimchi. Many studies have reported the beneficial effects of kimchi, including its anti-obesity [4], anti-asthma [5], anti-cancer [6], anti-oxidative [7], anti-atherosclerotic [8], and cholesterol-lowering effects [9].

Diets rich in vegetables and fruit are associated with healthy effects based on studies examining trends in vegetable intake [10-14] and effects on disease prevalence [15-17]. The World Health Organization (WHO) and World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) recommend at least 400 g of vegetable and fruit daily [18,19]. In Korea, the objectives of the National Health Plan 2020 included increasing vegetable and fruit intake up to 50% in Koreans, who already eat more than 500 g of vegetables and fruit per day [20]. Since kimchi is an important source of vegetable intake in Korea, assessing vegetable intake through changes in kimchi consumption is important.

Many researchers have reported the perception and preferences of consumers related to kimchi [21], development of kimchi and
menu items for school foodservice [22,23], physicochemical, sensory, and functional qualities of ingredients [24-31], and the functional properties of lactic acid bacteria from kimchi [1,32].

The Korea National Health and Nutrition Examination Survey (KNHANES) is used to obtain stratified, multistage probability data on Korean households. These data could reflect characteristics of the general Korean population. Studies on food intake based on KNHANES data have examined Korean dietary patterns [33], including consumption of rice and whole grains [34,35], eggs [36], beef and processed meat [37,38], ramen and noodles [39], and vegetables and fruit [14,40-42]. However, studies on average kimchi intake in the Korean population have never been performed other than to examine physicochemical, sensory, or preference characteristics using a convenient sampling method.

Therefore, the purpose of this study was to analyze daily kimchi consumption by general characteristics and vegetable and fruit consumption from 1998 to 2012 in the Korean population based on data from the KNHANES.

SUBJECTS AND METHODS

Study population

The study was based on the 1998-2012 KNHANES. Analysis data on 54,700 subjects (1998: n = 7,501, 2001: n = 7,092, 2005: n = 6,526, 2007: n = 2,939, 2008: n = 6,274, 2009: n = 6,974, 2010: n = 5,944, 2011: n = 5,884, 2012: n = 5,566) aged 19 years and older by using a health behavior interview and 24-hour dietary recall method were obtained. Individuals who ate less than 500 kcal or more than 5,000 kcal of daily total caloric intake were excluded to minimize any biases.

General characteristics

General characteristics of subjects included gender, age, marital status, residential area, occupation status, educational level, and household income. We classified subjects into 19 to 29, 30 to 49, 50 to 64, 65 to 74, and 75 years and older for age and low, middle-low, middle-high and high for household income, city and rural area for residential area.

Categorization of meal occasion and serving place

For analysis of meal occasion, we categorized meal occasion into breakfast, lunch, and dinner by using the daily meal (N_meal) in the 24-hour recall method. Cooking location was categorized into breakfast, lunch, and dinner by using the daily meal occasion (N_mtype). The study was based on data from the KNHANES.

RESULTS

General characteristics

General characteristics of subjects are presented in Table 1. Among the 54,700 subject study sample, 50.5-50.8% were women. For distribution of age, those aged 30-40 years constituted more than 40% of subjects by survey year, whereas those aged 75 years and over constituted the least number. Percentage of individuals with 12 years of education decreased from 39.5% in 1998 to 30.9% in 2012, whereas the percentage of those with 12 years of education and over constituted the least number. Percentage of individuals with 12 years of education decreased from 39.5% in 1998 to 30.9% in 2012, whereas the percentage of those with 12 years of education and over constituted the least number.
whereas the proportion of unemployed declined from 40.2% in 1998 to 36.7% in 2012. For household income level, the proportion of the low household income group decreased by approximately 4.0% from 18.7 to 14.7%. However, the proportion of the middle-high and high household income group did not significantly change from 1998 to 2012. The proportion of obese individuals increased from 22.6% in 1998 to 30.6% in 2012.

Daily consumption of kimchi by general characteristics

Daily mean consumption of kimchi by general characteristics from 1998 to 2012 is shown in Table 2. Daily mean consumption of kimchi decreased among all general characteristics (gender, age, residential area, marital status, job status, education level, and household income) from 1998 to 2012. The proportion of obese individuals increased from 22.6% in 1998 to 30.6% in 2012.

Table 1. The general characteristics of the subjects

|                | 1998 (n = 7,501) | 2001 (n = 7,092) | 2005 (n = 6,236) | 2007 (n = 2,939) | 2008 (n = 6,274) | 2009 (n = 6,974) | 2010 (n = 5,944) | 2011 (n = 5,884) | 2012 (n = 5,566) | P-value1) |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------|
| Gender         |                |                |                |                |                |                |                |                |                |             |
| Male           | 3,480          | 49.3           | 3,253          | 49.4           | 2,918          | 49.2           | 2,840          | 49.4           | 2,914          | 49.3        |
| Female         | 4,021          | 50.7           | 3,839          | 50.6           | 3,608          | 50.5           | 3,794          | 50.6           | 4,060          | 50.5        |
| Age (yrs)      |                |                |                |                |                |                |                |                |                |             |
| <19-29         | 1,550          | 26.7           | 1,370          | 25.5           | 1,045          | 22.2           | 331            | 20.8           | 763            | 20.5        |
| 20-49          | 3,327          | 45.6           | 3,406          | 45.9           | 3,025          | 46.2           | 1,205          | 45.4           | 2,511          | 46.6        |
| 50-64          | 1,650          | 18.0           | 1,400          | 18.2           | 1,452          | 19.6           | 692            | 20.8           | 1,542          | 21.5        |
| 65-74          | 682            | 8.5            | 626            | 7.1            | 719            | 8.1            | 501            | 8.6            | 979            | 8.7         |
| ≥75            | 291            | 3.2            | 290            | 3.3            | 285            | 3.0            | 210            | 4.5            | 479            | 4.7         |
| Average age    | 41.3 ± 0.3)    | 41.8 ± 0.3)    | 43.3 ± 0.3)    | 44.2 ± 0.6)    | 44.5 ± 0.4)    | 45.2 ± 0.4)    | 45.6 ± 0.5)    | 45.8 ± 0.4)    | 45.8 ± 0.4)    | <0.001      |
| Marital status |                |                |                |                |                |                |                |                |                |             |
| Married        | 6,299          | 79.2           | 5,902          | 77.8           | 5,450          | 77.5           | 2,372          | 84.0           | 5,473          | 80.0        |
| Single         | 1,202          | 20.8           | 1,189          | 22.2           | 1,069          | 22.5           | 323            | 16.0           | 765            | 20.0        |
| Residential area|              |                |                |                |                |                |                |                |                |             |
| City           | 4,750          | 78.8           | 5,529          | 80.5           | 5,145          | 81.5           | 2,124          | 79.7           | 4,736          | 84.0        |
| Rural area     | 2,751          | 21.2           | 1,563          | 19.5           | 1,381          | 18.5           | 815            | 20.3           | 1,538          | 16.0        |
| Job            |                |                |                |                |                |                |                |                |                |             |
| Employed       | 4,611          | 59.8           | 4,140          | 59.3           | 3,938          | 61.1           | 1,241          | 43.6           | 2,252          | 40.0        |
| Unemployed     | 2,890          | 40.2           | 2,950          | 40.7           | 2,583          | 38.9           | 1,241          | 43.6           | 2,252          | 40.0        |
| Education Level (yrs) |            |                |                |                |                |                |                |                |                |             |
| <12 yrs        | 3,232          | 34.5           | 2,400          | 31.4           | 2,223          | 28.8           | 1,094          | 30.5           | 2,458          | 29.8        |
| 12 yrs         | 2,606          | 39.1           | 2,524          | 37.5           | 2,244          | 35.5           | 750            | 32.6           | 1,684          | 31.1        |
| >12 yrs        | 1,663          | 26.4           | 2,160          | 31.1           | 2,056          | 35.7           | 760            | 36.9           | 1,777          | 39.1        |
| Household income|              |                |                |                |                |                |                |                |                |             |
| Low            | 1,684          | 18.7           | 1,435          | 21.5           | 1,412          | 19.3           | 616            | 16.5           | 1,305          | 15.6        |
| Middle-low     | 1,753          | 22.0           | 1,646          | 25.2           | 1,645          | 26.0           | 720            | 25.9           | 1,594          | 26.5        |
| Middle-high    | 2,149          | 30.7           | 1,660          | 25.8           | 1,731          | 28.2           | 712            | 28.4           | 1,571          | 28.2        |
| High           | 1,915          | 28.6           | 1,939          | 27.5           | 1,675          | 26.5           | 729            | 29.1           | 1,599          | 29.7        |

1) Weighted %
2) P-value by chi-square
3) P-value by one-way anova from proc surveymreg procedure of SAS
4) Mean ± SE
5) Different superscript letters mean significantly different between year and age group at α = 0.05 level by Tukey’s multiple comparison.

Daily consumption of kimchi by meal occasion and cooking location

Table 3 presents daily kimchi consumption by meal occasion and cooking location, daily consumption of kimchi, non-salted vegetable and fruit, and portion size of kimchi from 1998 to 2012. Daily kimchi consumption for unadjusted and adjusted energy and age decreased in 2012 compared to 1998 (P for trend < 0.05).

Daily consumption of non-salted vegetable and fruit did not significantly change from 1998 to 2012, whereas that of kimchi and non-salted vegetable and fruit reached more than 400 g, which is the recommended guideline of the WCRF/AICR. Portion size of kimchi for adjusted and unadjusted instances significantly decreased in 2012 compared to 1998. For daily kimchi
consumption by meal occasion, kimchi consumption at breakfast, lunch, and dinner also decreased in 2012 compared to 1998. Specifically, kimchi consumption at breakfast for adjusted and unadjusted instances significantly decreased (P for trend < 0.0001), and that at dinner for the adjusted instance significantly decreased in 2012 compared to 1998 (P for trend = 0.0021). Daily kimchi consumption of snacks increased in 2012 compared to 1998, whereas that for adjusted and unadjusted instances significantly decreased (P for trend < 0.0001). For females, daily kimchi consumption also significantly

### Table 2. Daily kimchi consumption of general characteristics by year

| Year       | Gender     | Mean (n=7,501) | SE | Mean (n=7,092) | SE | Mean (n=6,526) | SE | Mean (n=2,939) | SE | Mean (n=6,274) | SE | Mean (n=6,974) | SE | Mean (n=5,944) | SE | Mean (n=5,566) | SE |
|------------|------------|---------------|----|---------------|----|---------------|----|---------------|----|---------------|----|---------------|----|---------------|----|---------------|----|
| Daily      | Male       | 154.1         | 3.6| 133.3         | 2.9| 119.4         | 2.7| 155.5         | 5.8| 156.1         | 3.8| 158.4         | 3.9| 154.1         | 3.9| 152.9         | 4.4| 136.3         | 4.2|
|            | Female     | 121.9         | 2.7| 122.4         | 2.8| 102.0         | 2.3| 110.1         | 4.2| 115.6         | 2.6| 111.9         | 2.7| 106.9         | 2.8| 103.8         | 2.6| 88.8          | 2.2|

### Table 4 presents daily kimchi consumption according to food intake, meal occasion, and cooking location by gender

Daily kimchi consumption according to food intake, meal occasion, and cooking location by gender

Table 4 presents daily kimchi consumption according to food intake (kimchi, non-salted vegetable and fruit, non-salted vegetable, fruit, and kimchi, and kimchi portion size), meal occasion, and cooking location by gender. For males, daily kimchi consumption significantly decreased in 2012 compared to 1998 for adjusted and unadjusted instances (P for trend < 0.05). Daily consumption of non-salted vegetable, fruit, and kimchi reached more than 400 g, which is recommended by the WCRF/AICR from 1998 to 2012, whereas daily consumption of non-salted vegetable and fruit did not significantly change in 2012 compared to 1998. Daily kimchi consumption at breakfast, lunch, and dinner decreased in 2012 compared to 1998 for both adjusted and unadjusted instances, whereas daily kimchi consumption of snacks significantly increased in 2012 compared to 1998 for both instances (P for trend < 0.0001). Daily kimchi consumption at home significantly decreased (P for trend < 0.0001), whereas that at commercial locations significantly increased in 2012 compared to 1998 for both instances (P for trend < 0.0001).

For females, daily kimchi consumption also significantly
For age and energy intakes, the proportion of subjects with insufficient intake of non-salted vegetable and fruit showed no significant difference in 2012 compared to 1998. Meanwhile, the proportion of females with insufficient intake of non-salted vegetable and fruit except kimchi increased more than 1.3 times in 2012 compared to 1998 after adjustment for age and energy intake (P for trend < 0.0001). The proportion of females with insufficient intake of kimchi increased approximately 2-fold in 2012 compared to 1998 after adjustment for age and energy intake (P for trend < 0.0001).

The proportion of subjects with insufficient intake of non-salted vegetable and fruit except kimchi increased more than 1.1 times in 2011 and 1.2 times in 2012 compared to 1998 (P for trend < 0.0001). After adjustment for age and energy intake, the proportion increased more than 1.3 times in 2012 compared to 1998 for both instances (P for trend < 0.0001). The proportion of males with insufficient intake of non-salted vegetable and fruit except kimchi showed no significant difference between 1998 and 2012 but increased 1.4 times in 2012 after adjustment for age and energy intake (P for trend < 0.0001).

For subjects with insufficient intake of non-salted vegetable, fruit, and kimchi, all subjects showed no significant differences between 1998 and 2012. After adjustment for age and energy intake, it is shown that subjects with insufficient intake of
Table 4. Kimchi, vegetable, and fruit intake by year

| Year | Kimchi intake | Non-salted vegetable + fruit intake | Non-salted vegetable + fruit + kimchi intake |
|------|---------------|------------------------------------|---------------------------------------------|
| 1998 | 154.1±3.6     | 352.2±8.4                          | 506.2±8.9                                   |
| 2001 | 133.3±2.9     | 357.9±8.5                          | 491.2±7.3                                   |
| 2005 | 119.4±2.7     | 357.2±12.9                         | 409.9±7.4                                   |
| 2007 | 155.5±5.8     | 357.5±10.1                         | 513.6±10.7                                  |
| 2009 | 154.1±3.9     | 357.5±10.1                         | 513.6±10.7                                  |
| 2010 | 152.9±4.4     | 357.5±10.1                         | 513.6±10.7                                  |
| 2011 | 158.4±3.8     | 357.5±10.1                         | 513.6±10.7                                  |
| 2012 | 154.1±3.9     | 357.5±10.1                         | 513.6±10.7                                  |

| Year | Daily meal size | Cooking location | Kimchi's portion size |
|------|-----------------|------------------|-----------------------|
| 1998 | 51.4±1.6        | 123.7±3.3        | 51.2±1.0              |
| 2001 | 42.0±1.4        | 22.6±1.3         | 40.2±0.7              |
| 2005 | 34.0±1.1        | 211.9±1.1        | 37.0±0.7              |
| 2007 | 34.0±1.1        | 211.9±1.1        | 37.0±0.7              |
| 2009 | 34.0±1.1        | 211.9±1.1        | 37.0±0.7              |
| 2010 | 34.0±1.1        | 211.9±1.1        | 37.0±0.7              |
| 2011 | 34.0±1.1        | 211.9±1.1        | 37.0±0.7              |
| 2012 | 34.0±1.1        | 211.9±1.1        | 37.0±0.7              |

1) Adjusted for age & energy intake
2) P-value by chi-square test
non-salted vegetable, fruit, and kimchi increase 1.1 times in 2012 among total subjects (P for trend = 0.0017) and 1.2 times in 2012 among males (P for trend < 0.0001) compared to 1998, whereas those of females showed no difference between 1998 and 2012.

**DISCUSSION**

This study shows trends in consumption of kimchi, vegetable, and fruit among Korean adults using data from the KNHANES from 1998 to 2012. Daily kimchi consumption and portion size of kimchi decreased significantly from 1998 to 2012 (adjusted P for trend < 0.0001). Meanwhile, daily consumption of both non-salted vegetable and fruit with and without kimchi did not significantly change between 1998 and 2012. Reduced consumption of kimchi was observed for both genders as well as daily meal episodes and cooking locations. All subjects consumed at least 400 g/day of non-salted vegetable, fruit, and kimchi in each survey year, although they consumed insufficient amounts (< 400 g/day) of non-salted vegetable and fruit without kimchi.

According to general characteristics of subjects (gender, age, residential area, marital status, job, educational level, and household income), daily mean consumption of kimchi tended to decrease from 1998 to 2012. In particular, women aged 19 to 29 years showed significantly decreased daily mean consumption of kimchi (P = 0.0017) and 1.2 times in 2012 compared to 1998, whereas those of males showed no difference between 1998 and 2012.

**Table 5. Odds ratio(CI) of insufficient kimchi, fruit and vegetable intake by years**

|                | 1998 | 2001 | 2005 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | P for trend |
|----------------|------|------|------|------|------|------|------|------|------|------------|
| Insufficient kimchi intake |      |      |      |      |      |      |      |      |      | < 0.0001   |
| (< 40 g/day) | 1.256 | 1.600 | 1.066 | 1.064 | 1.205 | 1.276 | 1.401 | 1.648 |     |            |
| Adjusted(1)  | 1.254 | 1.683 | 1.052 | 1.070 | 1.227 | 1.397 | 1.536 | 1.780 |     | < 0.0001   |
| Insufficient non-salted vegetable + fruit + kimchi (< 400 g/day) |      |      |      |      |      |      |      |      |      |            |
| Adjusted(1)  | 0.932 | 1.834 | 1.129 | 1.167 | 1.141 | 0.999 | 1.128 | 1.059 |     | 0.4185     |
| Insufficient non-salted vegetable + fruit (< 400 g/day) |      |      |      |      |      |      |      |      |      | < 0.0001   |
| Adjusted(1)  | 0.911 | 2.031 | 1.078 | 1.155 | 1.150 | 1.122 | 1.283 | 1.147 |     | 0.0017     |
| Insufficient non-salted vegetable + fruit (< 400 g/day) |      |      |      |      |      |      |      |      |      | < 0.0001   |
| Adjusted(1)  | 0.951 | 1.702 | 1.104 | 1.143 | 1.133 | 1.031 | 1.156 | 1.223 |     | 0.0098     |

1) Adjusted for age & energy intake
This change in daily dietary patterns is positively associated with a general decline in daily kimchi consumption among young adults. Regarding kimchi consumption by educational level, subjects with <12 years of education showed significantly decreased from kimchi consumption 1998 to 2012 (unadjusted \( P \) trend = 0.0012, Adjusted \( P \) trend = 0.0018). Hong et al. [40] reported that kimchi intake by the low-educational group increased, whereas vegetable and fruit consumption except kimchi gradually decreased. Education may affect knowledge of good nutrition and appropriate food choices. On the other hand, kimchi is a traditional Korean side dish and easy to afford and access as a main dish for general Koreans.

The WHO and WCRF/AICF recommend no less than 400 g of fruit and non-starch vegetable every day [18,19]. However, insufficient kimchi (< 40 g/day) and fruit and non-salted vegetable (< 400 g/day) intake in subjects ratio significantly increased from 1998 to 2012 (\( P < 0.0001 \)). Lee et al. [41] reported that only 5.3% of subjects satisfied the recommended intake of vegetables and fruit in the 2008 KNHINES. Especially, consumption rates of adolescents aged 13 to 18 years and adults aged 19 to 39 years were shown to decrease compared to other aged groups.

Kwon et al. [44] reported 25.7% of Koreans satisfy the recommended vegetable and fruit intake of 400 g/day. It was reported that 33% and 27% of American adults satisfy the recommended intake of vegetable and fruit, respectively, by the Centers for Disease Control and Prevention (CDC) [47]. Many studies have suggested that vegetable and fruit intake can prevent chronic diseases such as cancer, diabetes, and cardiovascular disease since they contain essential vitamins, minerals, fiber, and biological compounds [6,10,11,13-15]. Therefore, sufficient intake of vegetables and fruit is very important to maintain health.

For kimchi consumption of subjects by meal occasion, kimchi consumption at breakfast decreased significantly from 1998 to 2012 (Unadjusted \( P \) trend < 0.0001, Adjusted \( P \) trend < 0.0001). This can be attributed to skipping or eating a light breakfast. Kwon & Ju [43] reported that proportions of skipping breakfast increased from 11.8% in 1998 to 22.3% in 2012 among Korean adults based on the KNHINES from 1998 to 2012. Regarding cooking location, daily kimchi, vegetable and fruit consumption of commercial and institutional places were increased significantly (unadjusted \( P \) trend < 0.0001, Adjusted \( P \) trend < 0.0001). This result can be attributed to a 2-fold increase in eating-out from 21.4% in 1990 to 46.6% in 2011 among Koreans [43]. The Korea Institute for Health and Social Affairs reported that approximately 25% of Korean people regularly eat meals provided by institutional foodservice, such as school, industry, office, hospital, military, and welfare facilities, at least once a day [48]. This result is closely associated with reduced kimchi consumption at breakfast, which is usually eaten at home. Therefore, kimchi consumption is increased when meals are consumed at commercial or institutional places.

Regarding daily kimchi consumption by gender, both male and female subjects showed significantly decreased kimchi consumption between 1998 and 2012 (Adjusted \( P \) trend < 0.0001). In particular, kimchi consumption by females decreased more than 2-fold from 1998 to 2012 (\( P \) for trend < 0.0001). Daily consumption of non-salted vegetable, fruits, and kimchi by both genders reached more than 400 g as recommended by the WCRF/AICR from 1998 to 2012. Male and female subjects with insufficient non-salted vegetable and fruit intake were increased 1.4 times and 1.3 times, respectively, in 2012 than 1998. Based on this result, it is necessary to promote consumption of kimchi among the Korean population and research the development of low sodium kimchi in the future.

This study has some limitations. First, this study may not be extrapolated to the general Korean population since it excluded children and adolescents. Second, it is difficult to measure general kimchi consumption due to the convenient sampling survey of the one day 24-hour recall method, food intake frequency, and within-person variation. Lastly, since many studies have shown that kimchi contains a high amount of sodium, it is necessary to investigate excellence and improvement of kimchi based on objective data and experiments by analyzing the relationship between kimchi intake and sodium-associated diseases.

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