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To cite this article: Probo Y. Nugrahedi, Inneke Hantoro, Ruud Verkerk, Matthijs Dekker & Bea Steenbekkers (2015) Practices and health perception of preparation of Brassica vegetables: translating survey data to technological and nutritional implications, International Journal of Food Sciences and Nutrition, 66:6, 633-641

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Int J Food Sci Nutr, 2015; 66(6): 633–641
 DOI: 10.3109/09637486.2015.1064868

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FOOD COMPOSITION AND ANALYSIS

Practices and health perception of preparation of *Brassica* vegetables: translating survey data to technological and nutritional implications

Probo Y. Nugrahedi[1,2], Inneke Hantoro[2], Ruud Verkerk[1], Matthijs Dekker[1], and Bea Steenbekkers[1]

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Abstract

Food preparation practices are known to have large nutritional implications on the final product. This article describes survey data on preparation practices of *Brassica* vegetables and the translation of these data into technological and nutritional implications using knowledge on the mechanisms of changes in the content of phytochemicals. The survey on preparation practices was performed with food service establishments ($n = 123$) and households ($n = 477$) in Semarang, Indonesia, and assessed the food handlers' perception of the health benefits of these vegetables. Boiling and stir-frying are the most frequently applied techniques to prepare *Brassicas*. The respondents perceive that steaming, boiling, and stir-frying result in vegetables with a high health benefit. White cabbage and choysum are the most frequently prepared *Brassicas*. However, broccoli is perceived as the healthiest. The consequences of the various applied preparation techniques on the content of alleged health promoting phytochemicals (glucosinolates) in dishes containing *Brassica* vegetables are discussed.

Keywords

Brassica vegetables, food service establishment, household, preparation practices

History

Received 7 January 2015
Revised 22 May 2015
Accepted 26 May 2015
Published online 14 July 2015

Introduction

Previous studies reported the substantial contribution of fruit and vegetable consumption toward promoting health (Bazzano et al., 2002; Dauchet et al., 2006; Liu, 2003). In particular, intake of *Brassica* vegetables, such as broccoli, cabbages, Brussels sprouts, and cauliflower, are inversely associated with the risk of certain types of cancer and cardiovascular diseases (Herr & Büchler, 2010; Higdon et al., 2007; Soengas et al., 2011).

Vegetables are usually prepared into various dishes and are consumed on a daily basis. Food preparation techniques, particularly that involving heat aim to inactivate pathogens, to increase sensorial liking and digestibility, and other beneficial changes, but it can also lead to negative impacts, such as loss of certain (micro)nutrients and phytochemicals, formation of toxic compounds or of compounds with negative effects on sensorial perception (van Boekel et al., 2010). Previous studies reported that different preparation techniques performed on *Brassica* vegetables could diversely affect the sensorial acceptance (Poelman & Delahunty, 2011; Poelman et al., 2012) and unfortunately, decrease the content of health promoting compounds, such as glucosinolates, vitamin C and polyphenols (Bongoni et al., 2013, 2014c; Miglio et al., 2007; Pellegrini et al., 2010).

Preparation of food is one of the activities individuals or groups perform regarding food. Previous studies described that various factors influence the association between food preparation and consumers' health (Gittelsohn et al., 1998; Larson et al., 2006; West et al., 1999). Others reported the relationship between food preparation behavior of the food handlers and food safety, particularly related to food borne illnesses (Green & Selman, 2005; Green et al., 2005; Woodburn & Raab, 1997). However, to our knowledge the documentation on practices of vegetable preparation and the food handlers' perception on health are still scarce.

This article describes *Brassica* vegetable preparation techniques performed by food handlers in food service establishments and households. The respondents' health perception of both the vegetables and the preparation techniques is also presented. Since the popularity of eating out of home is becoming more widespread in Asian countries, the role of food service establishments in providing daily meals to people is inevitably important. Nevertheless, the family still plays a vital role in providing the meals at home. *Brassica* vegetables were chosen in this study because these are commonly prepared by many food service establishments and families in Asia. Furthermore, these vegetables share common health promoting compounds, namely glucosinolates, found almost exclusively in the *Brassicaceae* family. The information on preparation practices of *Brassica* vegetables gathered in this survey is integrated with knowledge on the mechanisms of changes in the content of glucosinolates (Nugrahedi et al., 2015) for identifying the technological and nutritional implications. Thus, the translation of the preparation techniques in the survey to nutritional implication will be limited to the glucosinolate changes.

Methods

A questionnaire was designed, consisting of questions on the type of *Brassica* vegetables most frequently prepared, the type of preparation techniques most frequently applied on the *Brassica*

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vegetables, the name of the dishes prepared from the vegetables and the perception on the health benefit of the vegetables as well as of the preparation techniques. The survey was conducted in Semarang city, the capital of Central Java province, Indonesia from March 2010 to January 2011. Two groups of respondents were included, namely food handlers in food service establishments and in households. The data collection was divided into two parts. In Part I, the respondents were given a short questionnaire on *Brassica* vegetable preparation and the respondents' willingness to participate in the second part of survey was asked. In Part II, more detailed questions were asked. Results from both parts are used in this study.

Since the target population of the survey has no habit of making appointments, respondents were randomly visited in the food service establishments or at home by the interviewer and asked for his/her willingness to be involved in the research. An individual interview was performed by using the questionnaire, where in general the interviewer registered the responses. Some respondents however, preferred to fill in the questionnaire by themselves under supervision of the interviewer. The questionnaire consists of both closed and open questions. For some closed questions, an option was given to fill in other answers than the provided ones. For some questions, different types of answering categories were used for the food service establishments and the households, i.e. ranking and multiple choice types, respectively. The data were tabulated and descriptively analyzed using Excel office.

In order to assure that respondents know the types of *Brassica* vegetables, the vegetables were described or shown on a picture to the respondent prior to the interview. Furthermore, the respondents were informed that non-*Brassica* vegetables, such as spinach, water spinach, lettuce, papaya leaf, cassava leaf and celery, are not part of the questionnaire.

Food service establishments

The food service establishments were categorized into three subgroups, namely restaurants, permanent vendors and non-permanent street vendors. Another type of food service establishment, i.e. catering, was excluded from the sample. A food service establishment is categorized as a restaurant when it has a permanent building (sometimes it has a sign ''restaurant'' at the building), it has more facilities than other food service establishments and can be a part of a hotel. The dishes are mostly freshly prepared and various dishes are available, although several of these restaurants also serve already prepared dishes. A ''freshly prepared dish'' is prepared after being ordered by the customer, while an ''already prepared dish'' was prepared earlier and displayed in a way that the customer can see the available dishes and choose what to buy. A permanent vendor is located in a permanent building and the dishes served are mostly already prepared, although some of them also serve freshly prepared dishes. The types of dishes are less varied than in a restaurant. A permanent vendor often has better access to water than a non-permanent vendor, and can be a part of a canteen or food-stalls center. A non-permanent street vendor is located in a non-permanent stall nearby the street, mostly tent type. The dishes served are mostly freshly prepared, although some of them also have already prepared ones.

For the food service establishments, Part I of the survey was carried out among 40 respondents divided over the three subgroups. Subsequently, Part II of the survey was performed involving 123 respondents, consisting of 13, 70 and 40 respondents in the restaurant, permanent vendor and non-permanent street vendor groups, respectively. All respondents of Part I were also involved in Part II of the survey. The participating food service establishments are mainly located at or nearby the city center, campuses, main streets or dense settlements.

Households

Part I of the survey for the households involved 200 respondents coming from four areas in Semarang city, i.e. Tlogosari, Ngaliyan, Gabahan and Patemon, in which each area was represented by 50 respondents. The subsequent survey (Part II) was also conducted in these areas involving 477 respondents and comprised of 136, 106, 115 and 120 respondents from those areas, respectively. Out of the former 200 respondents, 71 respondents were involved in the subsequent survey.

Types of preparation technique

Various techniques can be performed to prepare *Brassica* vegetables. In each preparation and type of dish there are also various, yet subtle, differences among food handlers in both food service establishments and households. Therefore, the description of preparation techniques, such as time and temperature, cutting size of the vegetable, and the amount of added water, if any, or the ratio of water to vegetable, are not documented in details. Preparation in this study refers to the method or technique applied to process the raw *Brassica* vegetable into a dish. This excludes the preparation of the ingredients prior to cooking, such as washing, grinding, cutting, or chopping. Furthermore, the dish itself is defined as the product of vegetables, including *Brassica* (and other ingredients) after preparation. The non-vegetable based products accompanied with a small amount of *Brassica* vegetable to make a complete dish were also included here. Since white cabbage is also eaten raw as part of a dish, this is considered a dish as well. Except for blanching and steaming, the vegetable preparation usually involves adding spices and seasonings, e.g. garlic, onion, shallot, hot chili, salt, sugar, pepper, sauce and ketchup. The vegetables can also be prepared together with other ingredients such as meat, seafood and other types of (non-*Brassica*) vegetables.

Boiling is putting the vegetable into either hot or boiling water for some time and it is usually eaten as a soup, including the water. Stir-frying is performed as a few minutes frying the vegetable into a small amount of hot cooking oil with regular manually stirring. Depending on the type of dish or vegetable and the amount of moisture released from the vegetable, a small amount of water or thickener (e.g. maize solution) can be added during stir-frying. Frying is performed by cooking the vegetable or batter-coated vegetable in a larger amount of hot oil than used for stir-frying. Steaming is employed by putting the vegetable in steam from a boiling water source. For the context of the current survey, blanching is defined as very light boiling or immersing the vegetable in- or pouring with- boiling or hot water for a short time. The blanching water is usually not used as part of the dish. Other techniques, such as microwave cooking and baking are relatively uncommon in Indonesia for preparing vegetables. Another type of preparation commonly performed on *Brassica* vegetables is fermentation. Fermentation is usually employed by the food service establishments in the production of *sayur asin* made from Indian mustard (*Brassica juncea*) (Puspito & Fleet, 1985). However, this was not included in the survey because the *sayur asin* is commonly further prepared (e.g. by boiling to make soup).

Statistical analysis

A descriptive analysis of the data was performed by using Microsoft Excel to calculate frequency distributions.

Nutritional implication of preparation techniques used

The nutritional implications of the used preparation techniques will depend on the exact conditions applied. Although the survey information does not provide this information in detail, the expected changes in phytochemical (glucosinolate) intake are discussed by considering the general effects of the preparation techniques on various possible mechanisms for loss as described by Nugrahedi et al. (2015), namely, cell lysis, leaching, enzymatic inactivation and thermal degradation.

Results

Food service establishments

Characteristics of respondents

Table 1 presents the characteristics of the food service establishment respondents in the study. The majority of the respondents (63%) are the chefs or cooks (including combined chefs or cooks and owners) and 24% are owners of the establishment. Although the owners are usually not the food handlers, they play a significant role regarding the policy and the mode of operation of the food service establishment. In 55% of the food service establishments, the dishes involving *Brassica* vegetables are freshly prepared and in 33% of the food service establishments already prepared dishes are served. The rest of the food service establishments prepare both types of dishes. The majority of the respondents (89%) purchase raw vegetables every day and the rest every 2 days.

Table 1. Characteristics of the food service establishment respondents in the study ($n = 123$).

	N (%)
Status	
Owner	30 (24)
Chef or cook	8 (7)
Owner and Chef or cook	69 (56)
Others (e.g. manager, supervisor and servant)	16 (13)
Gender	
Female	60 (49)
Male	63 (51)

Types of Brassica *vegetables used*

The respondents were asked to rank seven commonly available types of *Brassica* vegetables according to the frequency of preparation. Figure 1 shows the distribution of this ranking and the number of respondents per rank. The decreasing number of respondents implies that not all vegetables are prepared by all food service establishments. White cabbage is the most frequently prepared *Brassica* followed by choysum. These vegetables are ranked as number 1 by 56 and 32% of the total number of respondents, respectively. Beside Chinese cabbage, these vegetables are also dominant at the second rank (23 and 33% respectively, of 78 respondents). Less frequently prepared *Brassicas* are broccoli and cauliflower. Chinese kale and pakchoy are the least frequently prepared *Brassica* vegetables in the food service establishments.

Preparation techniques

The distribution of the ranking on the techniques commonly performed by the food service establishments to prepare *Brassica* vegetables is shown in Figure 2. Clearly, boiling is the most dominant technique to prepare *Brassica* vegetables and ranked first by ~58% of the total 123 respondents, followed by stir-frying (~25%) at the first rank. These are also the most dominant techniques at the second rank, i.e. 31 and 54% of the 74 respondents, respectively. Meanwhile, blanching, steaming and other techniques (in this case mainly frying) are less frequently employed.

Type of prepared dishes

Various dishes containing *Brassica* vegetables are prepared by the food service establishments (Table 2). White cabbage followed by choysum are prepared into a larger variety of dishes than other vegetables, particularly to accompany the non-vegetable based dishes, e.g. any type of noodles (*mi*, *kwetiau*, *ifumi*), fried rice (*nasi goreng*) or meatball and dumpling soup (*bakso*, *pangsit*). A lower number of dishes are prepared from Chinese cabbage and cauliflower while Chinese kale, broccoli and pakchoy are used only in some dishes. These all *Brassica*-containing dishes are prepared with other ingredients and mainly consumed as a side dish for rice.

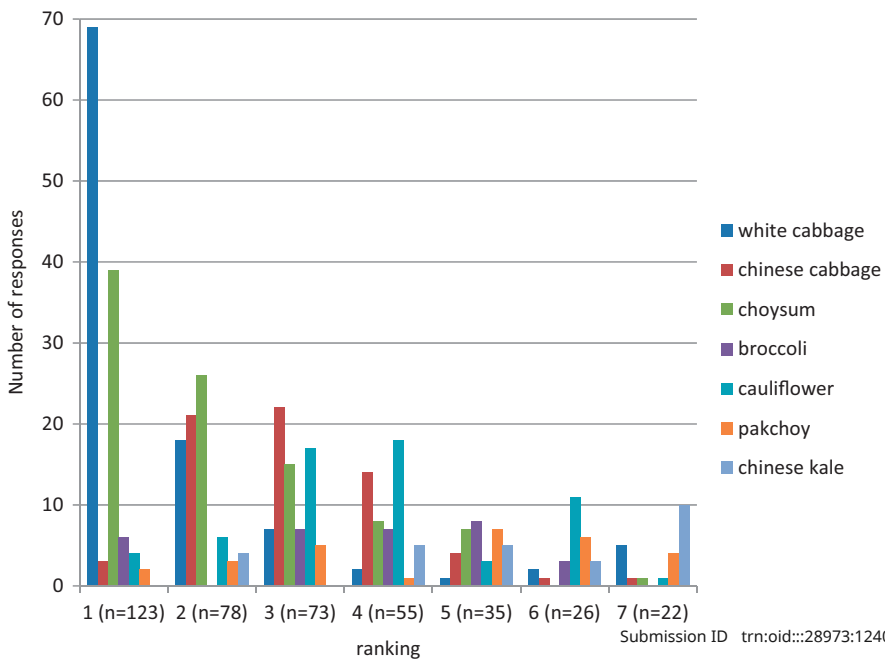


Figure 1. Ranking distribution of the frequency of *Brassica* vegetables prepared by food service establishments (rank 1 = the most- to rank 7 = the least frequently prepared; number of respondents for each rank is shown between brackets).

Int J Food Sci Nutr, 2015; 66(6): 633–641
Submission ID trn:oid:::28973:124071370

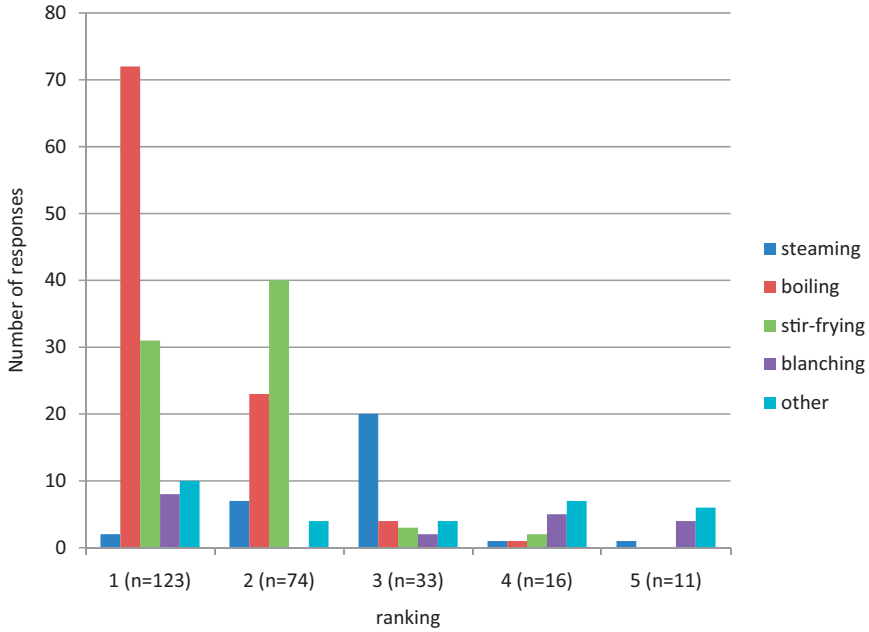


Figure 2. Ranking distribution of the frequency of preparation techniques performed by food service establishments (rank 1 = the most- to 5 = the least frequently applied; number of respondents of each ranking is shown between brackets).

Table 2. Dish variety and number of respondents from food service establishments ($n = 123$) that mention the respective *Brassica* vegetable as a commonly used ingredient for the dish and its preparation technique.

Vegetable based dishes	Commonly applied technique	Number of vegetables	White cabbage	Choysum	Chinese cabbage	Broccoli	Cauliflower	Chinese kale	Pakchoy
Cap cay (chop suey)	Stir-fry/boil	Mix	42	44	37		33	2	
Sup (soup)	Boil	Single or mix	55	6	10	3	51	1	1
Caltumis/oseng	Stir-fry	Single or mix	2	18	34	22	2	18	20
Lalapan	Raw/boil	Single or mix	24			1			
Pecel; *gado-gado*	Boil/blanch	Mix	15	1	1				
Orak arik	Stir-fry	Single or mix	9		1		1		
Sayur asam (tamarind vegetable soup)	Boil	Mix	3						
Gudangan; *urap*	Boil/blanch	Mix	2						
Non-vegetable based dishes									
Mi, *kwetiau*, & *ifumi* (noodles)	Boil/stir-fry/blanch	Single or mix	53	77			1		
Bihun (rice vermicelli)	Stir-fry/boil	Single or mix	11	12					
Bakso & *pangsit* (meatball & dumpling)	Boil	Single		13					
Bakwan	Fry	Single or mix	9						
Tahu isi	Fry	Mix	5						
Siomay (kind of dim sum)	Boil and steam	Single	4						
Tahu campur; *tahu gimbal*	Fry	Single	3						
Nasi goreng (fried rice)	Raw	Single	3						

The dishes and the preparation techniques are briefly described in the following paragraph, while the details can be found elsewhere (e.g. Brissenden, 2003 and many recipe books). The *cap cay* (chop suey) dish is prepared by stir-frying a mixture of various vegetables, including *Brassicas*, and other ingredients, with or without small amount of water added during preparation. Some amount of water, at up to three times higher volume than the solid, can also be added followed by boiling to produce the *cap cay* soup. The preparation of the vegetables can take for 3–15 min at boiling water temperature or higher temperature of stir-frying. Meanwhile, *sup* (soup) is the dish prepared by boiling one type of *Brassica* or a mixture of vegetables and other ingredients in boiling water. The boiling time for the vegetable can take for ~5–15 min and the ratio of the vegetable and other ingredients to the water varied from ~1:3–1:5. *Sayur asam* (tamarind vegetable soup) can also be categorized as soup. The *ca*, *tumis* or *oseng-oseng* dish is a dish prepared by stir-frying either a single *Brassica* or a mix of vegetables, and other ingredients in high temperature of cooking oil heated by a (high pressure) gas burner for 2–5 min. During stir-frying, some amount of water, at about half to one volume of the solid, can also be added followed by boiling. Differences in ingredients or spices may determine the variety of the dish names. Nevertheless, many respondents use the terms interchangeably. *Lalapan* is a kind of salad, mostly comprised of sliced raw white cabbage and other ingredients, such as tomato, cucumber and lemon basil, and usually be served with chili sauce. The *lalapan* is a complementary dish, served together with a main dish, e.g. fried chicken, fried fish, fried rice and satay. *Pecel* and *gado-gado* contain a mixture of light boiled or blanched vegetables, which are prepared for ~2–5 min, plus other ingredients dressed with peanut sauce. The difference between these dishes is the variety of ingredients and sometimes the sauce. *Gudangan* or *urap* is also a mixture of lightly boiled or blanched vegetables, including white cabbage, dressed or mixed with roasted or stir-fried shredded coconut and a spices mixture. *Orak-arik* is a mixture of stir-fried white cabbage and egg, prepared at

Figure 3. Frequency distribution of the scores on perceived health benefit per *Brassica* vegetable ($n = 123$, rating from 1 = very high- to 5 = very low in health benefit) by respondents from food service establishments.

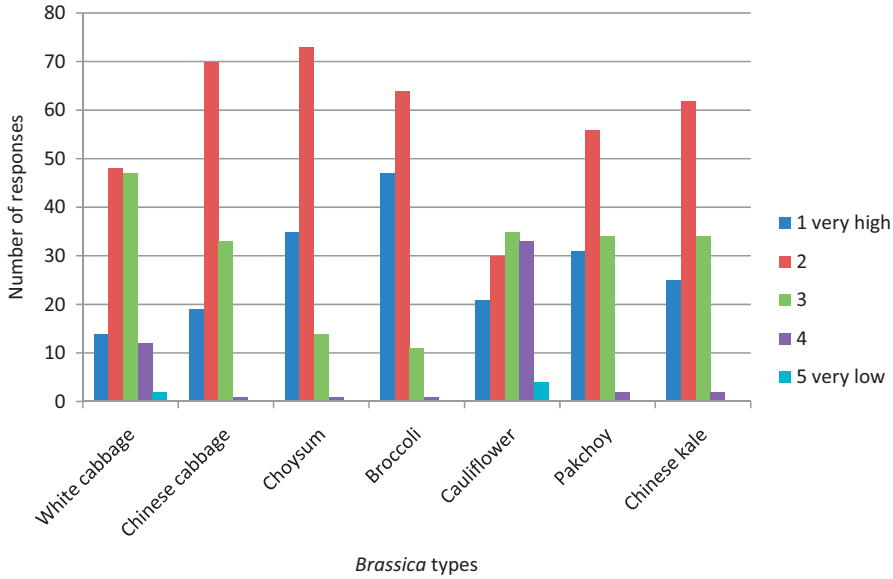
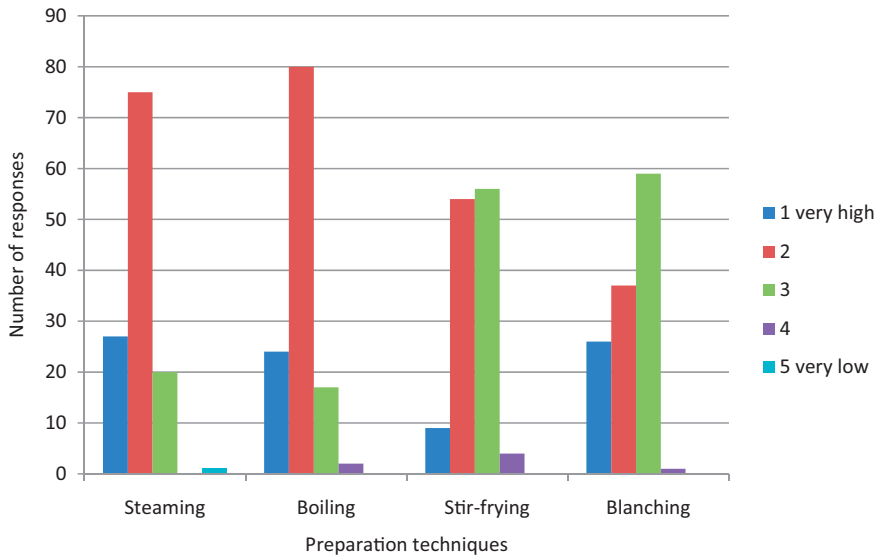


Figure 4. Frequency distribution of the scores on perceived health benefit by food service establishments per preparation technique ($n = 123$, rating from 1 = very high- to 5 = very low in health benefit).



very high temperature for few minutes. Other vegetables and ingredients can also be included. Furthermore, *Brassica* vegetables are also served as minor part of main dishes, such as any types of noodles, vermicelli, snacks (*bakwan*, *tahu isi*), meatball soup, etc. The vegetables can be prepared together with or separately from the main ingredients.

Perception on health

Out of 123 respondents, 41% agree with the statement that preparation can reduce the health benefit of the *Brassica* vegetables. Another 26% of the respondents disagree and the rest (33%) does not know. Figure 3 presents the frequency distributions of the scores on perceived health benefit of consuming some specific *Brassica* vegetables. Broccoli is perceived as the most health-beneficial *Brassica* (38% gave Score 1) followed by choysum (28.5% gave Score 1), and pakchoy (25% gave Score 1). Respondents perceived Chinese kale and Chinese cabbage lower in health benefit, i.e. 20 and 15% gave Score 1, respectively. Moreover, higher number of respondents gave Score 2 (high health benefit) than Score 1 (very high health benefit). About half number of respondents gave Score 2 for broccoli, choysum, Chinese cabbage, Chinese kale, and pakchoy, i.e. 52, 59, 57, 50, and 46% of the respondents, respectively. *Brassicas* perceived lowest in health benefit are cauliflower and white cabbage.

The frequency distribution of the scores on perceived health benefit of the techniques to prepare *Brassica* vegetables by food service establishment respondents is shown in Figure 4. Steaming, boiling and blanching are perceived to have the highest health benefit, i.e. 22, 19.5 and 21% of the respondents give Score 1, respectively. Steaming and boiling are also dominant at Score 2, accounting for 61 and 65% of the respondents, respectively. Blanching and stir-frying receive lower scores (30 and 44% gave Score 2 and 48 and 46% gave Score 3, respectively) and are thus perceived to have less health benefit.

Households

Characteristics of respondents

The majority of the household respondents in both Part I ($n = 200$) and Part II ($n = 477$) of the survey is female and about half of all respondents are housewives (Table 3). Furthermore, results from Part I of the survey show that 33% out of 200 respondents prepared and consumed *Brassica*

vegetables daily in the week prior to the interview. Meanwhile, 27.5 and 22% of the respondents prepared and consumed *Brassicas* three or two times in that week, respectively.

About 85% of the respondents said that the mother is the one who buys and prepares the vegetables. The vegetables are mostly prepared as fresh as possible. Most of the respondents (89%) buy the vegetable in the morning and 71% of the respondents prepare it during that morning, while 18% prepare the vegetable at noon of the same day. In addition, 44% of the respondents buy the raw vegetables from a traditional market nearby the settlement, 34 and 17% of them buy them from mobile or nearby permanent vendors, respectively, and 5% from a supermarket.

Types of frequently prepared Brassica *vegetables*

The results of Part I of the survey show that choysum is the most frequently prepared vegetable among the *Brassicas* (Figure 5). At the first and second rank choysum is chosen by 28 and 26% of the 200 and 198 respondents, respectively. Secondly, cauliflower is dominant, accounting for 23 and 25% of the respondents at the first and second rank, respectively, followed by Chinese cabbage. Compared to the food service establishments, white cabbage gets a much lower rank for frequency of preparing *Brassicas*, i.e. 12–13.5% of the respondents ranked it first to third. Subsequently, at lower frequency of preparation are broccoli and pakchoy, followed by Chinese kale as the least frequently prepared *Brassica* in the participating households.

Table 3. Characteristics of the household respondents in Part I and Part II of the study.

Part	I	II
Gender (%)		
Female	85	93
Male	15	7
Age (%)		
20–30	21	17
31–40	23	22
41–50	24	35
51–60	24	20
>60	8	6
Occupation (%)		
Housewife	52	59
Self-employee	24	21
Private-employee	10	9
State-employee	2	6
Others	12	5

Preparation techniques

The 477 household respondents of Part II of the survey were asked which preparation technique they employed most frequently. Stir-frying is the most frequently applied technique, accounting for 59% of the total responses, followed by boiling (38%). Steaming is hardly employed while blanching and frying are never chosen by the respondents as the most frequently applied technique to prepare *Brassica* vegetables.

Perception on health

The perception of household respondents on the health benefit of consuming *Brassica* vegetables and of the preparation techniques was also assessed. About 43% of the 477 respondents agree with the statement that preparation can reduce the health benefit of the *Brassica* vegetables. Another 50 and 8% of the respondents disagrees and does not know, respectively.

Broccoli is perceived as the most health beneficial *Brassica* by 69% of respondents, followed by choysum (15%). Lower percentages of respondents perceive cauliflower (6%), pakchoy (3%) and Chinese cabbage (3%) as the most health beneficial *Brassica*. Less than 1% of respondents perceive Chinese kale and white cabbage as the most health beneficial *Brassica* and ~3% of the respondents do not know. With respect to preparation technique, boiling and stir-frying are perceived as the most health beneficial techniques, equally chosen by 41% of the respondents. Steaming is perceived as the most health beneficial technique by 13%, ~2% of respondents perceive other techniques (i.e. frying or blanching) as most health beneficial, and the rest (3%) does not know.

Discussion

Food preparation techniques could reflect the diversity in food cultures, and refer to the ways in which humans use food (Kittler & Sucher, 2008). In the Southeast Asian cuisine pre-preparation of the ingredients, such as peeling, cutting/slicing/chopping and grinding, requires a lot of time, but in general the preparation times are short (Van Esterik, 2008). The current study shows that various types of *Brassica* vegetables and types of preparation techniques are commonly employed by food service establishments and households in Semarang city, Indonesia. Not only for

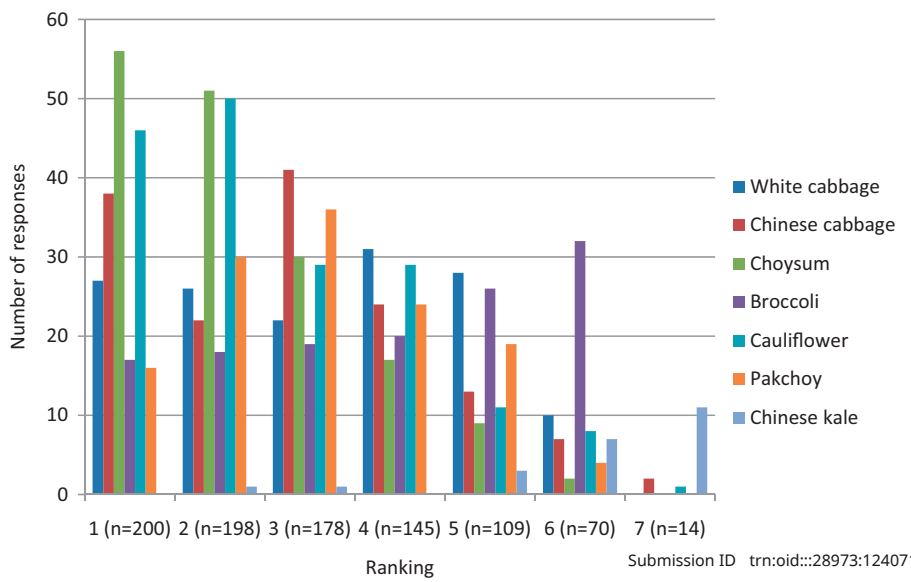


Figure 5. Frequency distribution of the ranking of *Brassica* vegetables prepared by households (ranking from 1 = the most- to 7 = the least- frequently prepared; number of responses for each ranking is shown between brackets).

Brassica vegetables, but these types of preparation were also applied for other vegetables, including carrot, green beans, radish and leafy vegetables (Bongoni et al., 2014a,b; Kala & Prakash, 2006; Kidmose et al., 2006; Faller & Fialho, 2009). There is a large number of variables that reflect the exact conditions for each of the possible preparation methods, in term of temperature, time, chopping/cutting size, (no)additional water, type and amount of other ingredient(s), and also the addition of spices.

This survey shows that in the food service establishments white cabbage is the most commonly prepared *Brassica* followed by choysum. The latter is the most commonly prepared *Brassica* by households, while white cabbage is less frequently prepared by them. White cabbage and choysum apparently are the most versatile and familiar *Brassicas*, which can be prepared into various types of dishes or as a complement of other dishes by the food service establishments (Table 2). Moreover, white cabbage is the only *Brassica* that is consumed either raw or cooked. Meanwhile, choysum is very popular to be prepared by boiling or sometimes blanching, usually as complement ingredient for noodle or meatball soups.

Boiling and stir-frying are the most dominant techniques to prepare *Brassica* vegetables in both food service establishments and households. These techniques are very familiar for preparing a wide range of *Brassica* vegetables and a large variety of dishes can be produced. However, stir-frying is a relatively seldom applied technique for preparing white cabbage, except for making the *orak-arik* dish (Table 2). Most vegetable preparation techniques utilize other ingredients, such as garlic, chili, salt and any kinds of herbs and other seasonings, as well as meat, seafood, noodle, etc. In practice, these are commonly cooked together in a pan or wok. Eventually, the dish is consumed as a side dish together with staple food, mainly rice.

Interestingly, the less frequently prepared *Brassica*, broccoli is perceived as the most health beneficial *Brassica* followed by choysum. Only a small part of the respondents perceive that white cabbage contributes to the highest health benefit, although it is prepared often. Moreover, the green *Brassicas*, i.e. broccoli, choysum, pakchoy and Chinese kale are perceived as healthier than the less green one, i.e. cauliflower, white cabbage and Chinese cabbage. Apparently, the perception on health benefits has no strong association with the frequency of preparing the *Brassica* types. Less than half of the respondents think that preparation can reduce the health benefit of the *Brassica* vegetables. The perception of the health impact of preparation techniques by the food service establishments respondents shows that steaming and boiling are perceived to have the highest health benefit. The health benefit of stir-frying, although being one of the most frequently employed techniques, is perceived to be less than others. On the contrary, for the household respondents, boiling and stir-frying are perceived as the most health beneficial technique, compared to others.

Thus, certain preparation methods and *Brassica* vegetable types that are most frequently applied are not always perceived as neither the healthiest *Brassica* nor the preparation method to have the highest health beneficial effect by the respondents. This might be due to the fact that in the (regular) practices, food handlers prepare and provide foods for consumers instead for themselves; except, probably for the family member in households. Hence, what type of *Brassica* will be cooked and how to cook the *Brassica* have no relation with the health perception of the food handlers. Besides that, perception is influenced by many variables. Perception is based on sensorial observations of individual and product characteristics, in this case the characteristics of *Brassica* vegetables. Moreover, indirect product characteristics like production methods can also influence the perception (Sijtsema et al., 2002).

A previous study on vegetable preparation of Dutch households reported that in the health-oriented consumers, steaming was used by a higher number of consumers, i.e. 27% for broccoli and 16% for carrots, compared to the total sample. Moreover, a low water level was used to prevent nutrient losses during cooking and shorter cooking times were applied for broccoli and slightly longer for carrots (Bongoni et al., 2014b). Other studies on food preparation practices by food handlers mainly focused on the hygienic aspect and food safety (Angelillo et al., 2000; Green et al., 2005; Woodburn & Raab, 1997).

The current study explores a new topic, yet limitations should be acknowledged. The behavior and health perception related to food preparation may differ from one population group to another and differ over time, as Wahlqvist & Lee (2007) emphasized that locality matters in relation to food culture, in which local conditions must be considered when applying the findings into society. However, the description of preparation techniques by food handlers in Semarang city may reflect a more general behavior regarding vegetable preparation, particularly in Asia. Semarang city, a capital of Central Java province, is located in a coastal area of $\sim$370 km^2, inhabited by more than 1.6 million population (Statistics Central Java, 2013). Like other urban cities in Southeast Asia, such as Bangkok, Jakarta, Manila and Ho Chi Minh City, this city has been facing a number of issues, e.g. sustainable urban development and rising populations, as well as the diversity of populations (Clammer, 2003). Van Esterik (2008) described the diversity as well as similarity of food culture in Southeast Asia by giving some examples of the ingredients, dishes and the preparation techniques.

Food service establishments in Southeast Asia, including street food vendors, have an important role on providing daily menu for society (Dawson & Canet, 1991; Van Esterik, 2008). For households, the role of family member in food preparation is also vital. Despite that preparation methods could reflect the diversity of food culture, globalisation of food (including the preparation of food) have been penetrating around the world. For instance, people in USA evolve into a culture marked by global food preferences and consumers explore more global food preparations and flavor (Paschel, 2007).

Food preparation, particularly that involving heat, is aimed to inactivate pathogens, to increase sensorial liking and digestibility, and other beneficial changes, but it can also lead to negative impacts, such as losses of certain (micro)nutrients and phytochemicals, formation of toxic compounds or of compounds with negative effects on sensorial perception (van Boekel et al., 2010). Processing or preparation of *Brassica* vegetables changes the amount of health promoting compounds, i.e. glucosinolates, depending on the technique and applied conditions and the type of *Brassica* vegetable (Nugrahedi et al., 2015). Glucosinolates are a group of plant secondary metabolites that present almost exclusively in *Brassica* vegetables (Hanschen et al., 2014; Verkerk et al., 2009). Eid et al. (2014) showed that glucosinolate intake in *Brassica* spp is associated with the reduction in colorectal cancer risks. The breakdown products of glucosinolates, particularly isothiocyanates, have been reported to act on the process of carcinogenesis by influencing several phases of tumor initiation, promotion and progression, and by suppressing the final steps of carcinogenesis (Traka & Mithen, 2009).

The variability of preparation techniques, as observed in the survey, indicates a diversity of potential impact on the glucosinolate amount of *Brassica* vegetables. Some of the techniques might reduce the glucosinolate content significantly while others might retain most of that content. Various mechanisms are taking place during thermal treatment of vegetables, either sequential or simultaneous, which involve (bio)chemical reactions, heat and mass transfer (Dekker et al., 2000). In this

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respect, the combination of time and temperature plays a critical role in the preparation technique applied.

A short-time stir-frying is supposed to have a limited effect on the reduction of glucosinolates due to the limited time the vegetable is heated and the absence of leaching, but inactivates the hydrolytic enzyme myrosinase. Previous experimental studies showed, for examples, the retention of glucosinolate content in green cabbage, broccoli, Brussels sprouts and cauliflower during stir-frying (Rungapamestry et al., 2008; Song & Thornalley, 2007). Moreover, there was no significant difference of glucosinolate loss during stir-frying of broccoli between with and without external water treatments (Yuan et al., 2009). Meanwhile during boiling, leaching is one of the critical factors leading to glucosinolate loss. Previous studies reported that losses of 25–75% of glucosinolates due to leaching are typically expected for boiling processes (Nugrahedi et al., 2015). For examples, the loss of total glucosinolates was ~46–55% in broccoli (Gliszczyñska-świglo et al., 2006; Vallejo et al., 2002), >50% in cabbage (Rosa & Heaney, 1993) and ~30% in turnips greens (Francisco et al., 2010). The losses of GS during boiling depend on time, amount and initial temperature of water used for boiling. Moreover, the diffusion of GS into water depends rather on the amount of water used for boiling than on time of this treatment (Dekker et al., 2000).

Boiling during a longer time as well as the habit of reheating leftovers of a dish, as these were commonly employed by some food handlers, can considerably reduce the glucosinolate amount due to thermal breakdown. Compared to boiling, blanching is expected to have lower effects on the glucosinolate loss (Nugrahedi et al., 2015). Meanwhile, steaming was reported to retain the glucosinolate content in *Brassica* vegetables as compared to other domestic preparation techniques (Conaway et al., 2000; Rungapamestry et al., 2006; Vallejo et al., 2002). Nevertheless, blanching and steaming were less frequently employed to prepare *Brassica* vegetables than stir-frying and boiling in this current study.

Further studies are needed to get more detailed insights into actual preparation behavior and to explain the motivation behind this behavior for both food service establishments and households. Recent work of Bongoni et al. (2013) introduced ''consumer-oriented food technology'' as a research approach for multi-criteria optimization of vegetable quality, including health properties, after domestic preparation. This approach can also be applied towards Asian food preparation practices. Eventually, the results can contribute to optimizing the quality of vegetable products.

Conclusion

The current study reveals that boiling and stir-frying are the most frequently applied preparation techniques to prepare *Brassica* vegetables in food service establishments and households, while other techniques are less frequently performed. Moreover, white cabbage and choysum are the most frequently prepared vegetables among the *Brassica* vegetables. These vegetables are also prepared to more diverse dishes. In terms of perception of health, broccoli is perceived as the healthiest *Brassica* by both households and food service establishments. Furthermore, steaming and boiling are perceived to have high health beneficial effects according to the food service establishment respondents. Meanwhile, for the household respondents boiling and stir-frying are perceived as the most health beneficial preparation techniques.

The obtained survey information on type of vegetables, dishes and especially preparation techniques were used to evaluate the nutritional implications of the different preparation techniques on the alleged health promoting glucosinolates in *Brassica* vegetable. The results of this study are useful as an approach for developing good and healthy vegetable preparation practices in both food service establishments and households.

Acknowledgements

The authors thank to Albert P. Cahya, Arif Budiyanto, Andi Saputra and Laurina D. Amilia for the survey assistance and to all respondents of the survey.

Declaration of interest

The authors report no conflicts of interest.

P.Y.N. received a scholarship for the PhD project from the Directorate General of Higher Education, Indonesia.

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